Rural Building – Basic Knowledge

Table of Contents

Rural Building – Basic Knowledge

PREFACE

This official text book is designed purposely to meet the needs of trainees who are pursuing rural building courses in various training centres administered by the National Vocational Training Institute.

The main aim of this book is to provide much needed trade information in simple language and with illustrations suited to the understanding of the average trainee.

It is the outcome of many years of experiment conducted by the Catholic F.I.C. brothers of the Netherlands, and the German Volunteer Service instructors, in simple building techniques required for a rural community.

The National Vocational Training Institute is very grateful to Brothers John v. Winden and Marcel de Keijzer of F.I.C. and Messrs. Fritz Hohnerlein and Wolfram Pforte for their devoted service in preparing the necessary materials for the book; we are also grateful to the German Volunteer Service and the German Foundation For International Development (DSE) – AUT, who sponsored the publication of this book.

We are confident that the book will be of immense value to the instructors and trainees in our training centres.

DIRECTOR: National Vocational Training Institute, Accra

INTRODUCTION TO A RURAL BUILDING COURSE

Vocational training in Rural Building started in the Nandom Practical Vocational Centre in 1970. Since then this training has developed into an official four year course with a programme emphasis on realistic vocational training.

At the end of 1972 the Rural Building Course was officially recognised by the National Vocational Training Institute. This institute guides and controls all the vocational training in Ghana, supervises the development of crafts, and sets the examinations that are taken at the end of the training periods.

The Rural Building programme combines carpentry and masonry, especially the techniques required for constructing housing and building sanitary and washing facilities, and storage facilities. The course is adapted to suit conditions in the rural areas and will be useful to those interested in rural development, and to farmers and agricultural workers.

While following this course, the instructor should try to foster in the trainee a sense of pride in his traditional way of building and design which is influenced by customs, climate and belief. The trainee should also be aware of the requirements of modern society, the links between the old and new techniques, between traditional and modern designs – and how best to strike a happy medium between the two with regard to considerations like health protection, storage space, sewage and the water supply. The trainee should be encouraged to judge situations in the light of his own knowledge gained from the course, and to find his own solutions to problems; that is why this course does not provide fixed solutions but rather gives basic technical information. The instructor can adapt the course to the particular situation with which he and the trainee are faced.

This course is the result of many years of work and experimentation with different techniques. The text has been frequently revised to serve all those interested in Rural Development, and it is hoped that this course will be used in many vocational centres and communities. It is also the sincere wish of the founders of this course that the trainees should feel at the completion of their training that they are able to contribute personally to the development of the rural areas, which is of such vital importance to any other general development.

We are grateful to the Brothers F.I.C., the National Vocational Training Institute and the German Volunteer Service for their assistance and support during the preparation of this course.

Bro. John v. Winden (F.I.C.)
Wolfram Pforte (G.V.S.)
Fritz Hohnerlein (G.V.S.)

LAY–OUT OF THE RURAL BUILDING COURSE

The Rural Building Course is a block–release–system course, which means that the trainee will be trained in turn at the vocational centre and at the building site. The period of training at the centre is called “off–the–job” training, and the period on the building site is called “on–the–job” training. Each will last for two years, so that the whole course will take four years and will end with the final test for the National Craftsmanship Certificate.

BLOCK RELEASE SYSTEM

YEAR	TERM 1	TERM 2	TERM 3
1	X	X	X
2	O	O	O
3	O	X	O
4	X	O	X

X = OFF–THE–JOB TRAINING
O = ON–THE–JOB TRAINING

The total “off–the–job” training period is approximately 76 weeks, each week 35 hours. During this training about 80% of the time is spent on practical training in the workshop. The remaining 20% of the time is devoted to theoretical instruction.

The total “on–the–job” training period is approximately 95 weeks, each week 40 hours. During this period the trainee does full–time practical work related to his course work. In addition some “homework” is assigned by the centre and checked by the instructors.

A set of books has been prepared as an aid to the theoretical training:

A – Rural Building, Basic Knowledge (Form 1)
B – Rural Building, Construction (Forms 2, 3, 4)
C – Rural Building, Drawing Book (Forms 1, 2, 3, 4)
D – Rural Building, Reference Book

All these books are related to each other and should be used together. The whole set covers the syllabus for Rural Building and will be used in the preparation for the Grade II, Grade I, and the National Craftsmanship Certificate in Rural Building.

BOOK INTRODUCTION

Rural Building, Basic Knowledge is your first construction book. This book plus most of the Reference Book (Rural Building Tools, Maintenance of Tools, Materials and Building Products) will be treated in the first year of centre training.

This book is divided into three parts:

PART 1: BASIC MASONRY TECHNIQUES

> This part covers the very basic techniques of masonry. These include the preparation of mortar, blocklaying, the proper arrangement of blocks, and building up walls. Some of the techniques mentioned in the section on the arrangement of blocks are techniques used mainly for bricklaying and therefore only apply to areas where bricks are available.

PART 2: BASIC CARPENTRY TECHNIQUES

> The basic techniques covered here include planning construction pieces, preparing wood for construction pieces, ways of fastening the pieces and the important types of joints and how to construct them.

PART 3: PREPARATION FOR ON–THE–JOB TRAINING

> This part is meant to be a preparation for the trainee's first year of on–the–job training. It should enable him to follow the basic procedures he is confronted with on a building site, and to understand the technical terms used there. This part of the book doesn't attempt to give detailed information about technical problems but merely to give an idea of them and to enable the trainee to understand the terms and deal with situations on the building site. Most of the procedures will be treated more intensively in the Construction and Drawing books.

At the beginning of both the carpentry and masonry sections there is a list of the terms you will need to know, together with explanations.

You will often be asked to refer to one of the supplementary books for additional information. Especially in the first part of the course, much of the basic knowledge you will need about tools and materials and products will be found in the other books.

You should prepare yourself for each lesson by reading the material before class and looking up the references given in the text for the Reference Book or Drawing Book. If you are not familiar with a tool that is mentioned, now is the time to look in the Reference Book and learn about the tool and how to use it.

There is ample space provided in the book for making notes and sketches.

SAFETY FIRST

When you first start doing construction work it is essential to realize the importance of being safety conscious. You must develop safe working habits in order to prevent injuries to yourself and others.

Accidents can generally be avoided by using ordinary care and skill. Most accidents are a result of thoughtlessness or carelessness on the part of some person.

To practise any kind of craftwork you need your hands, your legs and feet, a healthy body, and most of all your head.

Safety first means that you use your head and think out what you are going to do before going ahead with the job. By first thinking the operation through, you will discover that there is a correct way of doing the task, and some other ways of doing it that may cause danger to yourself and others. Look in the beginning of your Reference Book for a list of general safety rules.

Follow the safety rules, but also use your own sense. When you realize that certain actions can be dangerous, you can plan to prevent accidents and injuries. Look ahead to find the dangerous points of a task and plan to make them safe by taking proper precautions. We can make hundreds of safety rules, but they are useless unless we understand why they are needed and we all cooperate in following them.

One of the most important safety precautions is learning to use the right tool for the job, and in the correct way. The correct way is the safest way.

RESPECT OTHER PEOPLE: RESPECT YOURSELF!

PART 1: BASIC MASONRY TECHNIQUES

TECHNICAL TERMS

Before describing the methods used in bonding it is necessary to briefly define and explain a few of the technical terms commonly used.

– SUN–DRIED TRAINING BLOCKS: These blocks, as the name implies, are dried in the sun, because they do not contain cement (Fig. 1). They are often used by beginners during their first terms of in–centre training, as they are easy to make and to handle.

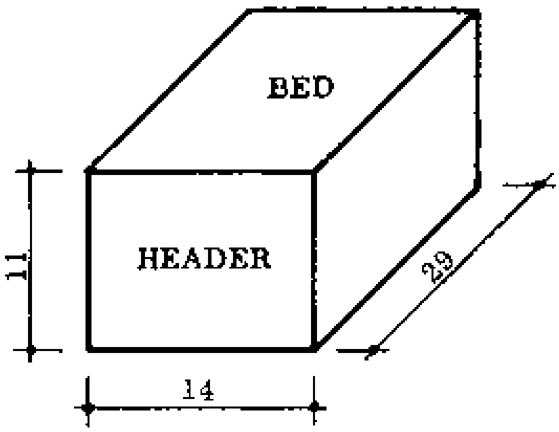


Fig. 1 SUN–DRIED TRAINING BLOCK

The dimensions of these blocks are approximately 29 cm × 14 cm × 11 cm, which allows us to construct complicated bonds with them. They can be used to make an excellent inside wall also, as the following chapters will describe.

– LANDCRETE BLOCKS: These are blocks used for actual building (Fig. 2).

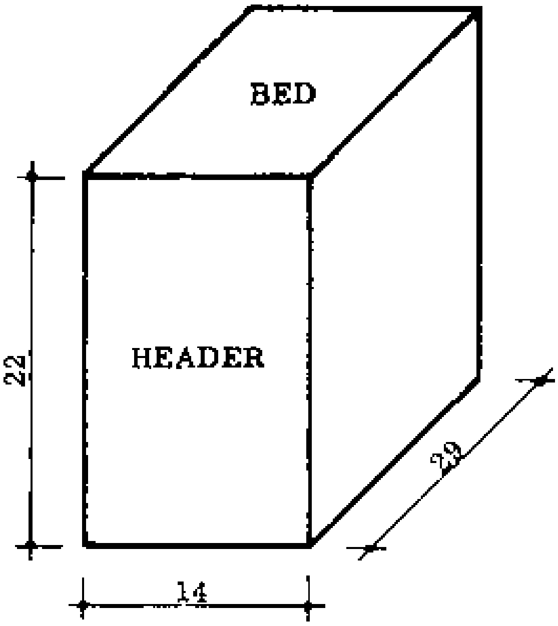


Fig. 2 LANDCRETE BLOCK

– SANDCRETE TRAINING BLOCKS: These are specially made small sandcrete blocks with the approximate dimensions of 24 cm × 14 cm × 11, 5 cm; so they can be used to teach the making of more complicated bonds (Fig. 3).

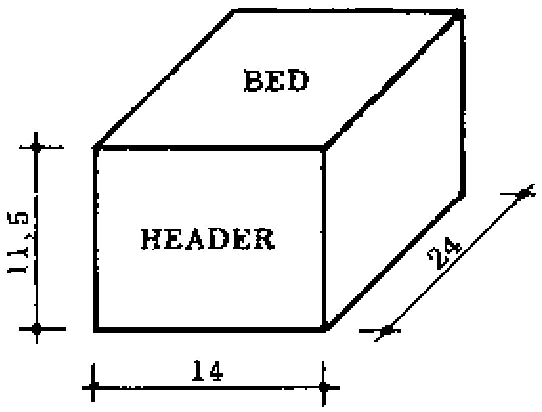


Fig. 3 SANDCRETE TRAINING BLOCK

Like the sun–dried blocks, they are often used in training because they are easy to handle. As they are made with cement they can be used for a long time before they wear out.

– SANDCRETE BLOCKS: This type of block is used for actual building (Fig. 4).

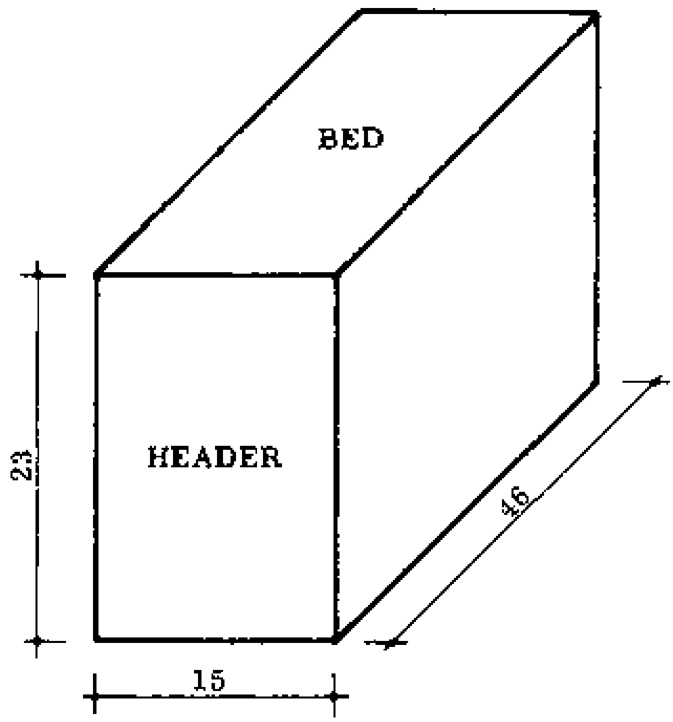


Fig. 4 SANDCRETE BLOCK

– 3/4 – 1/2 – 1/4 – BLOCKS: These are parts of blocks obtained by cutting a block through either the centre line or the quarter line, less half the thickness of the joint (Fig. 5). The cut is made along the width, not along the length. A special block gauge may be used for marking off the different sizes.

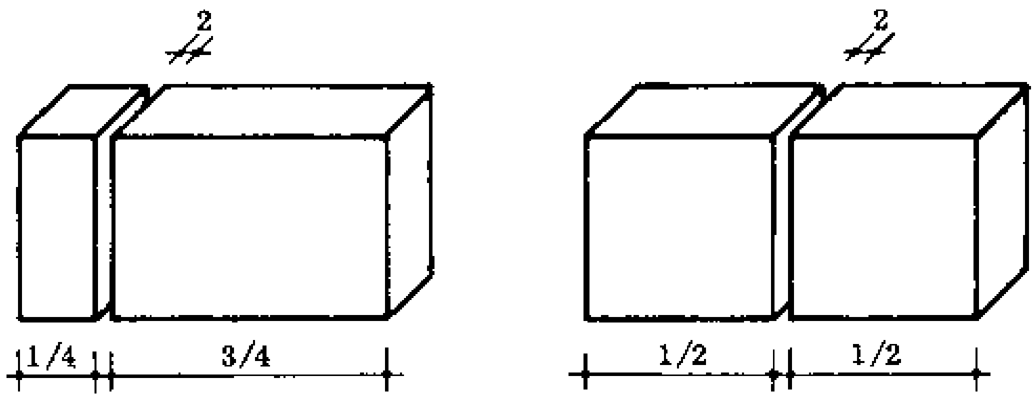


Fig. 5 1/4 – 1/2 – 3/4 BLOCKS

– HEADER: A block is known as a header when it is placed in a wall so that its smallest face is exposed (Fig. 1, next page).

– BED: The under–surface of a block, or the mortar on which the block is laid.

– STRETCHER: If the biggest face of a block is exposed, the block is called a stretcher (Fig. 1, next page). This is the way most blocks are laid in Rural Building, and we say that the block is laid edgewise. If a block is laid flatwise, so it is actually showing the top face, it is also called a stretcher (Fig. 1, next page).

– COURSE: This is the term applied to each layer or row of blocks, with the bed joint included (Fig. 1, next page).

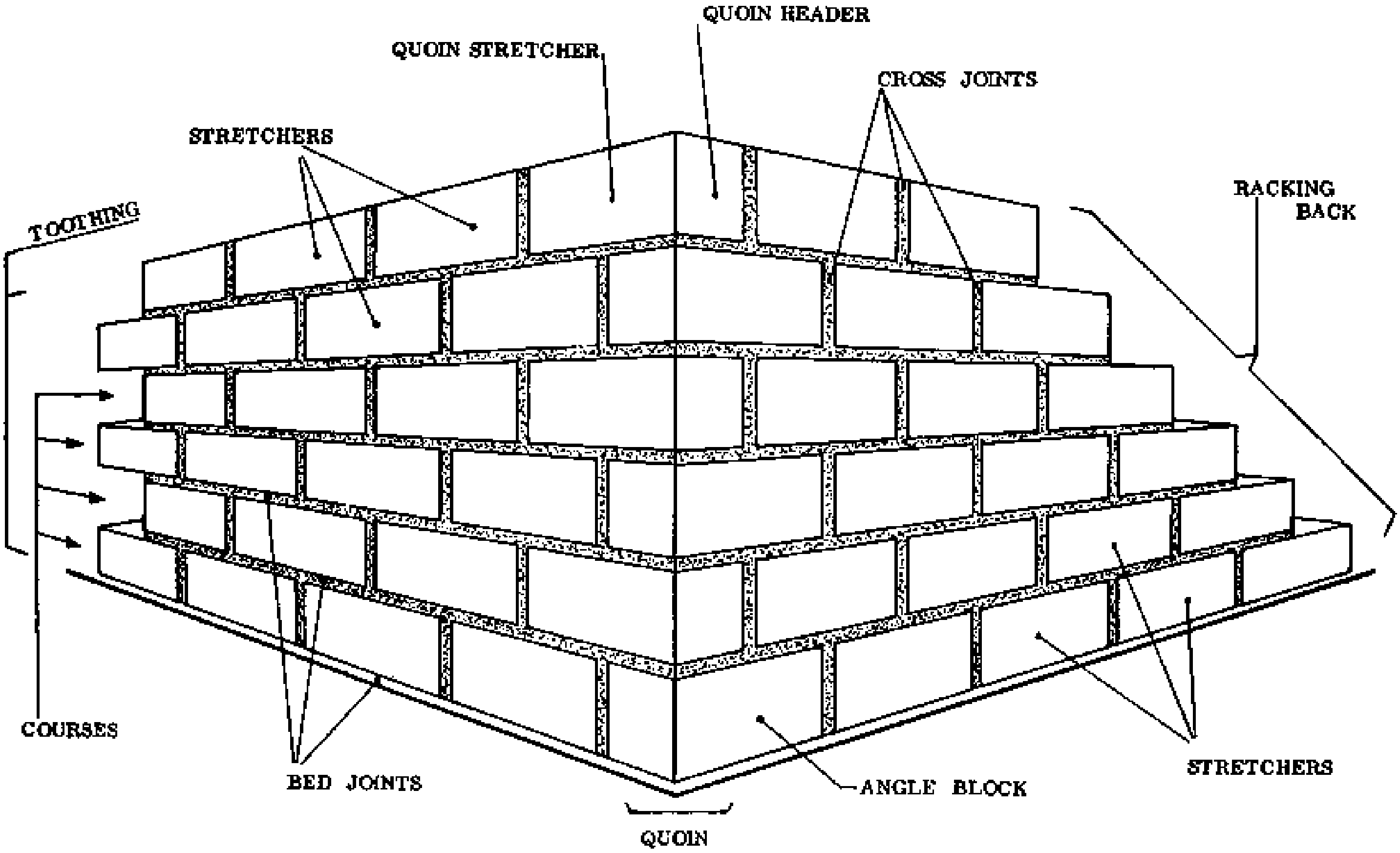


Fig. 1

– BED JOINT: This is the horizontal mortar joint between two courses (Fig. 1).

– CROSS JOINT: The vertical joints between the blocks (Fig. 1).

– QUOIN: The quoin is the outside corner of a wall or the external angle on the face side of the wall (Fig. 1).

– ANGLE BLOCK: This is the block which actually forms the corner in each course (Fig. 1).

– STOPPED END: A plain vertical surface which forms the end of a wall (see page 21).

– TOOTHED END OR TOOTHING: The form produced at the end of a wall by recessing every other course by half a block (Fig. 1) in order that the wall may be extended later using the same bond.

– RACKING BACK: As an alternative to toothing, the end of a wall may be set back half a block at each course (Fig. 1). This is also done so that the wall may be extended later using the same bond.

– BUILDING UNIT: This refers to the dimensions of a full block, plus one joint. For sandcrete blocks the building unit is 25 cm high by 48 cm long (2 cm joints).

– FOUNDATION: The base, usually concrete, on which the building rests. It is usually set below ground level, and is the only part of the building in direct contact with the ground.

– FOOTINGS: The courses laid directly on top of the foundations; usually three flatwise courses of sandcrete blocks (see page 35).

– PLINTH COURSE: The edgewise course of sandcrete blocks laid on top of the footings (see page 35).

– RISING WALL: The edgewise courses of sandcrete or landcrete blocks which build up the rest of the wall (see page 35).

NOTES:

BONDING OF WALLS

The practise of blocklaying requires a complete understanding of the correct arrangement of the blocks forming a wall. This correct arrangement of blocks, regardless of the method, is known as bonding.

The blocks are placed so that they overlap each other and care must be taken to ensure that as far as possible no vertical joint is immediately above another vertical joint in the course below.

General effect of bond

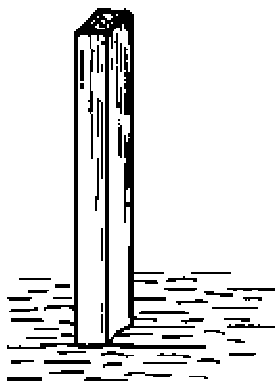


Fig. 1 POLE GIVES WAY AND SINKS DOWN

Fig. 1 shows a wooden pole placed vertically on soft ground. If this pole has to carry a heavy load it will sink down into the soil, because the total area on which the pole rests on the ground is far too small to support it (Fig. 2).

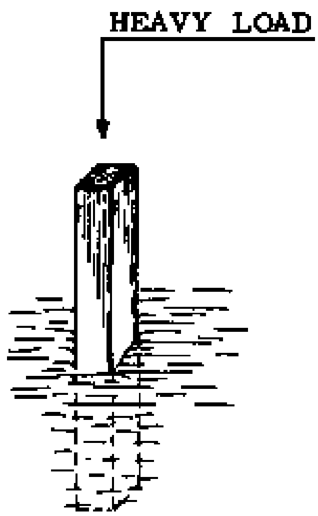


Fig. 2 POLE GIVES WAY AND SINKS DOWN

A possible solution to the problem is shown in Fig. 3: a board is laid flat on the ground and it now carries the pole with the load. In this way the total load is distributed over a larger area of ground and it is impossible for the pole to sink down.

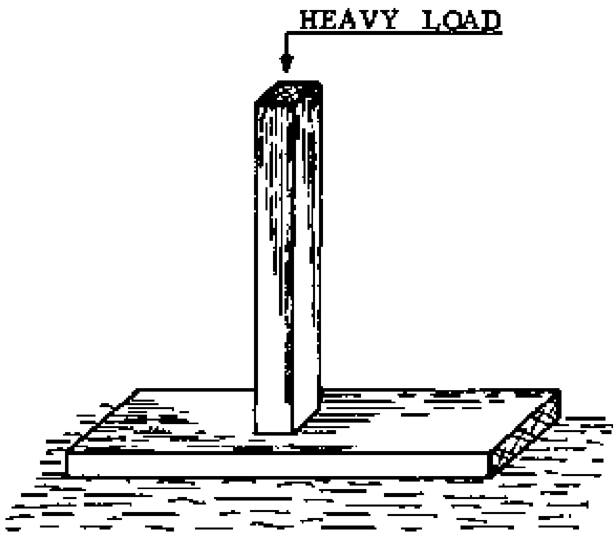


Fig. 3 LARGER AREA OF BOARD PREVENTS POLE FROM SINKING DOWN

If a wall is built up by simply placing blocks directly above each other, we say the wall is built without bond. If a heavy load is put on top of this wall (Fig. 4) the column of blocks immediately under the load tends to give way and sink down.

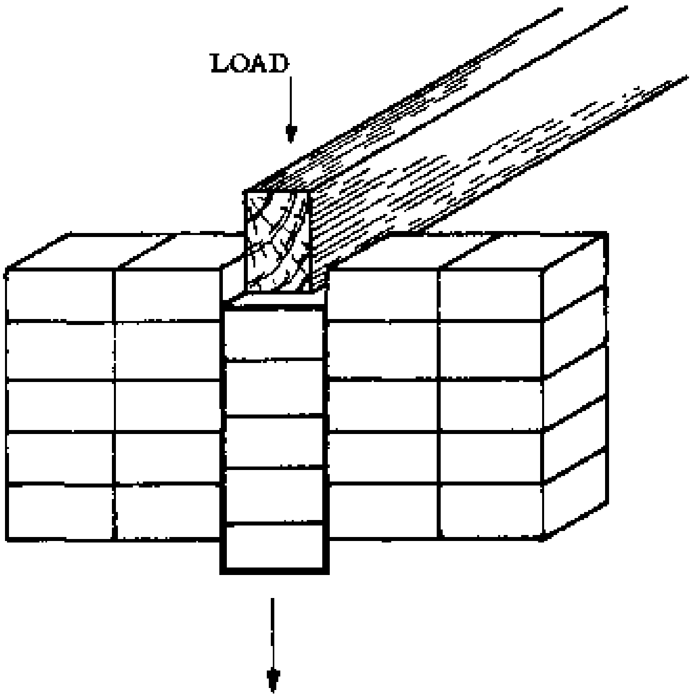


Fig. 4

In order to make the wall stronger in itself and able to distribute loads properly, the Rural Builder applies the so–called half–block bond.

A properly bonded wall which receives a heavy load will distribute the pressure over a large number of blocks and therefore over a much greater area (Fig. 5).

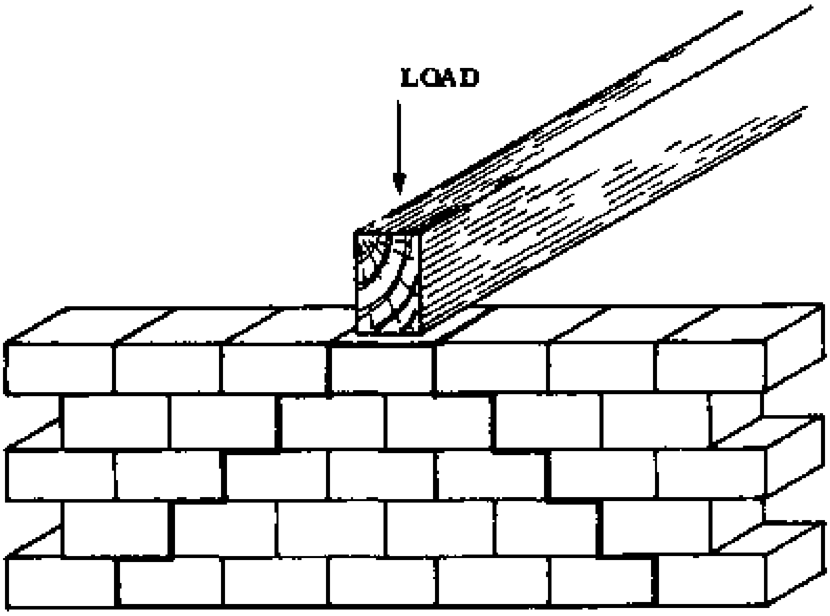


Fig. 5

NOTES:

Half−block bond

The simplest form of bonding is that where all the blocks are laid down as stretchers, each block overlapping the one below by half its length (Fig. 1).

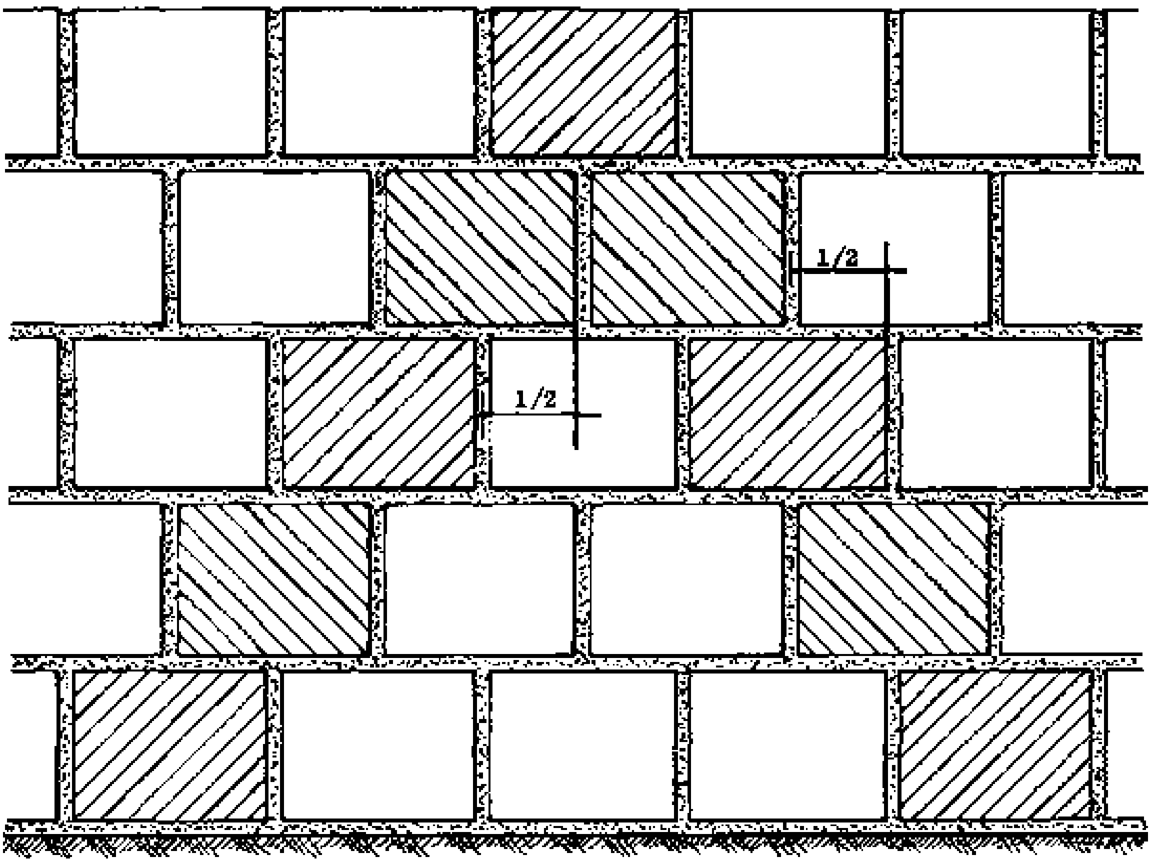


Fig. 1 HALF−BLOCK BONDING (LANDCRETE)

SCALE 1: 10 (cm)

This form of bonding is only suitable where a one−block thickness of the wall is sufficient. In Rural Building the most common wall thickness is 14 cm when landcrete blocks are used and 15 cm when using sandcrete blocks; provided that they are laid edgewise.

If for some reason a thicker wall is required, the blocks may be laid flatwise. By doing this the wall thickness will be increased to 23 cm, 29 cm or even 46 cm depending on the type of block and the way the blocks are laid.

Other types of bond

There are many types of bond in use, the two most common being the English Bond (Fig. 2) and the Flemish Bond (Fig. 3), both of which are used with bricks.

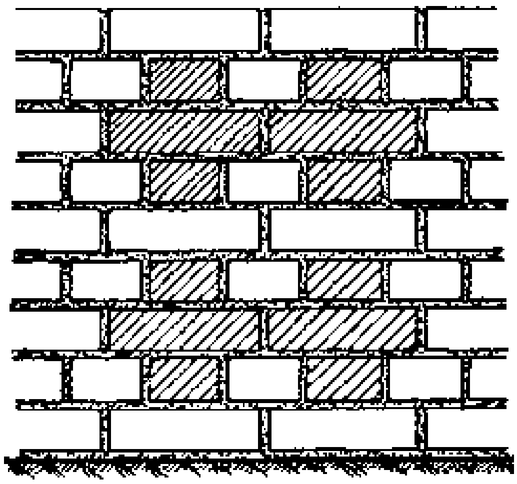


Fig. 2 ENGLISH BOND

SCALE 1: 10 (cm)

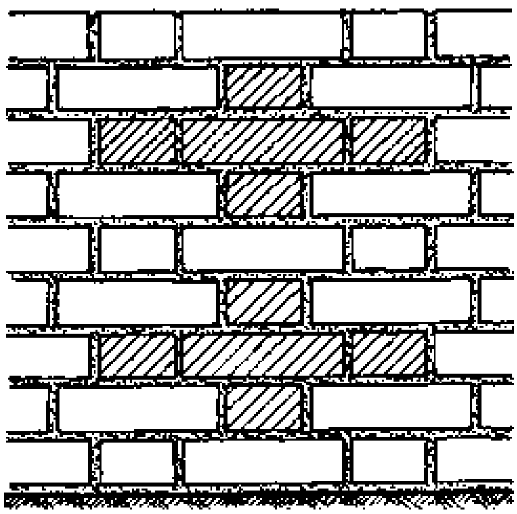


Fig. 3 FLEMISH BOND

SCALE 1: 10 (cm)

Bricks are smaller blocks with approximate dimensions of 24 cm × 11, 5 cm × 7 cm.

− ENGLISH BOND: This bond consists of alternate courses of headers and stretchers. The centre of any stretcher is in line with the centre of the header in the courses above and below.

– FLEMISH BOND: This bond consists of alternate headers and stretchers in the same course. Again, the centre of any stretcher is in line with the centre of the header in the courses above and below.

NOTES:

HANDLING THE TROWEL

In the process of laying blocks, the brick trowel is used to perform a series of operations during which the trowel is seldom put down or changed from one hand to the other.

All operations require free and easy manipulation of the trowel from the wrist and it is therefore essential to master the correct handling of the trowel.

Fig. 1 illustrates the correct grip on the handle, with the thumb resting on the ferrule. The thumb must be in this position in order to manipulate the trowel skillfully.

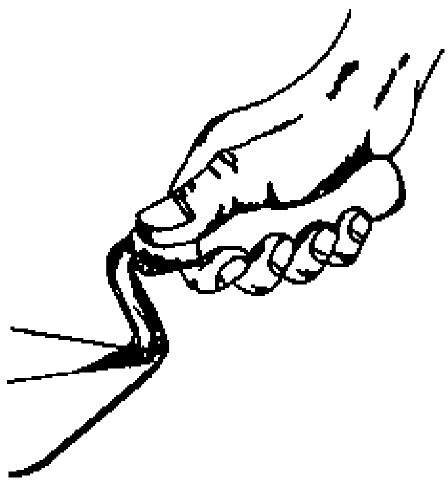


Fig. 1 CORRECT GRIP

The amount of mortar picked up from the headpan will depend on the nature of the job, but for the trainee it is advisable to pick up a sufficient amount to lay one training block, i.e. a heaped trowel. Later, when working with the common big blocks, it will become necessary to pick up two trowelfuls of mortar.

Preparing the bed joint

Place the mortar in the middle of the wall or the marked position of the first course and spread it out by a pushing movement with the back of your trowel, into a layer about 3 cm thick (Fig. 2).

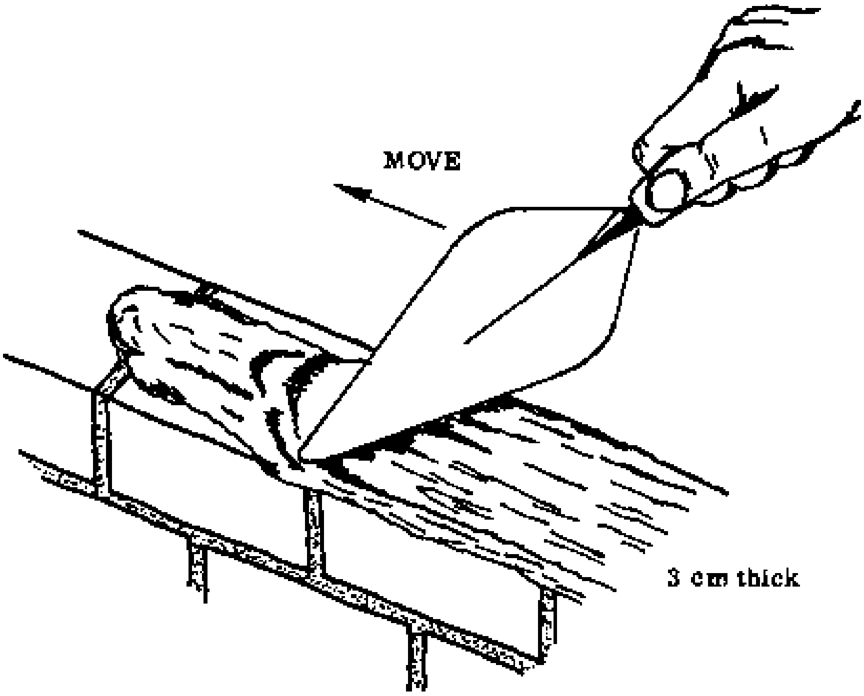


Fig. 2

Next draw the point of your trowel through the centre of the layer, making a mortar bed suitable for the block (Fig. 3).

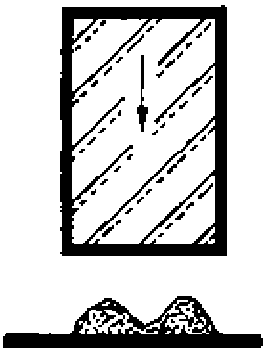


Fig. 3

A block laid on a bed prepared in this way will at first rest on the two outer edges, but when it is pressed down to its correct position it will not only squeeze mortar from the front and back of the block but will also squeeze it into the valley in the centre. In this way a solid bed is formed (Figs. 3, 4, & 5).

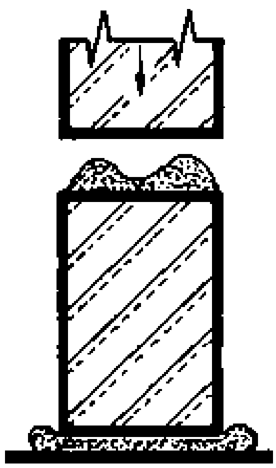


Fig. 4

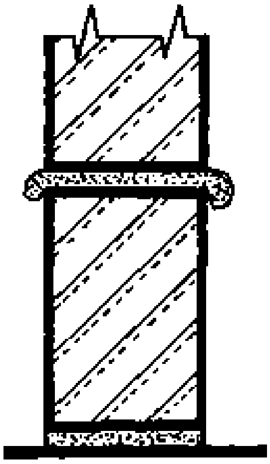


Fig. 5

– NOTE: All the tools mentioned in this section on masonry techniques are described in the Rural Building Reference Book, pages 3 to 15.

NOTES:

Removing surplus mortar

Before and after the block is layed, a certain amount of mortar will project from both sides of the wall. This must be removed before it drops down, as one of the most important principles of the Rural Builder is to work as economically as possible. This means saving materials. Fig. 1 shows the position of the trowel for these operations.

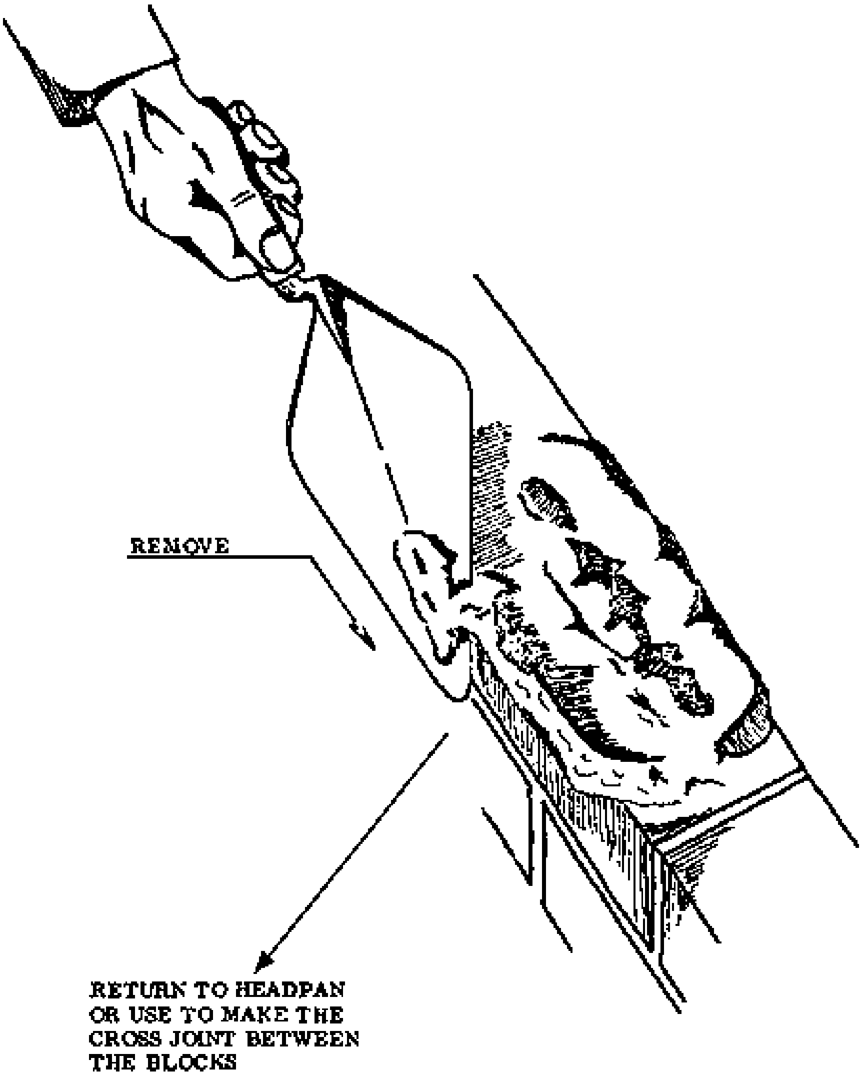


Fig. 1

The surplus mortar recovered on the trowel is usually taken to form the cross joint between the last laid block and the previous one, or it is returned to the headpan.

NOTES:

THE FIRST WALL

Setting out

Before actual building operations are started, you must know the correct position and dimensions of all the parts of the building.

This information is given in the plan or drawing of the building, which of course must have been already prepared and at hand.

The positions of the walls, for instance, have to be marked on the ground according to the measurements given on the plan before any building operation starts.

This operation is called “setting out” and we will deal with it repeatedly here, because it is one of the most important preparatory steps in building.

Organizing the work

The workplace has to be well organized in order to operate smoothly and safely.

Building materials such as blocks and mortar should be neither too close nor too far away from the wall being erected. A working space of about 90 cm will usually be all right. The blocks should be neatly stacked, not just thrown in a heap; and there should always be an adequate supply available, so that work is not delayed by waits for materials.

Keep your tools together and near your workplace so they are within easy reach. When you use a tool, put it back immediately afterwards so that it cannot fall off the wall etc. and injure you or other workers. Make a habit of putting your tools down in a way that prevents accidents.

– NOTE: You cannot expect to produce a good job with your tools and materials always scattered around. Neatness and orderliness show the professional.

Never throw, kick or drop tools as you might damage them.

Work on one side of the wall only. As the wall becomes higher, you won't be able to move from side to side anyway.

NOTES:

Preventive measures

Almost all of the building in the Northern and Upper Regions of Ghana is done during the dry season, with its high temperatures and low humidity. These conditions are important and our building procedures must take them into consideration to prevent problems with drying out.

Before you put the mortar down and spread ft, thoroughly wet the top of the foundation or the already laid course.

Do the same thing with the block that you are going to lay next. This is to prevent the block from absorbing too much moisture from the mortar. The porous landcrete or sandcrete blocks quickly suck in any moisture they come into contact with. This process is known as absorption. If the blocks absorb too much moisture from the mortar, it will not be able to set properly, and the joints will be weak. By sprinkling sufficient water onto the blocks, we ensure that there will be enough moisture left in the mortar to allow it to harden properly.

It is also important to never spread too much mortar at one time. Some masons prepare the mortar bed in advance for five, six or even more blocks in order to speed up the work. This is wrong.

While the first blocks are placed, lined–out, and levelled, the rest of the mortar is exposed for too long to the sun and air.

Due to the high temperatures and the low humidity, the mortar dries out very fast. As a result the mortar becomes too stiff, making it difficult to lay the last blocks and weakening the grip between the mortar and the block. The end result is a weak wall.

The Rural Builder should always keep in mind the dry climate and never spread more mortar than is actually needed.

NOTES:

The first blocks

After you have wetted the block and the area where it is supposed to be set, spread the mortar according to the method described on page 12. Set the block immediately onto the mortar bed and press it down firmly and evenly (Fig. 1).

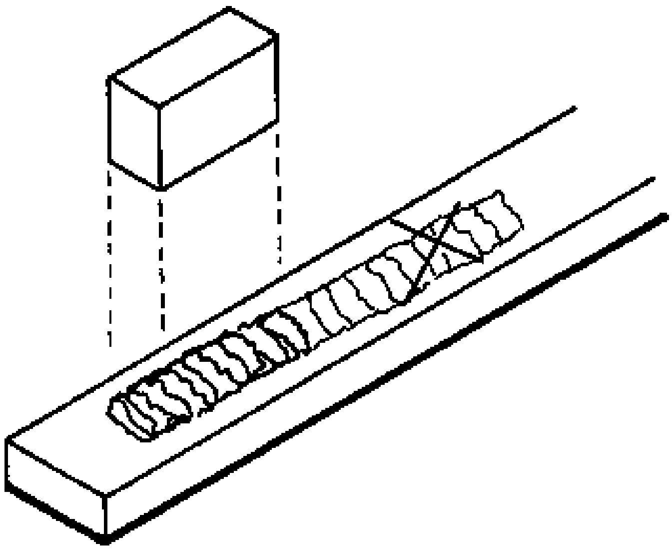


Fig. 1 SET THE BLOCK ON THE MORTAR

If the bed has been spread correctly, only a few taps with the handle of the trowel will be needed to adjust the height of the block. The height is checked by comparing the height of the block with the gauge marks on the straight edge (Fig. 2).

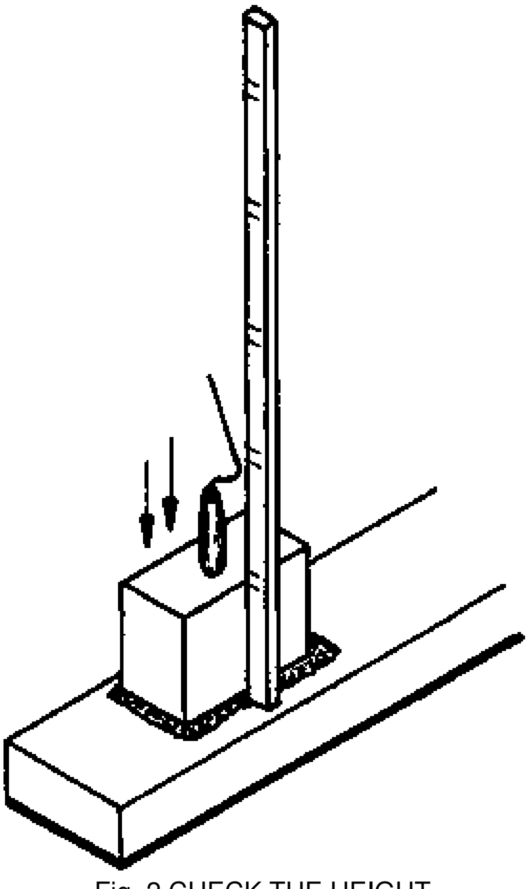


Fig. 2 CHECK THE HEIGHT

Next, plumb the block with the spirit level along the stretcher face and the header face as shown in Fig. 3. The pressure on the block will have squeezed out some of the mortar. Trim off this excess, collect it on the trowel and return it to the headpan.

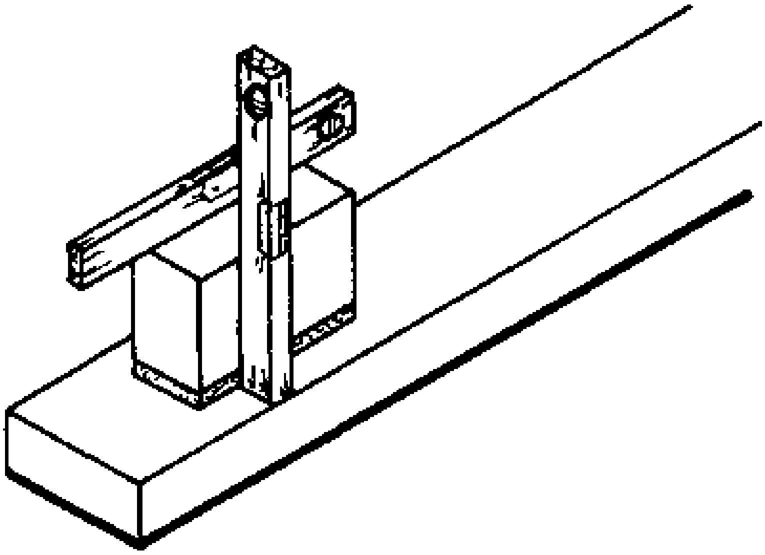


Fig. 3 PLUMB AND LEVEL THE BLOCK

If you don't use enough water to make the bed, the block will not come up to the required height; it will sit too low. If on the other hand too much mortar is used, the block will sit too high.

Do not try to correct problems like this by pushing some mortar from the edges towards the inside of the bed using your fingers; or by knocking hard on the top of the block to try and force it down. These are very poor practices. Instead, Simply remove the block and re−spread the mortar.

At the beginning of the training you will have to re−lay blocks quite often. As you gradually gain experience you will be able to spread just enough mortar to lay one block, without any of the problems mentioned above.

Lay the second block at a distance of four building units and one joint away from the first block (Fig. 4). Hold the straight edge against the stretcher faces of the two blocks to make sure that they are in line.

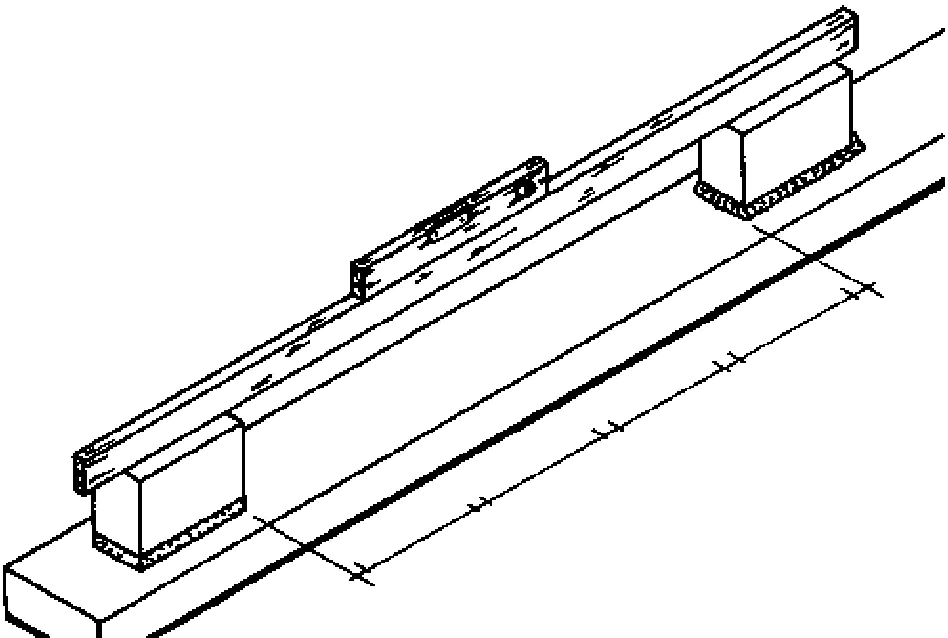


Fig. 4 LAY THE SECOND BLOCK MAINTAIN THE CORRECT DISTANCE OF 4 BUILDING UNITS PLUS 1 JOINT.

NOTES:

The first course

Because the first two blocks are in line and at the same height, we can complete the course without using the spirit level, only using the straight edge. Starting from either block (but still working on only one side of the wall) more blocks are inserted between the first two (Fig. 1).

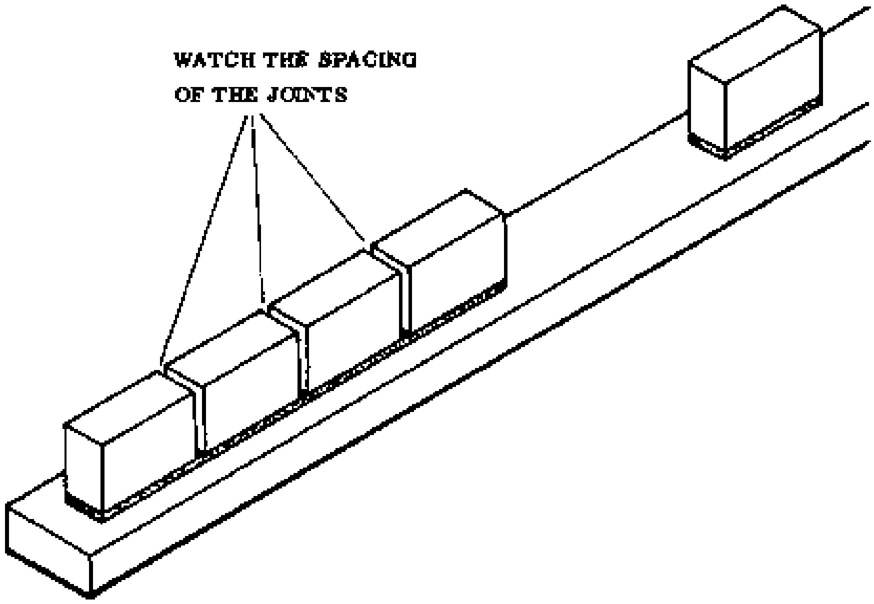


Fig. 1 LAYING THE FIRST COURSE

Their height is adjusted by placing the straight edge on top and pressing the blocks down until the top surfaces of all the blocks touch the straight edge equally, along their whole length.

Line out the course (make it perfectly straight) by holding the straight edge against the stretcher faces and moving the blocks until they touch it along their full length.

During these operations take care to maintain the proper distances between the blocks. The next step is to fill the remaining open gaps between the blocks with mortar, thus forming the cross joints. This job is done by closing the back of the gap with the aid of a small wood float while carefully pushing the mortar down into the joint with the trowel (Fig. 2).

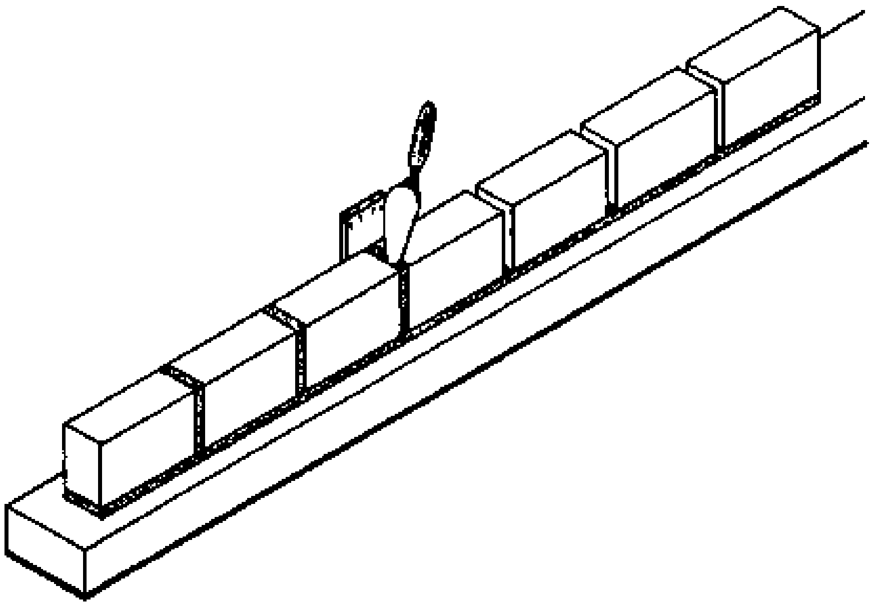


Fig. 2 FILLING UP THE CROSS JOINTS

REMEMBER: RETURN SURPLUS MORTAR TO THE HEADPAN!!

All cross joints must be completely filled up with mortar so that no holes are left, which would reduce the strength of the course and the whole wall.

All the excess mortar which has dropped down or was squeezed out of the bed must now be collected and returned to the headpan to be mixed with the rest of the mortar.

NOTES:

The second course

Lay the first block of the second course with its centre exactly above the first cross joint so that it overlaps both blocks below equally.

No matter what sort of wall−ending is desired, the first block of the second course is always a full block laid above the first cross joint between two stretchers. This is known as the 1−2−1 rule. By doing this you maintain the half−block bond throughout the wall (Fig. 1)

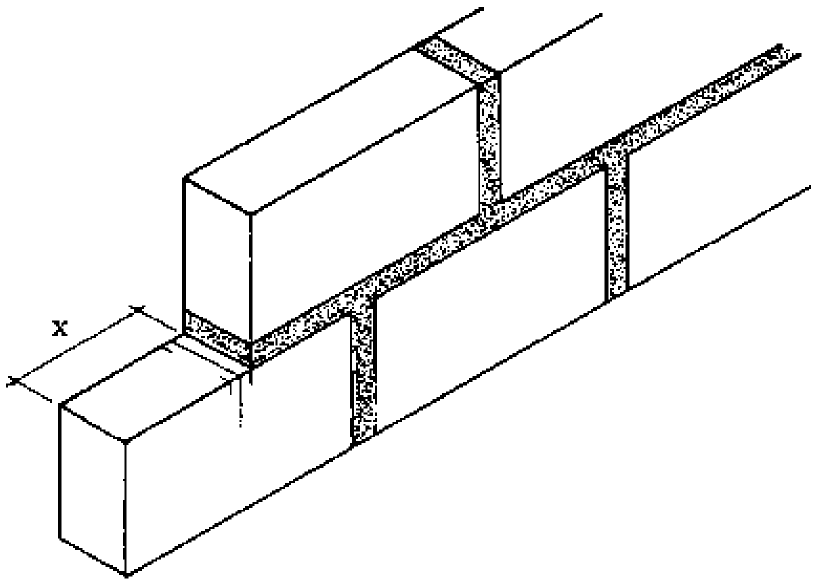


Fig. 1 SECOND COURSE

X = HALF BLOCK PLUS HALF JOINT

After you check the height of this block, you must plumb its face. Hold the spirit level vertically along the face of the lower block with one hand, while with the other hand you move the upper block until its face is also in full contact with the spirit level, and the bubble is in the centre of the tube.

Follow the same operation with the second block, laying it above the last cross joint in the lower course. Insert the remaining blocks between them according to the method used for the first course.

The construction of any subsequent course is merely a repetition of the above operations and will result in a wall with racking back at both ends (Fig. 2).

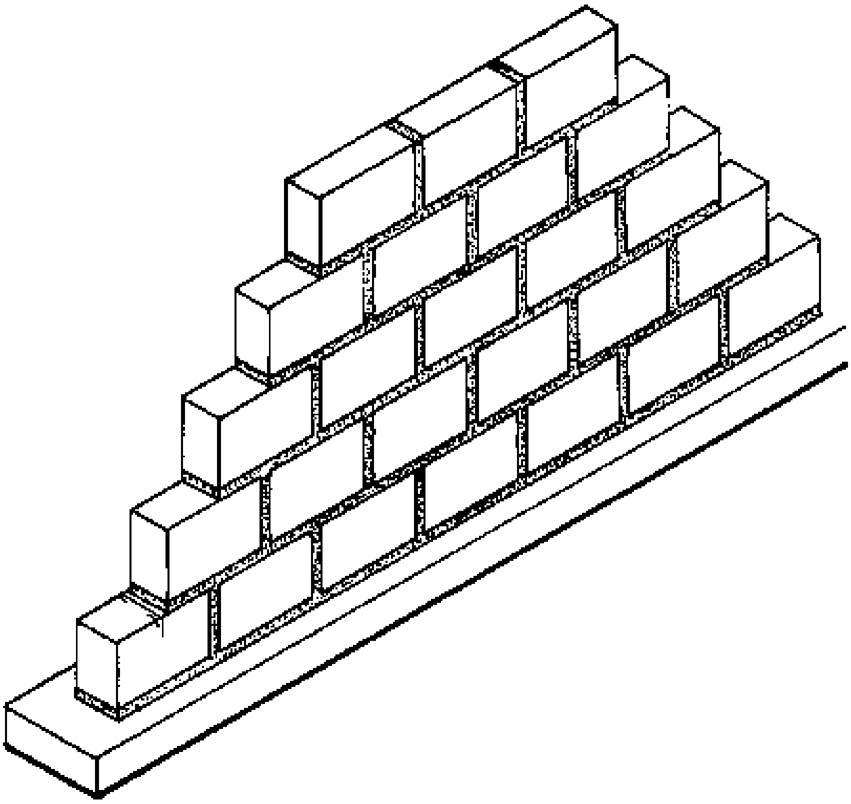


Fig. 2 RACKING BACK

– NOTE: If the Rural Builder has a choice between racking back and toothing, racking back should be the preferred method. This is because the joints used in toothing are difficult to fill properly when completing the wall, which often results in a weak grip all along the joints.

NOTES:

Toothed end

The construction of a wall with a toothed end starts with the same operations used for a wall with a racking back. After you lay the first block of the third course, the next block you lay forms the toothed end. As this block projects past the one below by more than half its own length, it should normally tip over on its projecting end. To prevent this, a temporary support must be provided until the block is overlapped by the first block of the fourth course and the mortar has set hard. This temporary support is preferably a short piece of board cut to the height of the block plus two bed joints. The upper and lower ends of the supporting board may be chamfered slightly to keep it from wedging between the blocks when it is removed (Fig. 1).

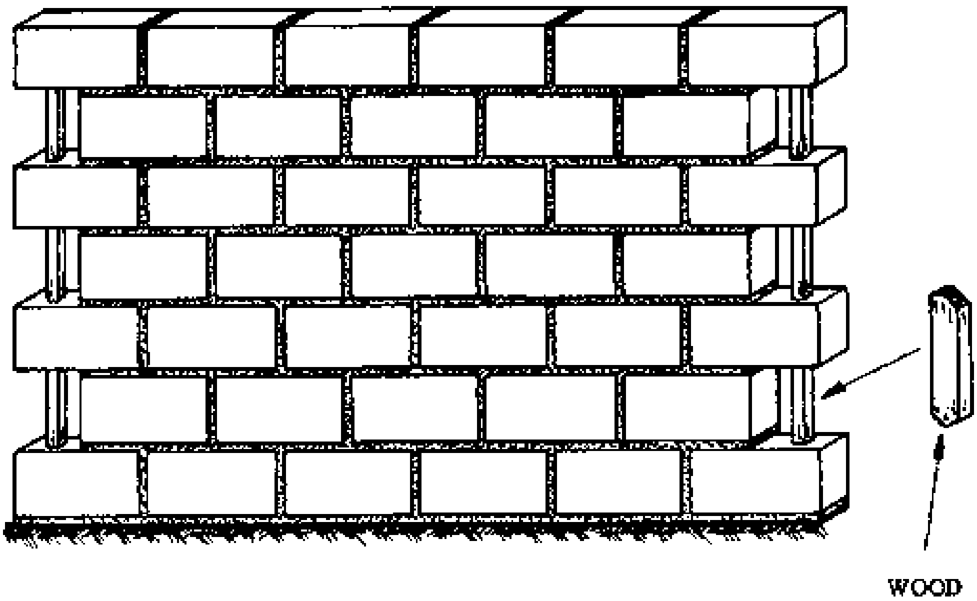


Fig. 1 TOOTHED END

This block must be exactly above the first block of the first course. To ensure this, hold the spirit level against both header faces and make any necessary corrections. It is not necessary to level the top face if the stretcher and header faces have been plumbed.

The construction of further courses is again only a repetition of these operations.

Stopped end

The construction of a wall with a stopped end is very similar to that with a toothed end. The sequence of operations is exactly the same except that instead of the supporting board, half a block is added at the end of the second course before the third course is laid (Fig. 2).

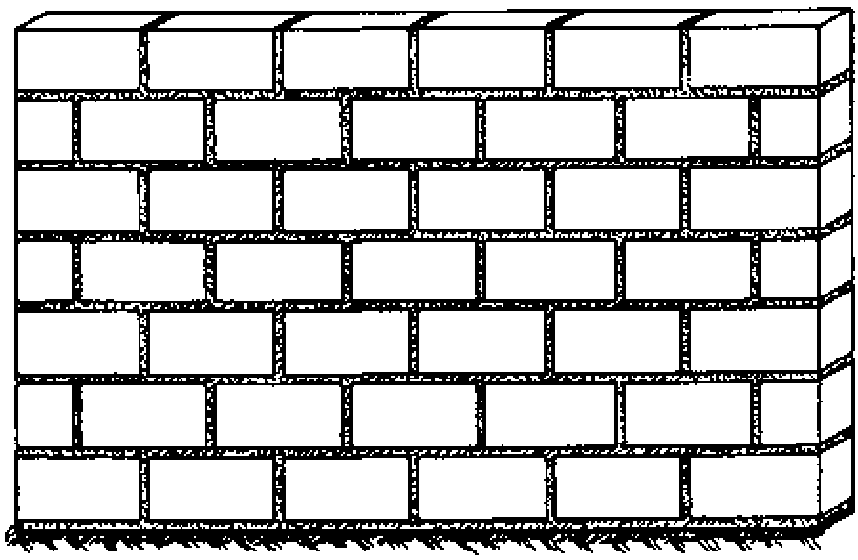


Fig. 2 STOPPED END

This means that there are no gaps left as in the toothed end, so it is called a stopped end.

NOTES:

Marking and cutting blocks

It is usually not possible to construct walls using only full blocks. In most cases 1/4, 1/2, and 3/4 blocks or intermediate sizes are also required. The previous description of the stopped end, for example, has shown the need for 1/2 blocks.

This does not mean that 1/2 blocks are obtained by simply cutting a full block into two identical halves. This is because the cross joint and its thickness must be considered.

Therefore, the 1/4, 1/2, and 3/4 blocks are actually that part of a full block minus half the thickness of the cross joint (Fig. 1).

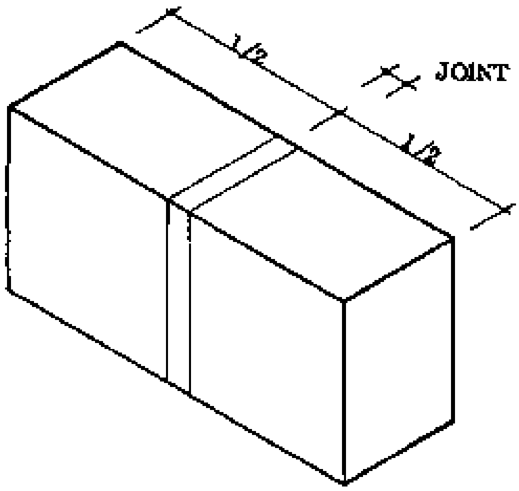


Fig. 1 MARKING THE BLOCK

Before cutting a block, mark the required size around all the faces. To prevent mistakes and to speed up the work, use a block gauge (see Rural Building Reference Book, Tools, page 12). Position the appropriate setting of the gauge against the block, then mark off the measurements on the block face using a pencil or a nail.

Set the marked block on a small heap of sand and then cut it with the block scutch by repeatedly and carefully knocking along the mark, making a groove in the surface. Direct the blows close to each other all around the four faces and continue until the block breaks apart along the groove (Fig. 2).

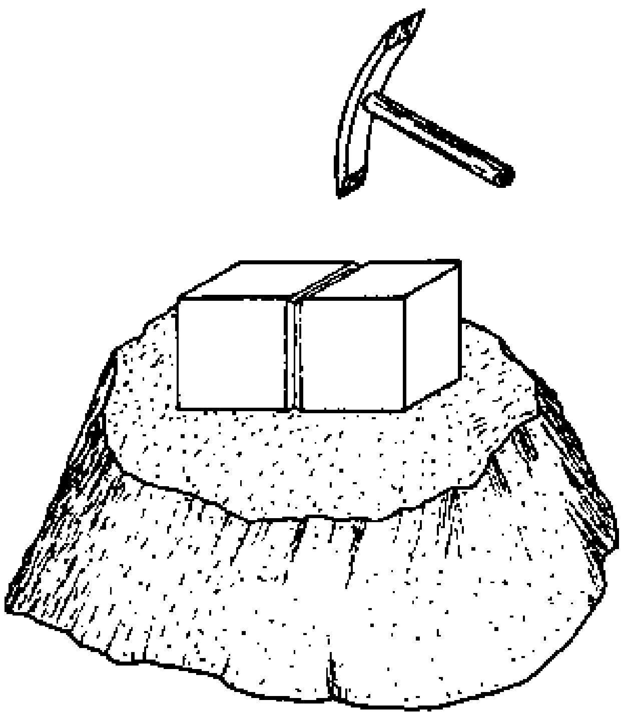


Fig. 2 CUTTING THE BLOCK INTO HALF BLOCKS

Trim the resultant rough header faces, if necessary, with the edge of your trowel blade (for landcrete blocks). When cutting sandcrete blocks, you should use the block scutch for trimming (Fig. 3).

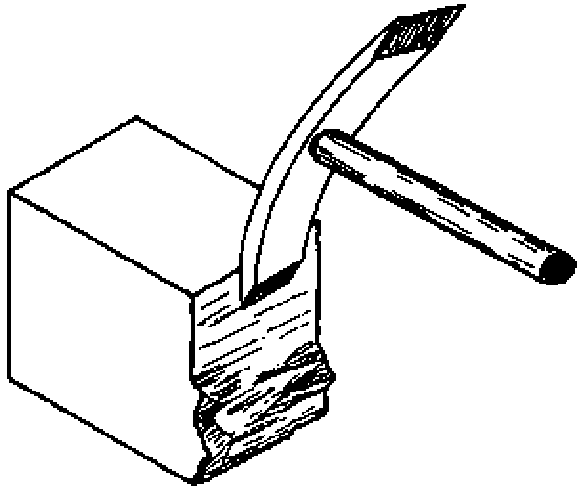


Fig. 3 TRIMMING OF HEADER FACE

– NOTE: Avoid cutting blocks on hard ground: they can easily break into irregular pieces and be wasted.

Never cut blocks on a scaffold for the same reason, also because they might fall and injure someone below.

It is always better to prepare in advance the number of blocks that you think will be needed that day.

Do not use blocks which are cracked; these must be replaced by good blocks or the wall will be weakened.

NOTES:

QUOINS

When external walls are constructed the corners or quoins are built first, to a height of several courses. Usually it is best to build six courses as this will reach to about 1,5 m high, the so–called scaffold height; and in most cases this will be half of the total height of the wall. The walling between the courses is completed later, course by course. The accuracy of the whole wall is determined by the corners, so great care must be taken to build them properly.

At the beginning of training, the positions of the quoins are determined by marking them out on the floor using the mason square.

A quoin is constructed in the following manner:

Blocks are sometimes not correctly shaped, so the first block or angle block must be chosen carefully so that all its faces are square to each other.

As you lay the angle block, stand close to the foundation with your head vertically over the block. You should be able to see that both outer faces of the block are aligned with the mark below (Fig. 1). After this the block has to be accurately levelled and plumbed.

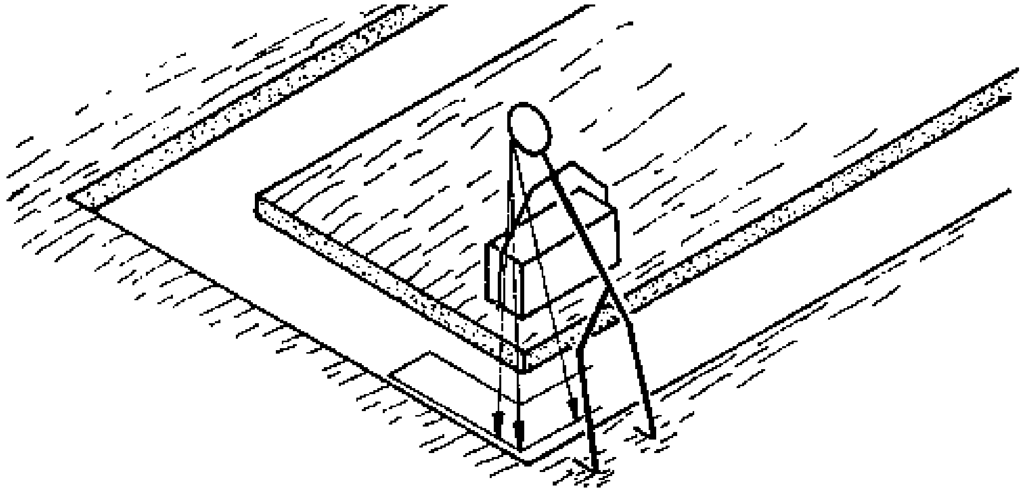


Fig. 1 ALIGN BLOCK WITH THE MARKS

Use the straight edge with gauge marks to ensure that the block is laid at the correct height. Hold the straight edge vertically against the block; the top edge of the block should correspond to the gauge mark (Fig. 2).

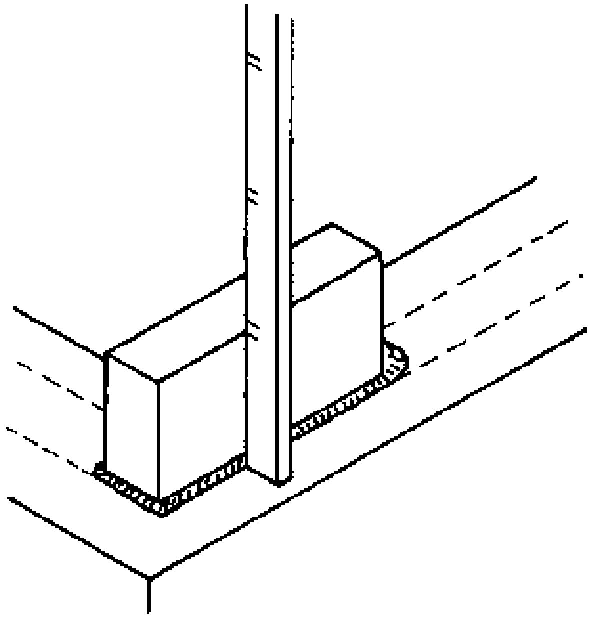


Fig. 2 CHECK CORRECT HEIGHT

Now you have to make certain that the header face and the stretcher face are truly vertical. To do this hold the spirit level against one face about 5 cm from the corner, keeping it in this position while with your other hand you move the block until the bubble in the tube is centered. This operation must be repeated with the other face of the block (Figs. 3 & 4).

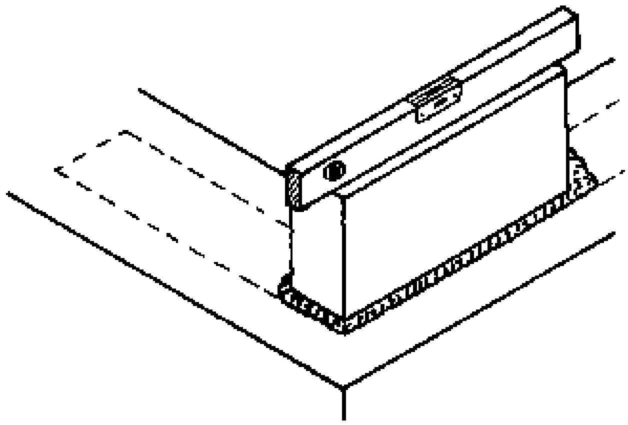


Fig. 3 LEVEL THE BLOCK

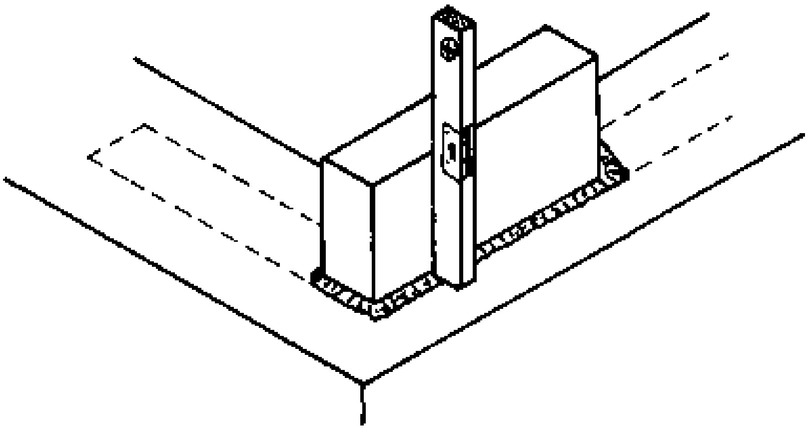


Fig. 4 PLUMB THE BLOCK

NOTES:

Now lay several blocks in each direction according to the method described before. On the quoin stretcher side three more blocks should be laid; followed by four on the header side of the quoin. This will be a sufficient base for building up a height of six courses with either a toothed end or racking back (Fig. 1).

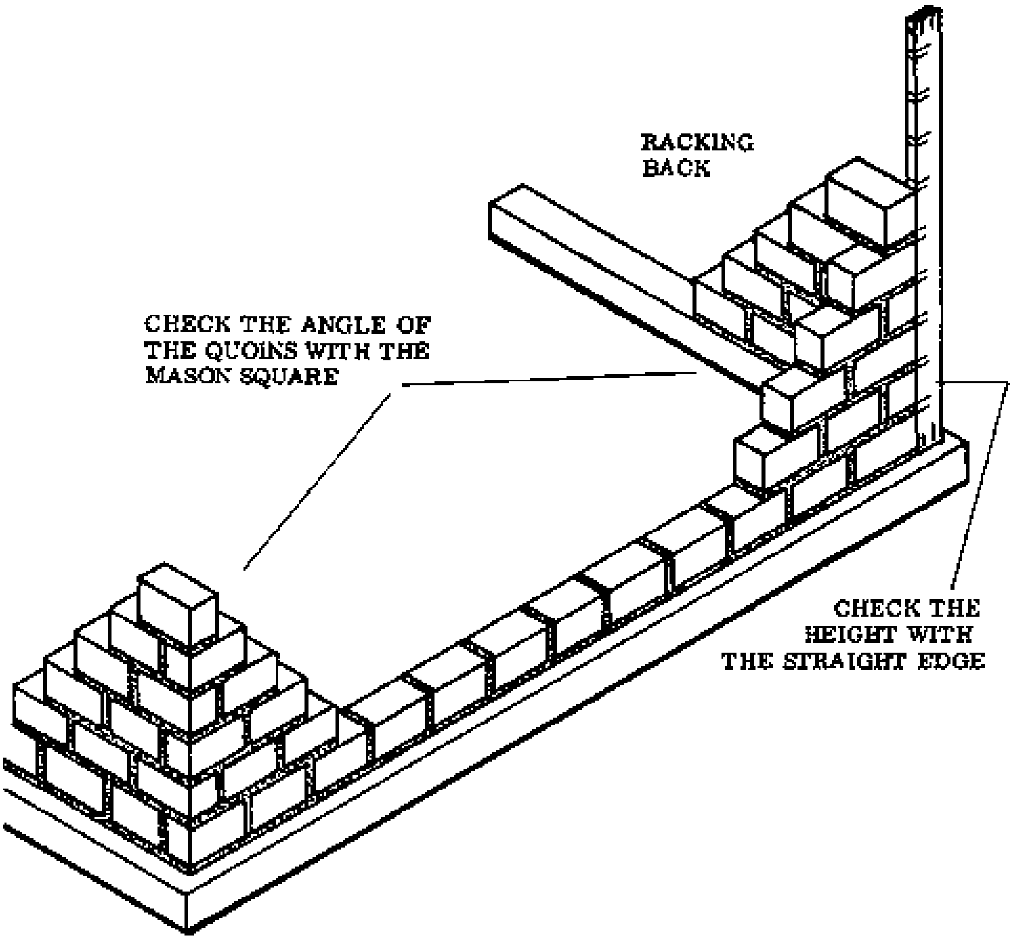


Fig. 1

Use the mason square to make sure that the quoin has an angle of 90 degrees. Hold it against the quoin so that both of the blades fully touch the faces of the blocks. Repeat this operation after turning the square around, so that the direction of the blades is reversed.

Second course

Following the 1−2−1 rule, the first block of the second course will not be the angle block; but the one covering the cross joint between the quoin stretcher and the adjoining stretcher. If the angle block were laid first it could get pushed out of position when the other blocks are laid. The correct method fixes the angle block in position by the cross joint between it and the first block. A further reason for this procedure is that the cross joint between the quoin headers and the adjoining stretchers has a different thickness than the other cross joints. This problem will be explained later when we come to bonding problems.

To complete the second course use the same method as described for the construction of the first course.

– NOTE: The arrangement in any course is repeated in the courses two above or two below it. Therefore only two alternating block arrangements are used.

Walling between quoins

When both corners of a wall have been built up to a height of six courses, it is necessary to fill in the blockwork between them. This is done with the aid of the mason line and either nails, pins, or line bobbins.

Fixing the mason line

If nails or pins are used, insert one of them in the bed joint at one corner so that the line will be level with the upper edge of the course (see Rural Building Reference Book, Tools, page 6). Fix the mason line to the nail or pin without using a knot, as shown in Fig. 2. This is so that later it can be easily removed.

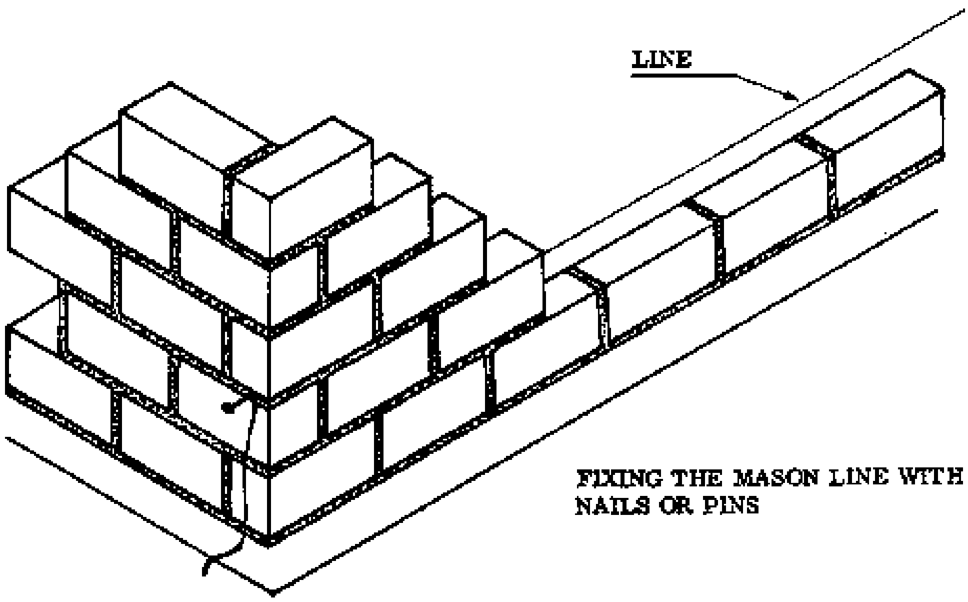


Fig. 2

Stretch the line taut to prevent any sagging, and push the second nail or pin into the corresponding bed joint in the opposite quoin. The line should now be level with the top of the course to be built; and about 2 mm or the thickness of a trowel blade away from the blockwork. Put a wedge of paper between the wall and the line to keep the distance of 2 mm. The line should be horizontal.

If you use line bobbins instead of pins, take one with the line fastened around the screws and engaged in the saw cut; and position it with the notch against the corner of the quoin so that the line is level with the top edge of the course to be built. At the opposite quoin insert the line in the saw−cut of the second bobbin and set it at the correct height against the corner. Stretch the line taut and secure it by winding around the screws (Fig. 1).

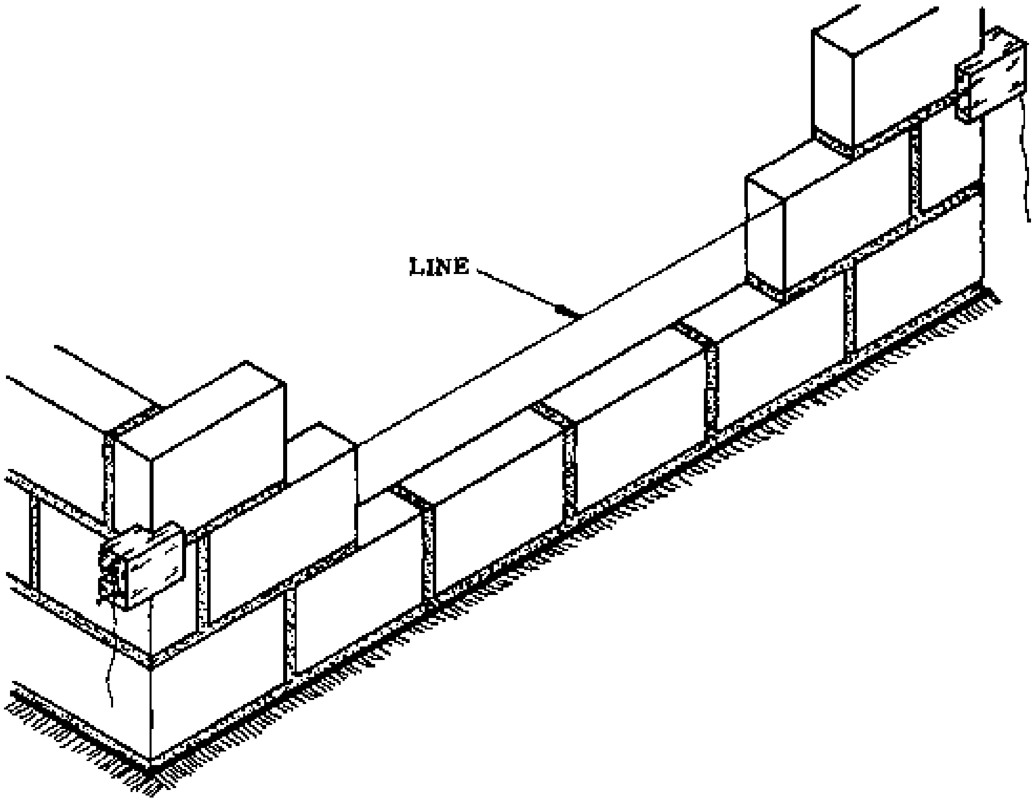


Fig. 1 LINE BOBBINS

The tight mason line holds the bobbins against the corners, keeping them in position. Once the line has been fixed in this manner no further adjustment is needed, unless the line starts to sag and needs tightening.

After one course is completed, simply slide the bobbins up the corners to the level of the next course.

Use of the tingle plate

If the line is stretched over a longer distance, it will tend to sag and will no longer provide a straight guide. In the case of a long wall where the distance between the bobbins exceeds 6 m, it becomes necessary to use one or more tingle plates (Fig. 2). This is done to keep the line from sagging. The tingle plate must be set on a so−called tingle block. Lay this block plumb, in position and at the correct height in the course to be built. This block keeps the tingle plate at the required height to support the mason line. Place the plate flat on the block, and weight it down with a half−block. The taut line is passed under the outer nibs and over the centre nib (Fig. 2).

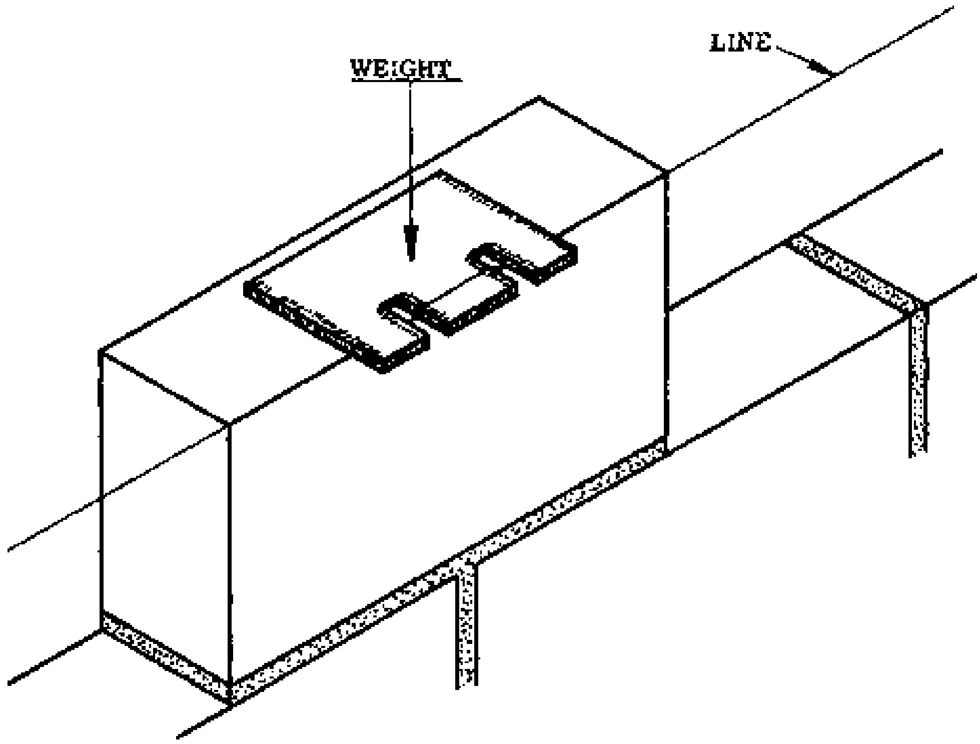


Fig. 2 TINGLE PLATE

Completing the course

Now lay the blocks to complete the course. Take care that the outer top face edge of each block is level with the line.

At the same time be sure to keep the lower stretcher face edge in line with the edge of the course below. Avoid the tendency to lay the blocks too close to the line; the 2 mm distance must be maintained and checked from time to time by sliding the trowel blade between the line and block.

If the blocks are laid correctly, plumbing and levelling are not necessary. It is advisable however to check the face of the wall for a possible overhang, using the straight edge.

After you have filled the cross joints, carefully rake out all the joints of the freshly laid courses to provide an additional grip for the plaster.

BONDING PROBLEMS

Problems arise when we use different types of blocks in the same wall. Usually in Rural Building we use sandcrete blocks for the lower courses of a wall to avoid problems with dampness, and landcrete blocks for the higher courses. Unfortunately the dimensions of sandcrete blocks and landcrete blocks do not match up well to each other. This means that it is not as easy to maintain a half−block bond as it is in a wall made up of only one kind of block.

For example, a sandcrete block has dimensions of 46 × 23 × 15 cm. A sandcrete half−block has the dimensions 22 × 23 × 15 cm. Even when the sandcrete blocks are cut in half they still will not match up exactly to the landcrete blocks (see the table below).

	Full block	Half block
Sandcrete	46 × 23 × 15	22 × 23 × 15
Landcrete	29 × 22 × 14	13,5 × 22 × 14

The dimensions of the 1/4 and 1/3 blocks also do not correspond, so in order to maintain the half−block bond between the sandcrete and landcrete courses we would have to make quite an adjustment.

Practically this means that although it would be better, we cannot maintain exactly a half−block bond between the sandcrete and landcrete. They must be considered as separate parts of the wall, properly bonded in themselves but not necessarily showing a half−block bond between them.

CORNER BONDS

Corner bond for footings

The materials used for footings are sandcrete blocks which must be laid flatwise, giving a wall thickness of 23 cm. Since this measurement exceeds the length of a half−block by 1 cm, the first cross joints following the quoin stretchers must be 3 cm wide instead of the normal 2 cm. All the other joints are still 2 cm thick. By doing this the half−block bond is maintained (Fig. 1).

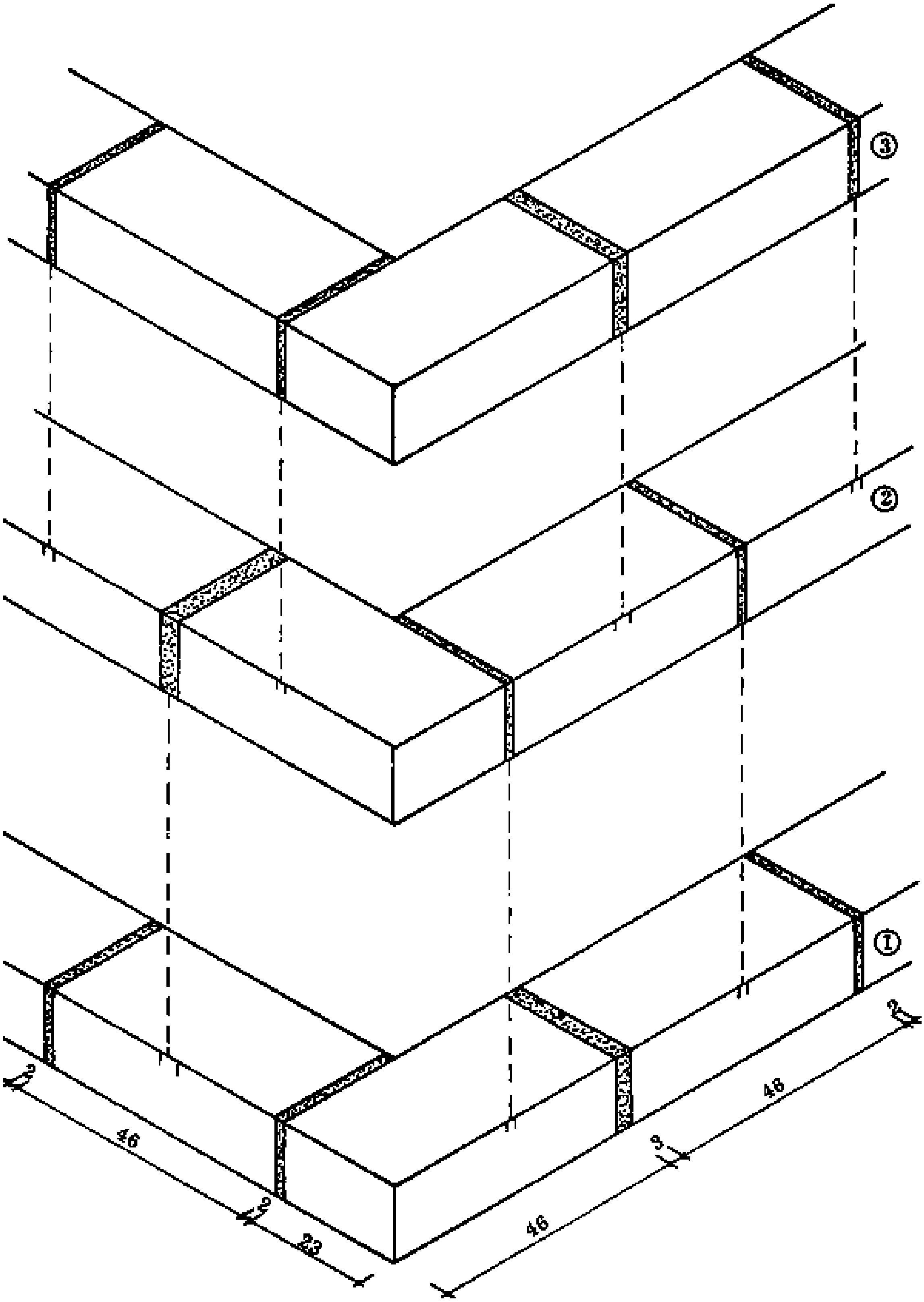


Fig. 1

There are of course two other ways to maintain the half−block bond:

− All the cross joints directly following the quoin header could be reduced to a thickness of only 1 cm. The effect would be the same but these joints would be difficult to fill properly, which could result in a weak quoin.

− All stretchers following the quoin headers could be cut to a length of 45 cm. This takes time and may damage the blocks.

In general, it is best not to use these last two methods.

Corner bond for a rising sandcrete wall

So−called wet rooms such as kitchens, showers and toilets must be built with sandcrete blocks. This is to avoid any damage to the walls caused by moisture.

If landcrete blocks are exposed to moisture for a long time the blocks will start to expand. This pushes the plaster off the walls and makes them weaker and weaker until finally they collapse under their own weight.

Rising walls in Rural Building are generally built by laying the blocks edgewise. When sandcrete blocks are used the wall has a thickness of 15 cm.

In order to avoid making too many cross joints within the quoin area, each quoin header as well as each quoin stretcher is followed by a full block.

To maintain the required half−block bond, a 7 cm lack of overlap has to be made up. This is done by inserting a 5 cm block between the first two stretchers that follow the quoin headers (5 cm plus 2 cm joint equals 7 cm). Almost every building project uses thin blocks for copings or rain gutters etc., and these specially made blocks can be simply cut in half and used to fill the gaps (Fig. 1).

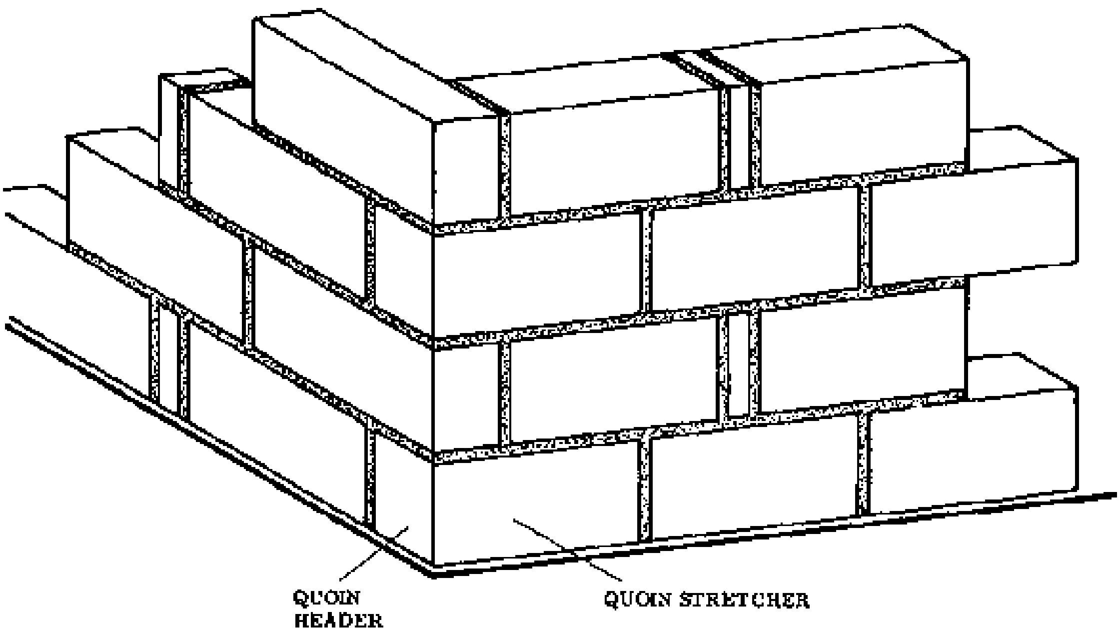


Fig. 1

NOTES:

Corner bond for rising landcrete wall

As far as bonding is concerned, the footings, the plinth course and the rising landcrete wall are all regarded separately. They are properly bonded in themselves but don’t necessarily show a half−block bond, especially between the plinth course and the landcrete wall.

As Fig. 1 illustrates, a half−block bond between footings and plinth course (both sandcrete) is possible despite the 4 cm setting back (c) and should be maintained.

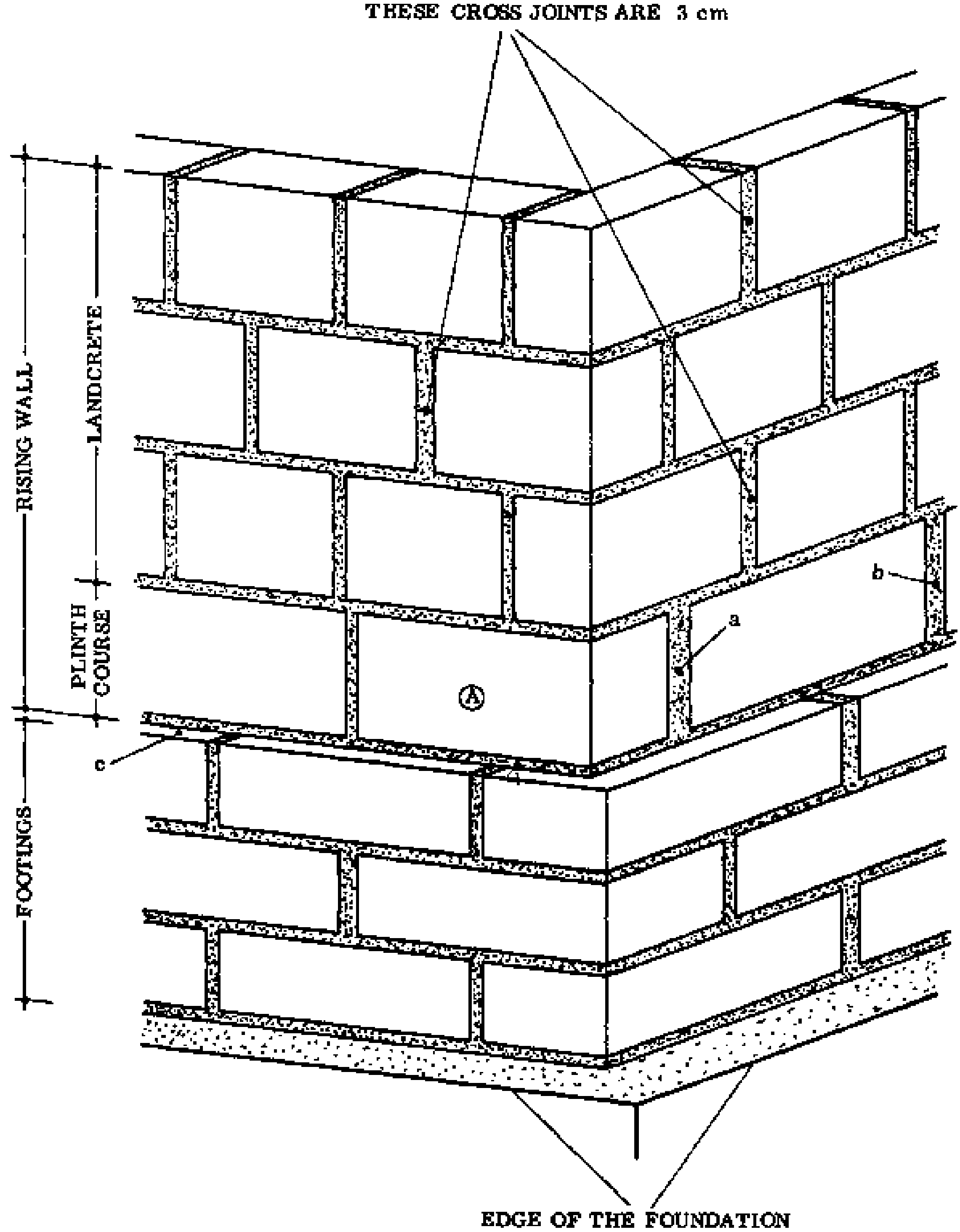


Fig. 1

– PLINTH COURSE: Since the rising wall is erected exactly in the middle of the footings, the plinth course has to be set back 4 cm from both faces: 23 cm (thick ness of footings) minus 15 cm (thickness of plinth course) divided by 2 equals 4 cm (at both sides).

The angle block (A) has to be shortened by 3 cm because of the setting back, thus we automatically make the correct half–block bond on the quoin stretcher side. The first two cross joints (a & b) following the quoin header must be widened to 4 cm each to overcome a lack of 4 cm in overlap. By doing this we distribute the lack of 4 cm over two joints equally.

– RISING LANDCRETE WALL: As already stated, the rising landcrete wall is regarded separately from the plinth course. This is because the dimensions of the landcrete and sandcrete blocks prevent the construction of a half–block bond between them.

However, one important rule must be observed: No matter what part of the construction or what material it consists of, each quoin header must be overlapped by a quoin stretcher; each quoin stretcher is automatically followed by a quoin header (Fig. 1).

To maintain the half−block bond within the landcrete wall, all the cross joints directly following the quoin stretchers must be widened to 3 cm. All other joints remain the same.

NOTES:

T−JUNCTION BONDS

The term T−junction is given to connections between walls which form a T shape, although it is not essential that the angles be right angles. This situation occurs most often where outside walls are met by inside walls.

T−junction bond for footings

Like quoins, the T−junctions are built first or at the same time as the quoins, and the walling between them is completed later.

The first block to be laid is the first block (A) of the inside wall: it will be seen as a header in the face of the outside wall (Figs. 1 & 2). This followed by a 1/4 block (B) at one side of it in the direction of the outside wall, and by a full block (C) on the other side (Fig. 2). This is followed by laying full blocks in all three directions.

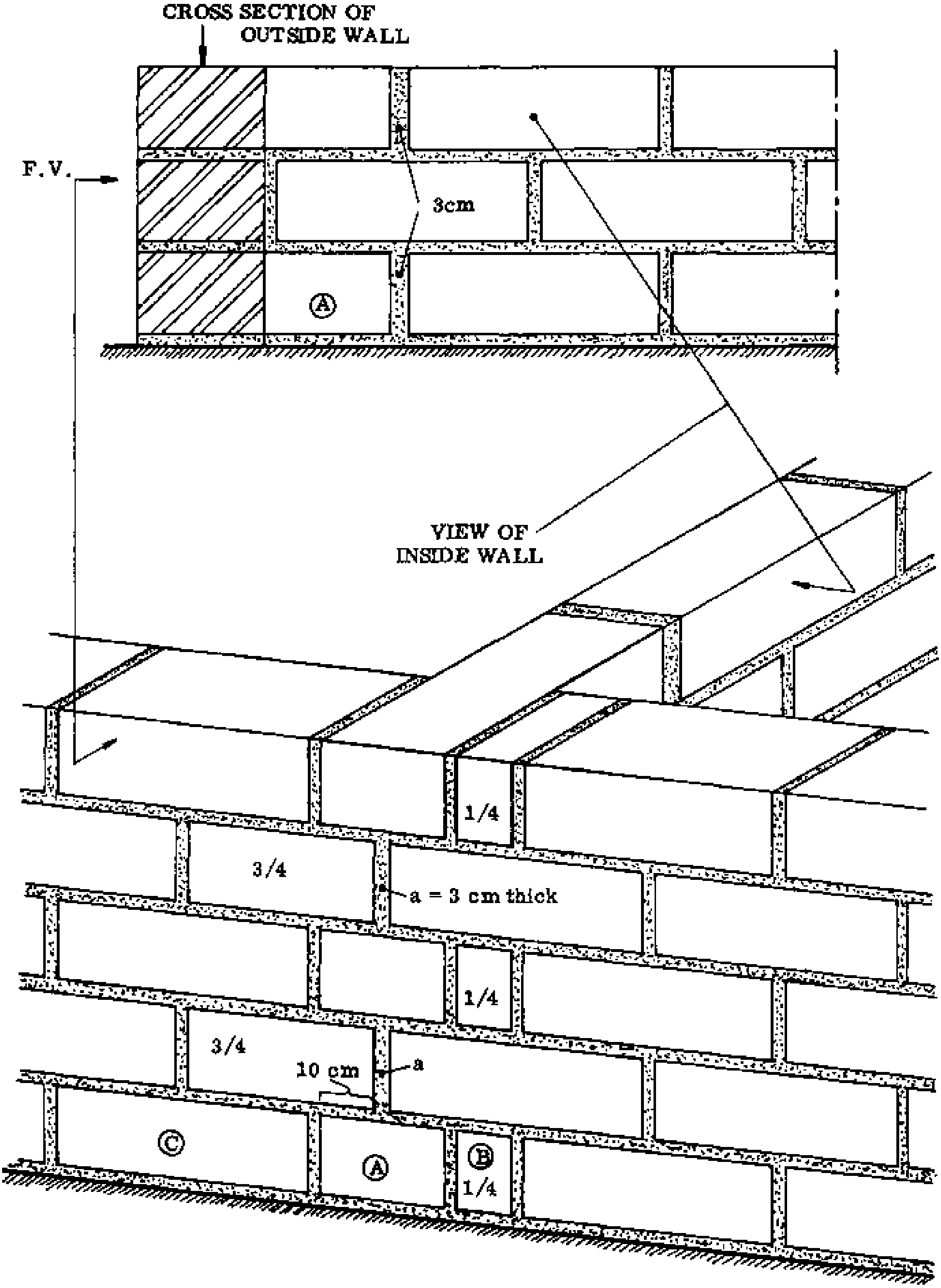


Fig. 1 & 2 COMBINED SECTION OF OUTSIDE WALL AND VIEW OF INSIDE WALL

The second course, and all the alternate courses, go through in the direction of the outside wall, that is, they do not share a block with the inside wall. Thus the inside wall is bonded to the outside wall only at alternating courses: at the 1st, 3rd, 5th etc. courses (Figs. 1 & 2).

The second course starts with a 3/4 block overlapping the header below by 10 cm but from the side opposite from the 1/4 block below. This is followed by full blocks in all three directions (Figs. 1 & 2).

The cross joints between the headers of the inside wall (a) are 3 cm thick and must be exactly in line with the centre of the headers (Fig. 1). The cross joints directly following the blocks which are bonded to the outside wall are also 3 cm thick (Fig. 2). All the other joints are 2 cm thick.

– NOTE: All courses with odd numbers (1st, 3rd, 5th etc.) share one block with the inside wall; these blocks are seen as headers in the face of the outside wall, each one next to a 1/4 block.

All courses with an even number (2nd, 4th, 6th, etc.) go through in the direction of the outside wall and contain a 3/4 block at the opposite side of the 1/4 block below and above.

NOTES:

The illustrations on the opposite page show three other possible constructions for T−junctions in footings, all of which maintain the half−block bond (Figs. 1, 2, & 3).

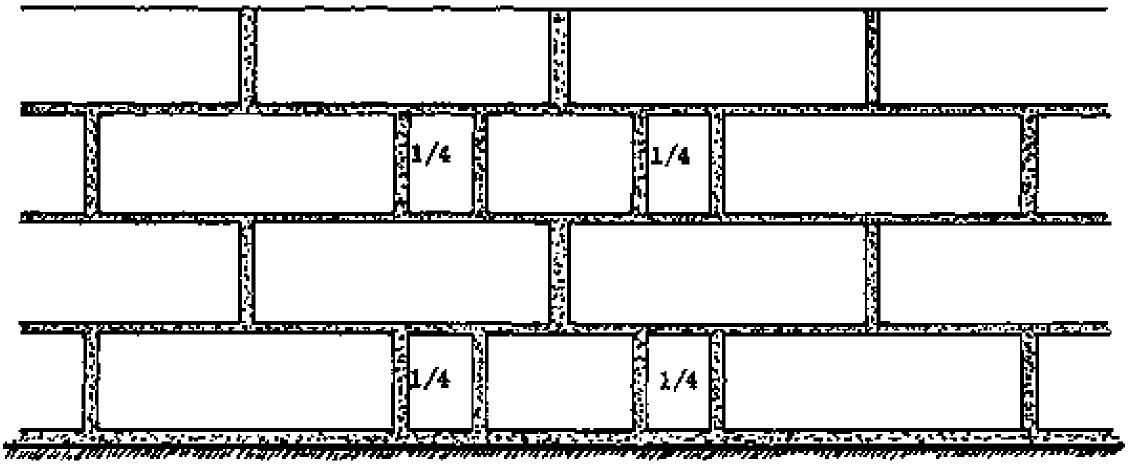


Fig. 1 2nd CONSTRUCTION

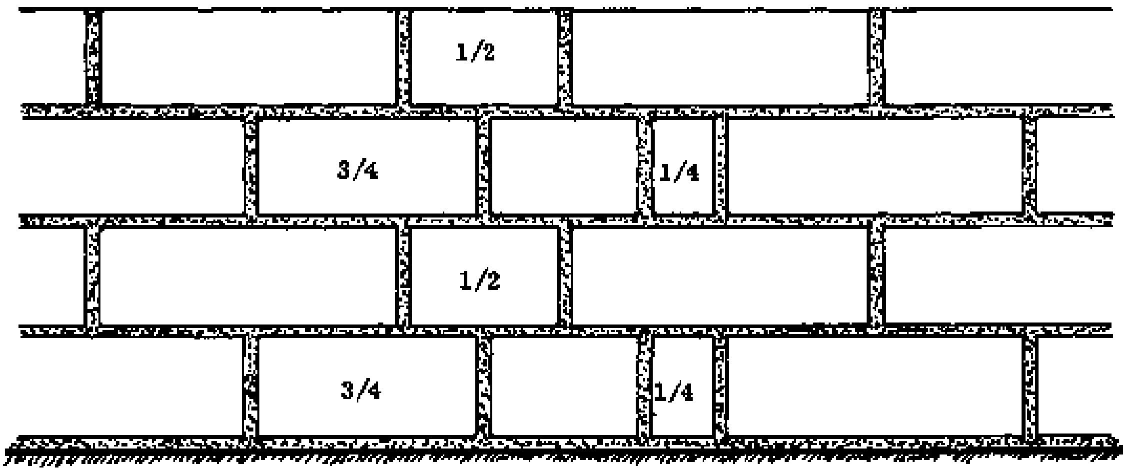


Fig. 2 3rd CONSTRUCTION

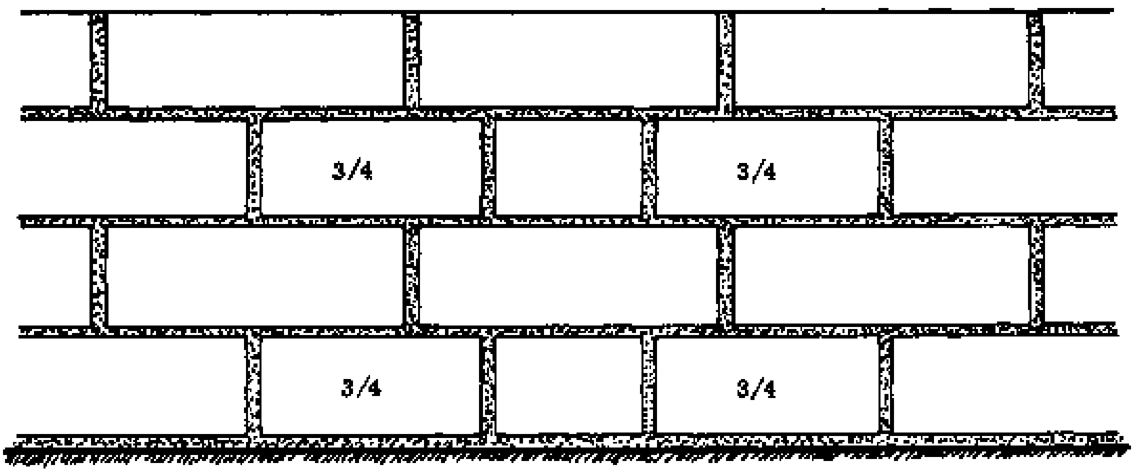


Fig. 3 4th CONSTRUCTION

Which method is used depends on factors such as the distance between the junction and the next quoin, or the next junction.

One way to find out the best choice is to lay out the first course of blocks without mortar, and try different arrangements. In this way the builder can decide what will be the best final arrangement.

If two or more constructions are possible the Rural Builder should chose the most efficient method. This is the method that wastes the least time and materials.

Specifically, the more blocks that have to be cut the more time will be needed; and if for example only 3/4 blocks are needed, the remaining 1/4 blocks are wasted unless there is a need for them somewhere else.

By comparing the four possible constructions (Figs. 1 & 2 on page 37, and Figs. 1, 2 & 3 at left) we see that the first three can be carried out without any waste of blocks while in the last case (Fig. 3) all the 1/4 blocks are left−over.

As far as efficient work is concerned, we see that for the first method (page 37) only one cut needs to be made for two courses as both parts of the block are used. The alternatives shown in Figs. 1, 2 and 3 need two cuts for two courses.

By considering carefully the advantages and disadvantages of the four, we see that the first construction is the best, the 2nd and 3rd constructions are less good and the 4th construction is the worst. Therefore the first type should be used whenever possible.

NOTES:

T−junction bond for rising sandcrete walls

Since the footings are normally 3 courses high, the third course of the footings contains the block which bonds the inside wall. Thus the first course of the rising sandcrete wall must go through in the direction of the outside wall to cover the header of the footings (see previous pages).

The first block of the rising wall is placed so that it extends past the header below by 12 cm on one side (Fig. 2, block A). Don't forget to set this block back from the face of the footings by 4 cm. This block is followed by full blocks on either side (Fig. 2, blocks B). The inside wall starts with a 1/4 block (Fig. 1, block C), this too is followed by full blocks.

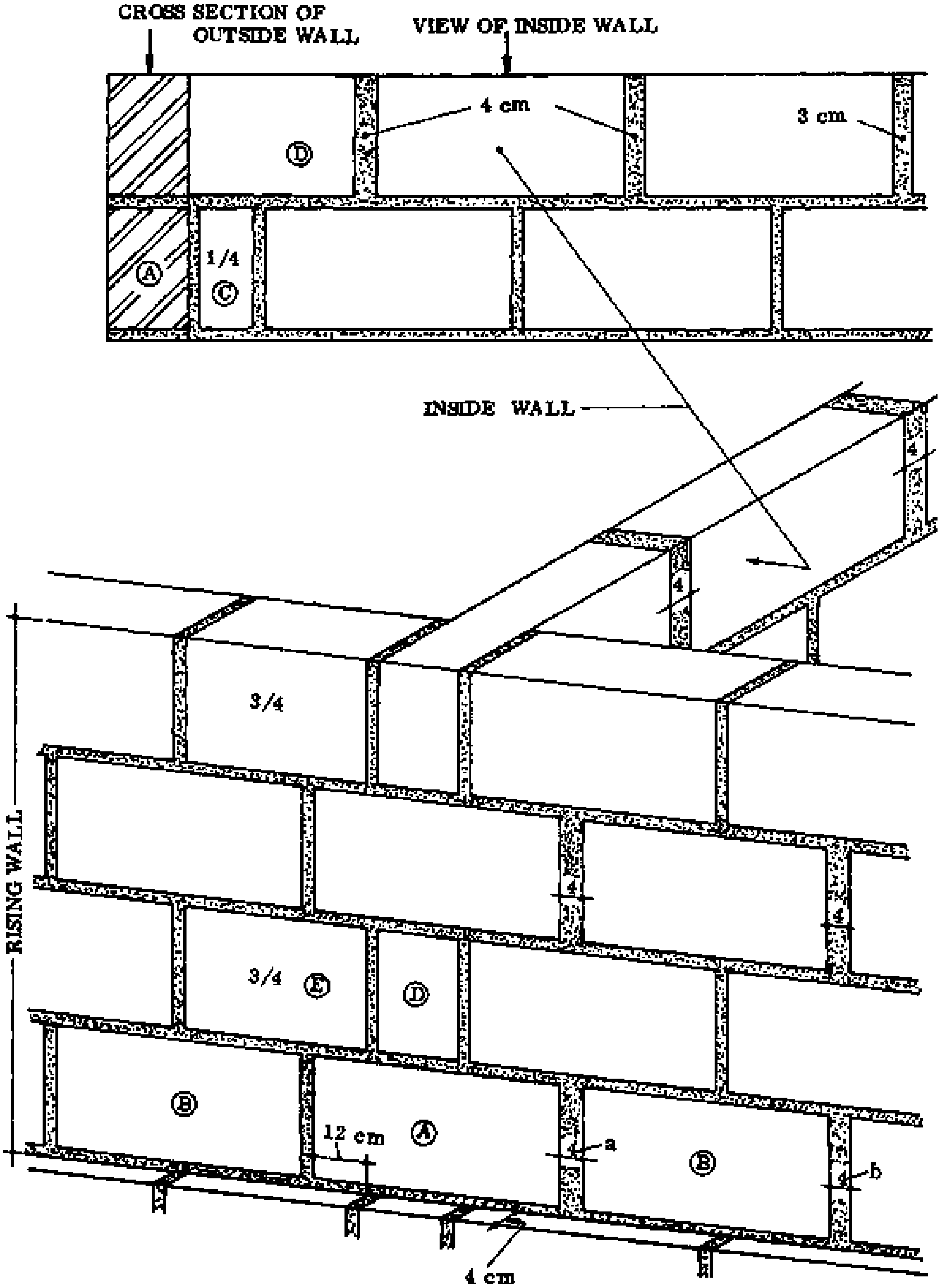


Fig. 1 & 2

The second course of the T−junction begins with the full block of the inside wall that is bonded into the outside wall (Figs. 1 & 2, block D). This is followed by a 3/4 block (Fig. 2, block E) on the same side of the header where the stretcher (block A) below projects by 12 cm. Continue with full blocks in all three directions.

The odd−numbered courses of the outside wall contain widened cross joints to catch up with the half−block bond. The first two cross joints opposite the 12 cm projection (Fig. 2, a & b) are 4 cm thick, followed by one more joint which is 3 cm thick (not shown). In this way the half−block bond is maintained.

The same must be done with the first three cross joints following the bonded block of the inside wall (Fig. 1).

NOTES:

T–junction bond for rising landcrete walls

– PLINTH COURSE: Except that the blocks are laid edgewise rather than flat, the plinth course is simply a repetition of the footing course two courses below (Fig. 1, blocks A & B).

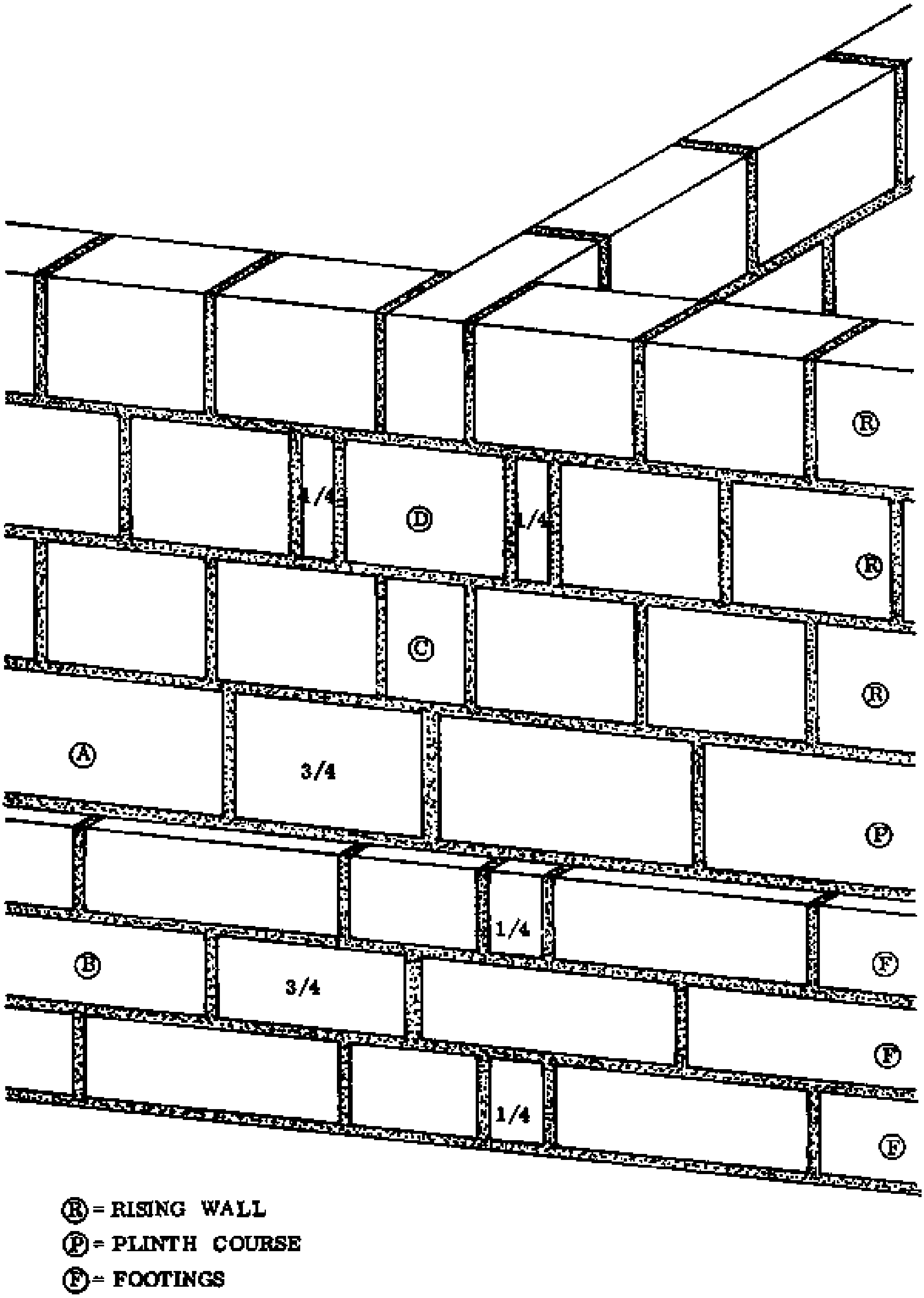


Fig. 1

The only difference is that the first two cross joints in the inside wall are widened to 4 cm each, in order to maintain the half–block bond in relation to the footings.

Do not forget to set the plinth course back from the face of the footings by 4 cm.

– RISING LANDCRETE WALL: Since the landcrete wall is 1 cm thinner than the plinth course, it is essential to continue the "good" face of the plinth by setting the landcrete blocks flush with the outside face of the plinth. The Rural Builder should choose one face of the inside wall to be the "good" face; where the surface of the plinth course is flush to that of the rising wall. This is the face from which the plumbing and levelling are done; the Rural Builder should always work from this face. On outside walls the "good" face is normally the outside face.

The first block of the landcrete wall is the one which is shared by the inside and outside walls and covers two cross joints (Fig. 1, block C). It is followed in all three directions by full blocks.

The second course of the rising landcrete wall begins with a full block centred exactly over the header below, with 1/4 blocks on either side (block D). All of the other courses in the rising wall are repetitions of these two courses.

NOTES:

CROSS JUNCTION BONDS

A cross junction, also called an intersection, consists of two continuous walls which intersect, or cross each other.

The following are only a few examples out of many methods for bonding at a cross junction. In actual practice the dimensions of the building will not always permit the use of these particular bonds. In such cases some adjustments must be made.

The essential requirements for a cross junction always remain the same:

- avoid making continuous cross joints; and
- try to use a minimum number of cut blocks.

Cross junction bond for footings

The first course consists entirely of full blocks (Fig. 1). The through–going block (A) projects equally from both sides of the crossing wall. This block has cross joints of 2, 5 cm on each end, but all the other joints are still 2 cm thick (Fig. 1).

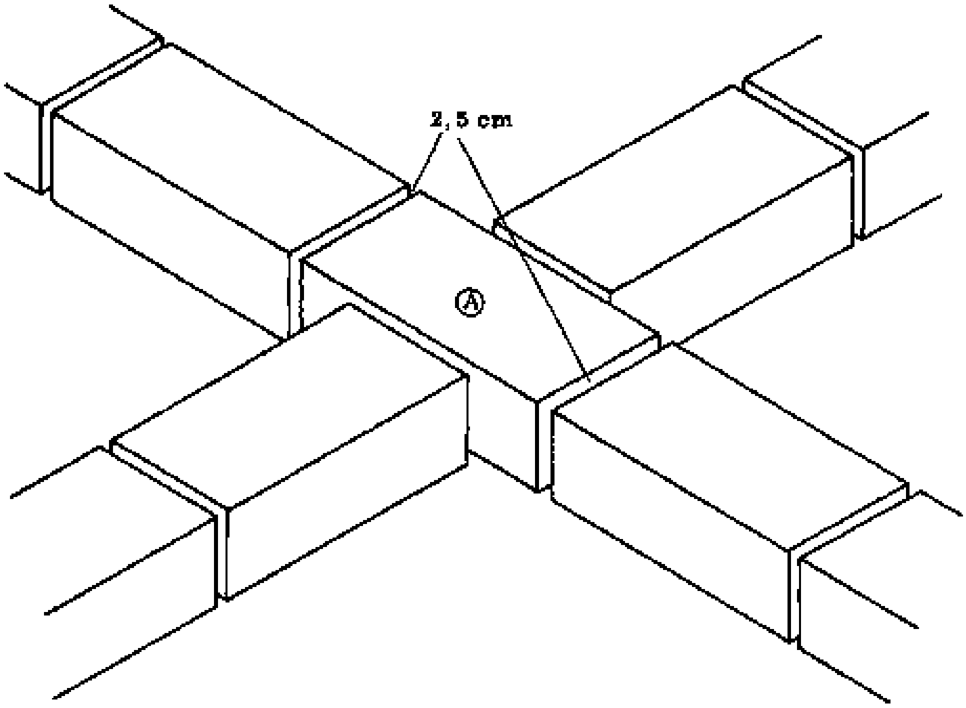


Fig. 1

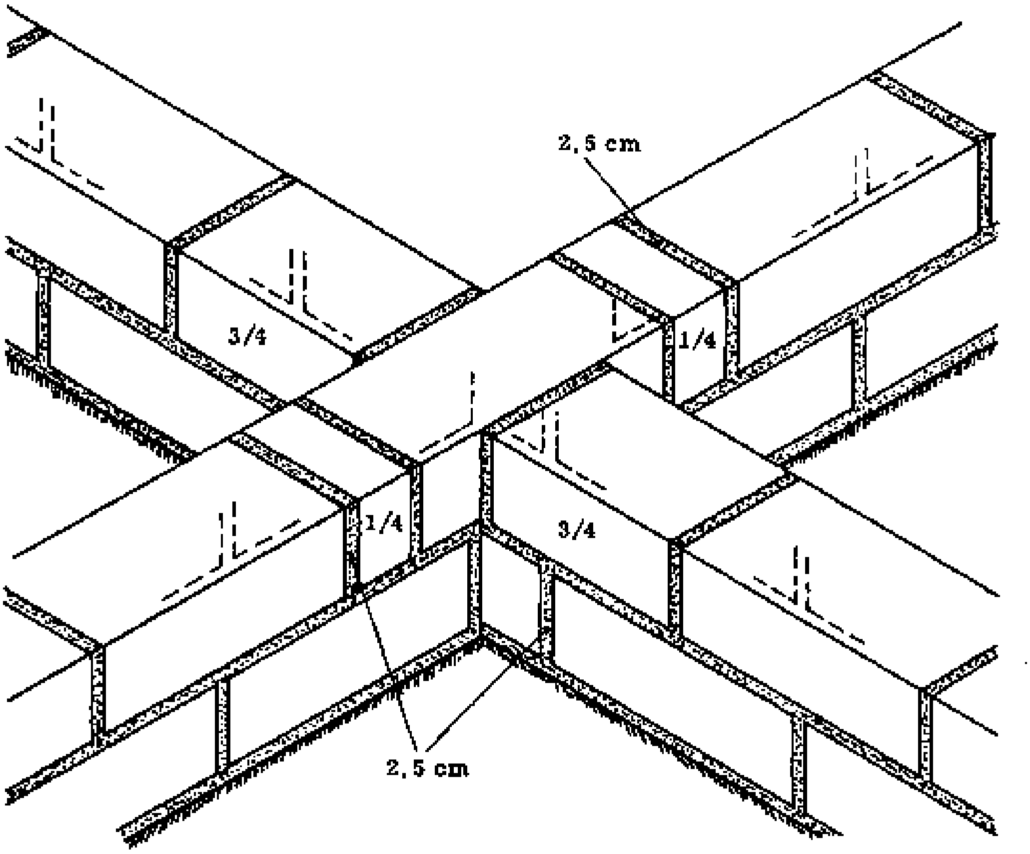


Fig. 2

The second course starts with a full block centred over the through−going block below. This block is followed by 1/4 blocks on either end. The 1/4 blocks each have one cross joint which is 2, 5 cm thick. All other joints are still 2 cm thick.

The second course of the crossing wall continues with 3/4 blocks on both sides. This is followed by full blocks in all four directions.

NOTES:

The second possible construction is where the crossing walls enclose a cross joint (Fig. 1, a). In this case two 3/4 blocks are used in the first course while the remaining 1/4 blocks are kept aside for the second course (Fig. 1).

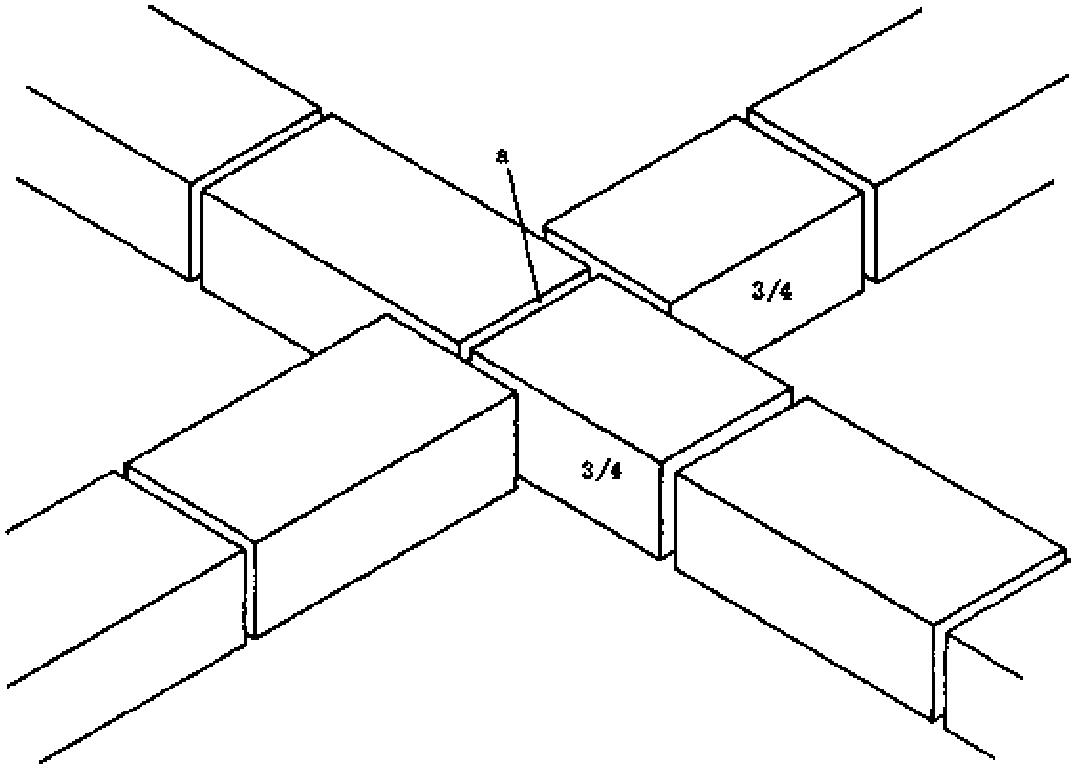


Fig. 1

The two 3/4 blocks of the first course are arranged so that they are at right angles to each other. One of the 3/4 blocks always starts from the middle of the crossing wall while the other is placed on either the right or left side of it. This is followed in all four directions by full blocks (Fig. 1).

The second course begins with a full block crossing the through−going wall below and overlapping equally at both sides. This block covers three cross joints at once instead of two as in the last method. The first block is followed by the 1/4 blocks placed on opposite sides from the 3/4 blocks below. The second course is continued with full blocks in all four directions (Fig. 2).

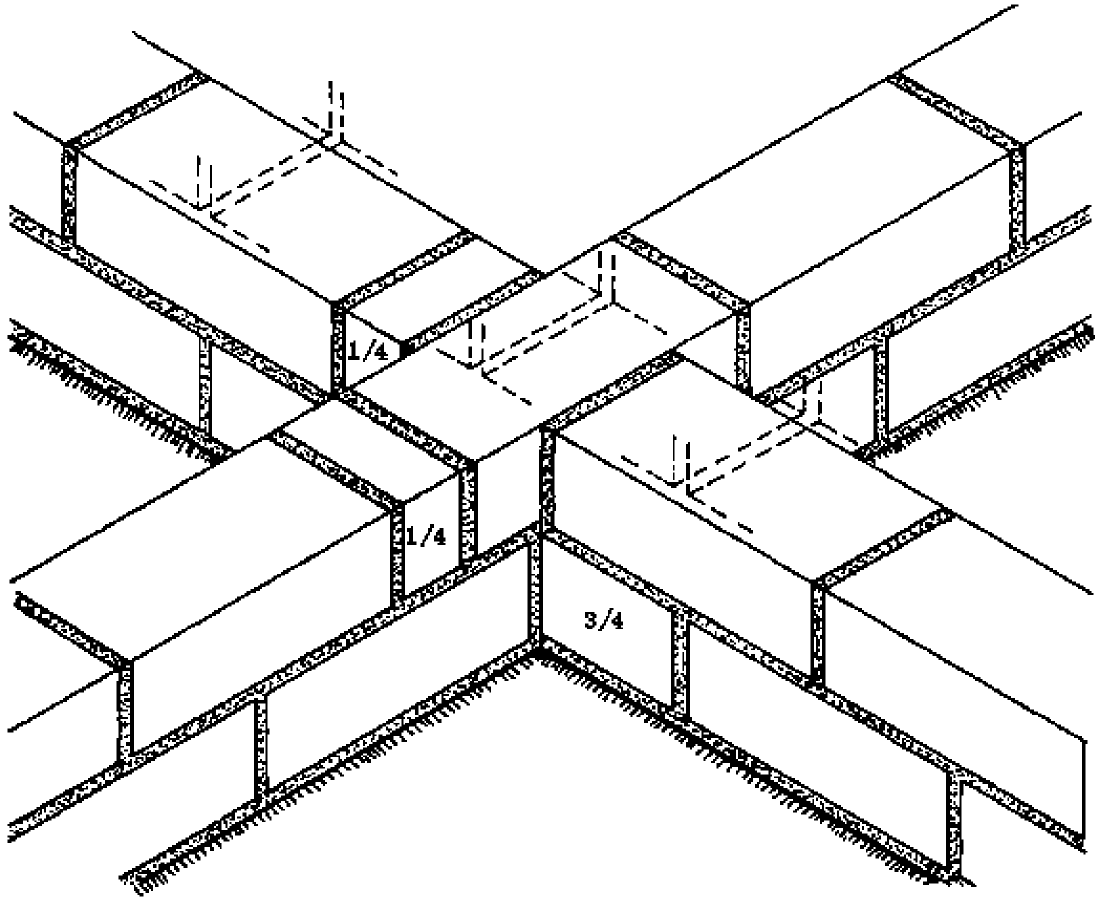


Fig. 2

Each 1/4 block must have one cross joint of 2,5 cm; all other joints remain the same, 2 cm thick.

Try to figure out more possible ways to do a cross junction bond, and discuss the results with your fellow trainees, your instructors, and your foreman on the building site.

NOTES:

Cross junction bond for rising sandcrete walls

The smaller wall thickness in relation to the block length makes it necessary that all cross junction bonds for rising sandcrete walls contain a block that is 5 cm thick (compare with corner bonds for rising sandcrete walls, page 34).

The opposite illustrations show the most economical method for constructing a cross junction. Apart from the one 1/2 block and one 5 cm block, both the first and second courses contain only full blocks.

Fig. 1 shows the first course. The through wall consists of only full blocks, while the crossed wall starts on one side with a 1/2 block combined with a 5 cm block. This is continued in all four directions with full blocks. The through−going block (A) must extend past the crossed wall by 24 cm, which is the length of a 1/2 block plus the joint.

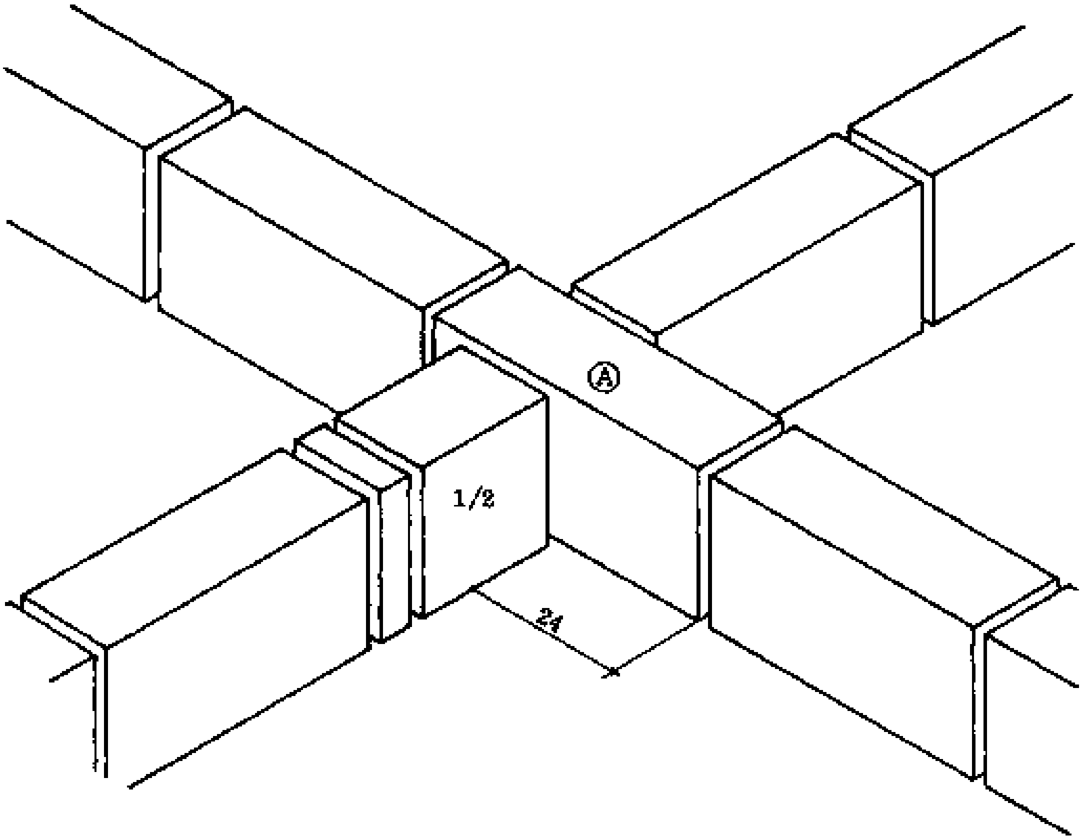


Fig. 1

In the second course, the wall which was crossed in the course below now goes through. The through block (B) again extends past the crossed wall by 24 cm, but on the side opposite from the 1/2 block in the course below. Block B is followed on its left−hand side by a 1/2 block (C) combined with a 5 cm block. This is continued in all four directions with full blocks (Fig. 2).

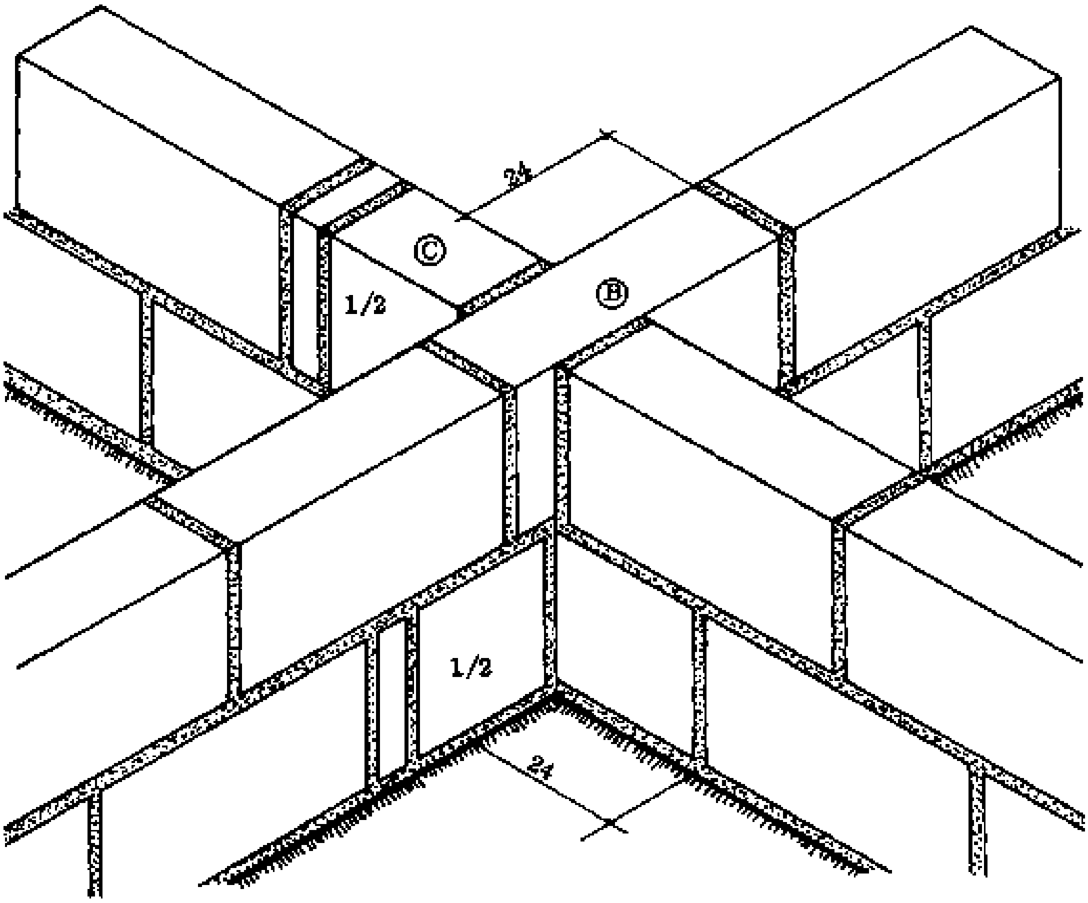


Fig. 2

In the first course the crossing block and the 1/2 block form a corner. This is also true in the second course but the corner is diagonally opposite from the one in the first course below.

– REMEMBER: All through courses in either wall consist of full blocks only. All crossed courses in either wall contain one 1/2 block combined with a 5 cm block.

NOTES:

The second method of making a cross junction in a sandcrete wall is different from the first method because 3/4 and 1/4 blocks are used instead of 1/2 blocks.

Because of this the rules for this bonding method are also different:

- All through blocks (Figs. 1 & 2, blocks A & B) project from the crossed wall by 12 cm at one end (12 cm is 1/4 block plus the joint). These blocks are followed by 1/4 blocks at the other end (Figs. 1 & 2).

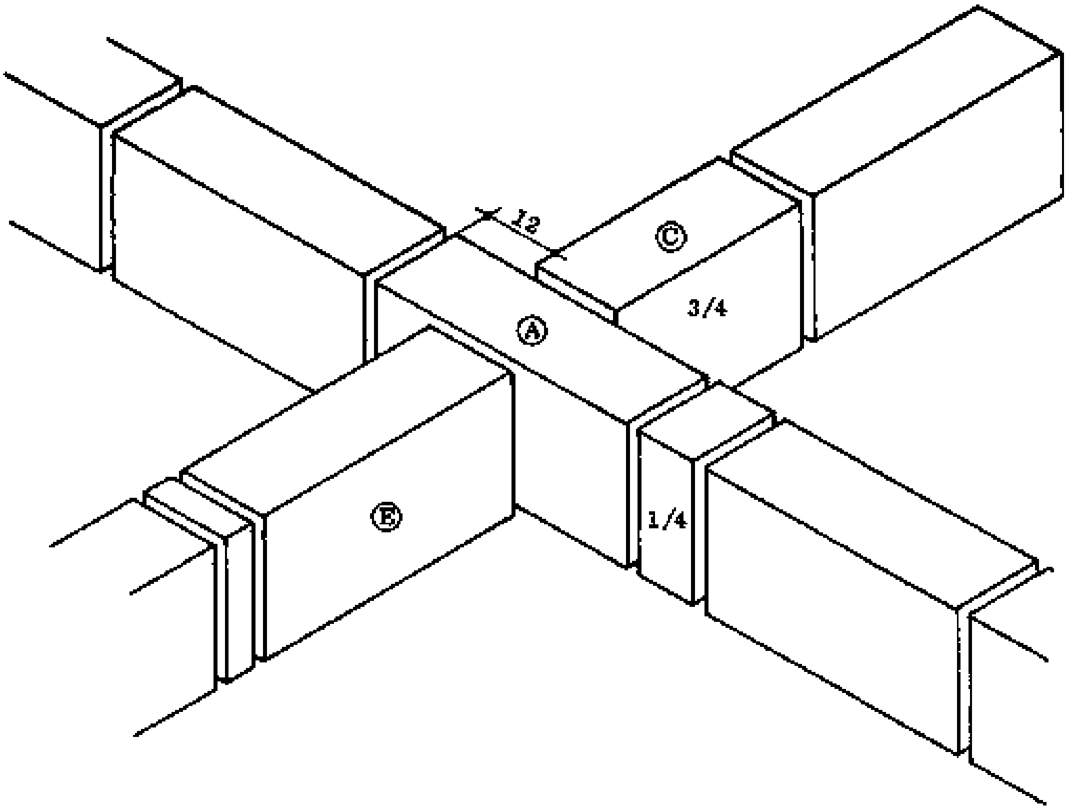


Fig. 1

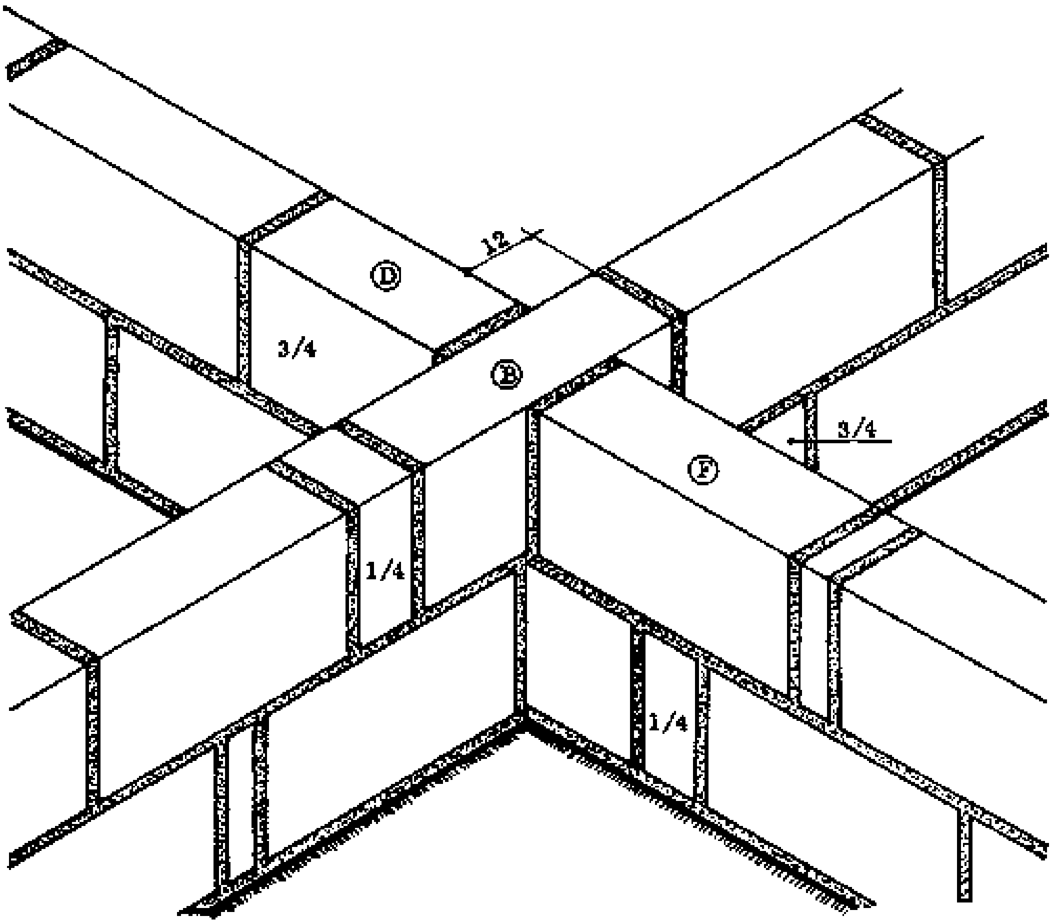


Fig. 2

– All crossed walls contain a 3/4 block (Figs. 1 & 2, blocks C & D) set directly against the through–going block. This 3/4 block is on the opposite side from the 1/4 blocks in the course below (Fig. 1). The crossed wall continues with a full block (Figs. 1 & 2, blocks E & F) and a 5 cm block, on the other side from the 3/4 block.

– NOTE: The above method involves a lot of block−cutting, which makes it less efficient than the other method.

Try to figure out more possibilities and discuss them with your fellow trainees, your instructors and your foreman on the building site.

NOTES:

Cross junction bond for rising landcrete walls

The arrangement of blocks to construct a cross junction with landcrete blocks is almost the same as for the footings (see previous pages).

Fig. 1 shows the bond for all courses with an odd number (1st, 3rd, 5th, etc.). These consist of full blocks only. The through block (A) is set exactly in the middle of the crossed wall.

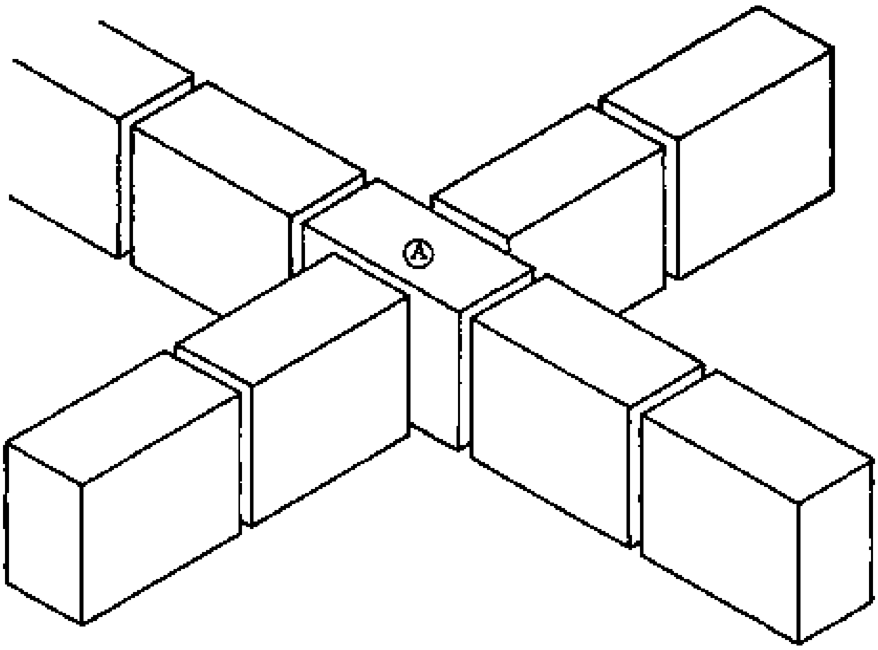


Fig. 1

The arrangement for courses with an even number (2nd, 4th, 6th, etc.) is shown in Fig. 2. These courses also start with a full block (B) set exactly across the middle of the through−going block below. This block is followed by 1/4 blocks on its ends and 3/4 blocks on its stretcher sides. This is continued in all four directions with full blocks.

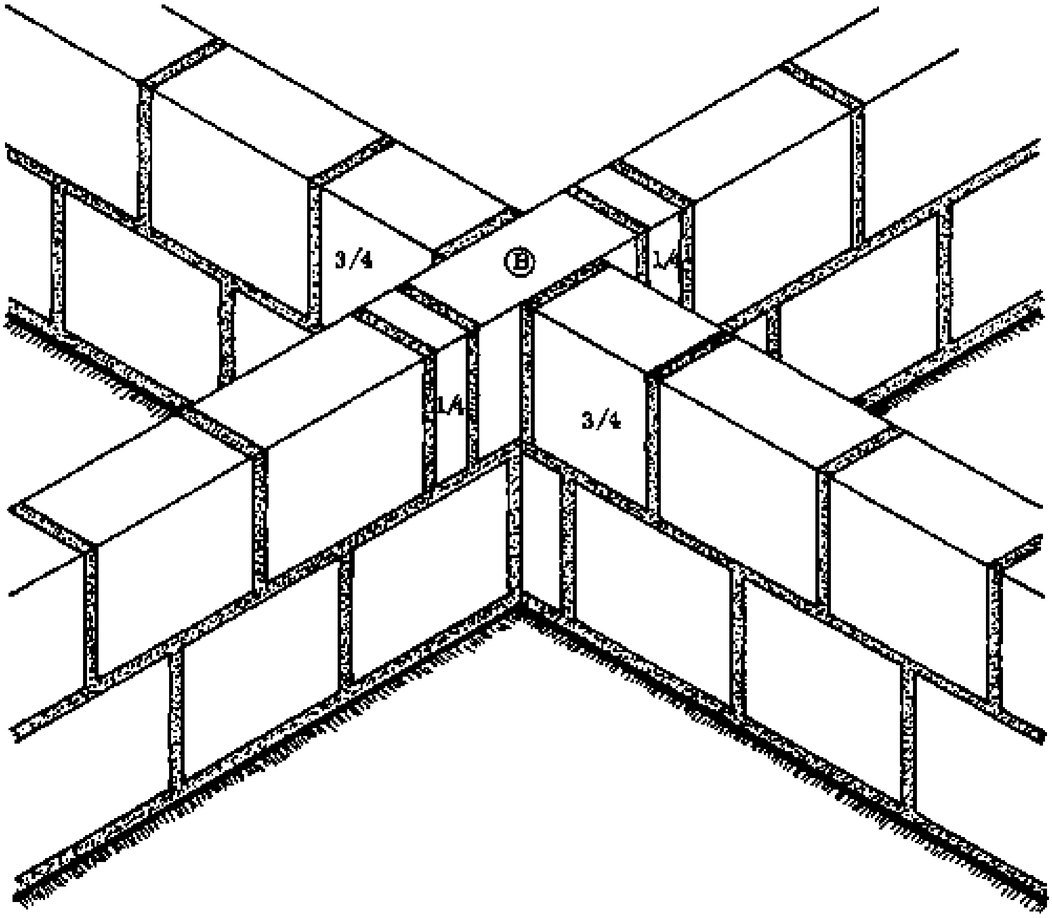


Fig. 2

NOTES:

Another method of bonding uses the cut blocks in alternate courses, unlike the last method which used all cut blocks in the same course. There is no waste in either method.

The first crossing (Fig. 1) is formed by two 3/4 blocks which project equally from the crossed wall, meaning that the joint between them is exactly in the centre of the crossed wall. The course is continued in all four directions with full blocks.

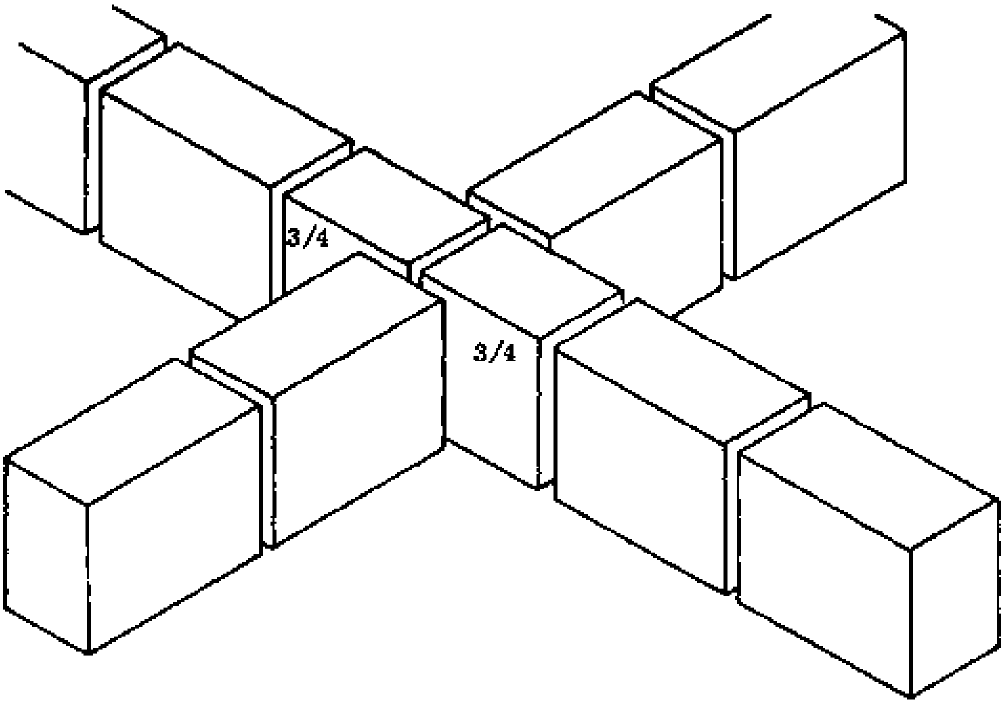


Fig. 1

The second course begins with a through−going block (Fig. 2, block A) set exactly in the middle of the crossed wall. In this way, three cross joints are covered by the block, instead of two as in the last method (Fig. 2).

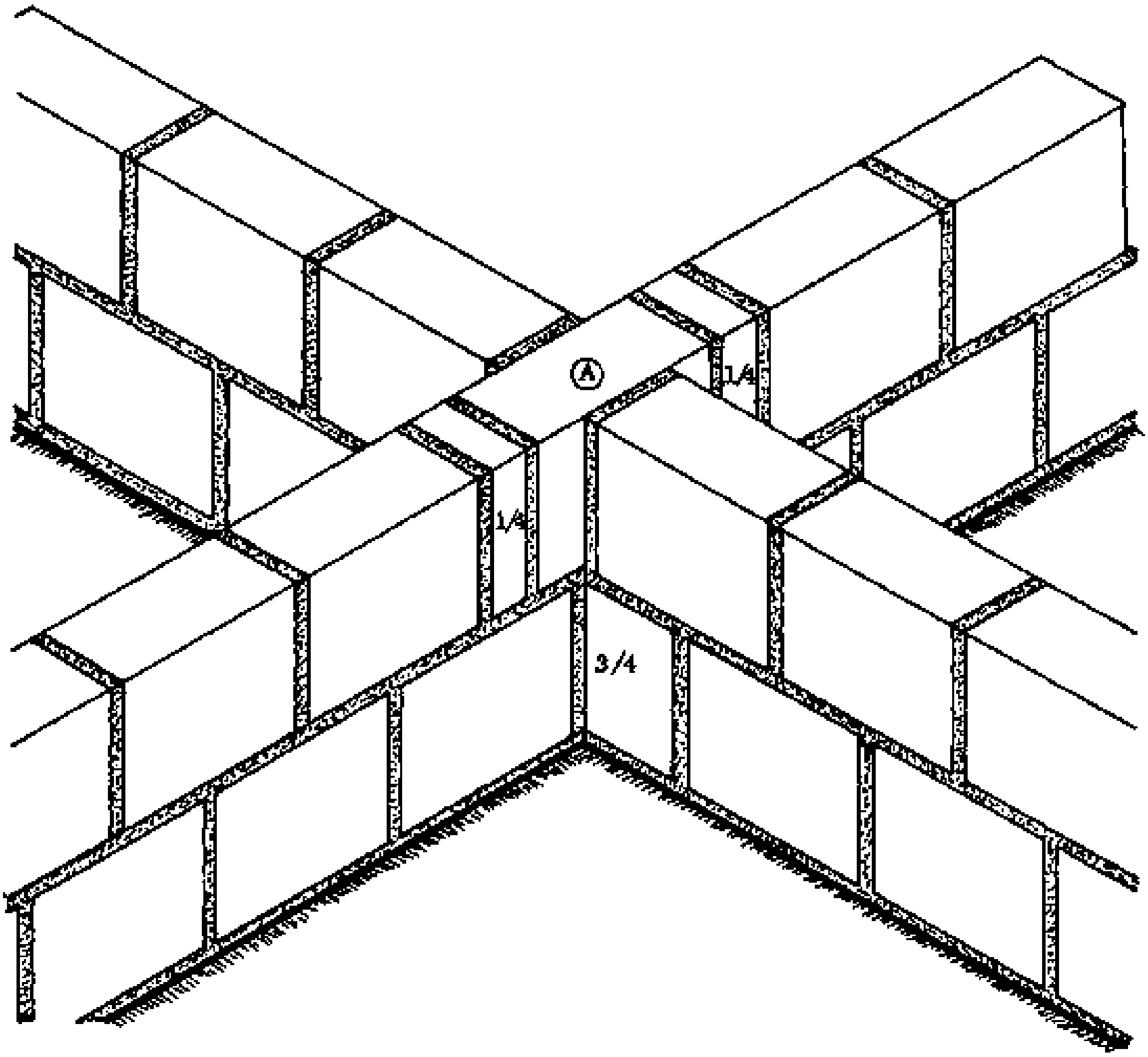


Fig. 2

The through−going block is followed by 1/4 blocks on its ends but then the course continues in all directions with full blocks.

Try to develop more possibilities but do not forget the requirements mentioned on page 46.

NOTES:

Footings – Plinth course – Rising landcrete wall

The illustration opposite shows what a cross junction will look like during the construction (Fig. 1).

(A) = FOUNDATION
(B) = FOOTING
(C) = PLINTH COURSE (SANDCRETE)
(D) = RISING WALL (LANDCRETE)

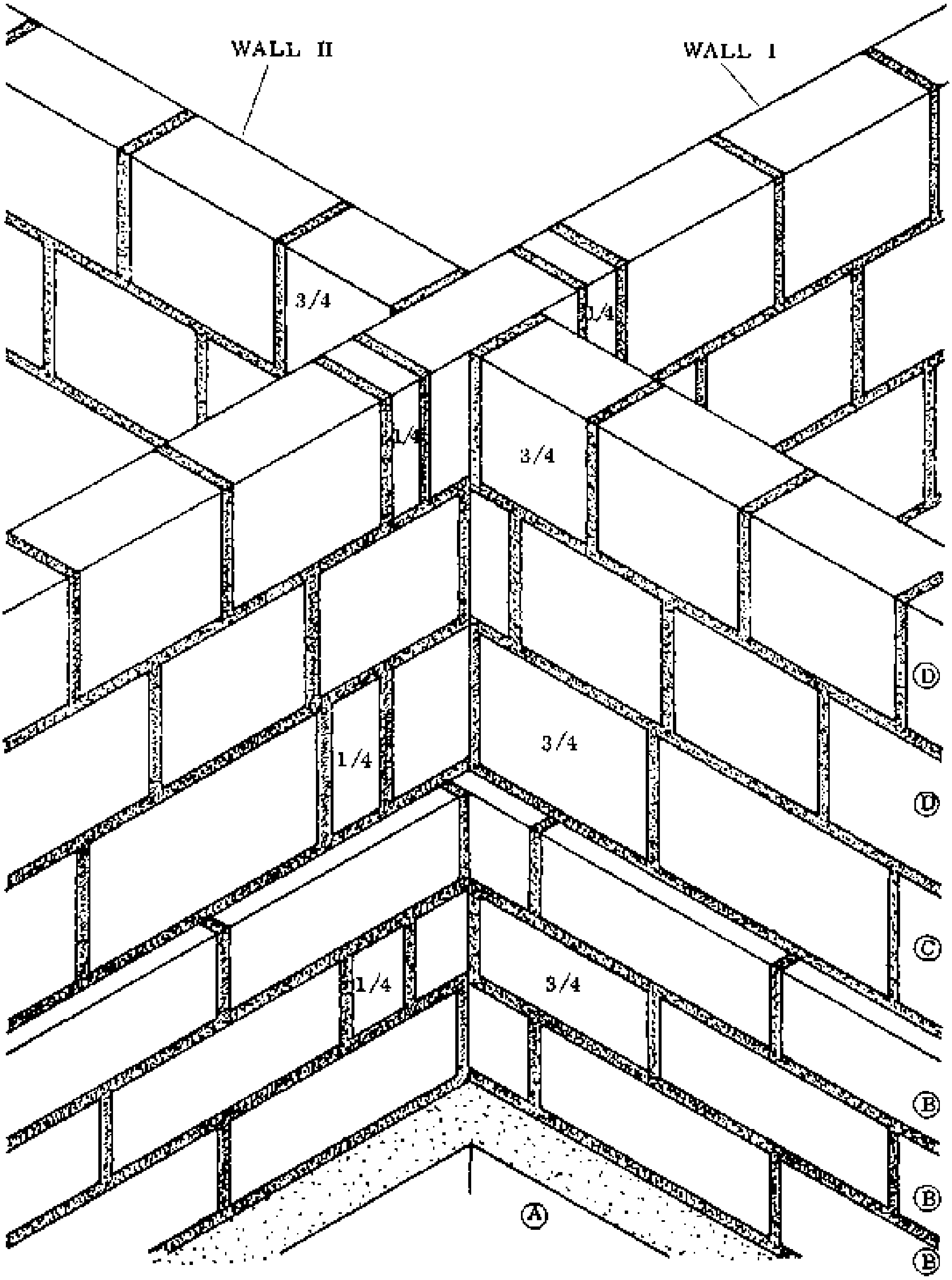


Fig. 1

Again, it is possible to maintain the half−block bond between the footings and the plinth course in wall I, as described on the previous pages. The bonding of the plinth course is a repetition of the bonding of the second footing course.

However, it can be seen that the half−block bond between the footings and the plinth course is not perfectly maintained in wall II. This is because of the 4 cm setting back on both sides as well as the reduced wall thickness.

The bond of the rising landcrete walls is the same as described on the previous pages. Only two courses are shown because the rest of the courses are repetitions of these two.

If you compare the bond of the rising landcrete wall with the plinth course, you will see that the half−block bond is not maintained between them. The only way it could be maintained is by cutting more blocks and changing the thicknesses of some of the joints. This would weaken the entire wall as well as wasting materials, so the Rural Builder should consider this bonding all right as it is shown here.

− REMEMBER: The rising landcrete wall is 1 cm thinner than the plinth course. Do not forget to maintain the “good” faces of the walls by laying the landcrete blocks flush with the plumbed faces of the plinth courses below.

NOTES:

PIERS

Attached piers

Attached piers; also called engaged piers, wall piers, blind piers or pilasters, are piers partly sunk into a wall and properly bonded into it.

Normally the visible part of a pier projects only slightly from the wall, but in Rural Building the projection may be as much as the thickness of the wall or even more.

Formerly, attached piers were most often used as decorative elements. The Rural Builder, however, uses attached piers chiefly to strengthen walls. At the same time he saves valuable materials such as cement, reinforcement bars and timber for formwork that would be needed for a reinforced concrete pillar.

The construction of an attached pier is very similiar to that of a T−junction. The only difference is that the wall which joins the front wall is very short, and with a stopped end, thus forming an attached pier (Fig. 1).

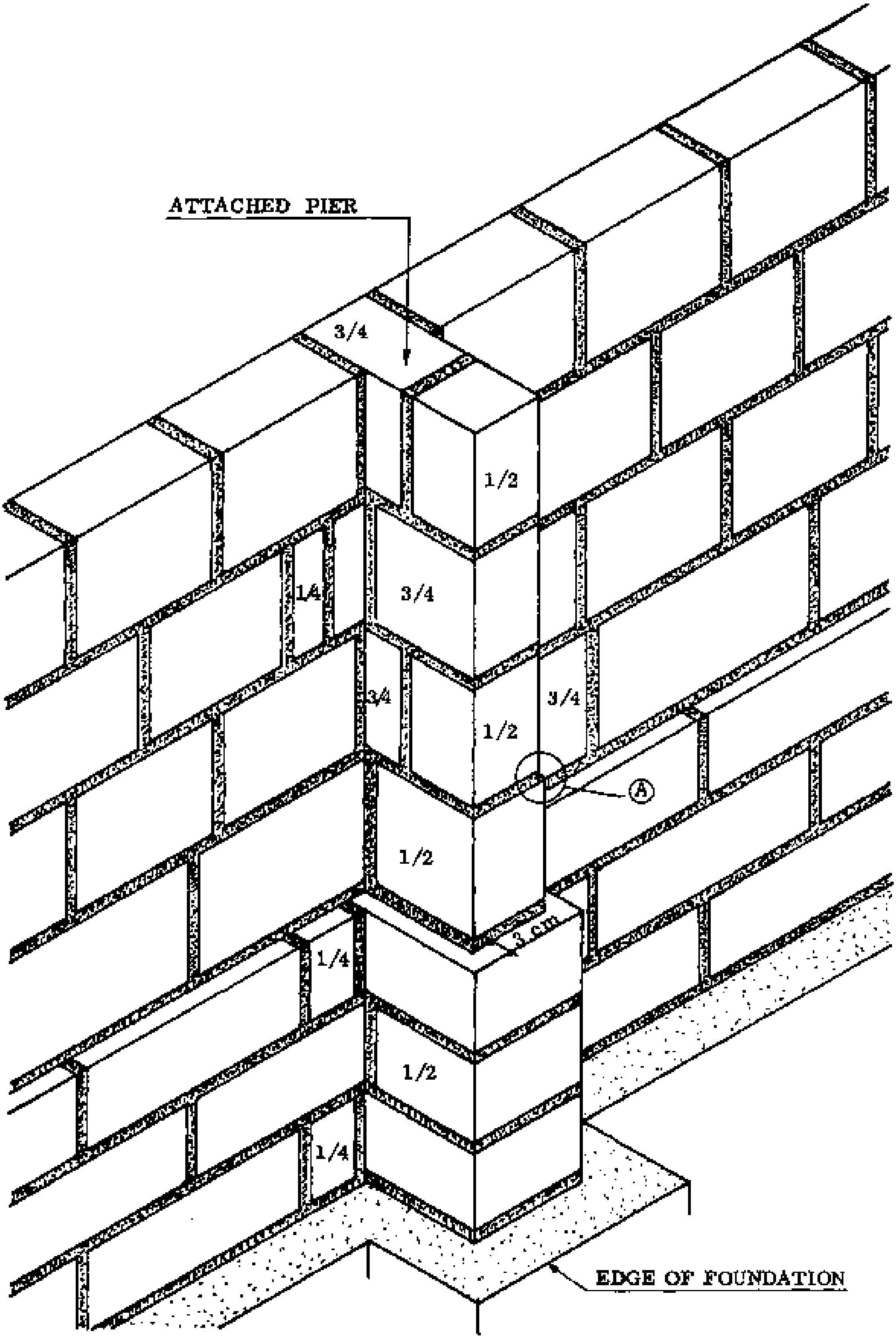


Fig. 1

The illustration shows that the bonds used to construct this pier are the same as those introduced in the chapter on T–junction bonds. Compare it with the text and illustrations from pages 38 to 44.

– NOTE: The plinth course is set back everywhere from the footings by 4 cm, except on the back side of the attached pier where it is set back only 3 cm (Fig. 1).

Do not forget to build the landcrete blocks flush with the plumbed (good) face of the plinth course. This means that on the other face of the wall there will be a 1 cm set–back caused by the 1 cm difference in size between the sandcrete blocks in the plinth course and the landcrete blocks in the rising wall (Fig. 1, point A).

NOTES:

Simple piers

A pier is a pillar–shape of brickwork, blockwork or stone which usually has a square or rectangular section, and supports a load. In Rural Building its mass also helps to anchor the roof structure.

The easiest way to construct a pier is by simply laying full blocks flatwise one above another (Figs. 1 & 2). This will be sufficient in situations where the pier does not have to carry a very heavy load.

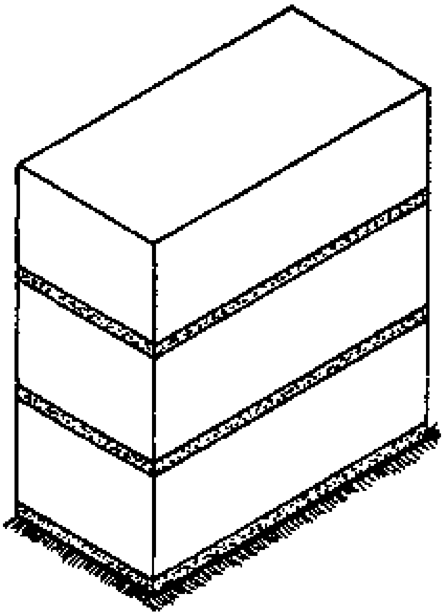


Fig. 1 SAND CRETE PIER

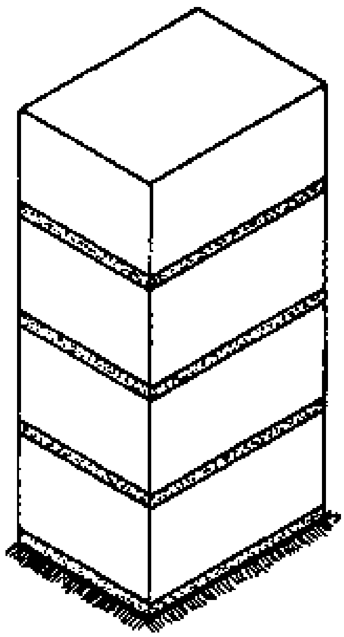


Fig. 2 LANDCRETE PIER

The disadvantage of this construction is that any roof anchorage must be fixed to the sides of the pier.

The best way to anchor a member of the structure to a pier is through the centre of the pier.

So−called perforated blocks can be made by using a specially made wooden mould (Fig. 3). In contrast to the common type of perforated block which has many smaller holes, this type has only one large hole through its centre. It is also called an open block.

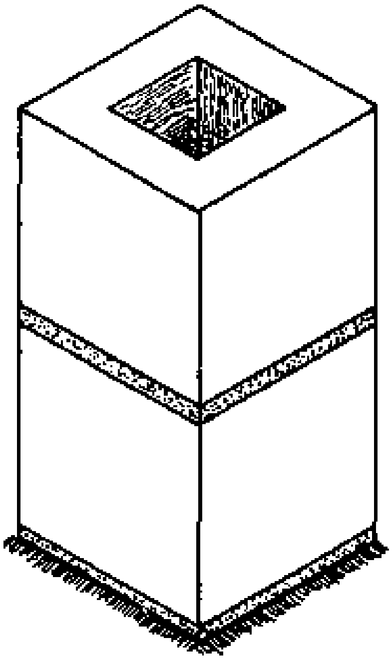


Fig. 3 PIER BUILT WITH OPEN BLOCKS

Open blocks are made by casting mortar between two frames (Fig. 4). The bigger frame is made similarly to the wooden mould described in the Reference Book, Tools section, page 29. The smaller frame is tapered and has a handle to make it easier to remove from the block.

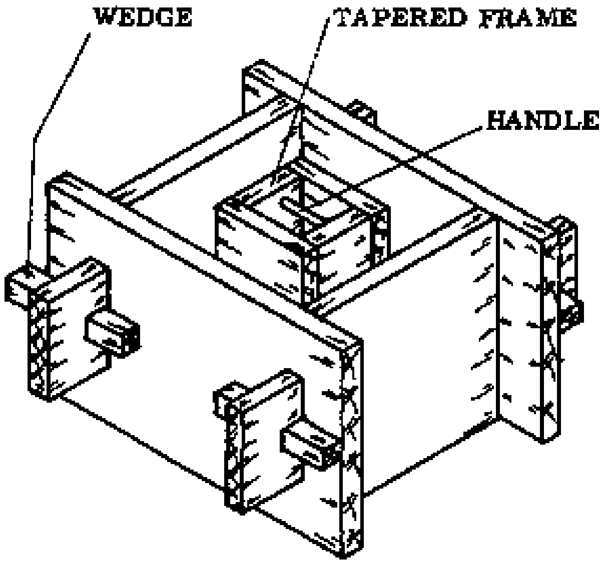


Fig. 4 WOODEN MOULD

After the pier is built, the anchoring bar is inserted in the hole and the remaining space is filled up with mortar or concrete.

NOTES:

Footings for piers

There are situations where piers are needed which not only have to carry heavy loads but also have to be very heavy in themselves. This is to anchor the roof against the suction of strong winds.

In order to save valuable building materials such as cement, reinforcement bars and timber, as well as to reduce the construction time, blockwork piers are often built.

There are several possible bonding arrangements. The bonds introduced in this chapter represent only a few types, but they will meet the requirements of the Rural Builder.

The type of bond which is used depends largely on which materials are available and on the size of pier which is desired.

The opposite illustrations show a bond for footings with sandcrete blocks laid flatwise. Refer to page 67 for another footing method. Both bonds can also be used to build up an entire pier, in case a heavy duty pier is desired.

All the courses in the illustration on the left consist of a pair of blocks which are set 2 cm out of line with each other at the header sides. You can see this 2 cm difference at points A, B, C, D in Figs. 1 and 2.

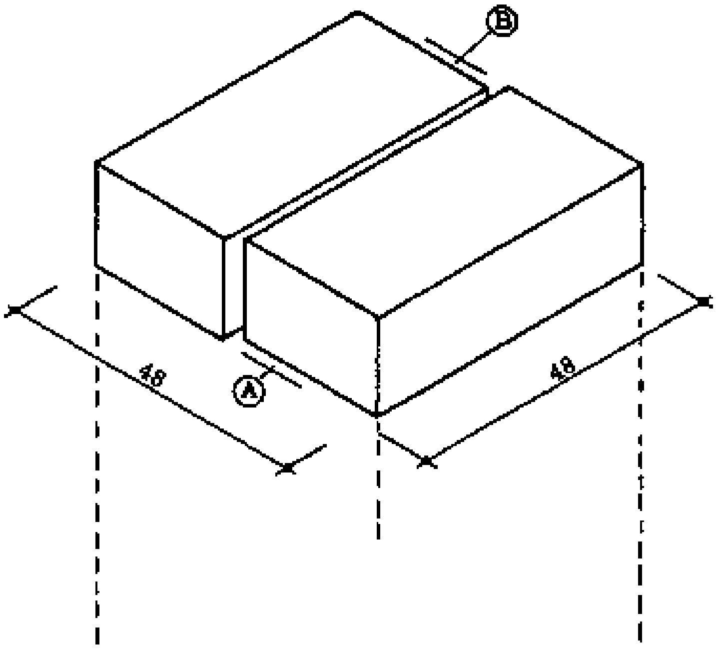


Fig. 1

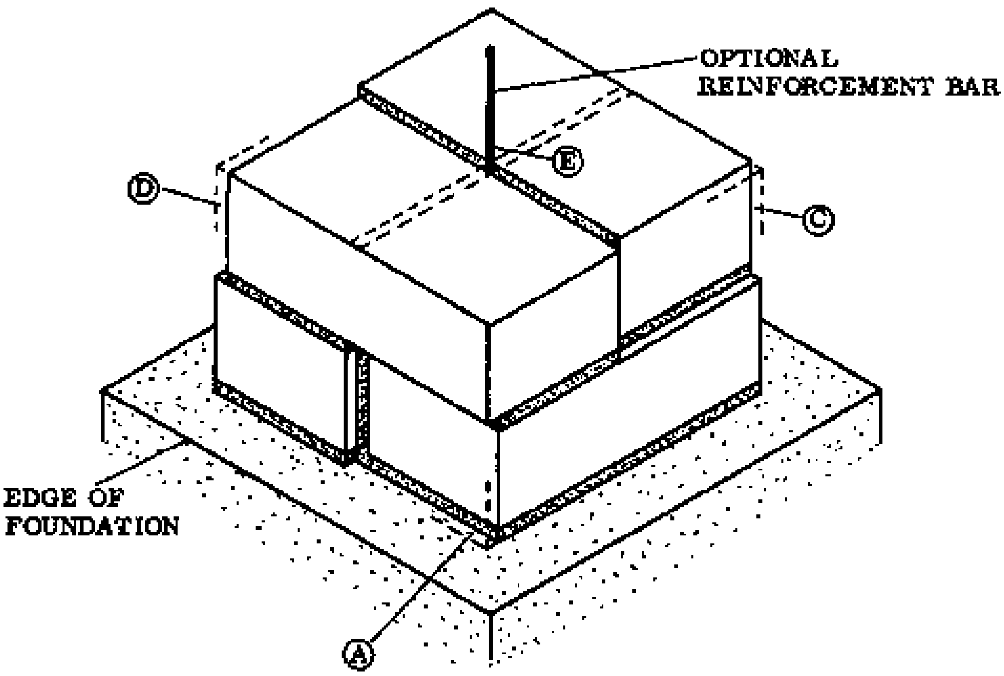


Fig. 2 FOOTING FOR PIER

This is done to maintain a square shape of 48 cm by 48 cm, since the width of the two blocks plus a joint is 48 cm, while the length of each block is only 46 cm. Since the courses cross each other, a reinforcement bar for anchorage could be built−in between the cross joints (Fig. 2, E).

NOTES:

Bonds for sandcrete piers

The following two bonds are also square−shaped but have shorter dimensions than the footing bonds: 34 cm by 34 cm.

Fig. 1 shows the best bond for a pier with the above measurements. This is because each course uses a total of 1 1/2 blocks, which means that there is no waste.

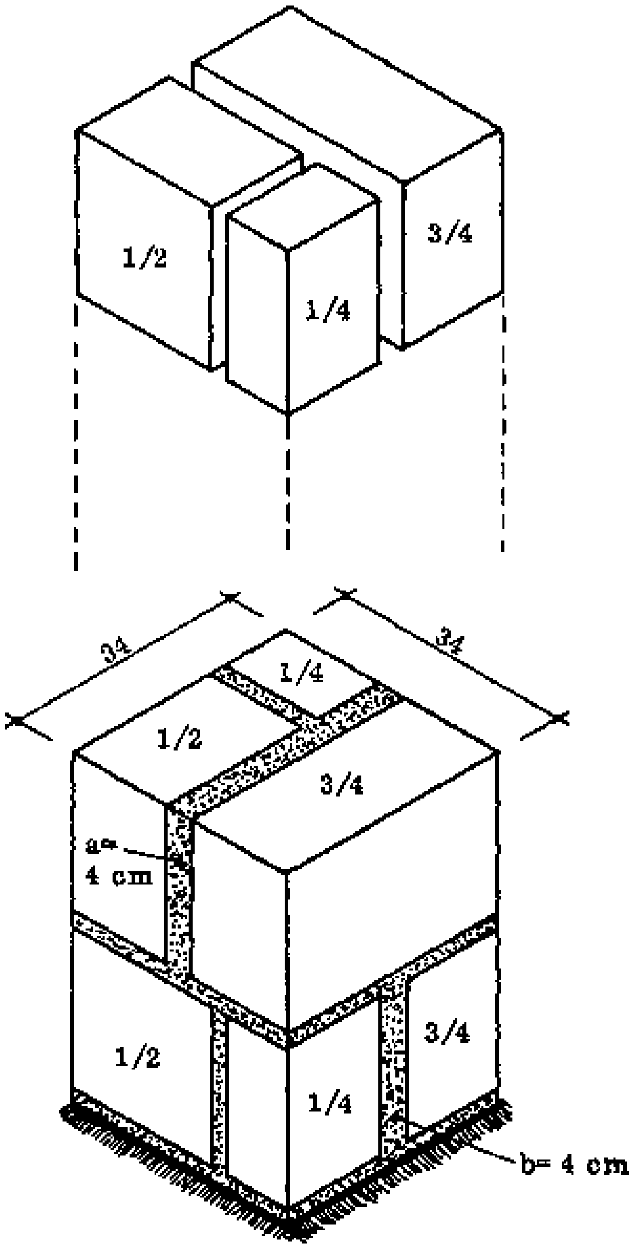


Fig. 1 SANDCRETE PIER EDGEWISE

The through−going cross joints in each course must be widened (Fig. 1, a & b) to 4 cm in order to obtain a width of 34 cm across the two blocks; 34 cm is the length of the 3/4 blocks.

The 3/4 block in each course is set over the 1/4 block below, and across the 4 cm joint, making an alternating arrangement as shown (Fig. 1).

Fig. 2 shows another bond for a sandcrete pier. The pier is built entirely of 3/4 blocks. The cross joints all go through and all have a 4 cm thickness.

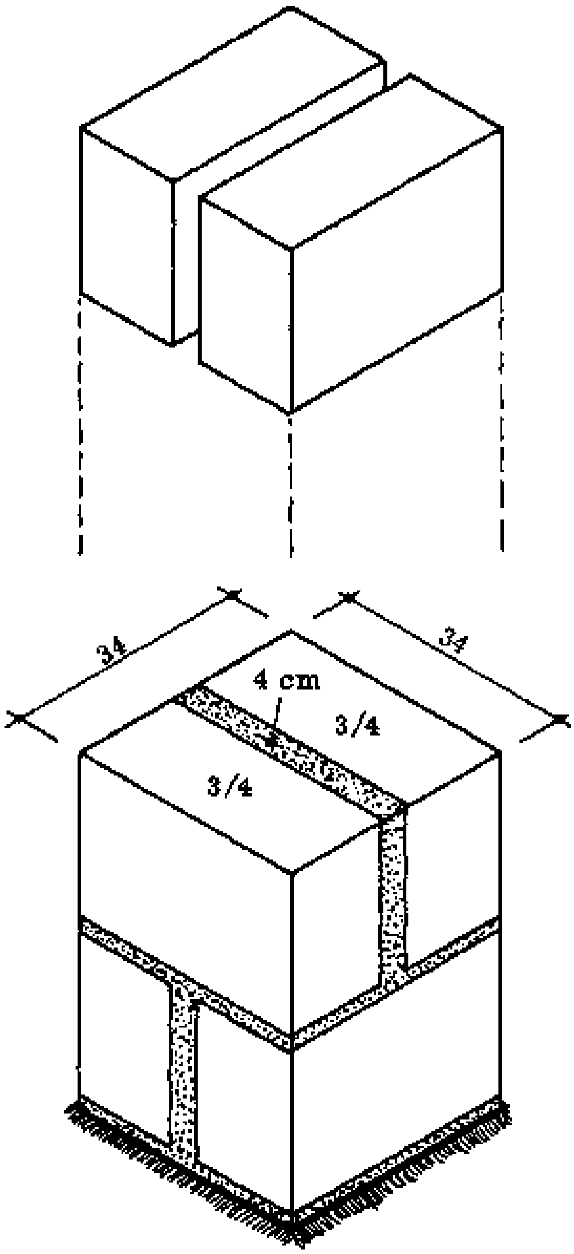


Fig. 2 SANDCRETE PIER EDGEWISE

It is obvious that this type of pier should be built only if there are a lot of 3/4 blocks left−over from another construction, because otherwise all the 1/4 blocks are left−over and wasted.

NOTES:

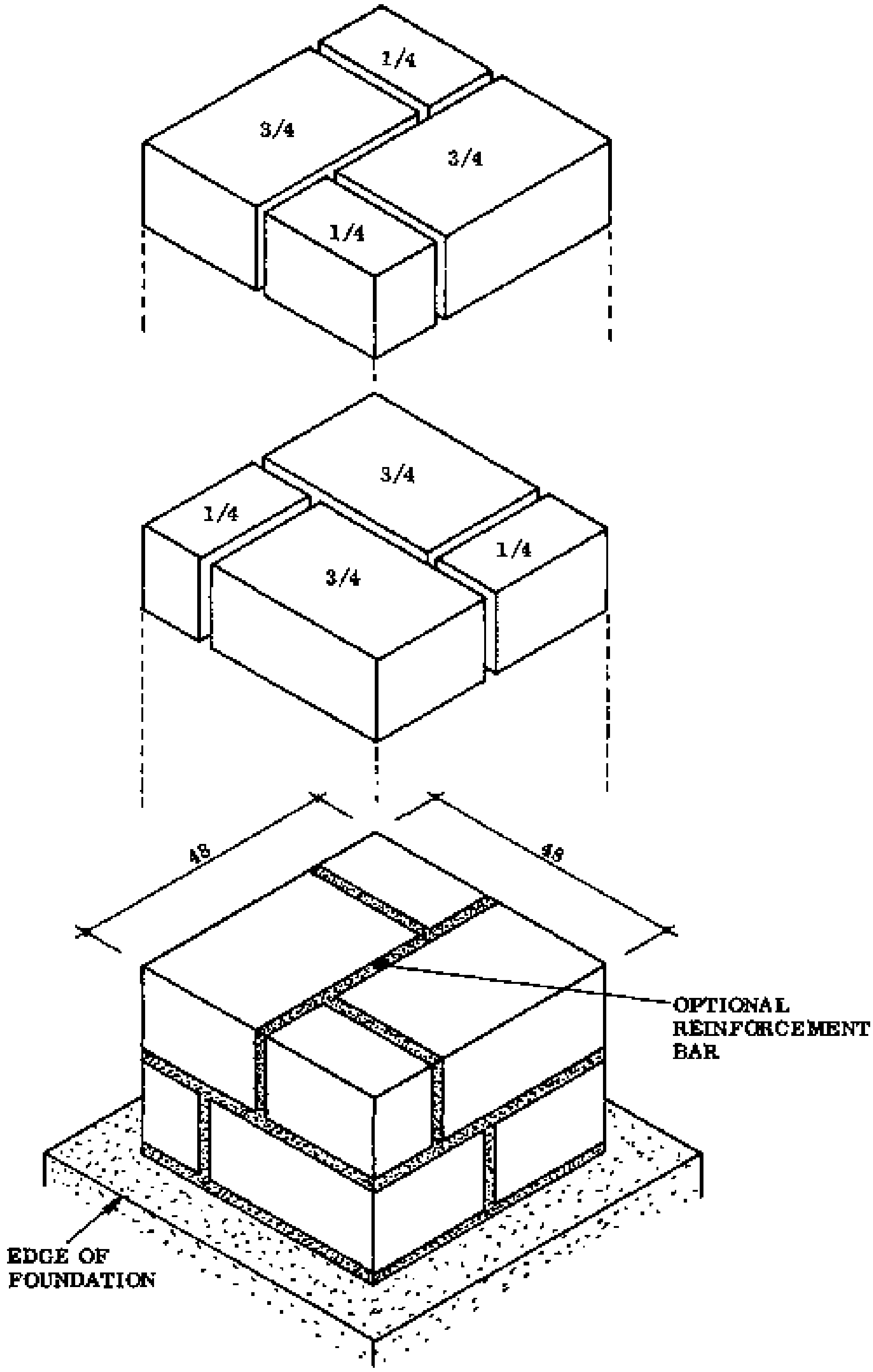


Fig. 1 SANDCRETE PIER FLATWISE

Bonds for landcrete piers

The examples of bonds for landcrete piers shown on pages 68 and 69 are similar to some of the bonds already explained. Fig. 1 shows a bond which is basically the same as the footing bond on page 63, except the blocks are laid edgewise.

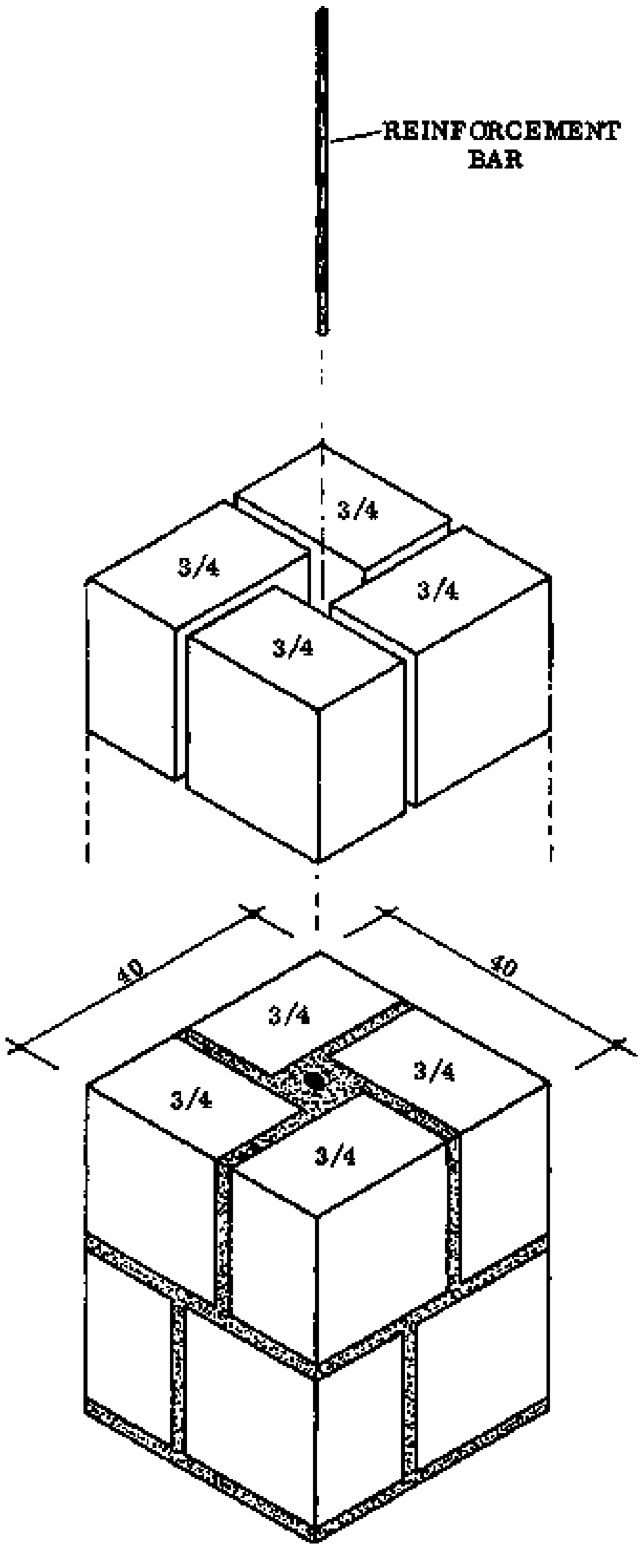


Fig. 1 LANDCRETE PIER EDGEWISE

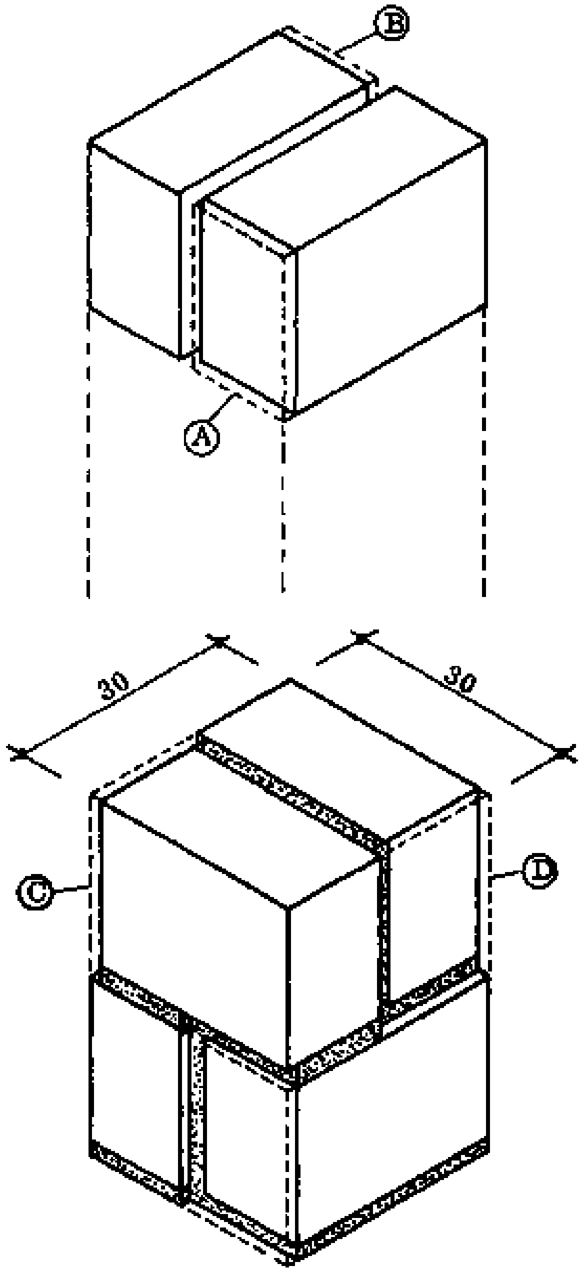


Fig. 1 LANDCRETE PIER EDGEWISE

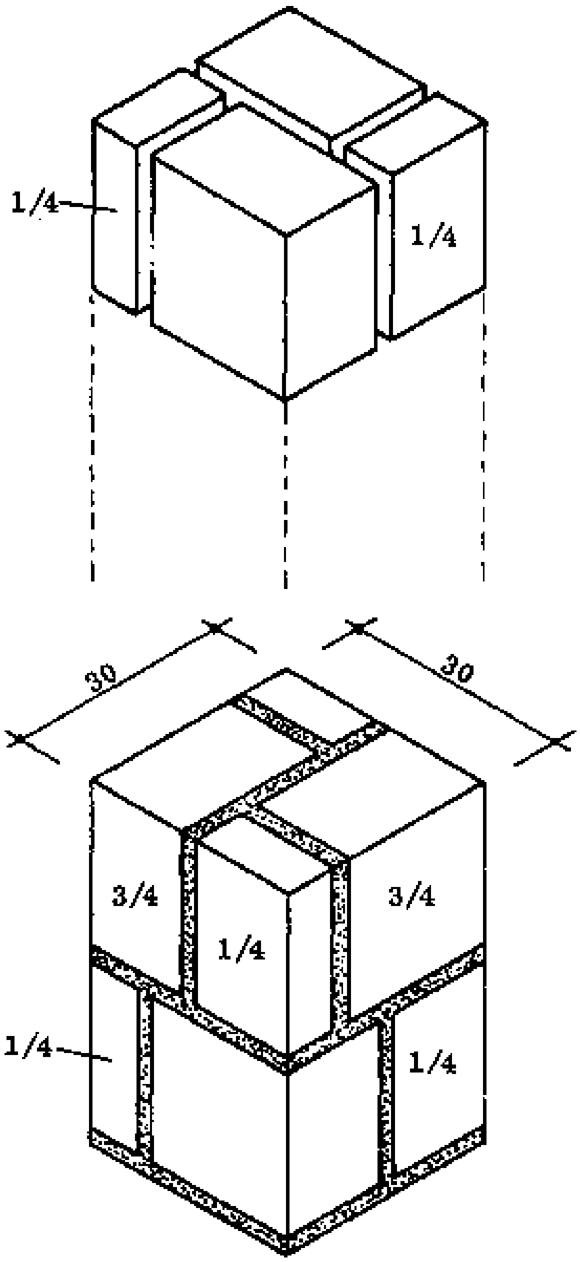


Fig. 2 LANDCRETE PIER EDGEWISE

Each course consists of two full blocks laid edgewise and across the course below. In order to maintain a square shape of 30 cm by 30 cm, the blocks are set 1 cm out of line with each other at their header sides (see points A, B, C, & D).

The bonding method seen in Fig. 2 requires cutting two blocks per course and results in a rather weak bond. The Rural Builder should avoid making this type of pier except when he needs to use up some part−blocks left over from another construction.

Fig. 1 on page 68 shows another bonding method for landcrete piers with the blocks laid edgewise. This method has the advantage that an iron rod can be set into the centre of the blocks, either to reinforce the pier or to act as an anchor, or both.

− NOTE: Landcrete piers should not carry heavy loads such as a truss or a concrete beam, because they are too weak. They may be used to support and anchor overhanging rafters of a roof above a verandah.

If a landcrete pier has to carry heavy loads, its dimensions should be increased to a minimum of 55 cm by 55 cm.

NOTES:

PART 2: BASIC CARPENTRY TECHNIQUES

TECHNICAL TERMS

– GRAIN: This refers to the direction of the wood fibres. Length is measured along the direction of to grain. Width is measured across the grain at right angles to the length. When wood is cut across the grain, END GRAIN is exposed.

– WITH THE GRAIN: This term is used in connection with planing. If the fibres are cut cleanly and smoothed down by the cutting iron, the wood is said to be planed with the grain; like stroking a dog's coat so the hair lies down smoothly.

– AGAINST THE GRAIN: This means that the plane goes in the opposite direction, lifting and breaking the wood fibres and leaving a rough surface; as if a dog's coat were brushed the wrong way and roughened.

– STRAIGHT GRAIN: The wood fibres lie straight and parallel to the length of the piece of wood. Such wood planes smoothly and easily.

– CROSS GRAIN: The wood fibres do not lie parallel to the length of the piece.

This makes the wood hard to work.

– BEVEL: This is made by planing off the sharp edge to form a new surface which is not at right angles to the side of the piece of wood. A CHAMFER is a special bevel, cut at 45 degrees. A "through" chamfer or bevel runs the whole length of the edge (Fig. 1). A "stopped" chamfer or bevel is stopped at one or both ends (Fig. 2).

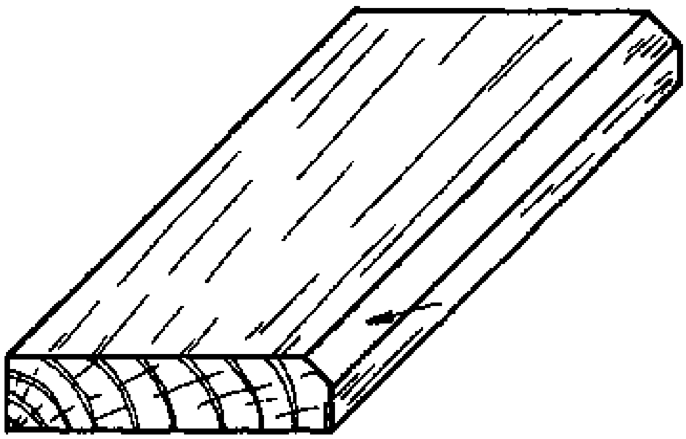


Fig. 1

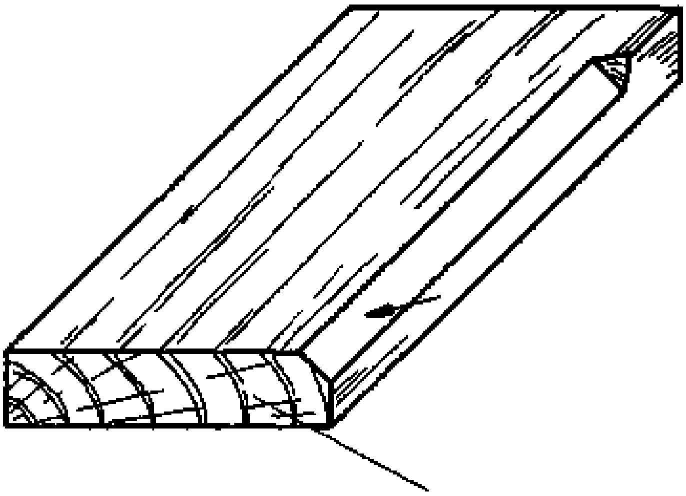


Fig. 2

– GROOVE: This is a recess cut along the grain. A “through” groove runs the whole length of the piece (Fig. 3, a); while a “stopped” groove is stopped at one or both ends (Fig. 3, b).

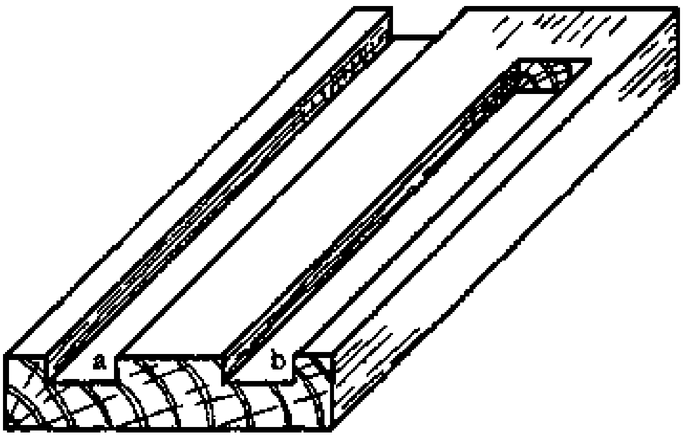


Fig. 3

– TRENCH: This is a recess cut along the grain. A trench can also be either through (Fig. 4, a) or stopped (Fig. 4, b).

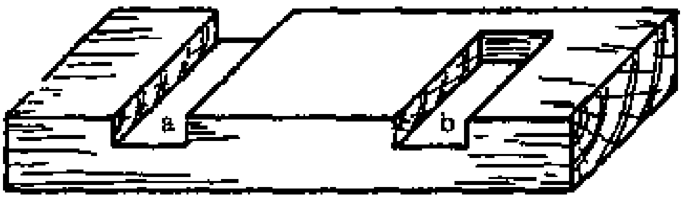


Fig. 4

– REBATE: This is a recess cut along the edge or across the end of a board as in Figs. 5 & 6.

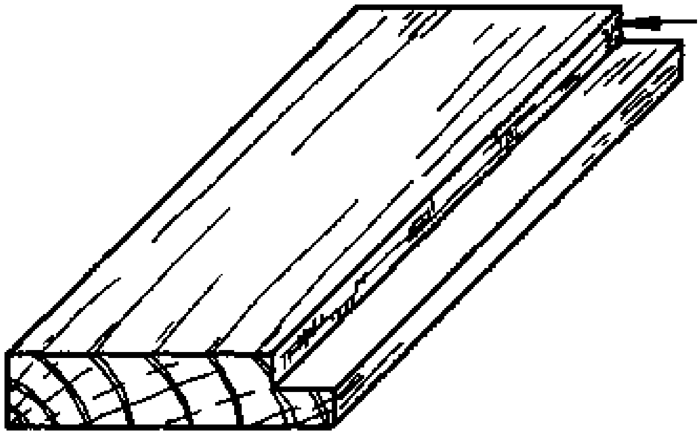


Fig. 5

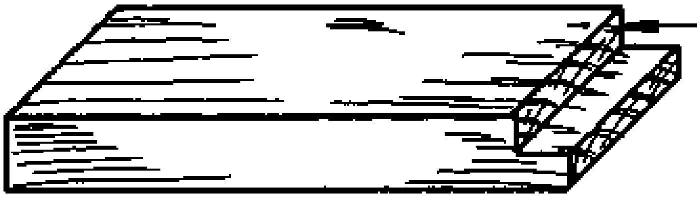


Fig. 6

– TRUE: In woodworking this indicates that a surface is flat and perfectly level.

– SQUARE: Square angles are exact 90 degree angles. “Square” is used to describe pieces in which all the corners and edges have 90 degree angles.

– SHOULDER: The vertical portion of a trench or rebate (arrows, Figs. 5 & 6).

TESTING BOARDS

When you prepare a board for use in some project, you must make certain tests on it to make sure that it is flat and true in all directions and that the angles and corners are all square. These tests are made during the actual preparation of the timber, but we describe them here separately because they are generally useful techniques which you will need again and again in your work.

Before you continue reading, look in your Rural Building Reference Book, Tools section, page 36, and read about the try square, which is one of the tools you will need for testing boards. You will also need winding strips (Fig. 2) and a straight edge (Fig. 1), which is usually a piece of wood with one long edge that you are sure is perfectly flat and straight.

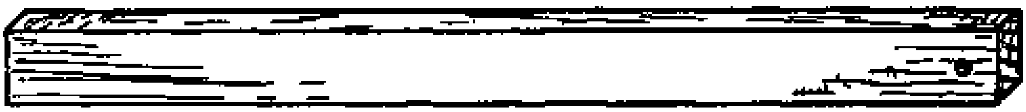


Fig. 1

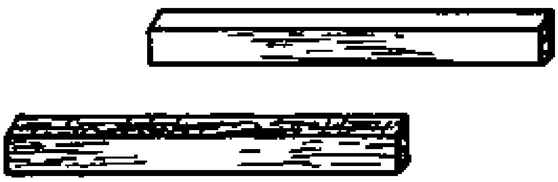


Fig. 2

Also look in the Reference Book, Materials section, page 132 and find out what is meant by the words: twisting; cupping; and bowing.

Winding strips

These are used as an aid to help you to see if a board twists or “winds”. They are two strips of wood about 35 cm long, 2,5 cm wide and 1, 5 cm thick. The top edge has a bevel and all the edges must be perfectly straight. One of the two strips may be made darker so that sighting along them is easier (Fig. 2).

How to test small work pieces

Test with the try square or the edge of a jack plane in different positions for flatness. Also test the squareness of the edges with a try square at a few different spots (Fig. 3).

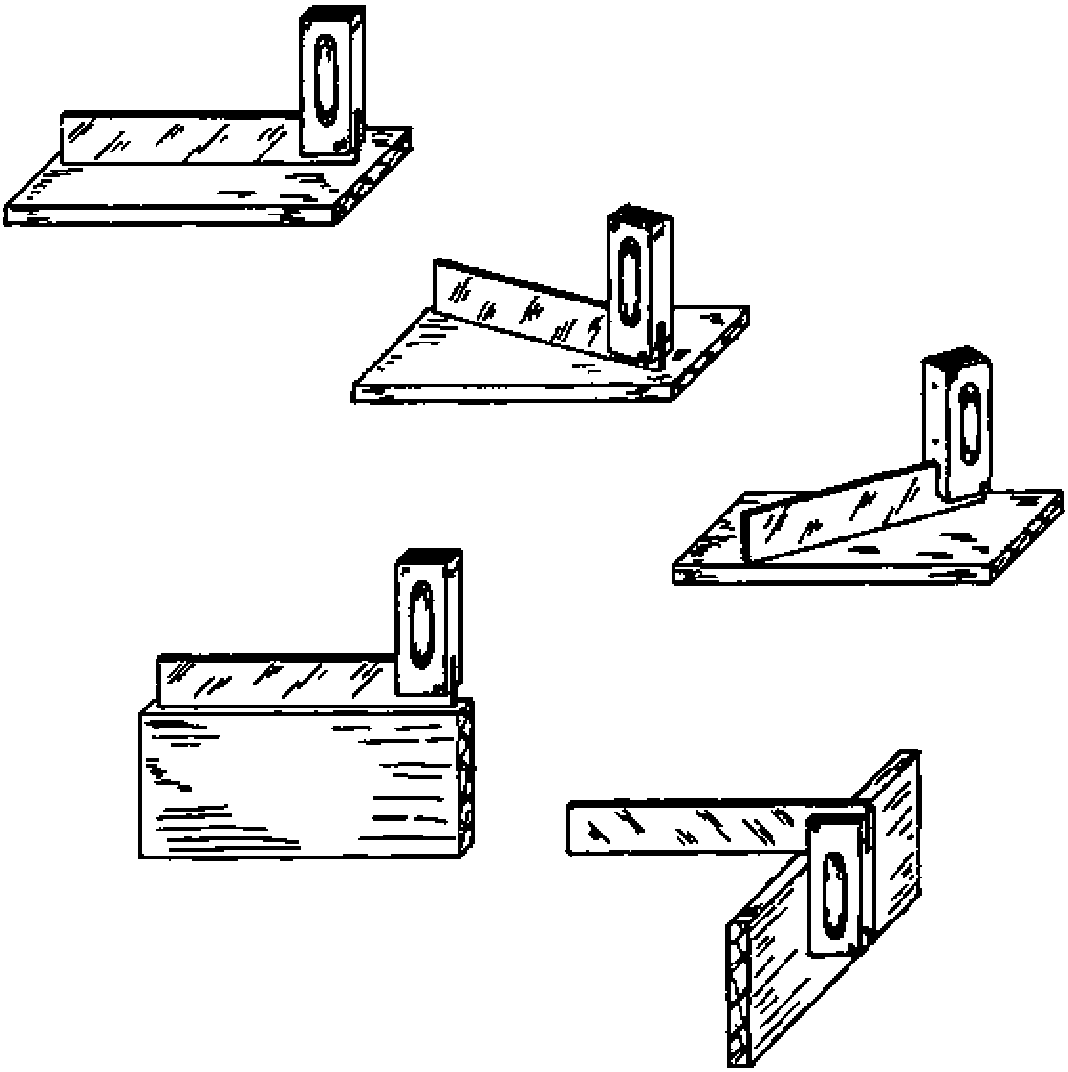


Fig. 3

NOTES:

How to test long work pieces

Test for winding (twisting) using the winding strips; one at each end of the board, across the grain. Go to the end of the board and look along the board, with your eye just at the same level as the strips (Fig. 1). When the top edges of the strips do not appear parallel (Fig. 1a), the board is not flat. Check with the winding strips at different spots, making sure that the strips are parallel (Fig. 1b).

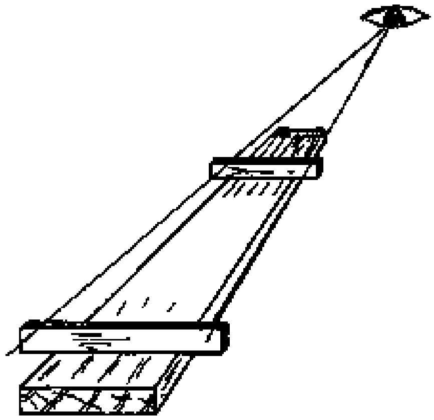


Fig. 1

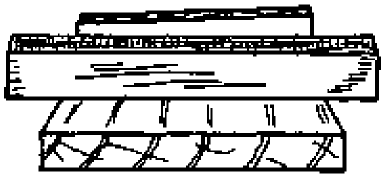


Fig. 1a

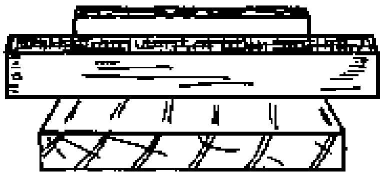


Fig. 1b

Test for cupping by putting a try square across the grain at different spots along the board. If you check this against the light, you will see all of the uneven places (Fig. 2).

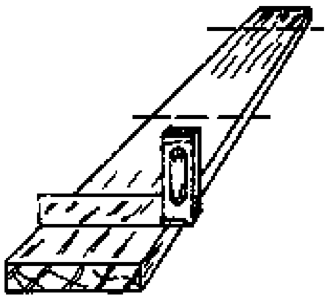


Fig. 2

To check for bowing you can do the same test, using a straight edge along the grain (Fig. 3).

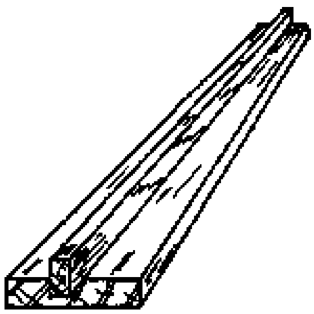


Fig. 3

For long boards you can sight along the boards with one eye closed, to see the places which are uneven (Fig. 3a).

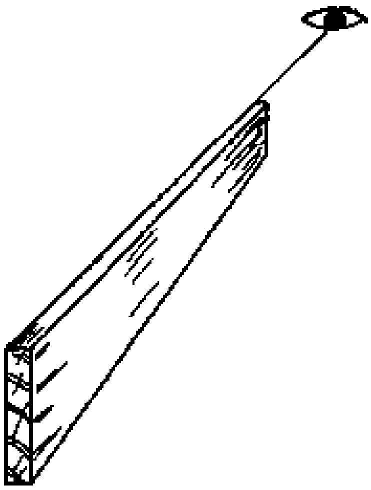


Fig. 3a

Using a try square, check whether the angle between the face side and the edge is exactly 90 degrees. Make this test at several places (Fig. 4).

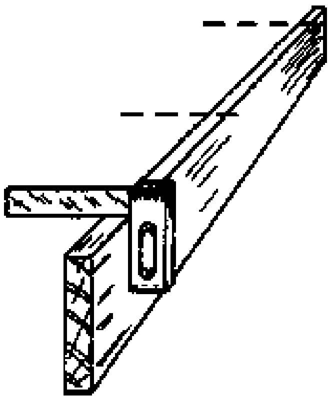


Fig. 4

When all these tests have been performed with satisfactory results, the board will be straight and true in all directions and it is ready to be used in a project.

NOTES:

MEASURING AND MARKING OUT TIMBER

Accurate measuring and marking out are the first requirements for success in the building trade. Common measuring and marking tools are the folding rule and zig−zag rule (Reference Book, page 11).

Measuring with a rule

To measure between two points, place the rule on one point and read the mark nearest to the other point (Fig. 1).

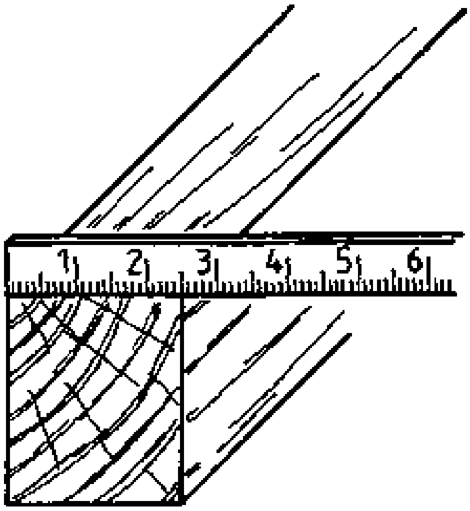


Fig. 1

When the end of the rule has become worn and inexact, you can still get an exact measurement. Place the 1 cm mark of the ruler at the first point and read at the second point. The true measurement is that reading minus 1 cm. For example, the measurement in Fig. 2 is: 3,5 cm minus 1 cm equals 2,5 cm.

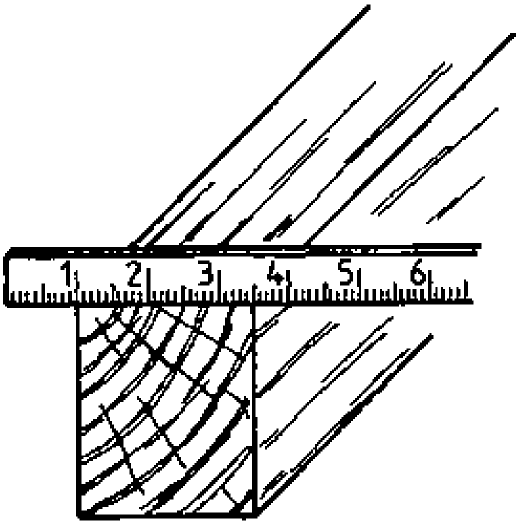


Fig. 2

Marking out with a rule

To mark out measurements with a rule, place the end of the rule (or the 1 cm mark) carefully at the start of the measurement and then make a fine mark with a pencil exactly even with the marking on the rule at the correct distance.

For very accurate marking and measuring, lay the rule on its edge so that the marks on the rule touch the work (Fig. 3).

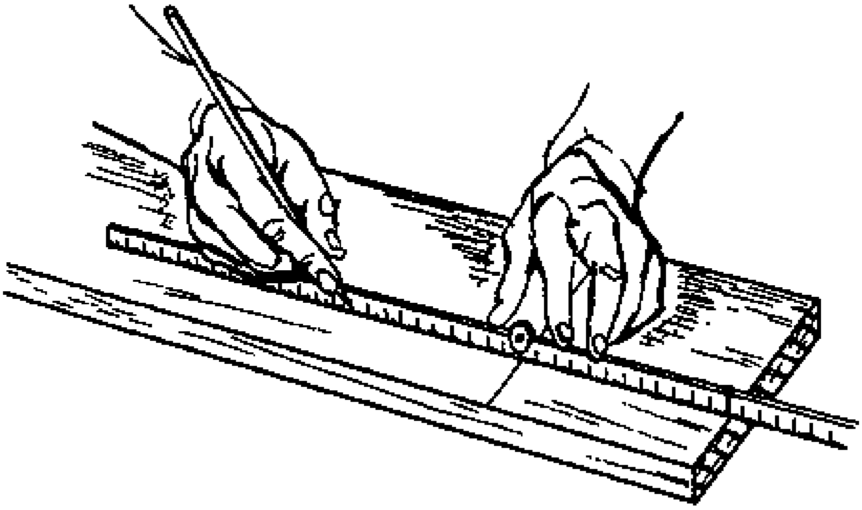


Fig. 3

To mark out several measurements on a line, it is best to mark all of the measurements without raising the rule or moving it. If the rule is moved and each measurement is made separately, there is a much greater possibility of error.

NOTES:

Marking with a pencil

When a marking gauge (Reference Book, Tools, page 39) is not available, straight lines can be gauged along timber by one of the following methods.

– Grasp the pencil lightly in your closed fist with the point protruding the desired distance. For example, to make a line 1 cm from the edge of the timber, the point of the pencil should stick out exactly 1 cm from your fist. Now pull the pencil along the board keeping your thumbnail pressed firmly to the edge of the board (Fig. 1).

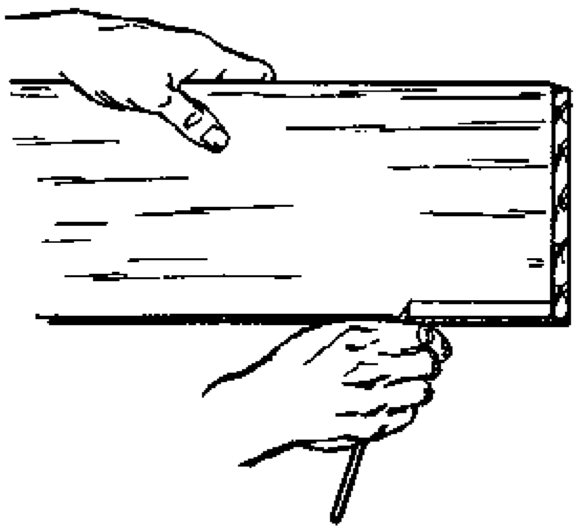


Fig. 1

– To gauge lines further from the edge of the board, use a rule and a pencil. Grasp the rule in one hand with your thumbnail at the desired marking. Then draw the rule along while keeping your thumbnail against the edge of the board. With your other hand hold a pencil at the end of the rule to make the line (Fig. 2).

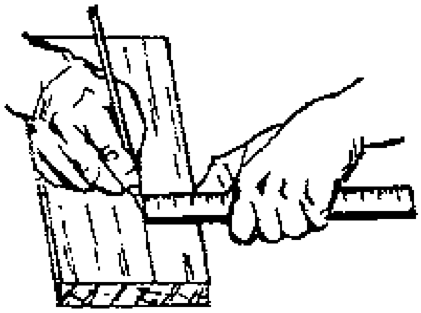


Fig. 2

With these methods you should be careful not to get splinters in your fingers.

– Another method of drawing lines parallel to an edge is with a small pencil gauge. This is simply a small, rebated wooden block which is pressed against the edge of the timber and used to guide the pencil, as shown in Fig. 3. The pencil gauge is often used to mark out the position of chamfers.

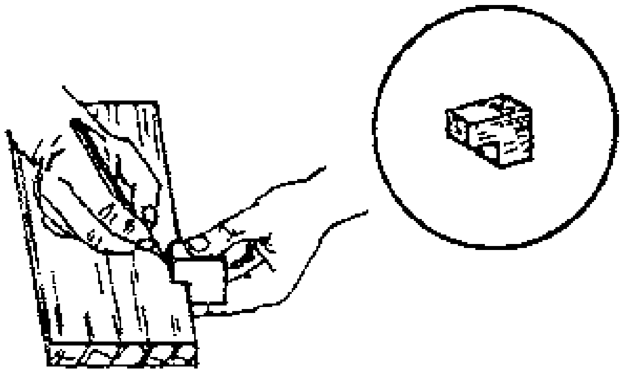


Fig. 3

– A straight edge can also be used in marking out longer lines.

Marking with a chalk line

A quick and simple way of marking out a straight line on any surface is with a chalk line. This is simply a piece of string that has been rubbed with chalk until it is coated in chalk dust (charcoal may also be used for this purpose).

To use the chalk line, stretch the line between two points which are the ends of the line you want to mark. Hold it in place by tying the ends to nails, or have a helper hold it for you.

Lift the line up in the middle and allow it to snap back (Fig. 4), making a straight chalk line on the surface.

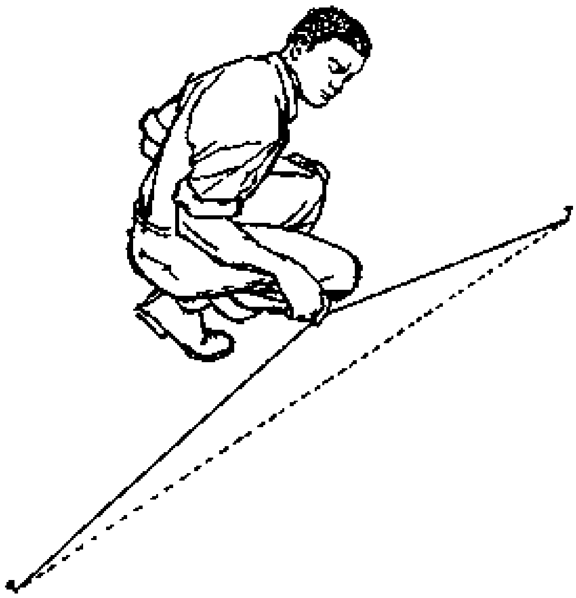


Fig. 4

NOTES:

TIMBER CONSTRUCTIONS

The last few lessons were about the very basic things you will need to know before you can actually make any construction of wood. Therefore we started with some technical terms which are important because you will see them again and again in the lessons and will use them in practical work.

The next sections include all the information you will need to prepare for a project: how to get the wood pieces to the right size and shape; how to mark the timber; and how to plan a project using a cutting list. Included here is a section on nailing and one on driving screws. Before you study those sections, look up nails and screws in the Reference Book, Products, pages 207 to 211, so that you are familiar with the parts of nails and screws and how they look.

Each section starts with a list of tools. Refer to the Reference Book, Tools section, and learn about each of these tools before you study the rest of the section.

NOTES:

PREPARATION OF TIMBER

In order to carry out the construction of any practical exercise or project, it is essential to have the wood pieces for the project prepared so that they have the correct size, true and flat surfaces, and square corners and angles.

There is of course a correct procedure to be followed for this preparation. It is important to carry out the following steps in their correct order on every piece of timber, whether large or small.

An easy way to remember the steps in their correct order is to keep the following word in mind: FEWTEL.

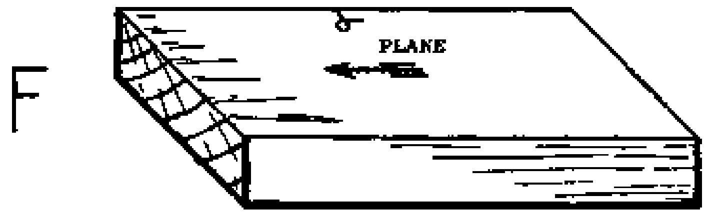
Face	Edge	Width	Thickness	End	Length
F	E	W	T	E	L

The tools which are required for this preparation are the bench, jack plane, straight edge, winding strips, pencil, try square, marking gauge, charcoal line, back saw, ruler and crosscut saw. Look these up in the Reference Book and make sure that you understand what they are and how they are used.

NOTES:

Sequence of operations for preparing timber

Step 1. Plane the face side (F)



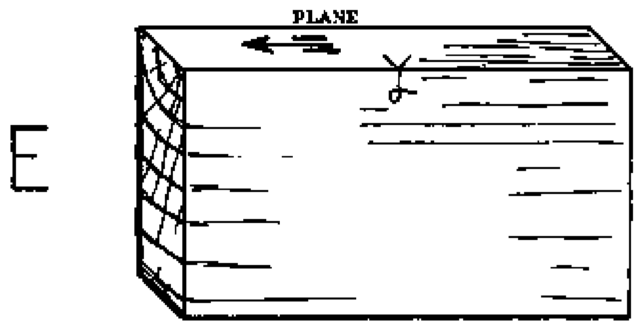
– Put your work on the bench with the better side up. If the board is not flat, put the hollow side down to keep it from rocking or moving around. In the case of very long or thin boards or twisted or deformed boards, put thin wedges of wood underneath where needed, to keep the work steady and keep it from bending in the middle during planing.

– Plane this side perfectly true.

– Test for flatness with the straight edge, winding strips and try square.

– Mark this side as the face side; the face mark should point to the edge which will be the face edge. The face edge will be the best edge of the board.

Step 2. Plane the face edge (E)



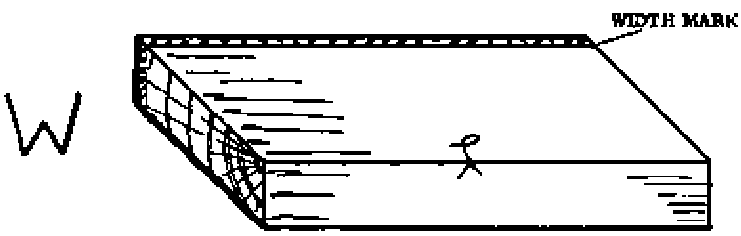
– Fasten your board to the side of the bench, with the face mark up. The planed side must be towards you and not against the bench, unless this would mean you would have to plane against the grain. In that case, you should turn the board so the other edge is up, keeping the face side towards you because the try square has to be set against the face side.

– Plane the face edge perfectly straight and square to the face side.

– Test for straightness with the straight edge and for squareness with the try square.

– Mark it with a face edge mark pointing to the face side.

Step 3. Plane the width (W)



– With a marking gauge, mark the width of the board. Press the gauge against the face edge and mark on the face side.

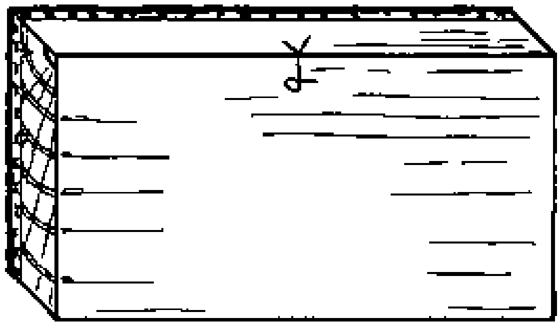
– Plane down to the middle of the gauge line and be careful to get a square, straight edge when you reach the mark.

– Test for flatness with a straight edge and try square.

NOTES:

Step 4. Plane the thickness (T)

T



– Use a marking gauge to mark the thickness of your board. Press the gauge against the planed side and mark both edges.

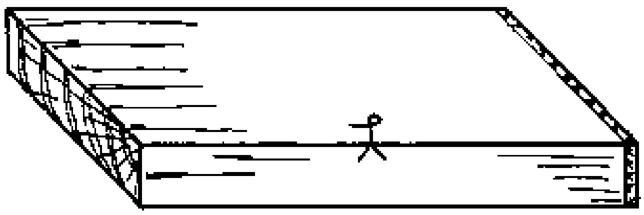
– Plane down to the middle of the gauge lines.

– Test for flatness as you get near the two marked lines. Be sure to check for flatness across the board at several points. Check for winding with the winding strips.

Generally timber is not prepared to the exact length. Waste is left on each end to protect the corners from damage. If it is necessary to prepare it to the exact length, the procedure is as follows:

Step 5. Cut one end (E)

E



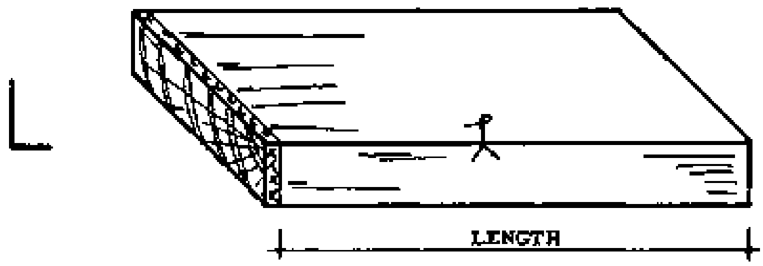
– With a try square, square the best end; with as little waste as possible.

– Cut that end perfectly square to the face side and face edge. Saw on the waste side of the line.

– Test for squareness in all directions.

– Mark the end with a cross, so that you know which is the prepared and tested end.

Step 6. Cut the length (L)



– Measure the required length from the prepared end and square with the try square.

– Cut that end perfectly square in all directions.

– Test it with a try square.

NOTES:

Timber marks

The purpose of face marks, as they are shown under preparation of timber, is to show clearly the prepared and tested sides and the edges which are square.

During all further marking, squaring and gauging we should try to work from these sides and edges.

Marking of frames

Making frames is an important part of Rural Building. We have to mark the members of a frame in a standard way so that we do not confuse their positions.

– Select and prepare the timber according to the sequence given in the section on preparation of timber. Lay out the various members as they will be when they are finally assembled into a frame (Fig. 1).

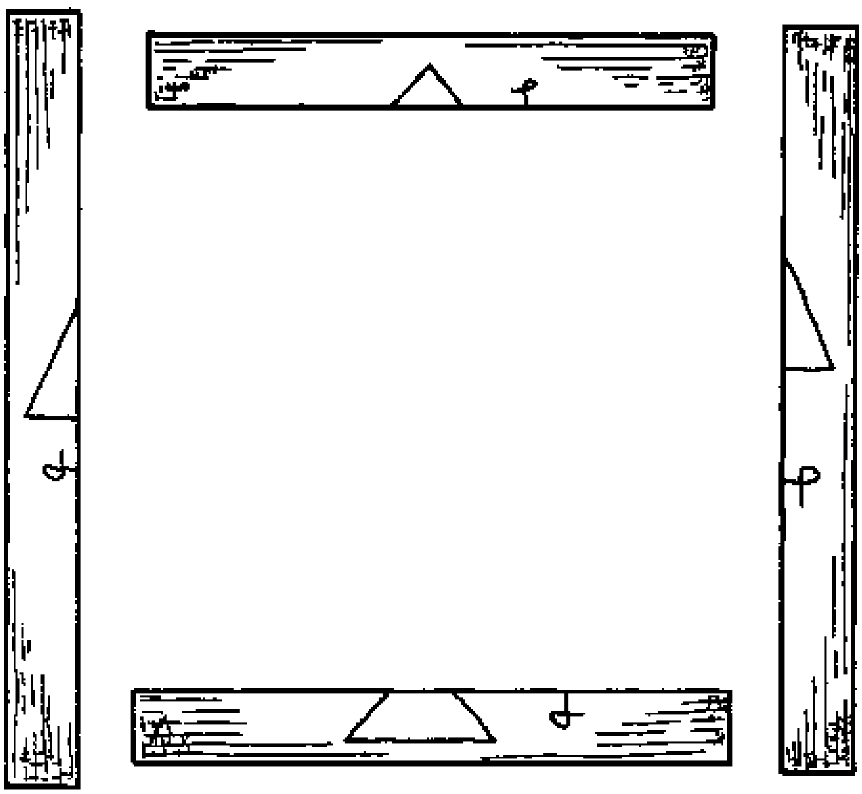


Fig. 1

– Take care that all surfaces which will be visible in the finished product are of good timber and without defects. Usually these will be the face sides and face edges. Always try to keep the face sides on one side, and the face edges all on the inside or all on the outside.

– Now put the inside edges of the horizontal members together, mark the length of the members and put the triangular mark as shown in Fig. 2. The triangle always should point up.

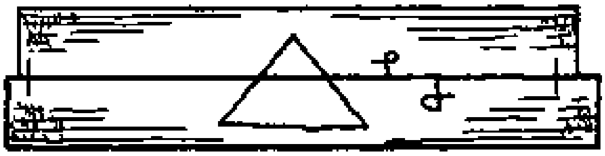


Fig. 2

– Now do the same thing for the vertical members. Put the inside edges together, mark the lengths and put the triangular sign, again pointing upwards (Fig. 3).

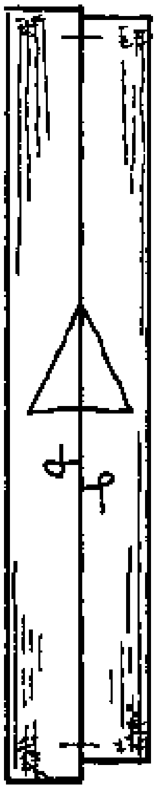


Fig. 3

– All further marking should be done using these sides as a reference.

NOTES:

Cutting list

After you design and make the drawing for a piece of work, you need to make a cutting list showing the length, width and thickness of all the parts. These will be the finished sizes. So that each part will be straight, true and smooth, we must begin with slightly bigger pieces to have an allowance for planing the sawn timber true.

The planing allowance for a board is:

3 mm extra in thickness
6 mm extra in width
12 mm extra in length

For square pieces the allowance is:

3 mm extra on each side
12 mm extra in length

An example is shown below of a cutting list for a simple box (Fig. 1). The list shows the parts of the box, the kind of wood, the number required of each part and the finished size of the part. In the last column we find the size of the timber that will be required when the planing allowance has been added.

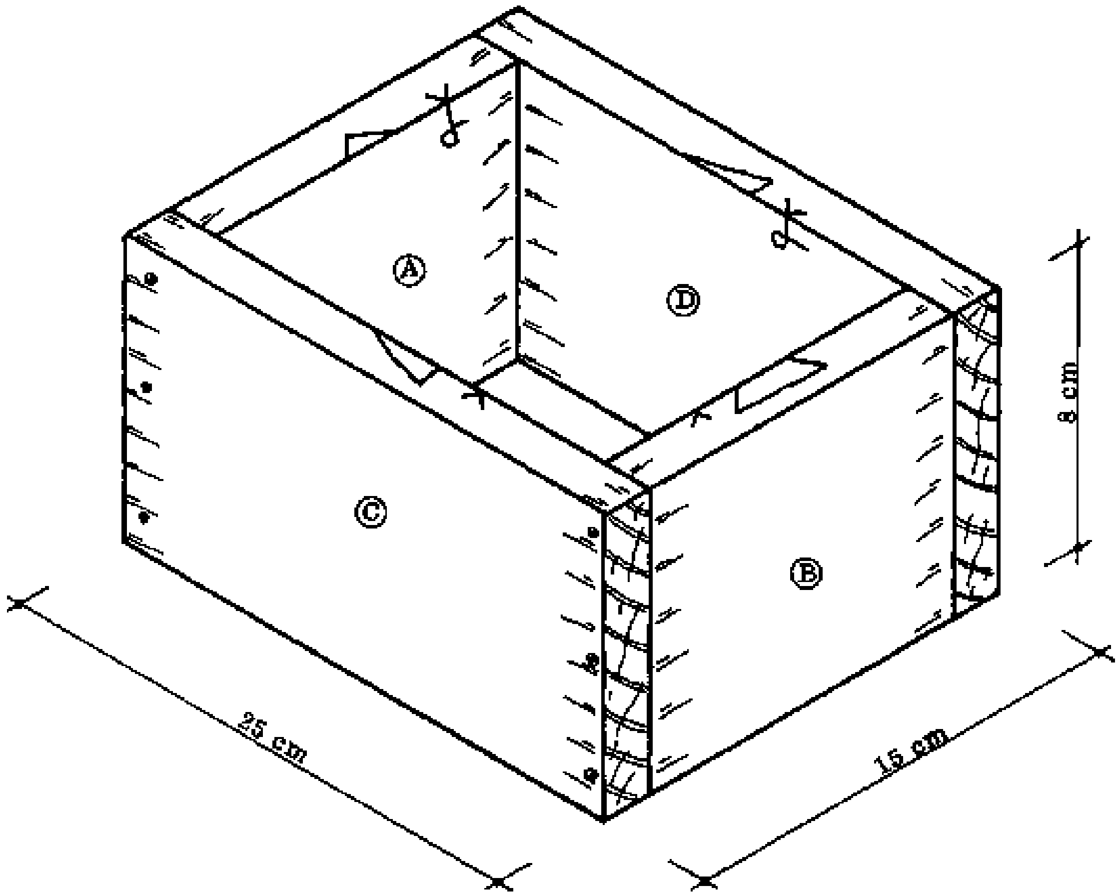


Fig. 1

NOTES:

Usually it is best to plan a project according to the sizes of timber you have available, subtracting the planing allowances first in order to prevent waste.

Cutting list:

			finished size (cm)			timber size (cm)		
part	wood	no.	L	W	T	L	W	T
A	Odum	1	10,6	8	2,2	11,8	8,6	2,5
B	Odum	1	10,6	8	2,2	11,8	8,6	2,5
C	Odum	1	25	8	2,2	26,2	8,6	2,5
D	Odum	1	25	8	2,2	26,2	8,6	2,5

When you are choosing timber for a piece, choose the best, straight boards for the long pieces. The crooked or defective boards can be used for the shorter pieces.

NOTES:

FASTENING WITH NAILS

Before you read this section, look up Nails in the Reference Book, Products section, page 207.

Driving nails

To start a nail, hold it steady between your thumb and fingers with one hand and strike one or two light blows with the hammer (Fig. 1).

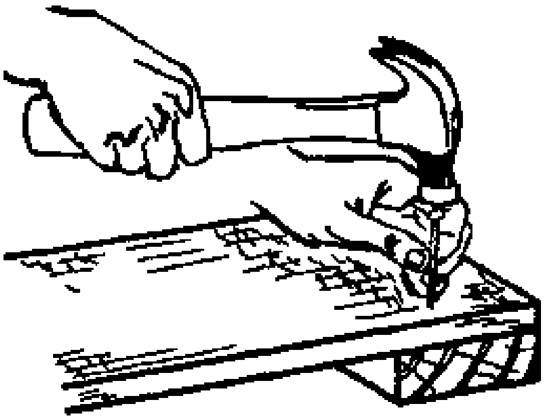


Fig. 1

After the nail is well started, drive it in with firm blows. Hold the handle of the hammer near the end and strike the nailhead straight.

When you drive a nail all the way in, be careful on the last blows not to hit the wood and leave a hammer mark on it.

Holding power

The holding power of the nail depends on the pressure of the wood fibres against the shank of the nail and also on the size of the nailhead (Fig. 2).

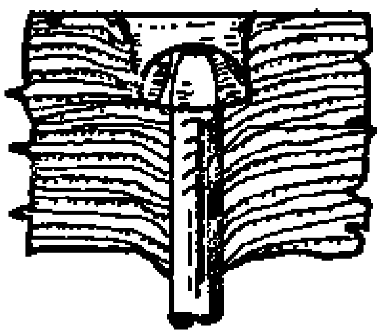


Fig. 2

Hard dry wood holds better than soft or wet wood. End grain doesn't hold nails very well. If the nail is driven across the fibres, the nail's length should be 2 1/2 times the thickness of the top piece (Fig. 3). If it is driven into end grain, the length should be 3 times the thickness of the top piece (Fig. 4).

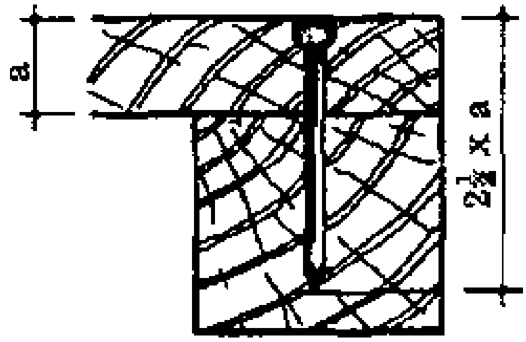


Fig. 3

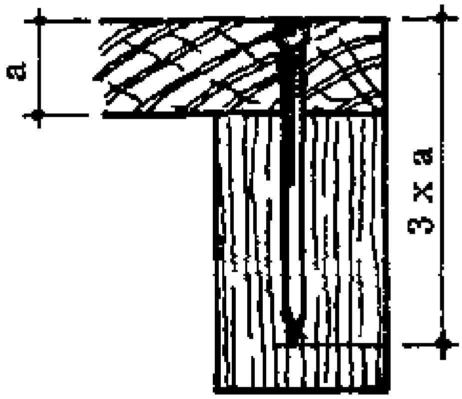


Fig. 4

The holding power of nails in end grain can be improved by dovetail nailing, which means the nails are inserted at slight angles (Fig. 5) instead of straight in (Fig. 6) which is the usual way.

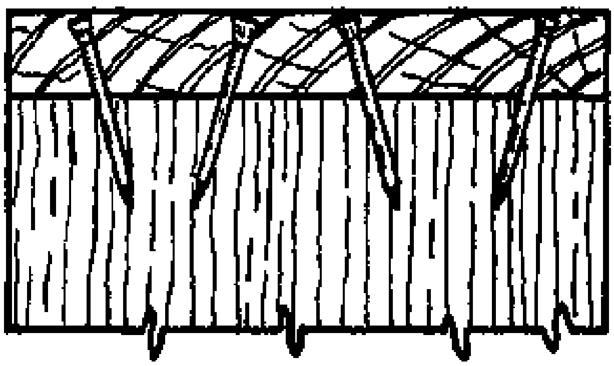


Fig. 5

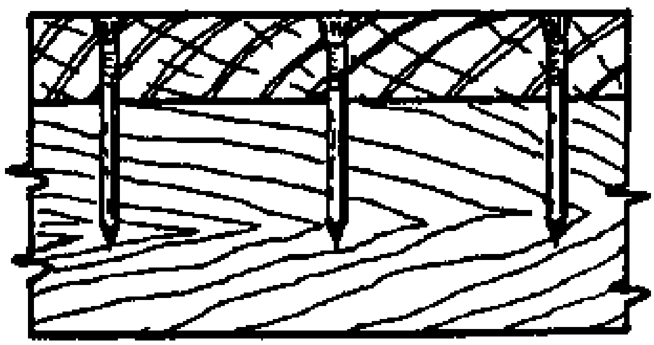


Fig. 6

If possible the nails should be inserted at right angles to the force that will be applied to the piece; so that any force tends to shear off the nail rather than pull it out.

The correct placing of the nails is important with respect to the strength of the finished piece.

NOTES:

How to prevent splitting during nailing

Nails can be staggered (inserted out of line) to prevent splitting along the fibres of the wood (Fig. 1).

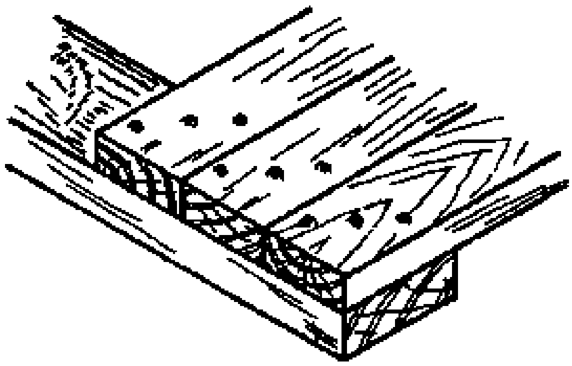


Fig. 1

Blunting the nail with one or two hammer blows on the tip also helps to prevent the nail from splitting the wood (Fig. 2).

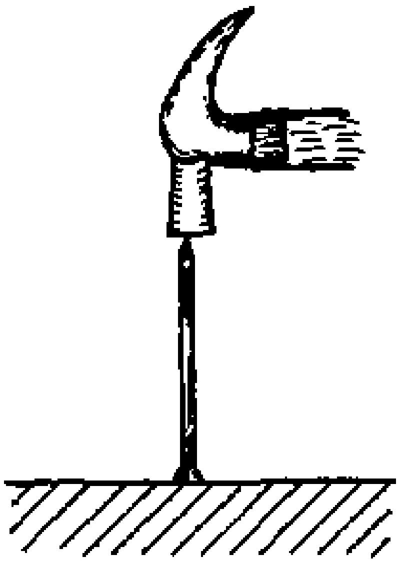


Fig. 2

If large nails are to be fixed, drill holes first to keep them from splitting the timber. The holes should be slightly smaller in diameter than the nails.

Finishing off

Lost head nails are punched (knocked below the surface of the wood) with a nail punch or a large blunt nail. The remaining hole can be filled with putty (Fig. 3).

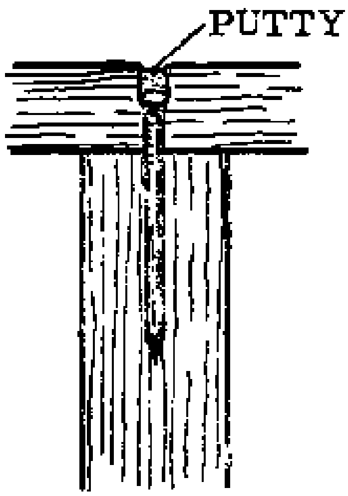


Fig. 3

When the sharp points of nails come all the way through the timber and out on the other side, they are clenched; that is the tips are bent over and flattened against the wood, out of the way. There are two ways of doing this:

– Knock the tip flat and punch it into the wood with a nail punch (Fig. 4).

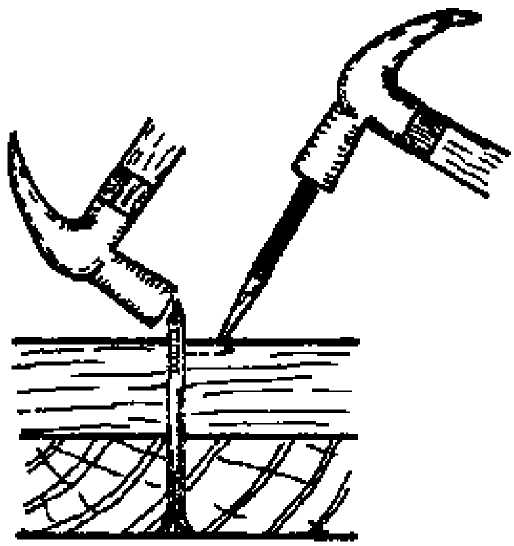


Fig. 4

– Bend the point at a right angle first, and then knock it back into the wood (Fig. 5; a, b, & c). This is done where the nail projects more than 1 cm.

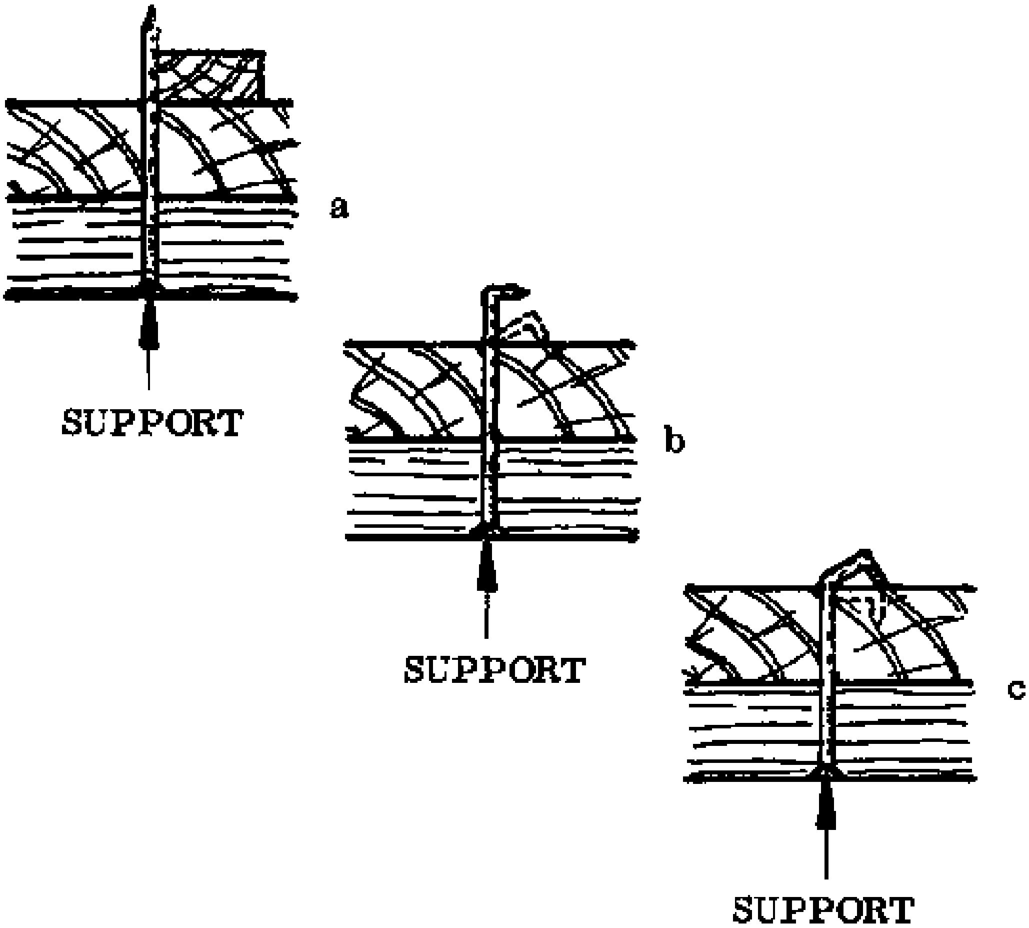


Fig. 5

The head of the nail should be supported during clenching to keep it from being pushed out again.

Bent nails can be straightened if you tighten one end in a vice and support the other end with a hammer while knocking out the bent part with another hammer (Fig. 6).

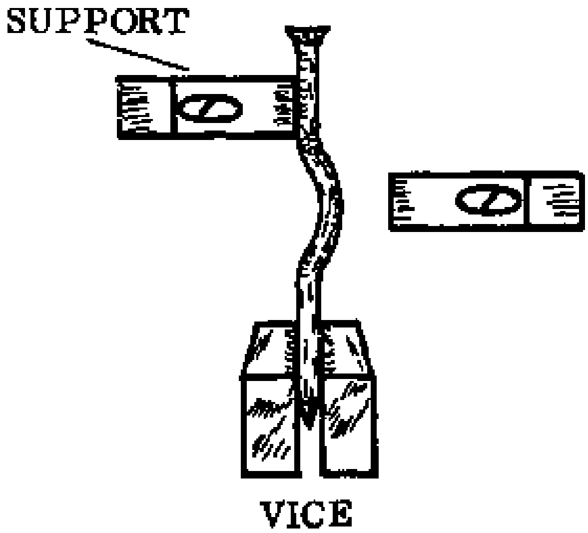


Fig. 6

NOTES:

FASTENING WITH SCREWS

Before you read this section, look up screws in the Reference Book, page 209; screwdrivers on page 77; and maintenance of screwdrivers on page 103.

Holding power

The holding power of a screw depends on how the thread embeds in the fibres, the length of the screw and the strength of the head which holds the top piece.

When a screw is driven across the grain, the screw's length should be about twice the thickness of the top piece (Fig. 1).

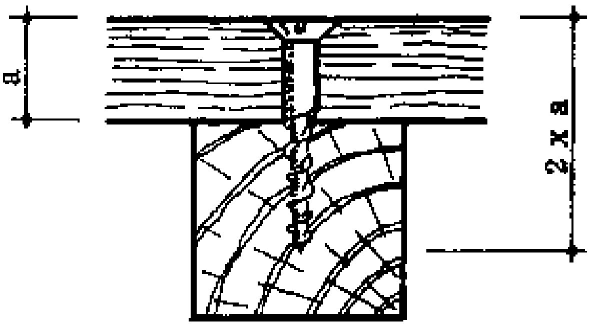


Fig. 1

Screws driven into the end grain should be longer, about 3 times the thickness of the top piece (Fig. 2).

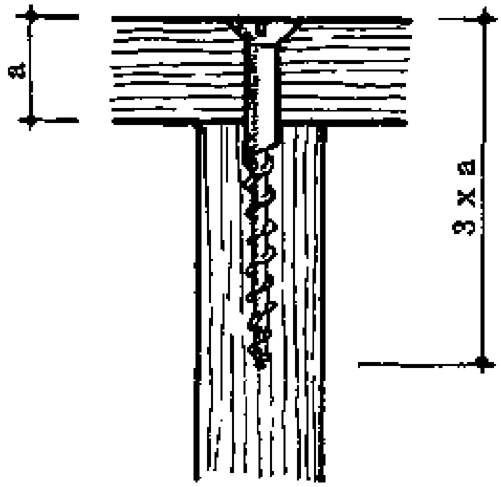


Fig. 2

Driving screws in soft wood

– Bore a hole in the top piece with the same diameter as the shank of the screw (Fig. 3a). The bottom piece may be punched with a large nail or awl (Reference Book, page 73).

– Countersink if necessary (Fig. 3b).

– Drive the screw (Fig. 3c).

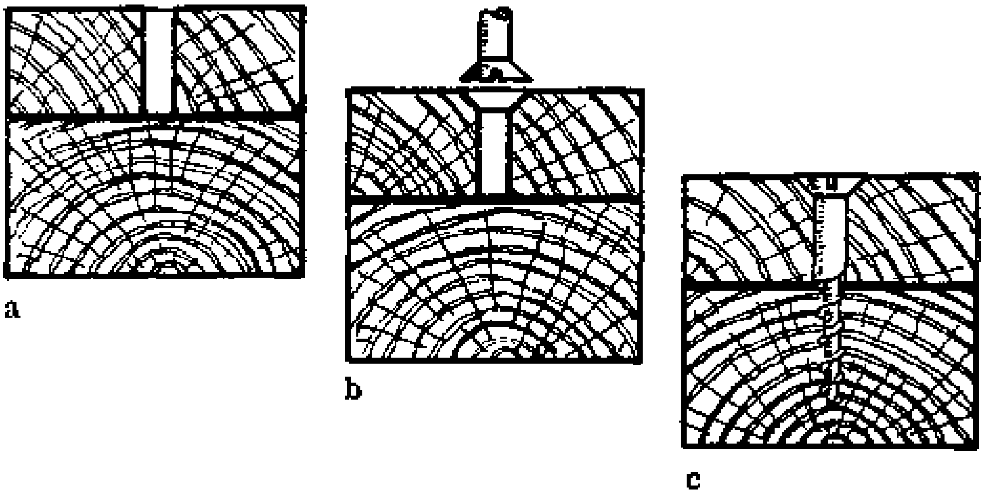


Fig. 3

Driving screws in hard wood

– Bore a hole in the top piece with the same diameter as the shank of the screw (Fig. 4a).

– Bore a hole in the bottom piece with the same diameter as the core of the screw (Fig. 4b).

– Countersink if necessary and drive the screw (Figs. 4c & 4d).

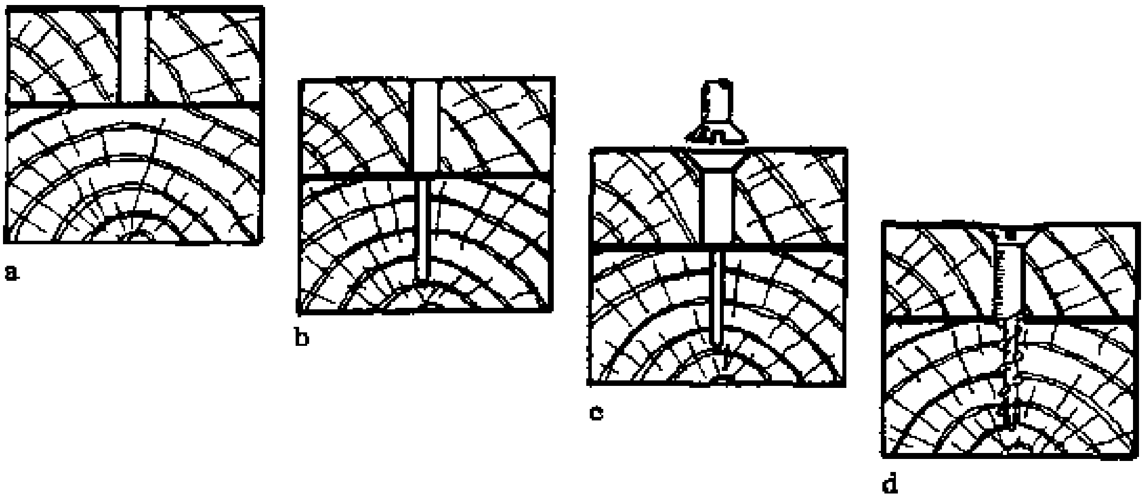


Fig. 4

Use a screwdriver with the correct tip only. If the screw turns too hard, the hole may be too small or not deep enough. Remove the screw and find out what the problem is so it can be corrected, otherwise the screw may break or split the board.

– Turn the screw down until the head is just seated. Overturning weakens the holding power and may break the screw.

– To make driving easier and to protect against rust, a bit of soap or oil may be put on the tip of the screw.

ANGLE JOINTS

Angle joints are joints where the sides of the pieces (the wide surfaces) meet at right angles to each other. Angle joints are used for box–like constructions such as small boxes, tool boxes etc. For an example of a box using angle joints, see the illustration for the Cutting List lesson, on page 89. In this chapter we will consider the most common types of angle joints and their construction.

Nailed butt joint

The simplest angle joint is the nailed butt joint. The end of one piece of wood is cut square, then butted against the face of the other piece. It is held in place with nails, or both nails and glue (Fig. 1).

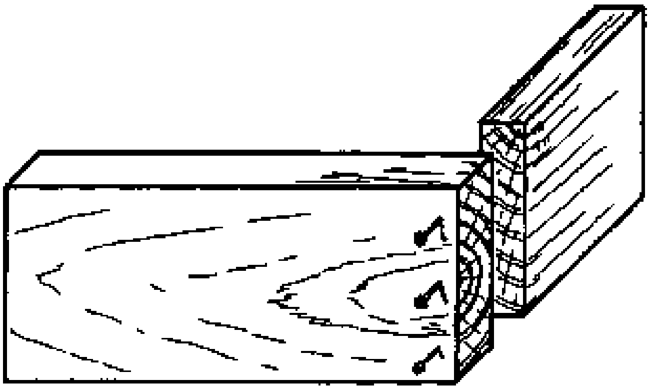


Fig. 1

Plain mitred joint

The ends of the pieces are mitred (cut at 45 degrees) across the thickness. The mitred ends are butted together and held in place with glue and nails (Fig. 2). This is a weak type of joint although it is stronger than the butt joint because it is nailed from two sides. Its advantage is that the end grain is not exposed to damage from water or insects, and it has a neater appearance.

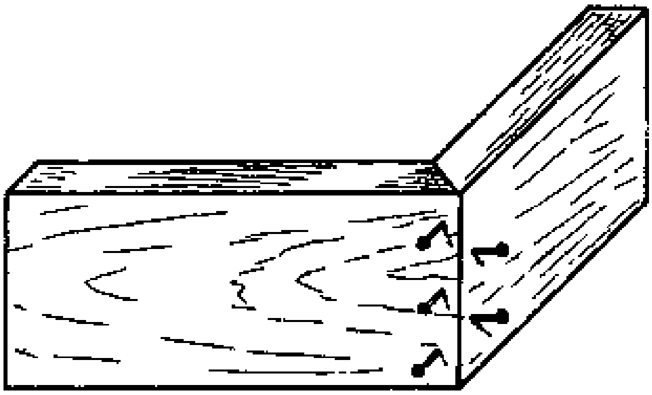


Fig. 2

Rebated butt joint

The end of one piece fits into a rebate at the end of the other piece. This joint is strong because two surfaces are available for nailing, and because the shoulder of the rebate supports and helps to hold the other piece (Fig. 3).

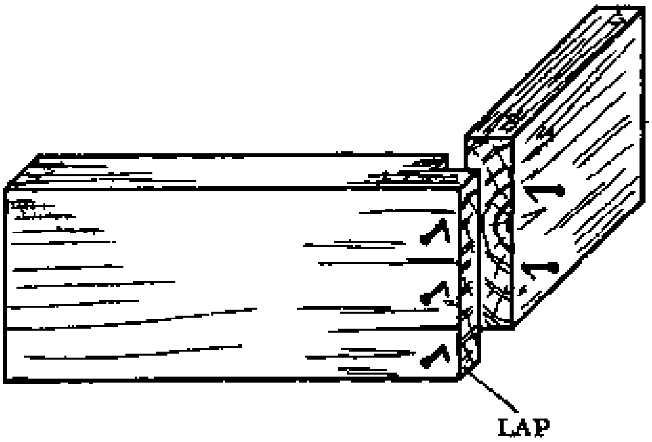


Fig. 3

The lap is the section of wood which is left projecting after the rebate is cut (Fig. 3). The lap is usually one−half of the thickness of the board. This lap will be important later when we are figuring out the length of our pieces for making a box.

The rebated butt joint is simple to construct. In the following sequence of operations we will describe how to make a simple box with this joint while also practising some techniques discussed earlier, like making a cutting list and preparing timber to size.

The tools required here will be the same ones we used for the preparation of timber; with the additions of a firmer chisel, a smoothing plane, and a backsaw. Make sure you know what these tools are and how to use them before you go on.

Sequence of operations for constructing a box with this joint

Step 1. Preparation of timber

− Make a cutting list. The end pieces can be cut to the required length, that is the outside width of the box minus the width of the two laps. Allow 3 mm extra at each end of the side pieces, for planing off after assembly (Fig. 2).

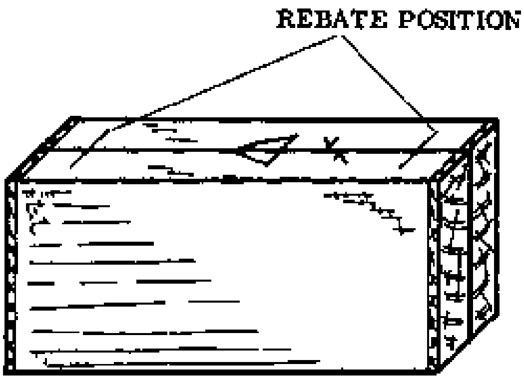


Fig. 2

− Prepare the pieces (see Preparation of Timber section, pages 84 to 86).

Step 2. Marking out

− Mark the sides and ends as shown in Fig. 1, on the face edges (Marking of frames, page 88). All further marking will be done from the sides with these marks.

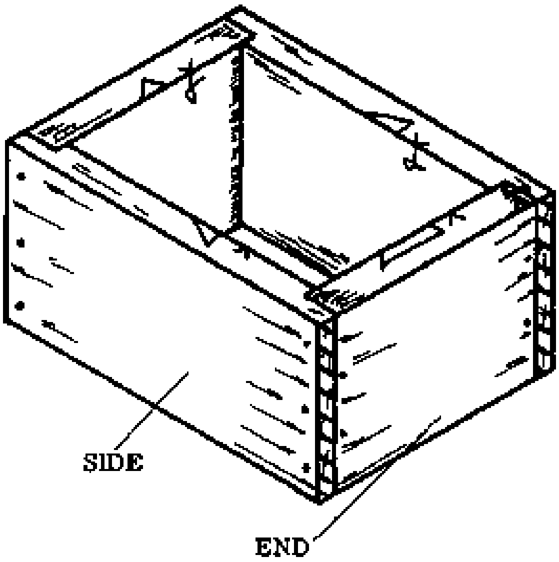


Fig. 1

– Place the two sides together and mark the position of the rebates, squaring with the try square (Fig. 2).

– Mark the shoulder lines of the rebate on the inside face of the piece, using the try square (Fig. 3).

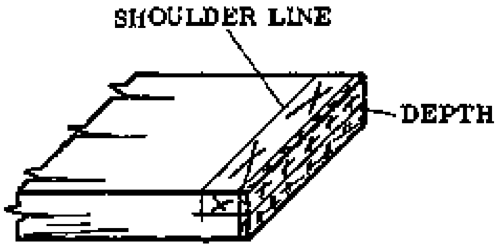


Fig. 3

– Mark the depth of the rebate on the end grain and the edge, using a marking gauge (Fig. 3). Show the waste with crosses.

Step 3. Cutting the rebate

– Saw the shoulders down to the gauge line. Cut on the waste side of the line. If the piece is very wide, nail or clamp a guide over the line to guide the saw. Use a backsaw (Fig. 4).

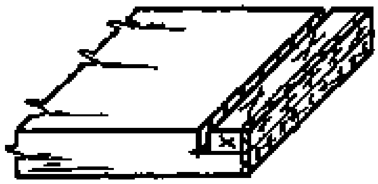


Fig. 4

– Remove the waste carefully to the gauge line with a firmer chisel (Fig. 5). Find out the direction of the grain by chiselling out small pieces first, so that you don’t accidentally chisel too deep.

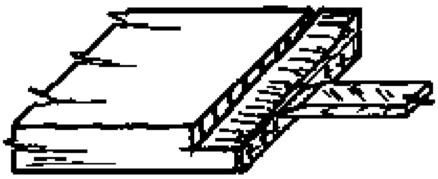


Fig. 5

Step 4. Assembling

– Clean up the inside faces with a smoothing plane (Fig. 6).

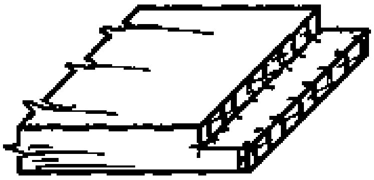


Fig. 6

– Assemble the box with glue and nails.

– Measure the diagonals to check for squareness.

– Clean up the face and bottom edges with a smoothing plane.

– Plane off the waste from the sides with the smoothing plane. Prevent splintering by working inwards from the ends (Fig. 7).

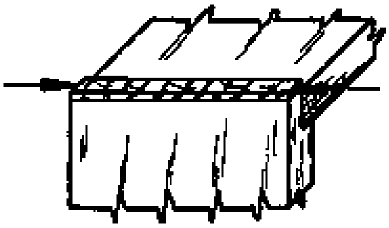


Fig. 7

NOTES:

Housed joint

These joints are another type of angle joint, also used in box–like constructions.

Housing consists of sinking the end of one piece into a trench which is cut into the face of another piece (Fig. 1).

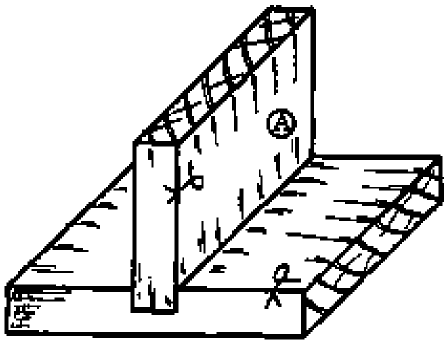


Fig. 1

The tools required for making this type of joint are the same ones used to make the rebated butt joint.

Sequence of operations for constructing the joint

Step 1. Preparation of the timber

– Make a cutting list.

– Prepare the timber (see Preparation of Timber section).

Step 2. Marking out

– Mark one edge of the trench with a try square and the other edge by using piece A as a guide (Fig. 2). (Smooth piece A before using it to mark the trench).

– Gauge the depth of the trench at each edge (Fig. 3).

– Show the waste with small crosses (Fig. 3).

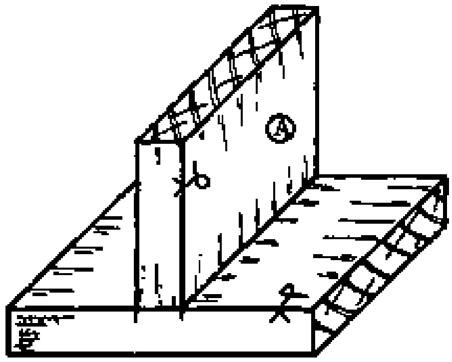


Fig. 2

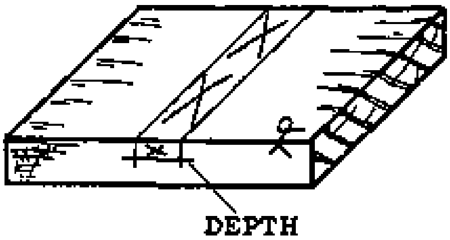


Fig. 3

Step 3. Cutting the trench

– Saw the sides of the trench (on the waste side of the lines) down to the gauge lines (Fig. 4).

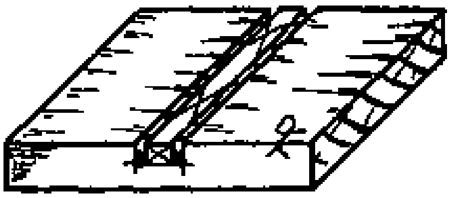


Fig. 4

– Chisel out the waste from the trench (Fig. 5).

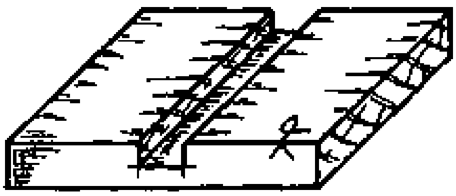


Fig. 5

Step 5. Assembling

– Assemble the two parts with nails and glue.

– Clean up the edges with a smoothing plane.

NOTES:

Common mortice and tenon joint for box-like constructions

This is one of the commonest and strongest joints. The two parts are (Fig. 1): the tenon (B) which is a projection on the end of one part and the mortice (A), the hole in the other part into which the tenon fits. The tenon is usually 1/3rd of the width of the board.

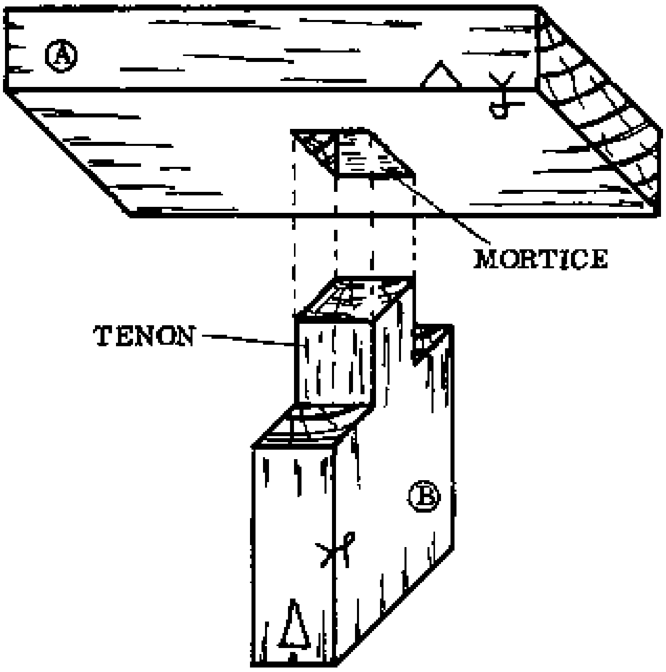


Fig. 1

The tools we need are ones we have discussed before, plus a mortice chisel, a brace and drilling bits.

Sequence of operations for constructing the joint

Step 1. Preparation of timber

– Make a cutting list.

– Prepare the timber to the required sizes. (In the following steps, the piece with the mortice is “piece A” and the one with the tenon is “piece B”.)

Step 2. Marking out

– Mark out the length of the tenon on piece B. Allow 3 mm waste in the length and make square lines all around with a try square and pencil (Fig. 2).

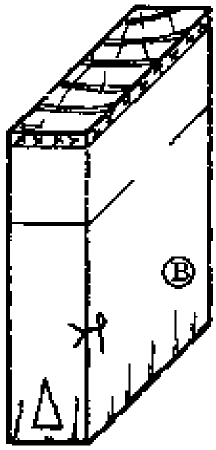


Fig. 2

– Take piece A and mark out the position of the mortice on the face edge and make square lines on the edges on both sides with the try square (Fig. 3).

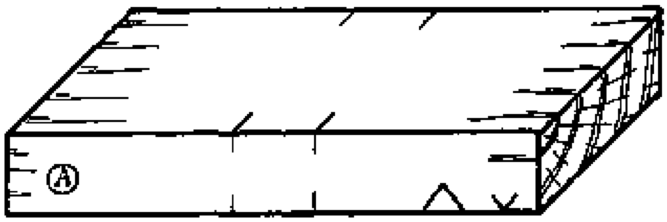


Fig. 3

– Set the marking gauge to the width of the tenon and mark the lines around piece B at the width. Mark the waste with small crosses (Fig. 4).

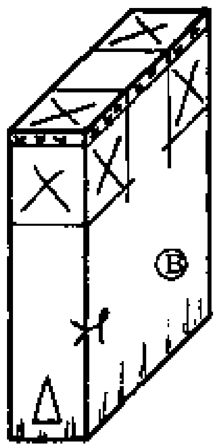


Fig. 4

– Use the same setting to mark both faces of piece A and use a try square and (already smoothed) piece B to mark the remaining two lines for the width of the mortice (Fig. 5). Mark the waste with a small cross.

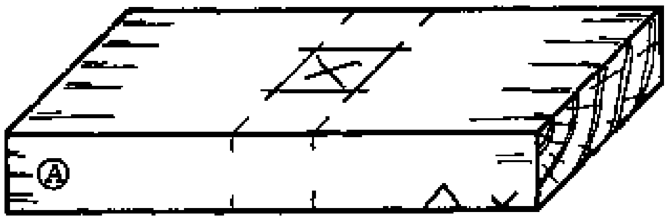


Fig. 5

If the marking gauge has two pins, set each at its correct measurement and mark both lines at once. If not, mark with the first setting on all the members, then change the setting and mark the other measurement on all the members.

– Always mark from the face edge. Check the marking by setting piece B against the marks on piece A to see if they fit. Piece B must be smoothed first.

NOTES:

Step 3. Cutting the mortice

– Bore out most of the waste, using a brace and bit (Fig. 6). Clamp a piece of wood to the underside to prevent splintering and damage to the bench.

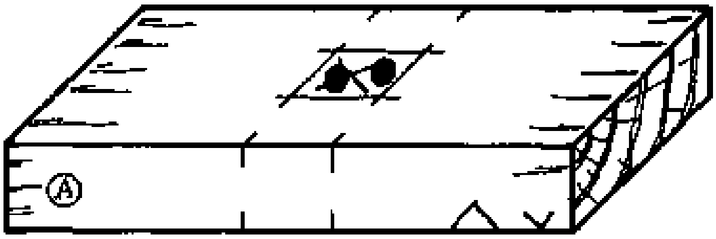


Fig. 6

– Chop out the remaining waste with a mortice chisel, chiselling halfway through from both sides. Leave about 2 mm extra waste on all sides to prevent damage to the sides. Keep the cutting edge of the chisel across the grain.

– Carefully chop out the rest of the mortice up to the lines (Fig. 7). Keep the bevel of the chisel towards the inside of the mortice. Do not use the mallet.

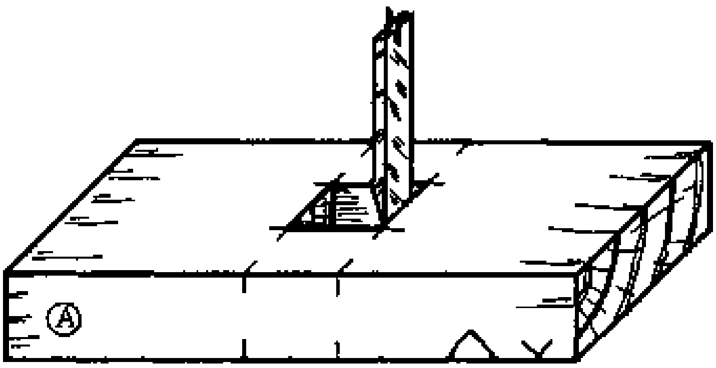


Fig. 7

Step 4. Cutting the tenon

– Rip the sides of the tenon, sawing on the waste side of the line (Fig. 8). Cut in stages as shown in (Fig. 11, a, b, c, & d).

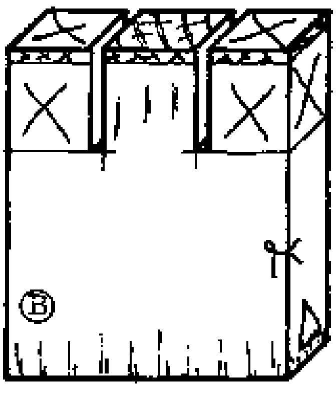


Fig. 8

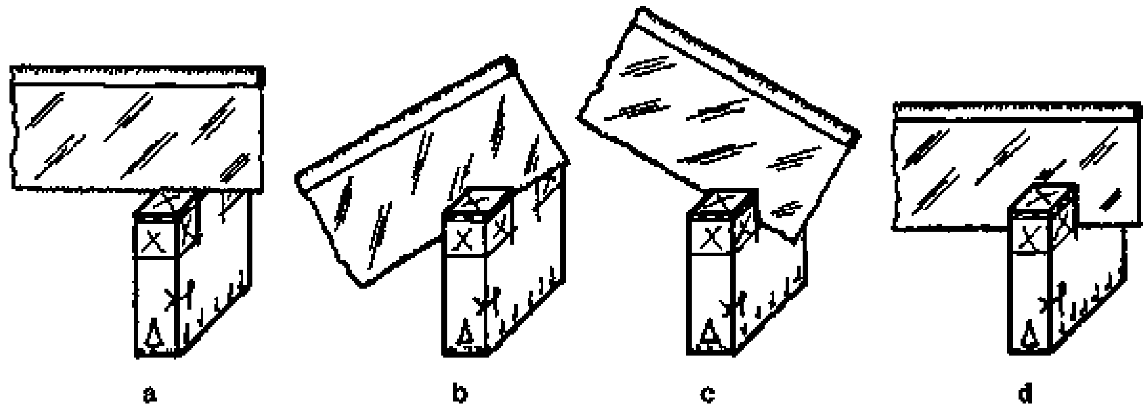


Fig. 11

– Carefully saw the shoulders, making sure to hold the saw straight. Keep on the waste side of the line (Figs. 9 & 10).

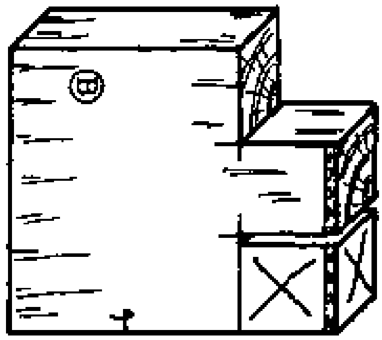


Fig. 9

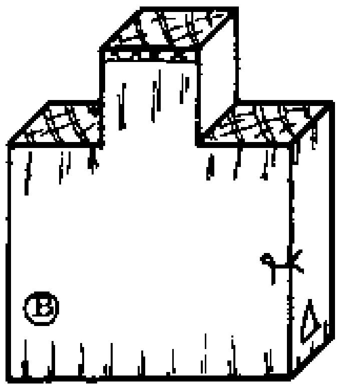


Fig. 10

Step 5. Assembling the joint

– Check the fit of the members. The tenon should fit tightly into the mortice without splitting the morticed piece. There should be no gap between the shoulders of the tenon and the morticed member. Don't force the members together. If they don't fit, find the problem and correct it.

– Clean up the inside of the joint where it can't be reached after assembly with a smoothing plane. (Remember that the tenon should be smoothed before using it to mark out.)

– Assemble the joint.

– Plane off the waste end of the tenon, clean up all sides and edges with the smoothing plane.

NOTES:

Cornerlocked joint

The cornerlocked joint is similar to the mortice and tenon joint. It is an angle joint with a series of tenons on one member which correspond to slots on the other member (Fig. 1). The resulting joint is strong because it can be nailed from two sides, and the interlocking tenons and slots also help hold the pieces together.

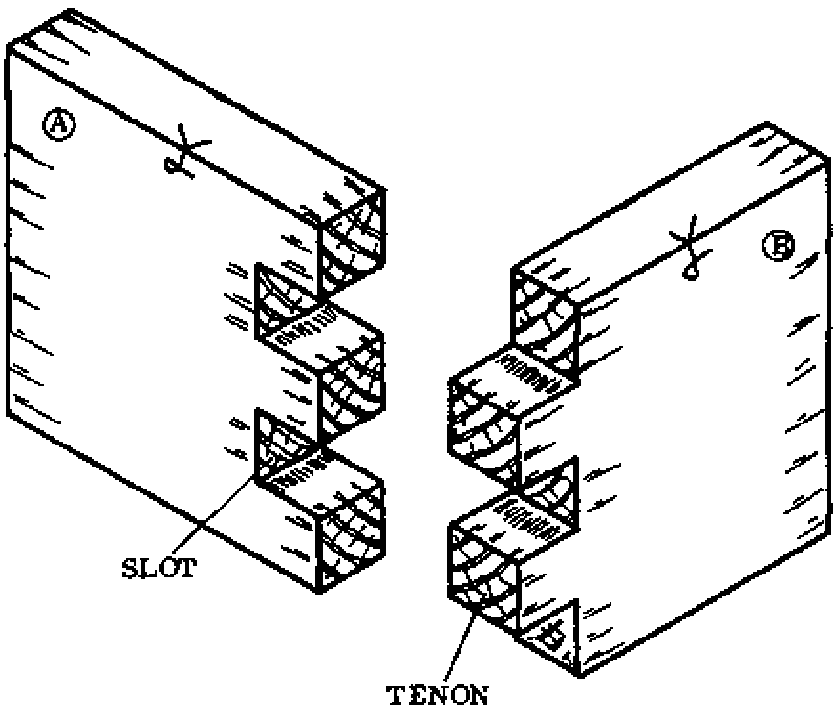


Fig. 1

The tools required to make this joint are the same ones used for the mortice and tenon joint.

Sequence of operations for constructing the joint

Step 1. Preparation of the timber

– Make a cutting list.

– Prepare the timber to the required sizes. (In the following steps, the member with the slots is piece “A” and the one which has the tenons is piece “B”.)

– If the members are to be used for a box where the external appearance is important, the face sides should be outside.

– In most cases the face edges are kept upwards.

Step 2. Marking out

– Mark out the position of the tenons and slots by gauging or squaring lines at the corners on the ends of the pieces: on piece A the depth should be equal to the thickness of piece B (Fig. 2); while on piece B the depth should be equal to the thickness of piece A (Fig. 3). Allow 2 mm waste for cleaning up after assembly.

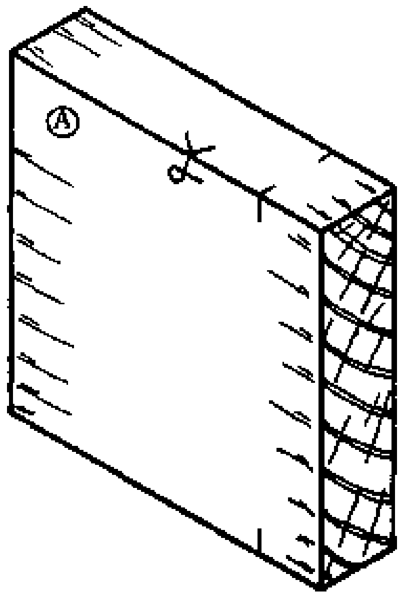


Fig. 2

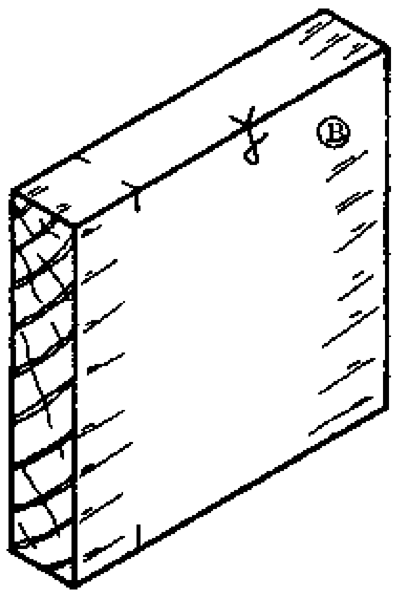


Fig. 3

– Mark out the shape of the tenons on piece B. Keep all tenons the same size (Fig. 4).

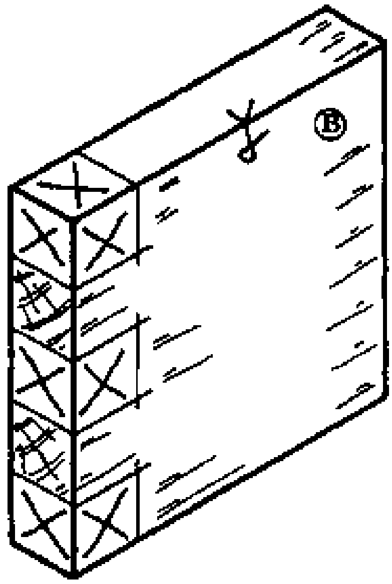


Fig. 4

– Immediately mark the waste between the tenons with crosses (Fig. 4).

NOTES:

Step 3. Cutting the tenons

– Rip the sides of the tenons down to the gauge line (Fig. 5). Saw on the waste side of the line.

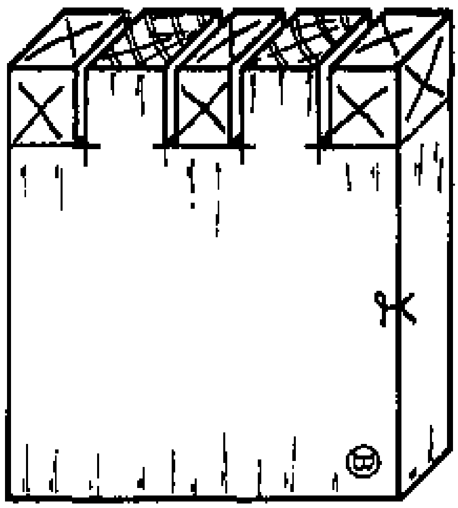


Fig. 5

– Chop out the waste by chiselling alternately vertically and then at an angle, making “V” cuts halfway through from each side (Figs. 6, 7, & 8).

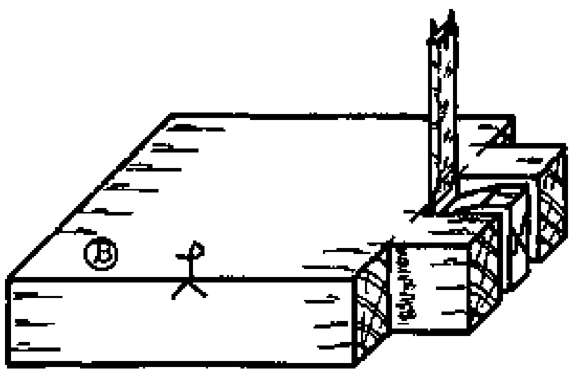


Fig. 6

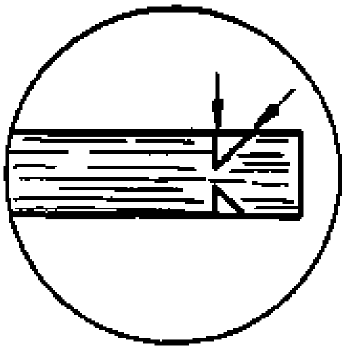


Fig. 7

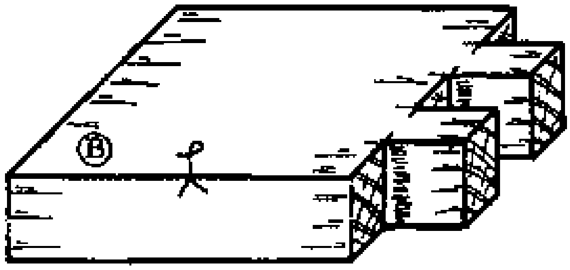


Fig. 8

Step 4. Cutting the slots

– Place piece B (with the tenons) over the end of piece A, with the face side to wards the outside as indicated in Fig. 9.

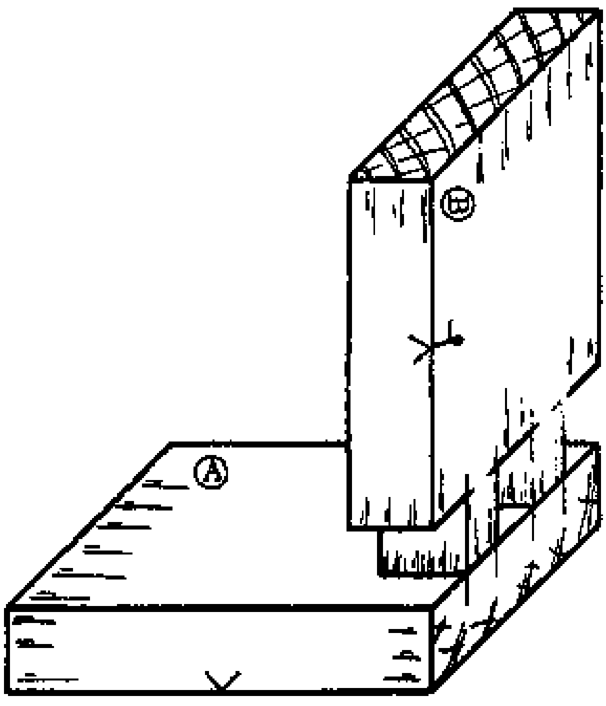


Fig. 9

– Mark the shape of the tenons onto piece A with a pencil (Fig. 9).

– Square the sides of the slots down both sides (Fig. 10).

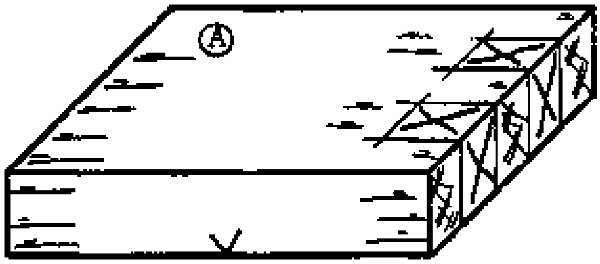


Fig. 10

– Mark the waste with small crosses (Fig. 10).

– Rip the sides of the slots, sawing on the waste side of the line.

– Chop out the waste from the slots, chiselling from both sides as explained in the previous step (Fig. 11).

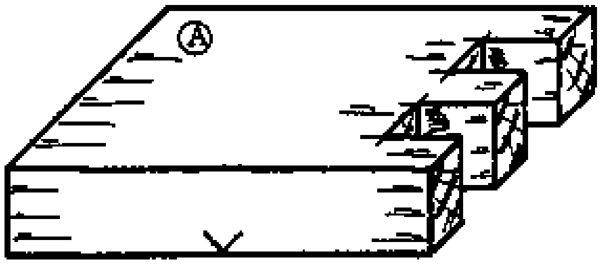


Fig. 11

Step 5. Assembling the joint

– Clean up the inside faces of the joint.

– Assemble the joint with glue and nails.

– When the glue is dry, clean up the waste of the tenons and slots with a smoothing plane. Make sure the nails are punched well below the surface to prevent damage to the sole of the plane.

– Clean up the outside faces and edges with a smoothing plane.

NOTES:

FRAMING JOINTS

Framing joints are those used in frame−like constructions. The members are usually constructed with their edges at right angles to each other; in contrast to the angle joints used in box−like constructions, where it is the sides which form the right angle (previous pages).

Halved joints

Halved joints are one type of framing joint. The name is applied to joints where the pieces of timber which meet or cross each other are halved; that is, at the place where they cross, each piece is 1/2 the thickness of the rest of the piece. The result is that in the assembled joint, the surfaces of both pieces are flush.

Halved joints are used for constructing simple frames.

In Rural Building, we deal with four different kinds of halved joints. Here we will cover the description and construction of the "tee−halved joint", since the construction of the other joints follows much the same procedures.

The tee−halved joint consists of a pin (a) on the end of one piece which fits into a socket (b) in the other piece (Fig. 1).

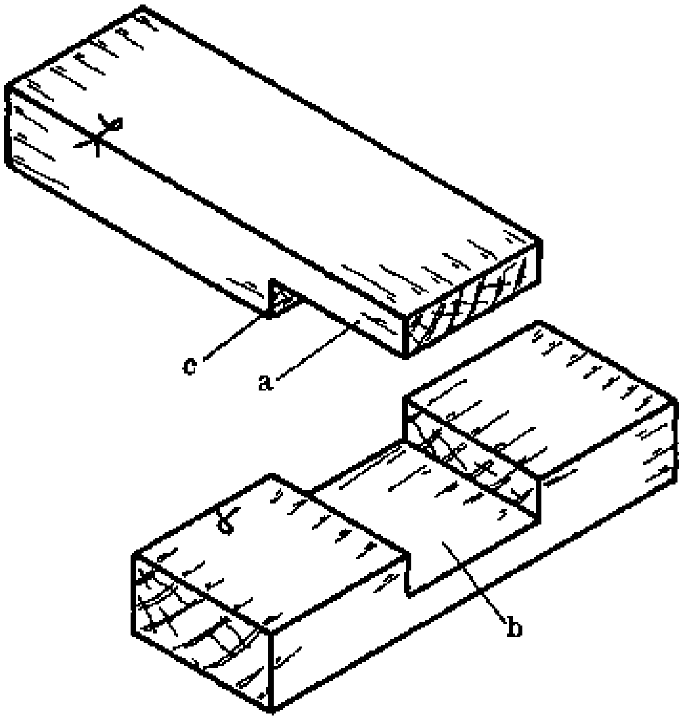


Fig. 1

The pin is half the thickness of the timber, and the depth of the socket equals the thickness of the pin. The shoulder of the pin (c) fits against the face edge of the socket (Fig. 1).

The tools required to make this joint are the same ones we used to make the mortice and tenon joint in the last chapter.

Sequence of operations for constructing the joint

Step 1. Preparation of timber

– Make a cutting list.

– Prepare the pieces to the required size.

Step 2. Marking out

– Mark the length of the pin by placing the socket piece on top of it and marking at the width. A small amount of waste can be left on the end of the pin, to be planed off after the joint is assembled.

– Make lines square at the shoulder of the pin, drawing them across the side and halfway down the edges, with a try square and pencil (Fig. 2). Mark the waste.

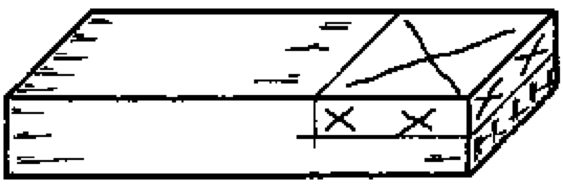


Fig. 2

– Mark the position of the socket, using the piece with the pin as a guide. Smooth the pin before using it to mark the socket.

– Square the lines across the side and halfway down the edges with a try square. Mark the waste (Fig. 3, previous page).

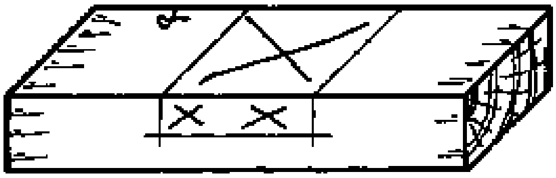


Fig. 3

– Gauge the thickness of the pin around its edges and mark the waste (Fig. 2, previous page).

– With the same setting, gauge the depth of the socket on both edges and mark the waste (Fig. 3, previous page).

– Both pin and socket should be gauged from the face side.

– Place the pin over the position of the socket and check the fitting (Fig. 4, previous page).

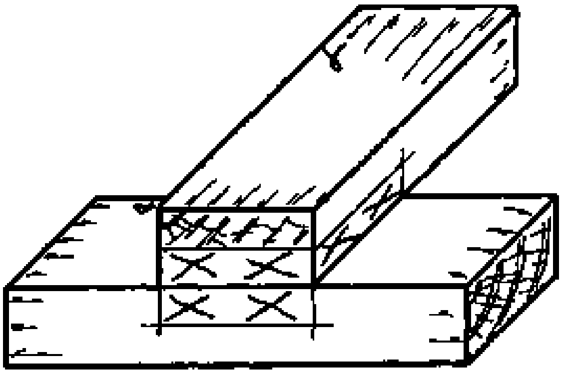


Fig. 4

Step 3. Cutting the pin

– Rip the thickness of the pin. Cut in stages as shown in Fig. 5, a through d. Take care to keep on the waste side of the line.

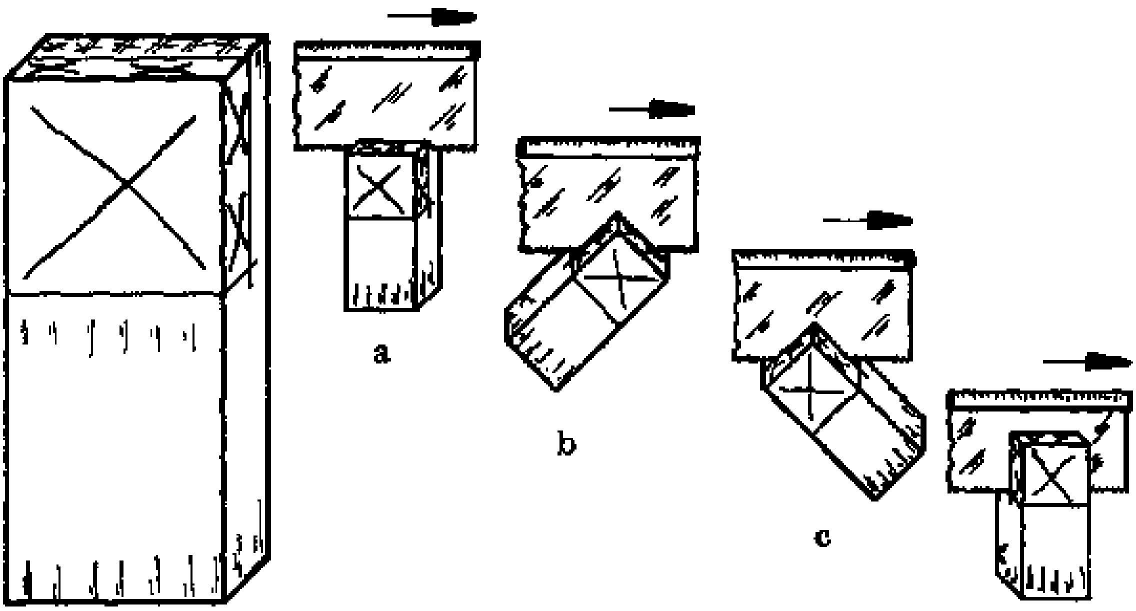


Fig. 5

– Saw the shoulder of the pin, keeping on the waste side of the line (Fig. 6).

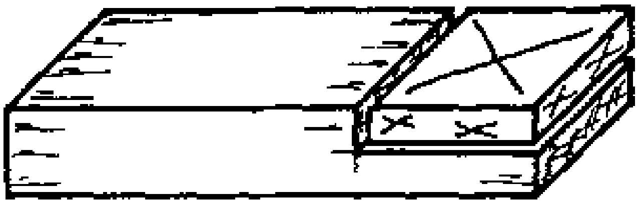


Fig. 6

Step 4. Cutting the socket

– Saw down to the gauge lines of the socket, keeping on the waste side of the lines (Fig. 7).

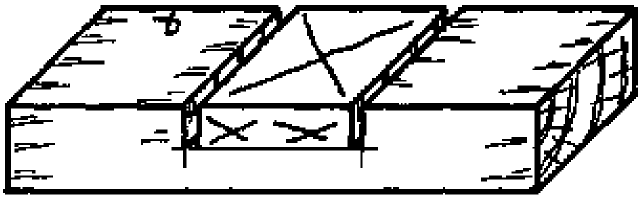


Fig. 7

– Chisel out the waste, chiselling halfway through from both edges (Figs. 8 & 9).

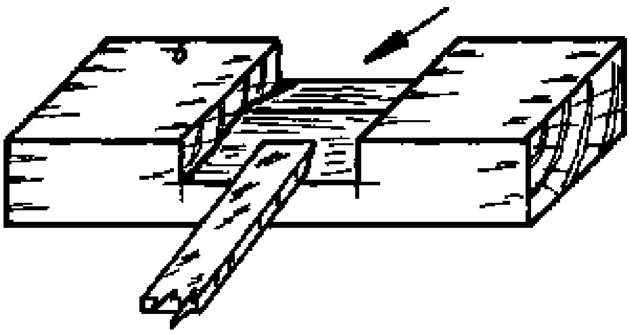


Fig. 8

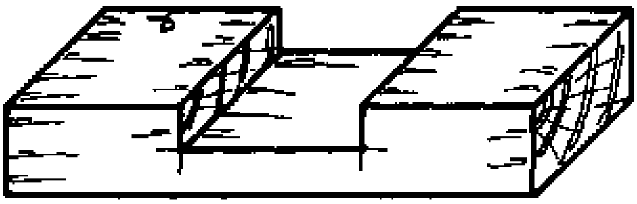


Fig. 9

– Test the flatness of the socket with the blade of the try square.

Step 5. Assembling the joint

– Clean up the inside edges with a smoothing plane.

– Assemble the joint with glue and nails.

– When the joint is dry, plane off the waste of the pin.

– Clean up all sides and edges with the smoothing plane.

NOTES:

Corner−halved joint

Another halved joint is the corner−halved joint (Fig. 1). It is used where the pieces meet at their ends to form a corner.

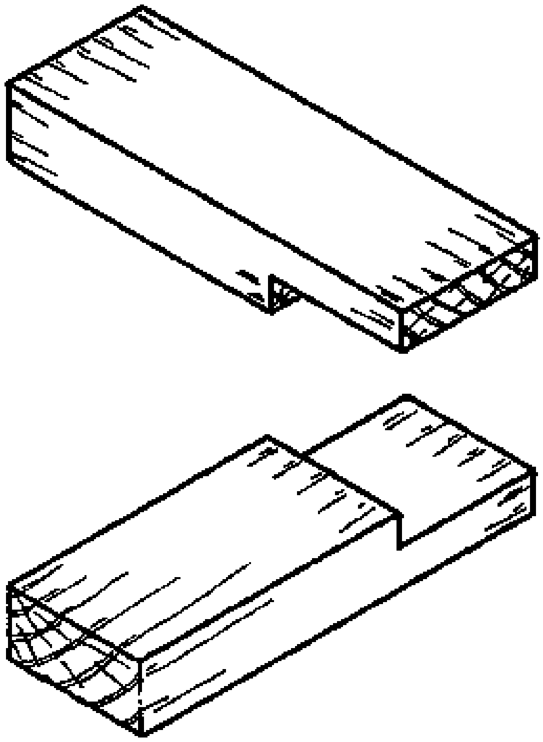


Fig. 1

The sequence of operations to construct this joint is similar to the one for the tee−halved joint, except that instead of a pin and a socket, two pins have to be marked and cut.

Cross−halved joint

The third halved joint we deal with is the cross−halved joint (Fig. 2). It is used where two members cross each other.

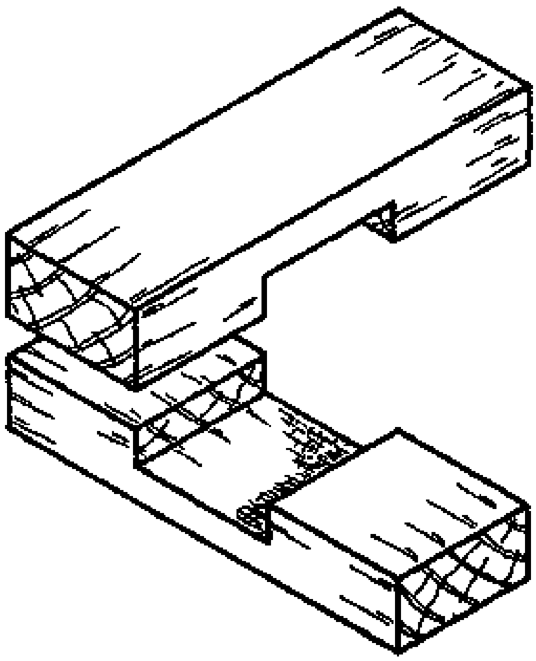


Fig. 2

The sequence of operations to construct this joint is similar to the tee−halved joint, but instead of a pin and a socket, two sockets have to be marked and cut.

Stopped tee−halved joint

In this joint the socket is stopped away from the edge and the pin is cut short, so that in the assembled joint the end grain of the piece is not seen (Fig. 3).

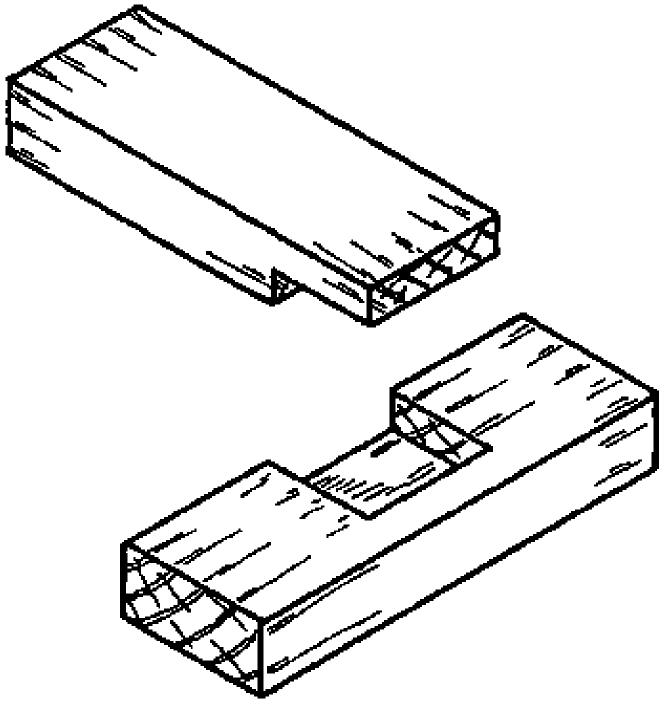


Fig. 3

Otherwise, the same sequence is followed as for the tee−halved joint.

NOTES:

Common mortice and tenon joint for frame−like constructions

One of the most common and strongest forms of framing joint is the mortice and tenon joint (Fig. 1).

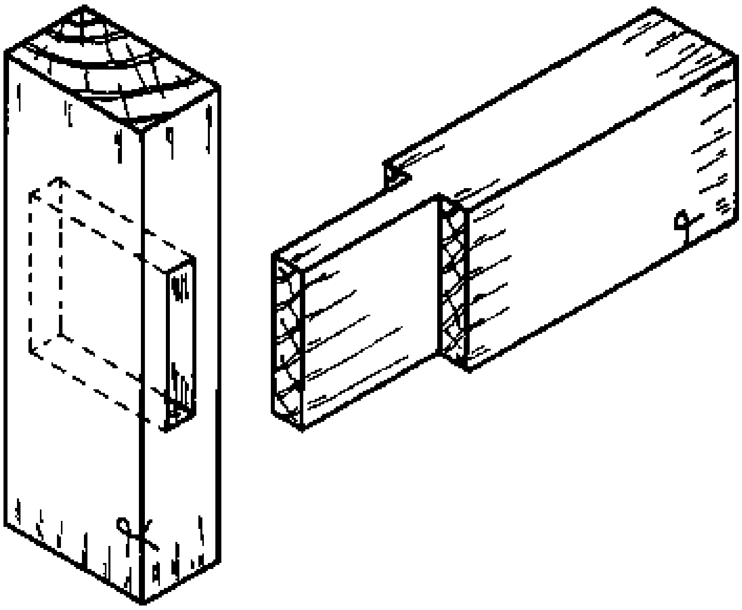


Fig. 1

The sequence of operations to construct a mortice and tenon joint for frame−like constructions is almost the same as for box−like constructions. Of the four types of mortice and tenon joints mentioned in this chapter, we will only go into detail about the construction of one of them, the common mortice and tenon. No new tools will be needed.

Sequence of operations for constructing the joint

Step 1. Preparation of timber

− Make a cutting list.

− Prepare the timber.

Step 2. Marking out

− Mark out the position of the mortice and square the lines across the face side and edges, using a try square and pencil (Fig. 2).

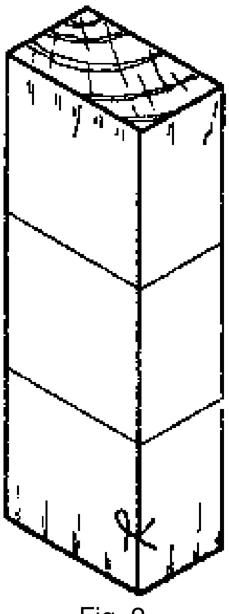


Fig. 2

– Mark out the length of the tenon on the other member. Allow 3 mm waste on the end.

– Square lines all around (Fig. 3).

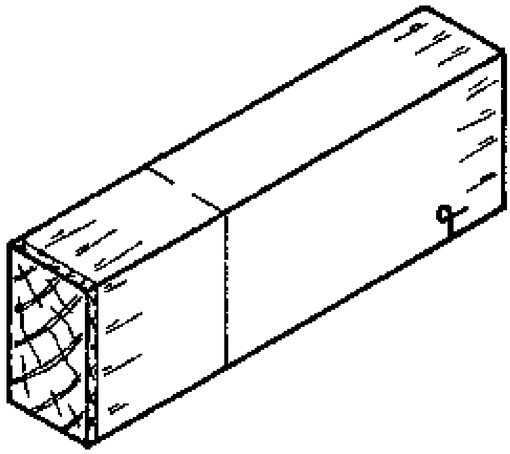


Fig. 3

– Set a marking gauge to the size of the tenon (one–third of the width of the piece) and mark around the end of the tenon (Fig. 5). Mark the waste.

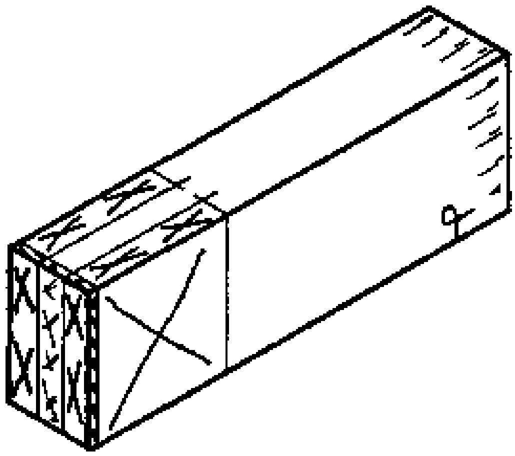


Fig. 5

– Use the same setting to mark both edges of the mortice and mark the waste (Fig. 4).

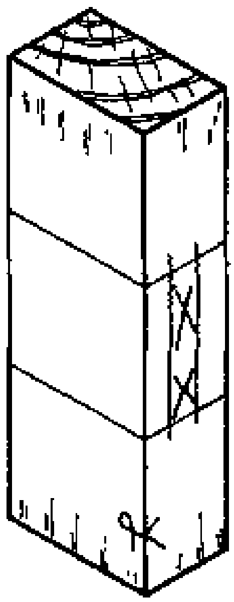


Fig. 4

– Do all marking from the face side.

– Check the marking, using the pieces as a guide by placing them over the marks (compare this sequence to the mortice and tenon for box–like constructions, page 104).

NOTES:

Step 3. Cutting the mortice

– Most of the waste may be bored out (Fig. 6). Bore halfway through from both edges. Make sure you keep the brace at a 90 degree angle to the edge.

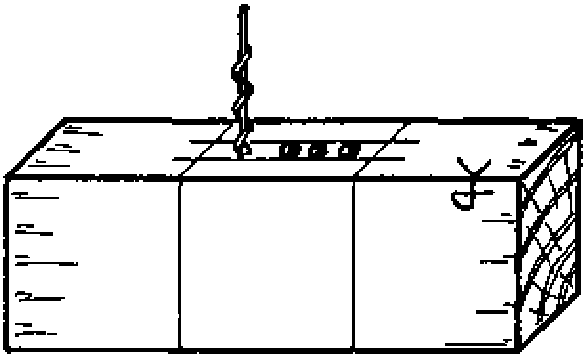


Fig. 6

– Chop out the remaining waste, chiselling halfway through from both edges. Leave about 2 mm extra to prevent damage to the sides of the mortice during chiselling (Fig. 7).

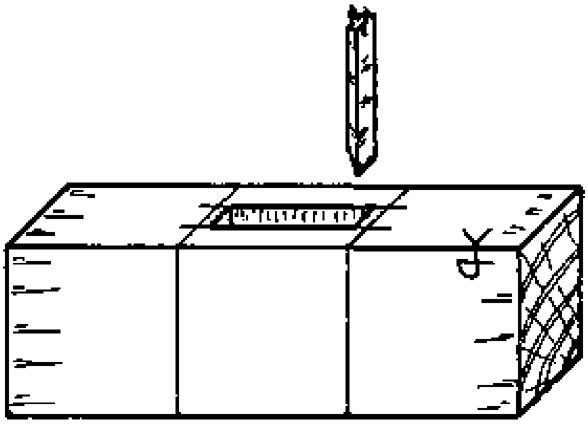


Fig. 7

– When most of the waste is out, chisel out the remainder to the line (Fig. 8).

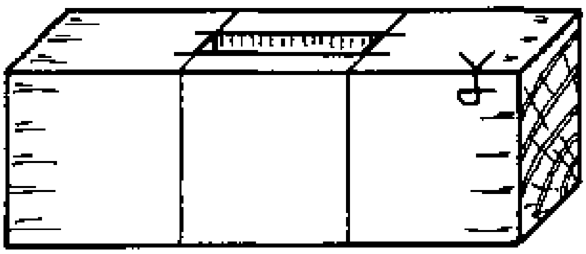


Fig. 8

– Keep the cutting edge of the chisel across the grain.

Step 4. Cutting the tenon

– Rip the sides of the tenon, sawing on the waste side of the lines (Fig. 9).

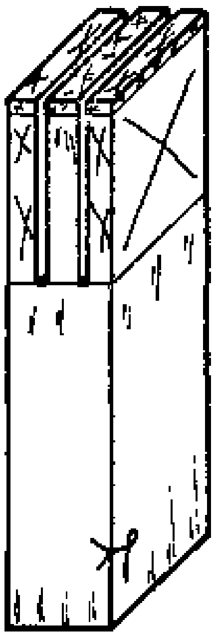


Fig. 9

– Saw in steps (see tee–halved joint).

– Carefully saw the shoulders, keeping the saw vertical and on the waste side of the line (Fig. 10 & 11).

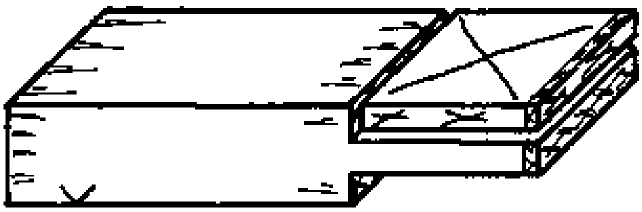


Fig. 10

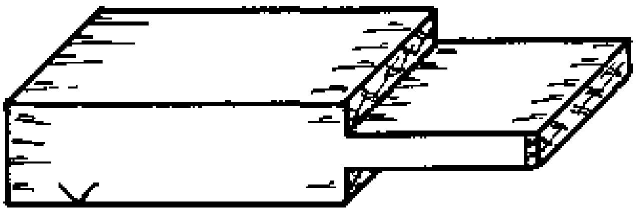


Fig. 11

Step 5. Assembling the joint

– Check whether the members fit together (see Assembly section for the mortice and tenon joint for box–like constructions).

– Clean up inside the joint where it cannot be reached after assembly.

– Assemble the joint with glue.

– When it is dry, plane off the waste of the tenon.

– Clean up the edges and sides with a smoothing plane.

Note the importance of marking the waste as you mark out the pieces. This cannot be over–emphasized. Most construction mistakes are made by cutting on the wrong side of the line, due to improper marking.

NOTES:

Haunched mortice and tenon joint

Another type of mortice and tenon for frame−like constructions is the haunched mortice and tenon (Fig. 1). This joint is used where one member meets another at a corner.

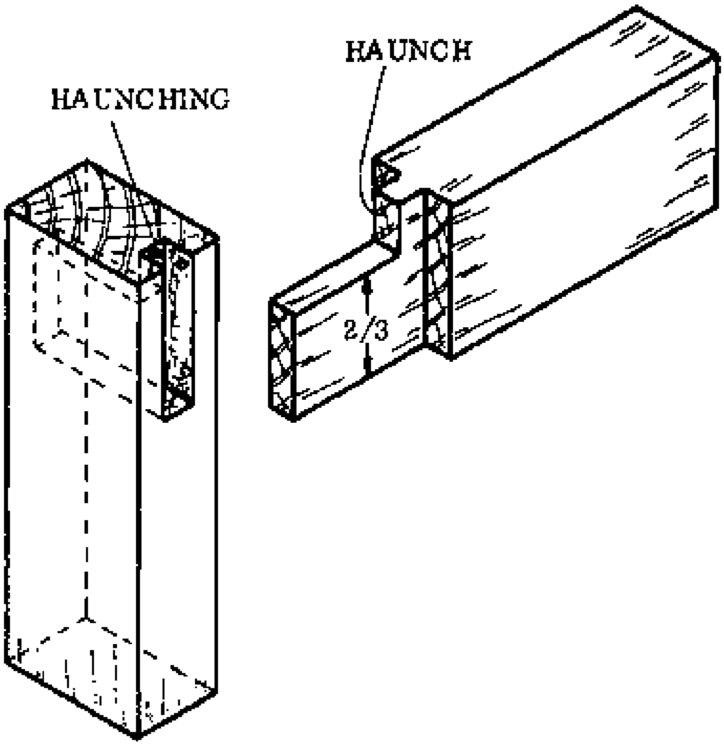


Fig. 1

The width of the tenon is reduced to 2/3rd of the width of the board and the mortice size is reduced to suit (Fig. 1).

A haunch is left on the tenon to prevent it from twisting in the mortice. The length of the haunch is equal to the thickness of the tenon and it fits into a recess above the mortice, called the haunching.

Otherwise, the sequence of operations for construction of this kind of joint is the same as for the common mortice and tenon joint.

When you make the cutting list for this type of joint, the allowance in length for the member with the mortice should be 25 mm instead of 12 mm to help prevent splitting of the haunching (see Cutting List, page 90).

Stub tenon joint

Where the end grain of the tenon and the opening of the mortice must be hidden, the stub tenon joint is chosen (Fig. 2). In this joint the tenon does not pass through the morticed member, but is stopped inside. The sequence of operations for constructing this joint is the same as for the common mortice and tenon joint. Stub tenons are also used for box−like constructions.

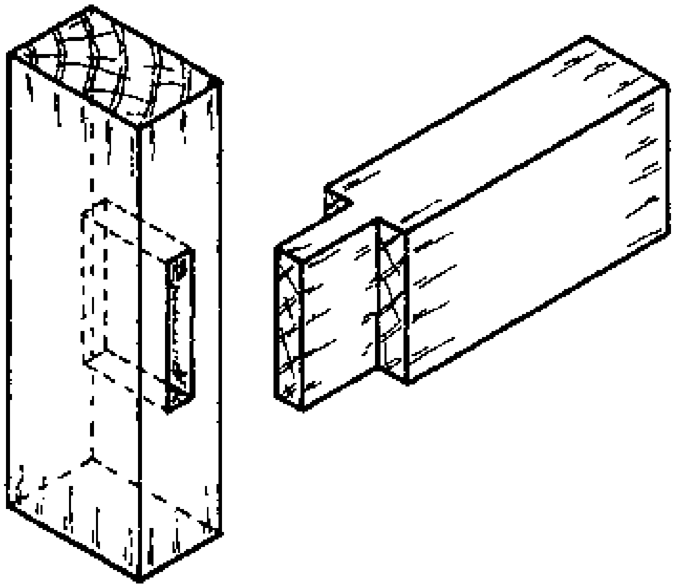


Fig. 2

At times a combination of the haunched and stub tenons is required. This is called a haunched stub mortice and tenon joint.

Twin tenon joint

Where the members to be joined are very thick, twin tenons are used (Fig. 3). Each tenon is then not 1/3rd, but 1/5th of the thickness of the members.

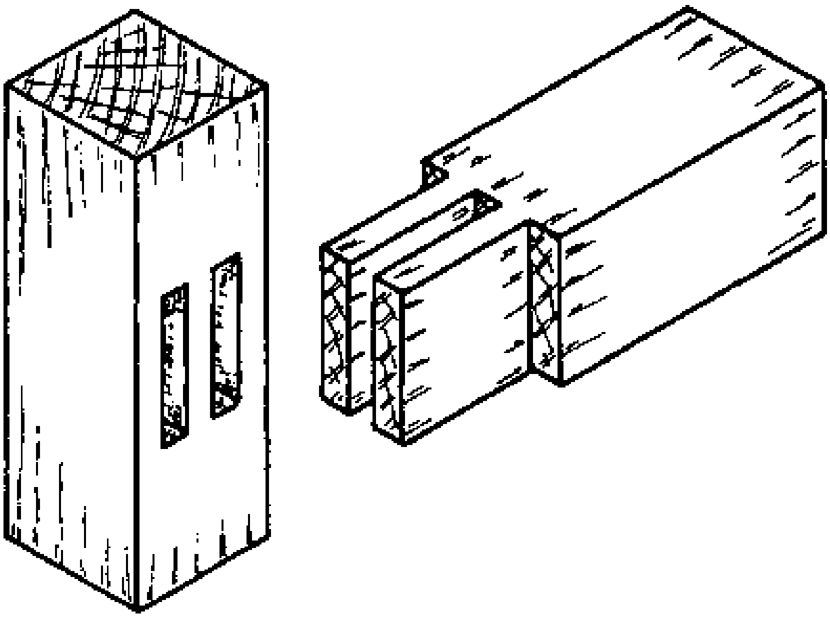


Fig. 3

The sequence of operations is almost the same as for the common mortice and tenon joint, with the only difference being that two mortices and tenons have to be marked and cut instead of only one.

This joint can be used for both frame−like and box−like constructions.

NOTES:

Securing the joints

Instead of nails to secure mortice and tenon joints, either pegs or wedges can be used.

One or two holes are drilled through the assembled joint and wooden dowels, or pegs, as they are called in this case, are inserted with glue to securely fix the joint (Fig. 1).

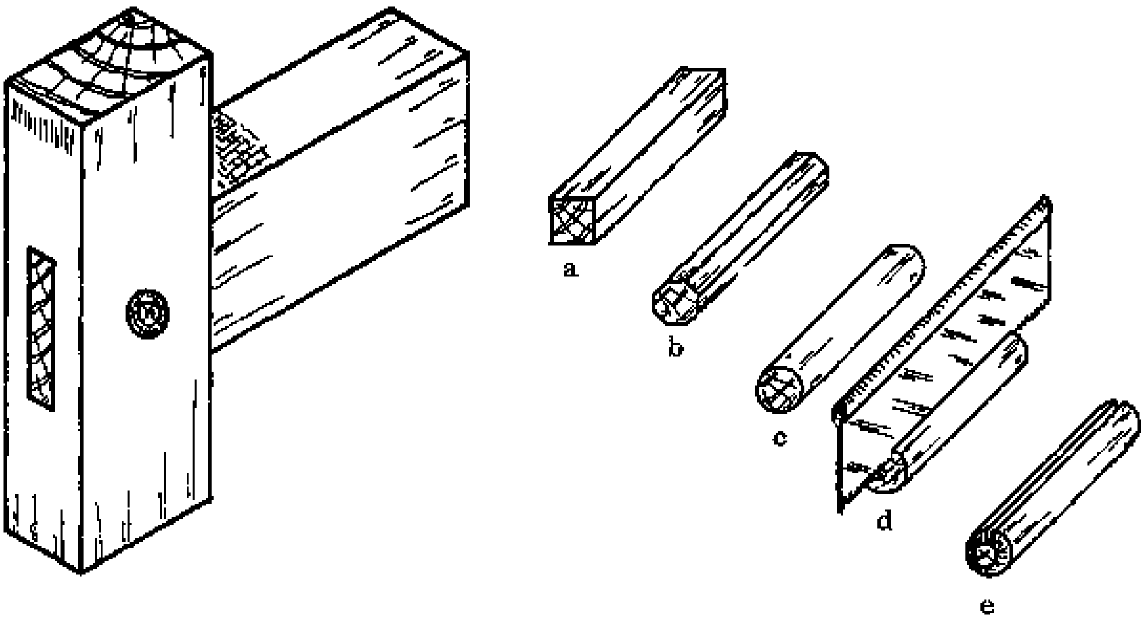


Fig. 1

– To make the dowels, plane off the corners of a square piece of hard wood, until the piece is round. When the dowel is cut to length, chamfer the ends and cut a groove along the length to permit air and excess glue to escape (Fig. 1, a – e).

Follow the steps below to secure a joint by means of wedges.

– Cut the mortice with an allowance of 2 mm in width, tapering from the outside edge to about 2/3rd of its depth (Fig. 2).

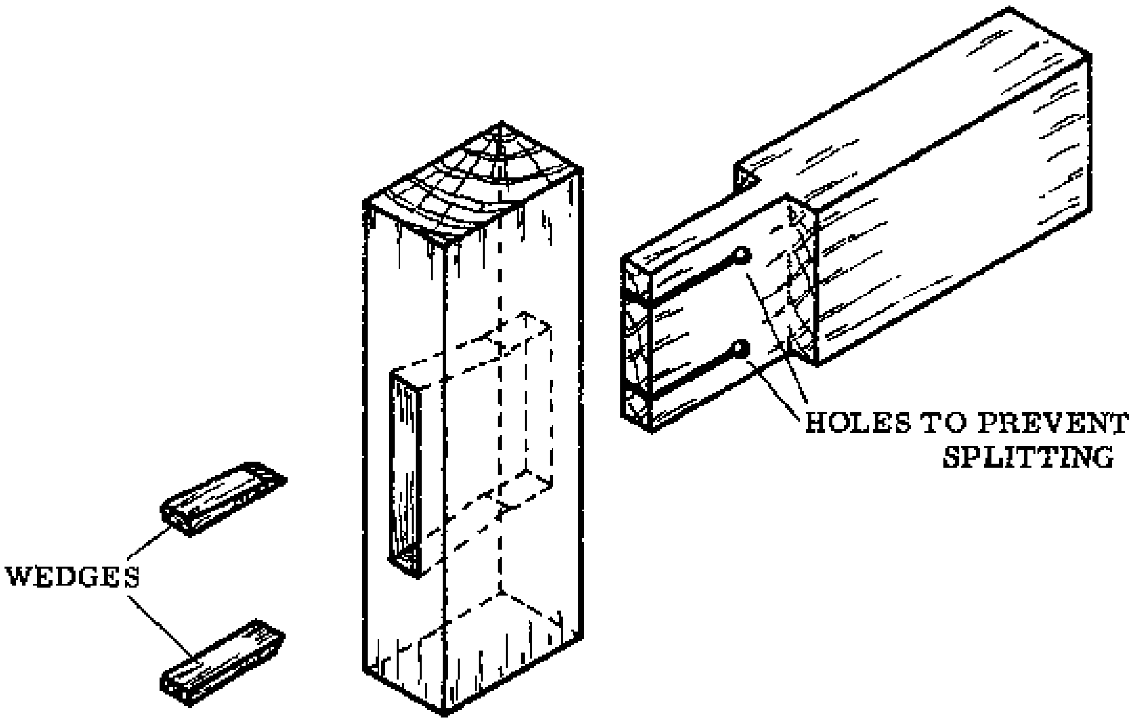


Fig. 2

– Make cuts in the tenon to receive the wedges.

– To prevent splitting of the tenon, drill small holes at the end of each cut.

– Cut the wedges from small pieces of waste wood; they should have the same length as the tenon.

Haunched mortice and tenon joints in frame–like constructions should not be wedged, because of the danger of breaking off the small haunch at the corner of the joint.

Both wedges and pegs can be used for securing mortice and tenon joints in box–like constructions.

NOTES:

Bridle joint

Bridle joints are similar to mortice and tenon joints. They consist of a pin and a socket (Fig. 1). The thickness of the pin is 1/3rd of the thickness of the member.

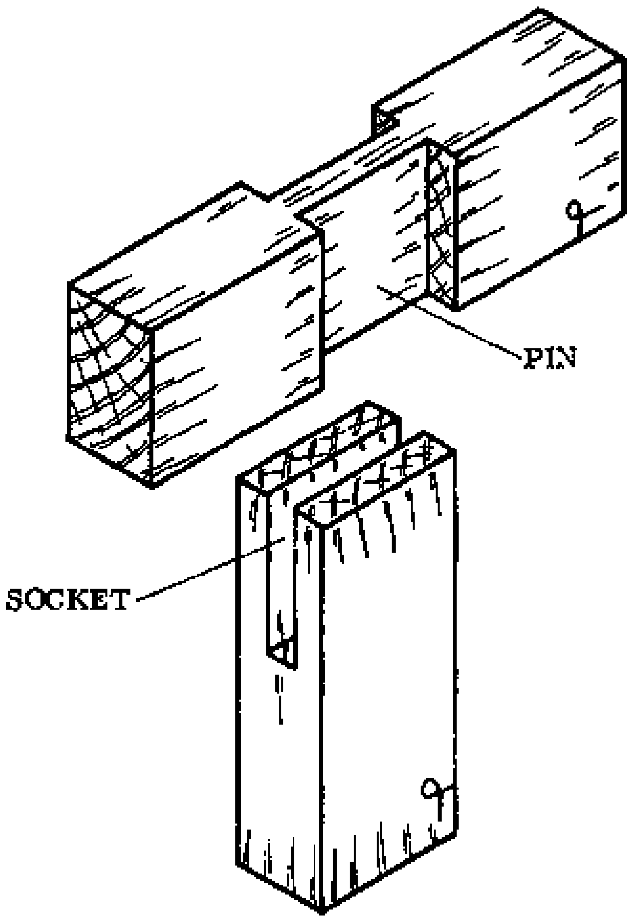


Fig. 1

The two types of bridle joint are the tee bridle (Fig. 1) and the corner bridle.

Here we will only go into detail about the tee bridle, since the construction of the corner bridle joint follows much the same procedure. .

Sequence of operations for constructing the joint

Step 1. Preparation of the timber

– Make a cutting list.

– Prepare the timber.

Step 2. Marking out

– Mark the position of the pin on one member, making the distance between the shoulders equal to the width of the other piece. Square the lines all around the piece with a try square and pencil (Fig. 2).

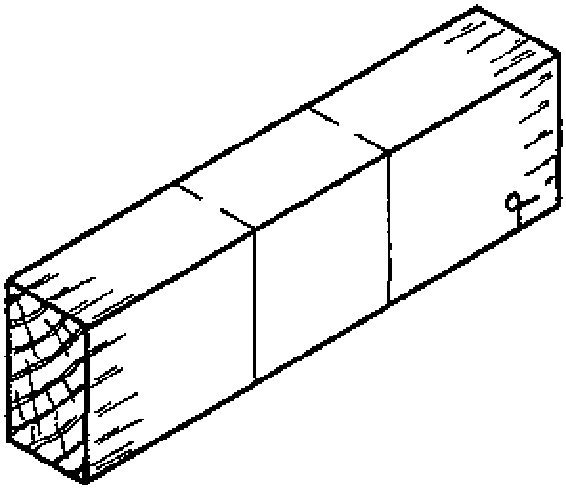


Fig. 2

– Mark the length of the socket (plus 2 mm waste) on the end of the other member, making the length equal to the width of the pin. Square the lines across the face side and on both edges (Fig. 3). Remember to smooth the pieces before using them to mark.

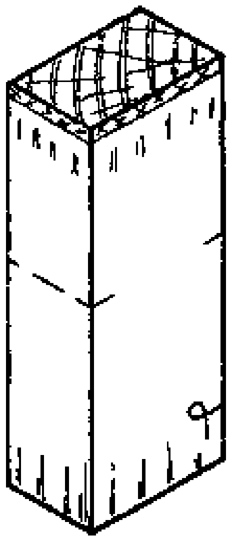


Fig. 3

– Set a marking gauge to 1/3rd of the thickness of the member and gauge along both edges of the pin. Use the gauge from the face side only. Mark the waste with small crosses (Fig. 4).

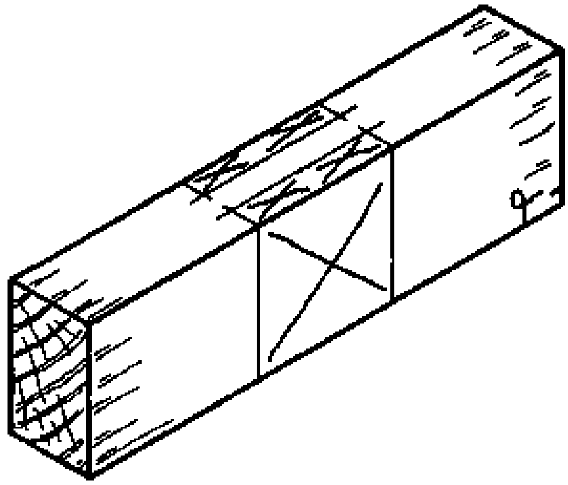


Fig. 4

– With the same setting on the gauge, mark around the end of the socket. Mark the waste (Fig. 5).

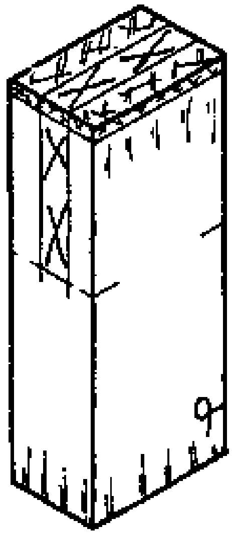


Fig. 5

– Mark the other side of the socket in the same manner, from the face side, with the gauge set at 2/3rds of the thickness of the piece. If you have a gauge with 2 pins, mark both lines at once.

– Check the fitting.

NOTES:

Step 3. Cutting the pin

– Carefully saw the shoulders down to the gauge line, sawing on the waste side of the line (Fig. 6).

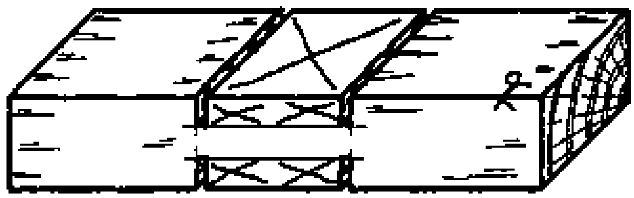


Fig. 6

– Chisel away the waste, chiselling halfway through from both edges (Fig. 7).

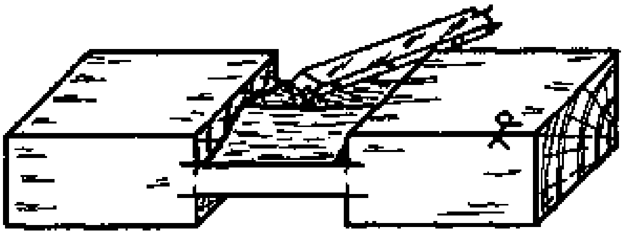


Fig. 7

Step 4. Cutting the socket

– Rip the sides of the socket down to the required depth, sawing on the waste side of the lines (Fig. 9). Saw in steps (see Tee–halved joint, Cutting the pin, page 114).


Fig. 8

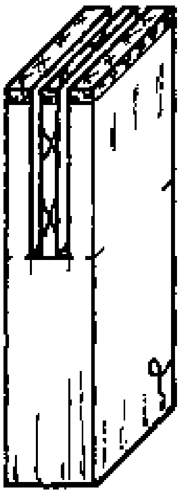


Fig. 9

– Chop out the waste with a mortice chisel, chiselling halfway through from both edges (Figs. 10 & 11).

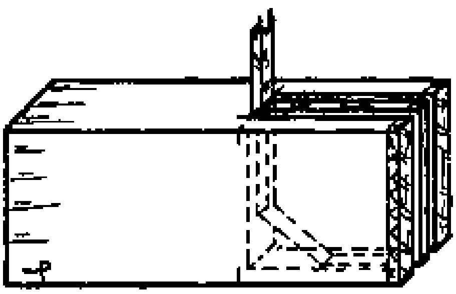


Fig. 10


Fig. 11

Step 5. Assembling the joint

– Clean up the inside edges which cannot be reached after the joint is assembled.

– Assemble the joint with glue and nails.

– When the glue is dry, plane off the waste of the socket.

– Clean up the sides and edges with a smoothing plane.

Corner bridle joint

The corner bridle joint is used where members meet to form the corner of a frame. Like the tee bridle, it consists of a pin and a socket (Fig. 12).

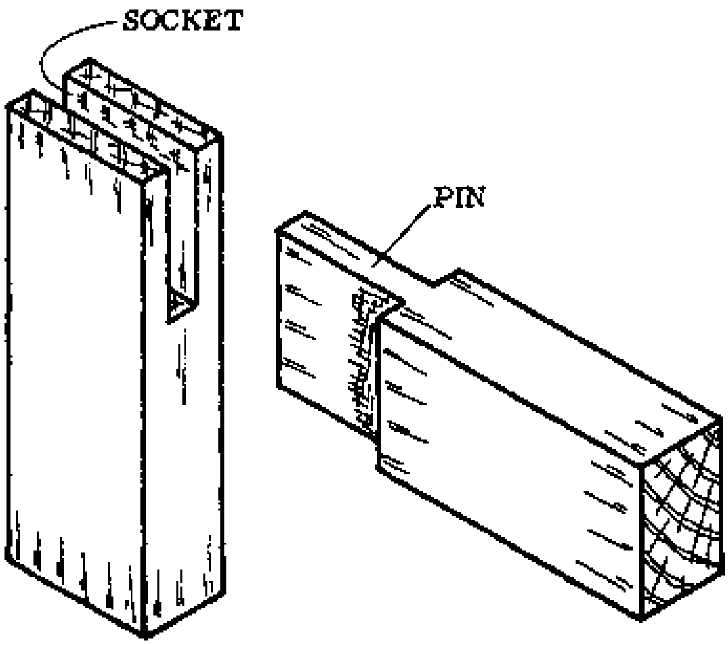


Fig. 12

The pin is constructed like the tenon in the sequence of operations for the mortice and tenon joint for frame−like constructions, pages 118 to 120.

The socket is constructed in the same way as the socket for the tee bridle joint, above.

NOTES:

WIDENING JOINTS

Widening joints are joints used to make a single, wide board by joining two or more narrow boards along their length, edge to edge (Fig. 1).

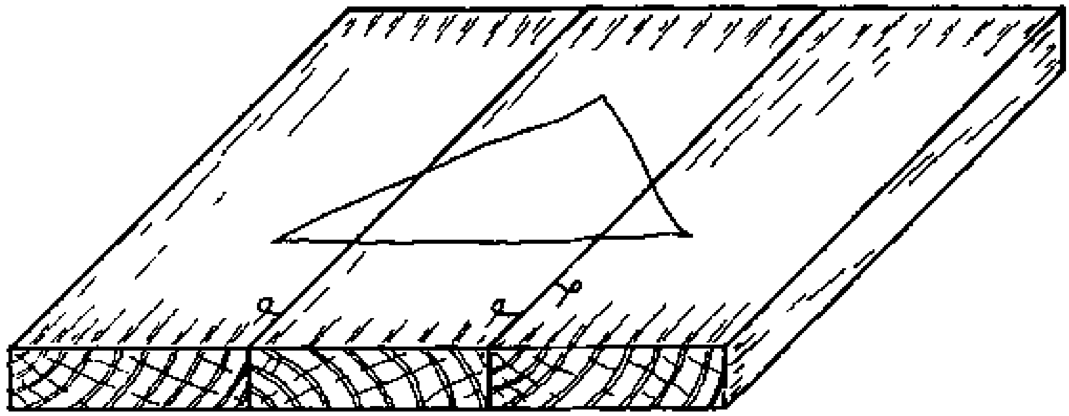


Fig. 1

The boards that will be joined must first be marked. Lay the boards out in the desired position and mark them with a triangular mark over all the boards (Fig. 1). The triangle should point upwards. This mark will help us to keep in mind the position of each board during the steps that follow.

Plain glued butt joint

This is the simplest widening joint (Fig. 2). The edges of the boards are planed perfectly straight and square, and then butted together. The joint is glued and clamped tightly to force out the surplus glue. For narrow pieces this is done with G−clamps. For wider pieces, wooden or metal sash clamps are used.

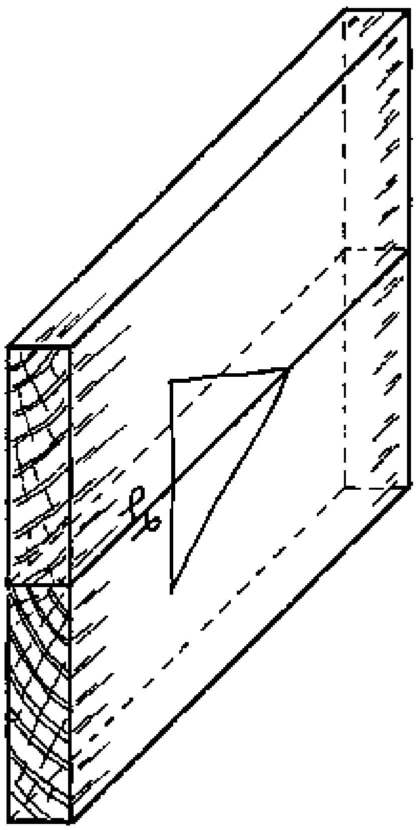


Fig. 2

Dowelled widening joint

This joint is similar to the plain glued butt joint, but strength is added by means of cylindrical wooden pins, called dowels. Dowels are made as explained in the section on securing joints. The dowels are then glued into holes in the edge of each board (Fig. 3). The diameter of the dowels should be about one−third of the thickness of the pieces that are being joined.

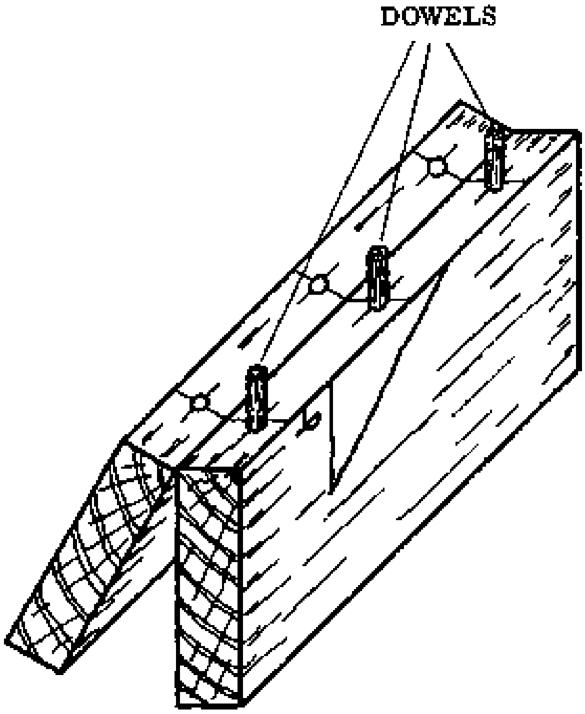


Fig. 3

The holes should be about as deep as the boards are thick, and they should be slightly countersunk (see Fastening with Screws, page 96).

Mark out the position of the dowels by putting the boards on top of each other, sides together and marking both edges at the same time. The centre can be marked with a marking gauge, marking from the face side.

Metal or wooden sash clamps are used to press the boards together during glueing.

NOTES:

Rebated joint

In this widening joint, the edges of the boards are rebated to match each other (Fig. 1). The rebating is done with either an ordinary rebate plane or an adjustable one. This joint is stronger than the plain glued butt joint.

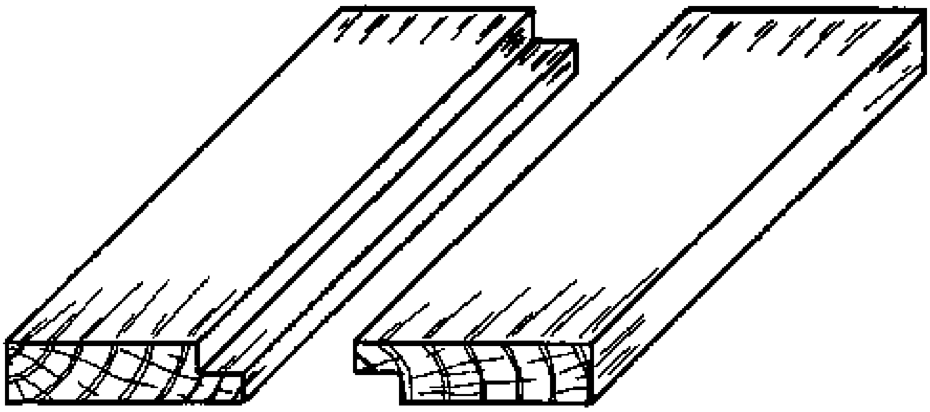


Fig. 1

How to plane a rebate with an ordinary rebate plane

Step 1.

– Mark the depth and width of the rebate with a marking gauge (Fig. 2).

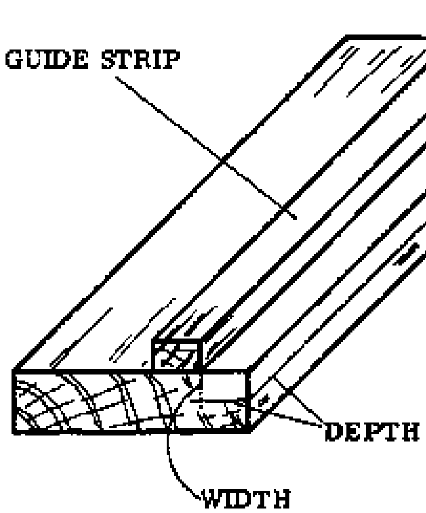


Fig. 2

Step 2.

– Fix a wooden guide strip along the line that marks the width of the rebate (Fig. 2).

The guide strip must be perfectly square and it should lie flat.

Step 3.

– Plane until you reach the line marking the depth of the rebate. Take care that the side of the plane is always against the guide strip, so that the width of the rebate is the same along the whole length.

– If you notice that you are planing against the grain, stop just before you reach the required depth and plane from the other direction. This will ensure that the surface of the rebate is smooth.

An important point in planing rebates is setting the plane correctly. The side of the cutting iron that faces the rebate must be set so it is exactly flush with or only slightly coming out at the side of the plane. If it projects too far it will damage the guide strip, and if it is set in from the side it will not plane true (Fig. 3).

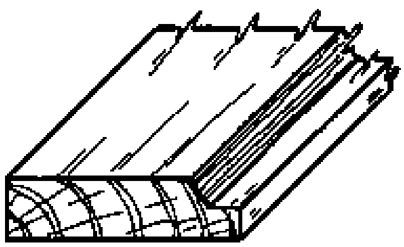


Fig. 3

When you set the cutting iron, do not knock on it with a steel hammer. This will damage the iron. Rather, loosen the wedge slightly and knock it with a mallet or a piece of wood.

When the rebate plane is not set well, it will tend to slip off the rebate and will not produce a good surface.

NOTES:

How to plane a rebate with an adjustable rebate plane

To make work simpler, we can fix guides onto the rebate plane itself. Thus, fixing guide strips on the boards is unnecessary (Fig. 1).

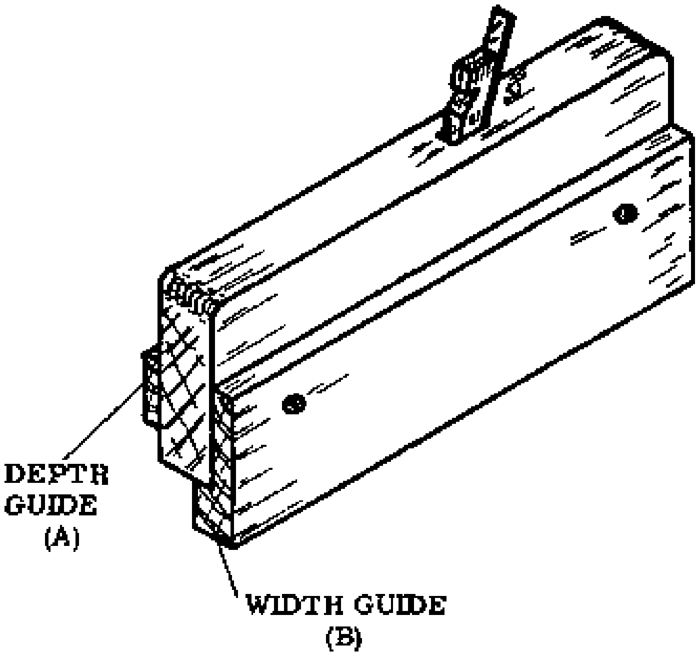


Fig. 1

One wooden piece is fixed on the sole of the plane (B) at the standard width for rebates and another piece is fixed on the side of the plane (A) and can be moved up or down to adjust the depth of the rebate. The width can also be adjusted, by using a wider or narrower wood guide (Fig. 2).

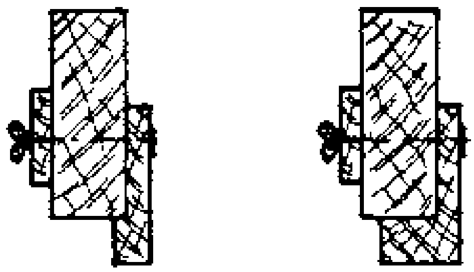


Fig. 2

The guides should not be nailed to the plane, since that would damage it. They should be fixed by bolts and nuts, so that they can be easily removed.

Plane until the depth guide just touches the work. Take care that the width guide is always firmly pressed to the side of the timber. If you notice that you are planing against the grain, stop just before you reach the required depth and finish planing with the guide strips removed, which enables you to plane in the other direction. This gives a good surface to the rebate.

See the section on the ordinary rebate plane for tips on how to set the cutting iron.

Loose tongued joint

This joint is used where a joint stronger than the plain glued or rebated joint is needed. The boards to be joined must be at least 2 cm thick (Fig. 3).

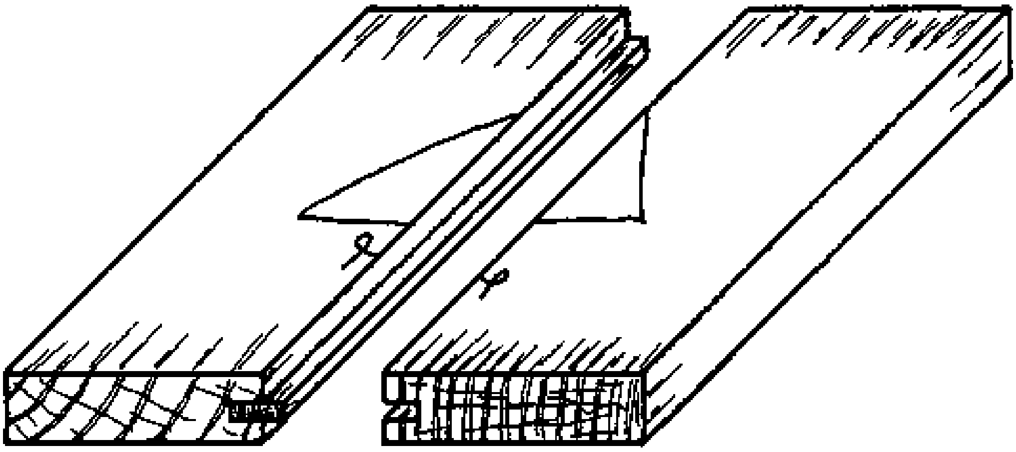


Fig. 3

The joining edges are grooved and a tongue is glued into the grooves. The depth of the groove is about 2/3rd of the thickness of the board. The width of the groove is equal to the thickness of the tongue. The groove should be slightly deeper than the projection of the tongue, to allow for expansion (Fig. 4).

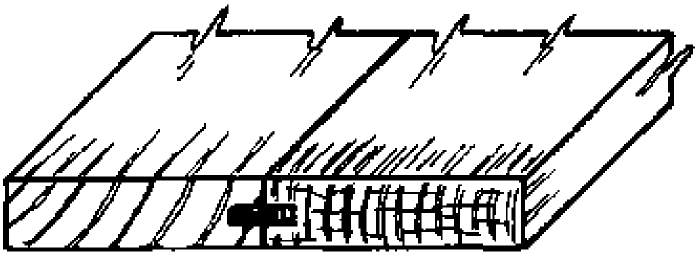


Fig. 4

Plywood makes a very strong tongue and it is frequently used for this purpose.

If solid wood is used as a tongue, care must be taken that it is always cut across the grain. A tongue cut with the grain will make a weak joint.

NOTES:

How to plane a groove for a loose tongued joint

Usually special planes called plough planes are used to plane grooves for this kind of joint. If a plough plane is not available, we can adapt our rebate plane for this purpose and make an improvised plough plane (Fig. 1).

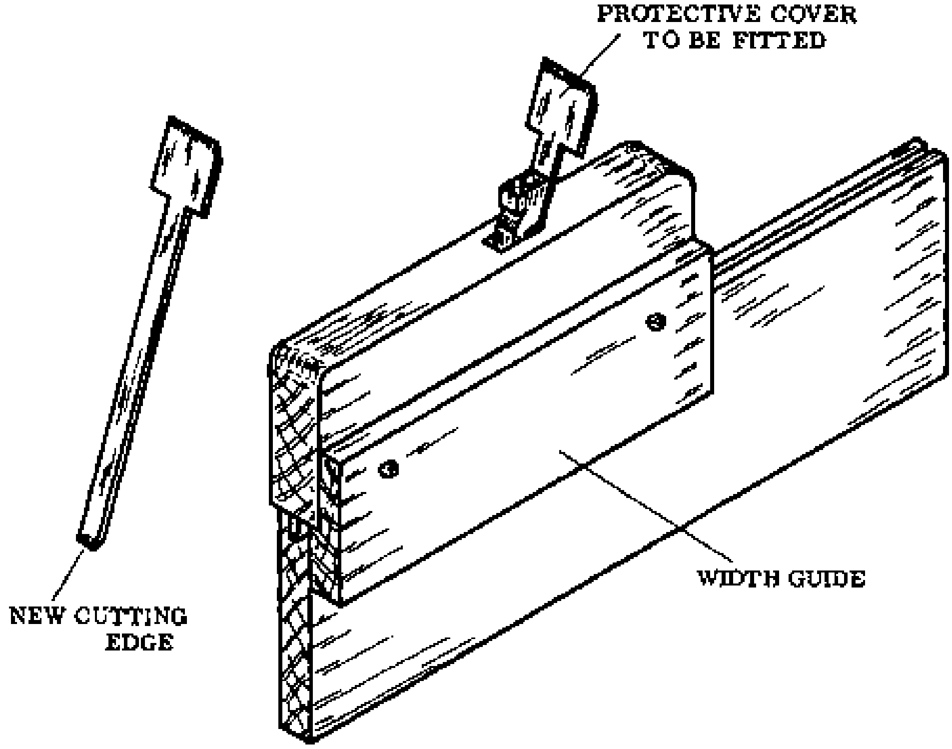


Fig. 1

To do this, grind and sharpen the narrow end of the rebate plane cutting iron to make a cutting edge. Grind the sides of the iron to the size of the most commonly used tongue, which is 6 mm plywood. The sides should be slightly bevelled to ensure free movement in the groove.

When the iron is fitted into the plane it is adjusted so that the cutting edge projects out of the sole by exactly the required depth of the groove.

A guide, similar to the one used for the adjustable rebate plane, is now fitted to the side of the plane. This guide keeps the cutting iron at the right distance from the face side of the boards. It should be adjusted according to the most common thickness of the boards, in this case it is about 22 mm for a planed board. For a tongue size of 6 mm then, the distance between the edge of the guide and the edge of the cutting iron will be 8 mm.

When planing press the guide firmly against the side of the wood and hold the plane exactly at a right angle to the edge of the board.

The most difficult part will be to start the groove, since the cutting iron will tend to slip off the edge and it requires some experience to keep it steady. Go slowly at first.

Work from the face side at all times.

To prevent injuries cover the cutting edge where it sticks out of the top of the plane.

NOTES:

MISCELLANEOUS CARPENTRY TECHNIQUES

Marking a board to fit an irregular surface

To mark the edge of a board which you want to fit against an irregular surface such as an unplastered wall, hold the board firmly and level to the wall and mark it with a compass or a similar device as shown in Fig. 1.

Fig. 1

As one leg of the compass moves along the wall, the other leg will mark on the board an exact copy of the irregularities of the wall surface. The legs of the compass have to be set apart by a distance a little greater than the width of the biggest gap between the wall and the board.

If no compass is available, a small wooden block can be used instead (Fig. 1a). The pencil is held in the notch at one end and the other end is moved along the surface of the wall.

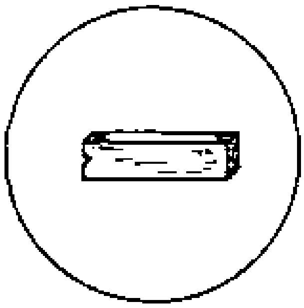


Fig. 1a

Measuring the width of openings

A convenient way to measure the width of openings such as doors and windows is to use two sticks as shown in the illustration (Fig. 2) to just span the opening. Then transfer the measurement to a single board by marking and measure it with a rule.

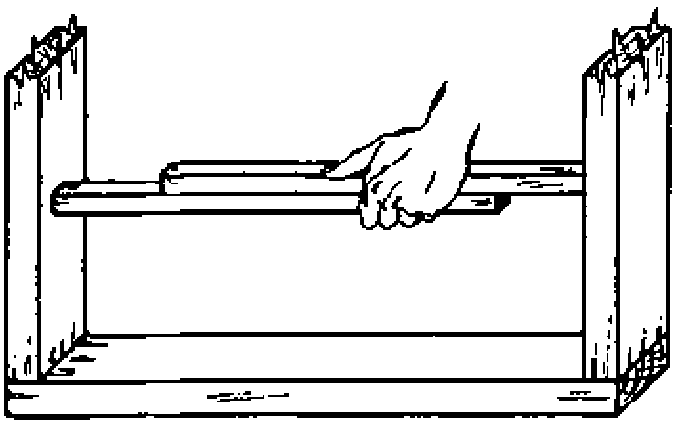


Fig. 2

Marking out irregular designs with templates

When you want to mark out several pieces with the same irregular shape, you can save time and ensure more accurate work by marking from a template (Fig. 3). Templates are thin pieces of cardboard or plywood onto which the required pattern is drawn and then cut out.

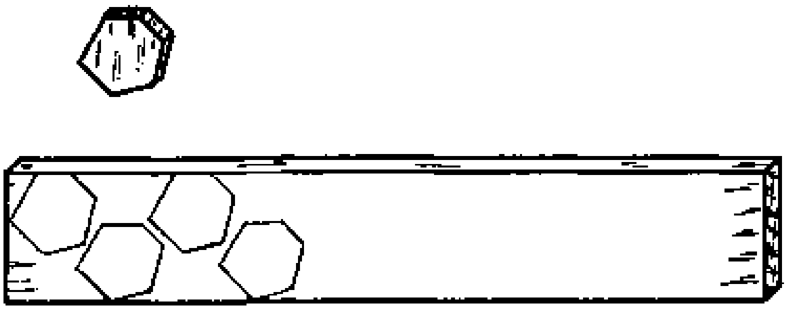


Fig. 3

The template is used by placing it on the material to be marked and holding it firmly in place while drawing around it.

NOTES:

PART 3: PREPARATION FOR ON–THE–JOB TRAINING

BUILDING PRELIMINARIES

Before anyone can actually start to erect a building, a number of preliminary steps must be completed. The very first step is the preparation of the plan.

Plan

The plan, also called the drawing, is a layout of a building drawn on paper. It contains all the information necessary to erect the house (see Drawing Book, page 55). The data and measurements given in the plan are essential for the builder to be able to construct the building so that it satisfies the customer's demands (Figs. 1 & 2).

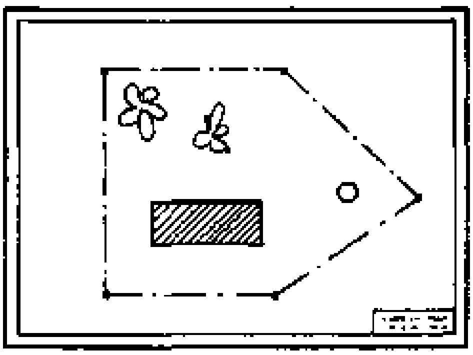


Fig. 1 LOCATION PLAN

Plot and site clearing

A plot is an area of land containing one or more sites. It is determined and limited by boundaries (Fig. 1).

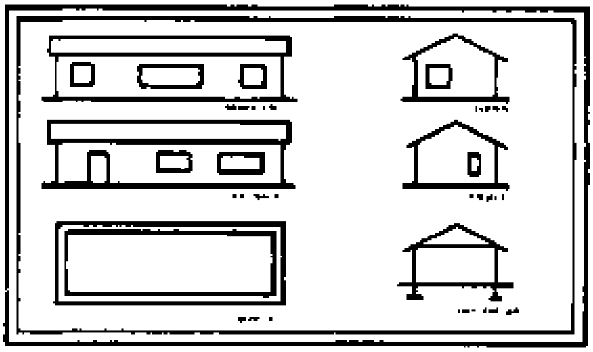


Fig. 2 BUILDING PLAN

The site is that area of land within the plot which is actually used for construction.

With the location plan in hand, the builder can prepare both plot and site for the construction of the building. The location plan tells him exactly where the trees and bushes have to be removed so that they don't interfere with the work. This preparation includes making a drive, cutting the grass, and levelling the surface of the ground.

The builder must pay special attention to the roots of trees which are on the site or very close to it. These must be completely removed. If some roots, such as those of the neem tree, remain in the ground, they can grow again and damage the structure.

Site organization

When the land clearing is completed, the building materials can be brought in to the building site.

Temporary work–sheds and stores may be erected in suitable places (Fig. 3).

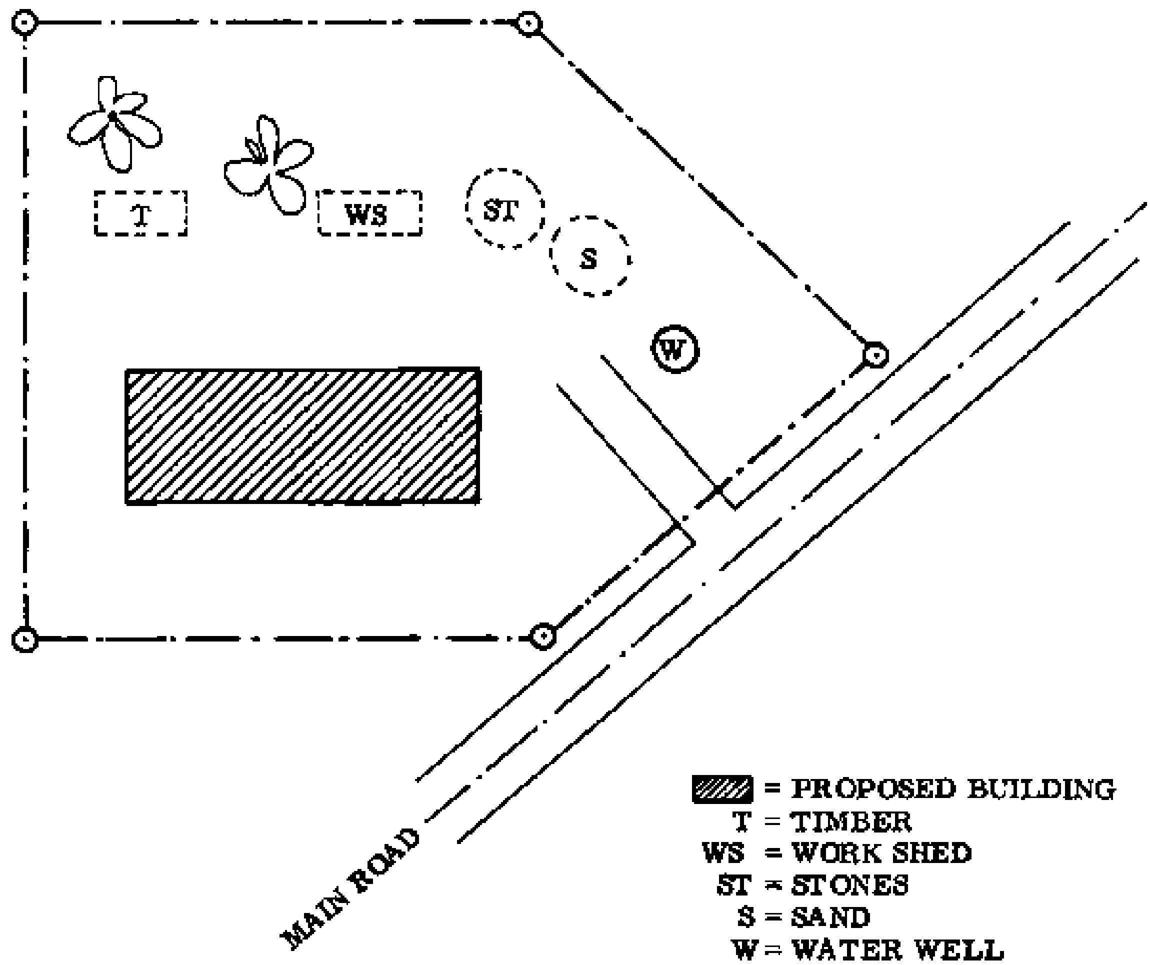


Fig. 3 SITE ORGANIZATION

The builder must ensure that there is an adequate supply of clean water. Without water no building can be constructed.

SETTING OUT

At the beginning of any construction activity the work must be carefully set out. This is also known as pegging out or lining out.

Setting out means to put pegs in the ground to mark out an excavation; or to mark on the floors to locate walls.

3–4–5 Method

The first line to be set out is the front line of the carcass (Fig. 1). A "carcass" is the building when it is structurally complete but otherwise unfinished. In this case we mean that the front line marks the position of the outside face of the (future) unplastered wall. The lines of all the other walls are measured from this front line. If the building is rectangular, right angles are set off from the front line by using the 3–4–5 method.

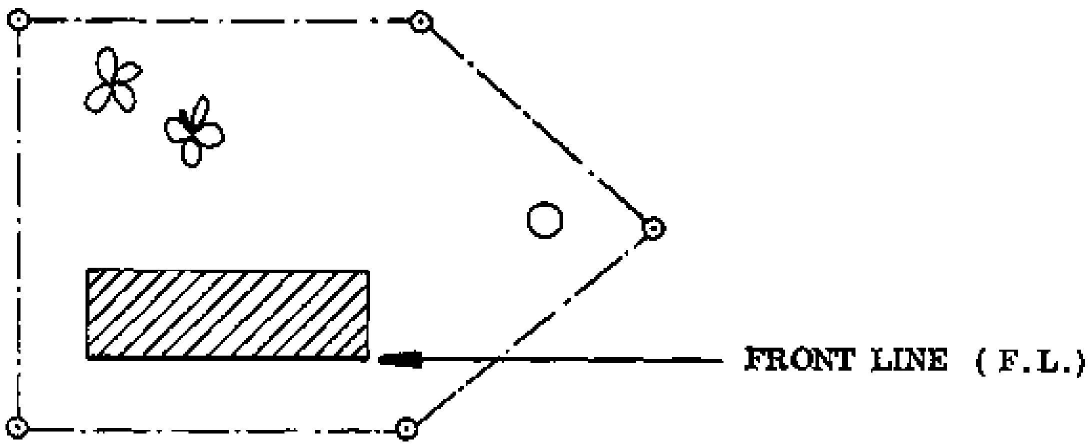


Fig. 1 LOCATION PLAN

The second line to be set out is the line of one of the side walls of the carcass. This line intersects the front line at the corner of the future building. To make sure that this corner is a right angle, we use the 3–4–5 method.

– Measure a distance of 4 m along the front line starting from point A, and mark this on the line (point B) (Fig. 2).

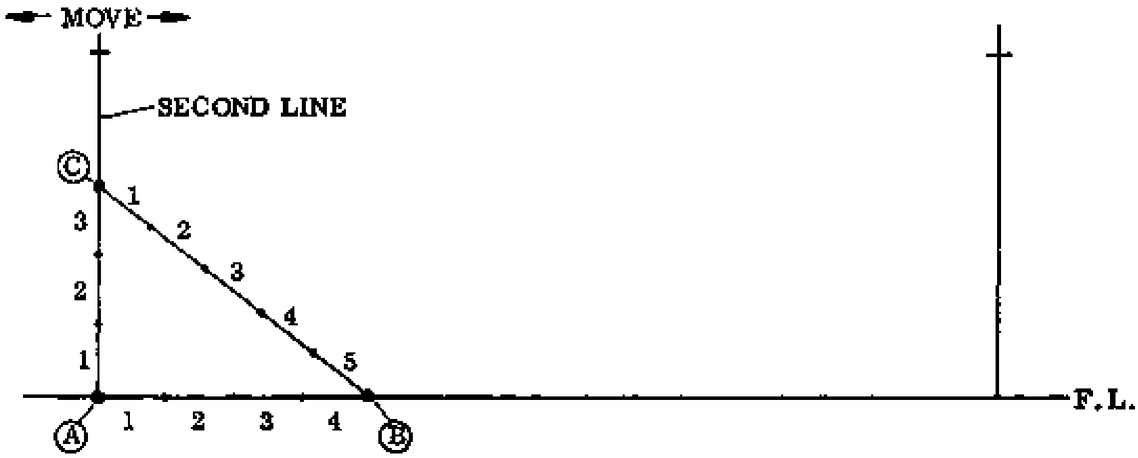


Fig. 2 3–4–5 METHOD

– Measure a distance of 3 m along the second line, starting from the corner (point A) and mark this distance (point C).

– Now take a line which is marked with a distance of 5 m, and stretch it taut from point B towards the line with point C. Keeping the end points of both lines steady (points A & B) and the lines taut; move the free ends of the side line and the 5 m line until the 5 m mark and the mark at point C meet each other. This is best done with two men, one at the end of each line.

– The corner angle must now be a right angle.

– Measure the required length of the side line and insert a peg at the end. Set out the opposite side line in the same way.

If the setting out has been done accurately, the length of the back line between the two pegs should be equal to that of the front line. Make a further check by measuring the diagonals, which must be equal (Fig. 3).

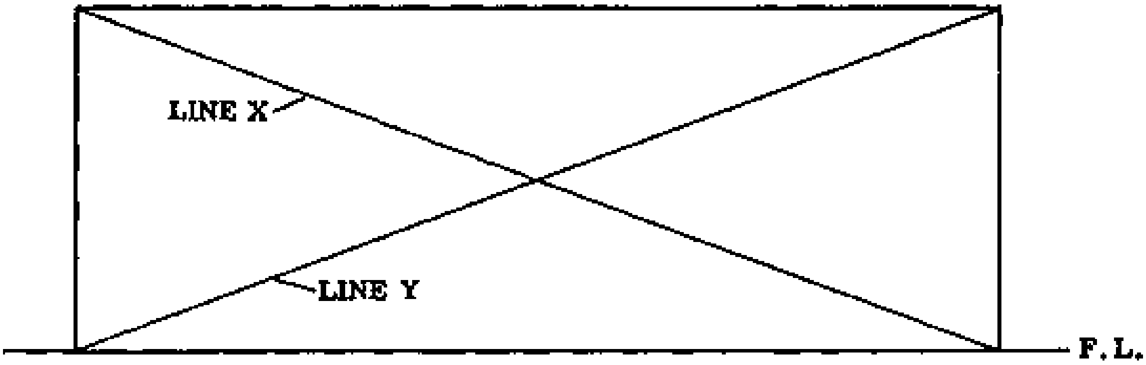


Fig. 3 LINES X AND Y ARE EQUAL IN LENGTH

NOTES:

Lining out

Once the positions of the corners and the distances between them are determined, the positions of the foundations, footings and walls as well as their thickness must be marked. A simple example of setting out and marking a foundation is shown in Fig. 1. The more complicated and permanent methods will be treated later.

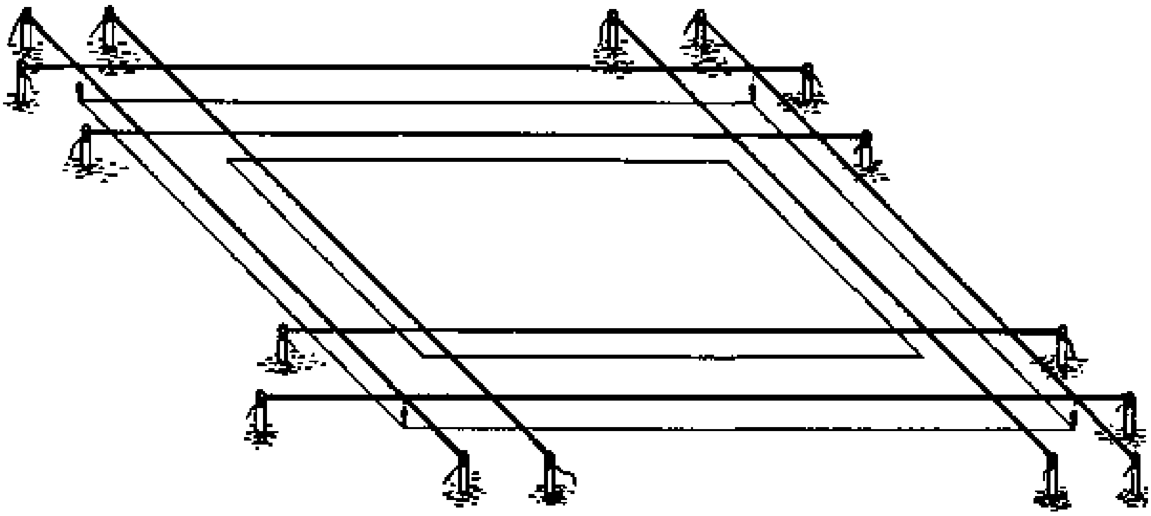


Fig. 1 SETTING OUT THE LINES & MARKING THE GROUND

These marks will be needed until the plinth course is completed, so they must be relatively durable, so that they remain accurate for a longer period and are not destroyed by rain or other influences.

Direct marking

Small buildings or small extensions of houses may be marked directly on the flat ground, provided that the excavation work can proceed immediately and can be quickly completed, so that the marking need not be repeated (Fig. 1).

In this procedure, the setting out must be done in stages.

– Mark the position and width of the foundation directly on the ground, and dig the trenches immediately.

– The next step is to level the bottom of the trenches and to peg off the foundation depth (Fig. 2).

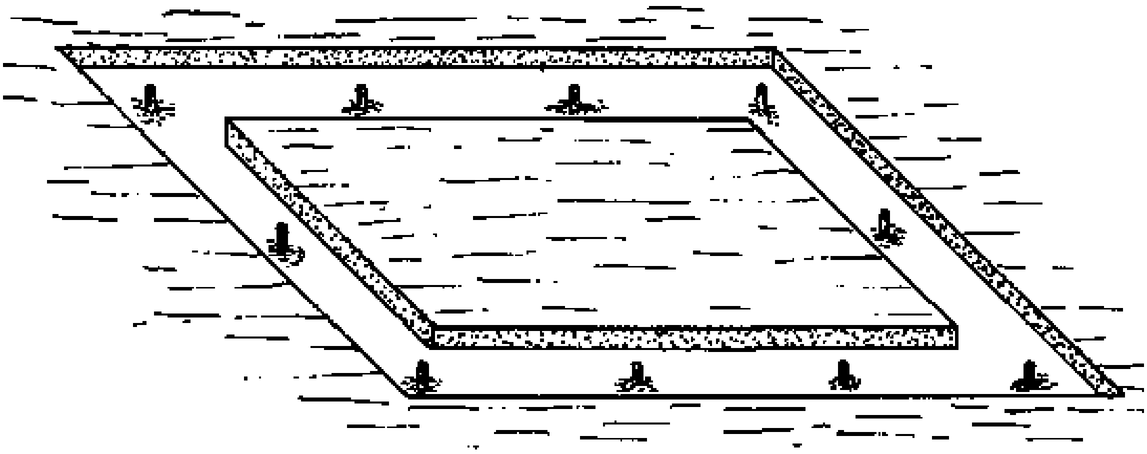


Fig. 2 PEGGING OFF THE FOUNDATION DEPTH

– After the foundation concrete is cast and set hard, set out the footings directly on the surface of the foundation (Fig. 3) and build them to the required height.

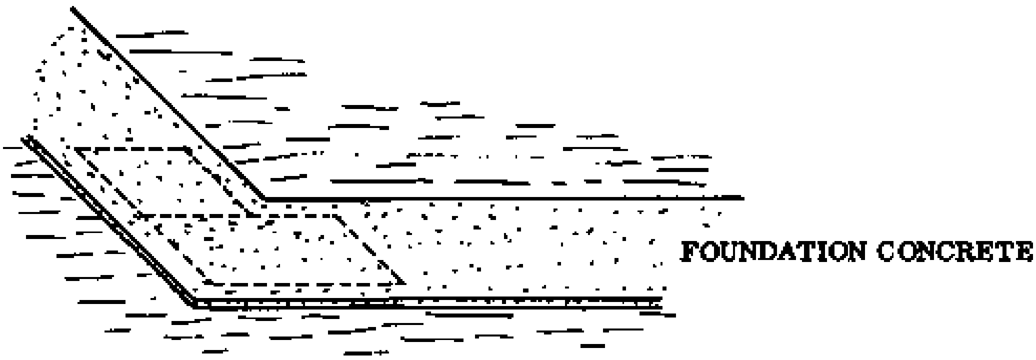


Fig. 3 SETTING OUT THE FOOTINGS (ENLARGED DETAIL)

– When the footings and hardcore filling are complete, set out the plinth course on the footings.

– NOTE: The information given in this section and in most of the following sections is not intended to be a detailed explanation. It is simply meant to give you, the trainee, an idea of the operations you can expect to encounter in your on–the–job training. Lining out, marking, etc. will be covered in detail in the Construction Book.

NOTES:

Using the plumb bob to mark the foundations

Hold the plumb bob with one hand by the suspending line so that the tip of the cylinder is just off the ground. Move it slowly until the suspending line just touches the intersection of the lines stretched between the pegs (see A & B, Fig. 1). When the swinging movement of the plumb bob has stopped, mark the point directly below the tip of the cylinder by inserting a peg.

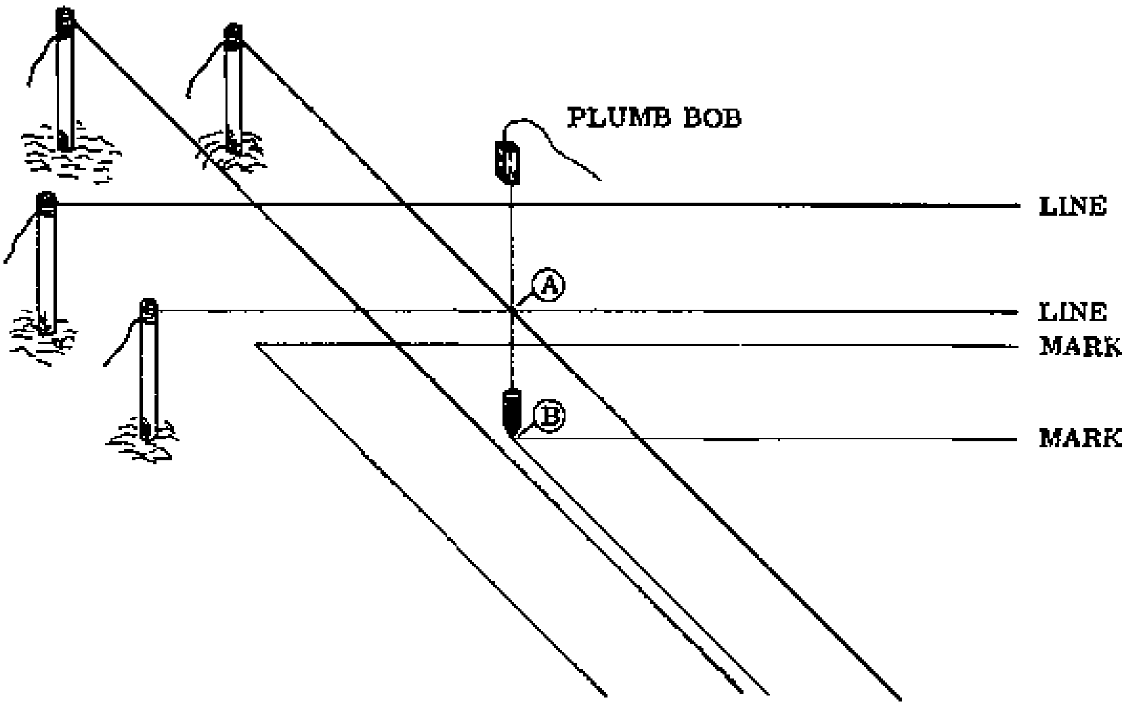


Fig. 1 USING THE PLUMB BOB

The peg is directly in line with the intersection of the lines above.

This procedure is repeated at all inside corners and outside corners, so that the edges of the foundation trenches can be marked on the ground.

Using the large square

The large square, described in the Reference Book, Tools, page 12, may be used to set out and mark off the positions of inside walls. This is less time−consuming than using the 3−4−5 method.

Place the large square on the ground with one side along an already determined line, and mark off the corner on the other side (Fig. 2).

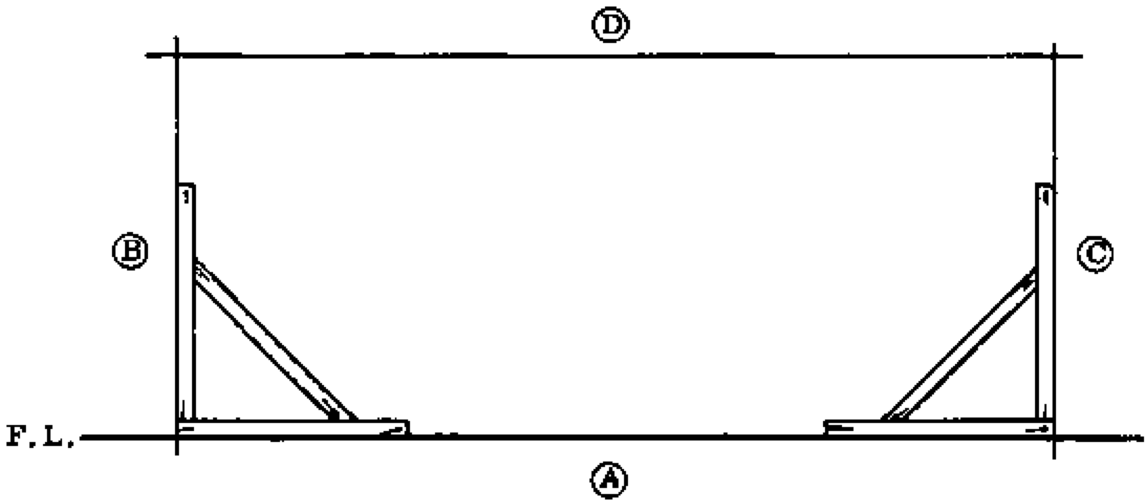


Fig. 2 USING THE LARGE SQUARE

PROCEDURE:

1 − FIX THE FRONT LINE; LINE A.
2 − MARK POINTS 1 AND 2.
3 − SET OUT LINE B SQUARE TO LINE A.

4 – SET OUT LINE C SQUARE TO LINE A.
5 – LINE D SHOULD BE THE SAME LENGTH AS LINE A.

Not only the whole building, but also each room in the building must be checked for squareness by comparing the diagonals, which have to be equal.

Using the mason square

Although it is less accurate than the large square because of its smaller size, the mason square can be used to mark off the corners of short set–backs such as niches designed to receive built–in wardrobes, etc. Follow the same procedure as with the large square (Fig. 2).

– NOTE: A niche, also called a blocked doorway, is a small recess in a wall, usually not extending to the ceiling. A set–back or return is the part which goes back, away from the front or direct line of the structure.

NOTES:

FOUNDATIONS

A foundation is the strong base of a building. It is the lowest part of the structure, the part which is in direct contact with the ground.

The purpose of the foundation is to receive the loads from the structure above and to spread them over a larger area of supporting soil or rock.

Excavating the foundation trenches

Once the setting out is completed and the position of the foundation is marked on the ground, the next step is to dig the trenches for the foundation concrete.

Remove the loose, soft topsoil to uncover the firm subsoil, preferably rocky soil. Dig the trenches to the required depth.

The soil which is taken out should be piled within or near to the area of the future building, so it can be used later for the hardcore filling. Take care to make the sides of the trenches vertical, and the bottom level. The corners should be sharp, not rounded (Figs. 1 & 2).

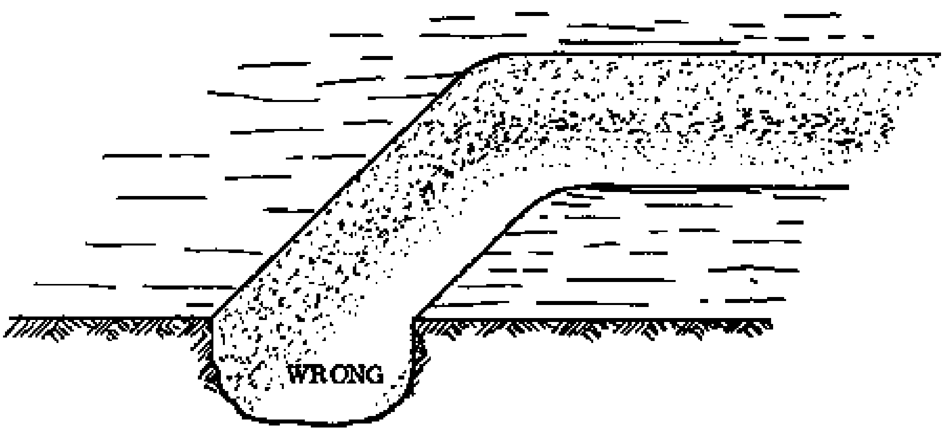


Fig. 1 CORNERS ARE NOT SHARP

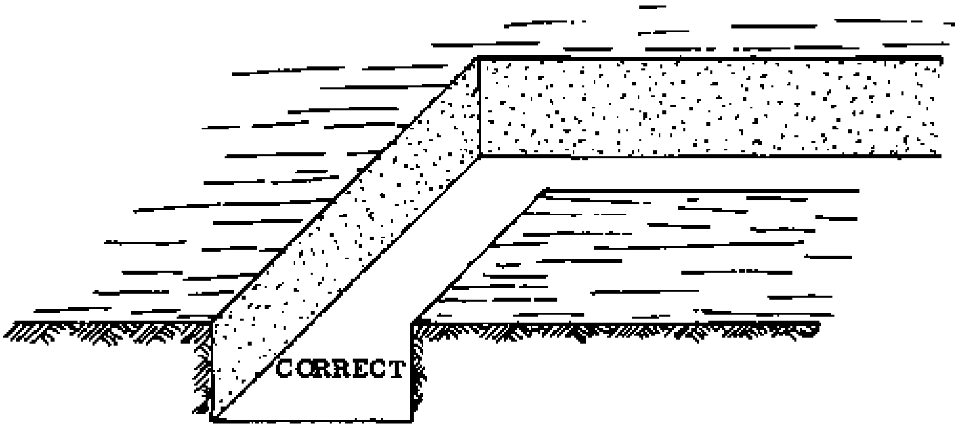


Fig. 2 CORNERS ARE SHARP

Marking the depth of the concrete and levelling the trench

When the trenches have been dug, the next step is to mark the depth of the foundation concrete. This is done by driving pegs in the bottom of the trench. The pegs are levelled across their tops, and their height above the trench bottom should be equal to the planned depth of the concrete bed (Fig. 3).

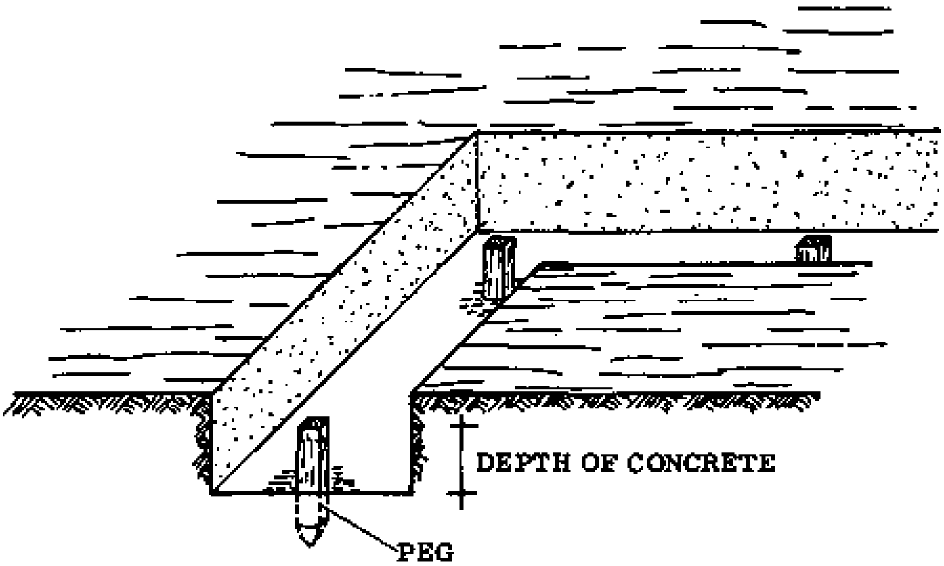


Fig. 3 HARKING THE DEPTH OF THE CONCRETE

If the exposed heights of the levelled pegs are not equal, that means the bottom of the trench is not level. The uneven spots have to be levelled by taking out some soil, until all the pegs project equally.

– NOTE: Never level the bottom of a trench by adding loose soil, as this might lead to uneven settlement which causes cracks in the structure. Trenches are always levelled by removing soil. If this means that the trench is deeper than planned, then either the foundation concrete has to be deeper or the height of the footings must be increased.

NOTES:

Foundation concrete

When the trenches are dug and the thickness of the concrete has been marked, the next step is to mix the foundation concrete. The proportions for the mix can be from 1:10 to 1: 15 (Reference Book, pages 166 to 170; and Tables of Figures, page 234).

Casting – Compacting – Levelling

If the work is done during the dry season, the sides and bottom of the trenches must be watered down before the ready–mixed concrete is cast. This keeps the soil from absorbing too much moisture from the concrete before it has set. The concrete is carefully poured into the trenches and compacted by tamping.

Rammers are used to compact the concrete (Reference Book, page 18). The heavy rammer is repeatedly lifted and dropped, compacting (packing together) the comparatively stiff concrete.

A strike–board (Reference Book, page 25) is used to level the concrete to the height of the pegs. A straight edge can also be used instead of the strike board.

If wooden trench pegs were used, remove them now and fill in the holes.

If iron pegs were used, they can be left in the concrete unless they are needed for another job.

Curing

Cover the top of the freshly cast foundation with empty cement bags or straw. This keeps it from drying out in the sun and air, and keeps the surface clean.

Once the concrete starts to harden, the top of the foundation should be kept wet.

NOTES:

FOOTINGS

The term footing is given to the courses of brickwork, stone or blockwork at the foot of a wall. The footing courses start immediately above the foundation and are laid flatwise. The rising wall is erected in the middle of the footing courses, so the footings, which are wider than the rising wall, project equally on both sides of the rising wall.

Purpose of footings

Two main functions must be fulfilled by the footings:

- They are the connecting link between walls and the foundation and act as an intermediate foundation for the walls, spreading the loads over a wider area of the concrete below.

- They raise the floor level high enough above ground level to keep water out during the wet season.

Height of footings

In Rural Building, the top of the foundations is usually at ground level, although they can be either above or below ground level depending on the subsoil.

When three footing courses are laid on top of the foundations, the soffit of the future floors will be 51 cm above ground level. This will meet the requirements of most situations.

If the building is in a valley, or in a place where the rain–water cannot run off quickly, the height of the footing courses must be increased.

NOTES:

HARDCORE FILLING

Hardcore filling is the compacted sub−base of floors; it consists of stones, broken sandcrete blocks or coarse gravel. It fills up the space between the subsoil and the soffit of the concrete floor.

Function of the hardcore filling

The hardcore filling has to carry most of the mass of the concrete floor, except for a small portion supported by the projecting inside edges of the footings. The filling must be well compacted to be firm enough to withstand the weight of the floors.

In addition, the hardcore filling must be built up in such a way that it prevents moisture from rising through it to penetrate the concrete floor.

Methods of filling and compaction

The topsoil is removed first (Figs. 1 & 2), then the hardcore filling is added in layers no more than 15 cm deep. Each layer is compacted very well before the next is added.

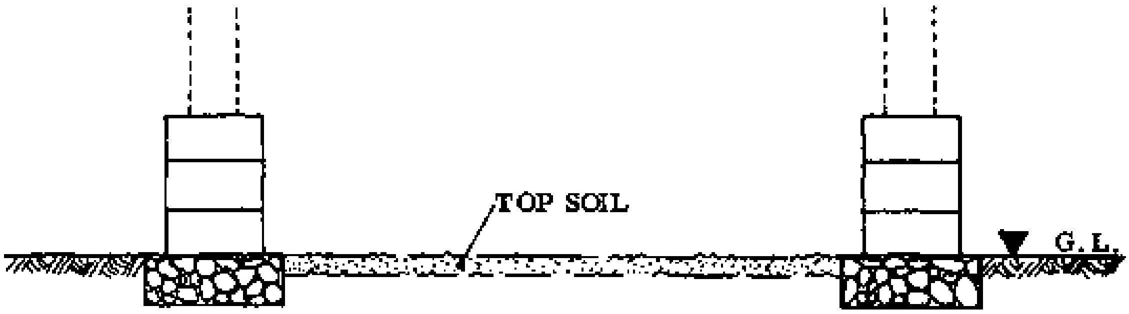


Fig. 1 FOOTING COMPLETED

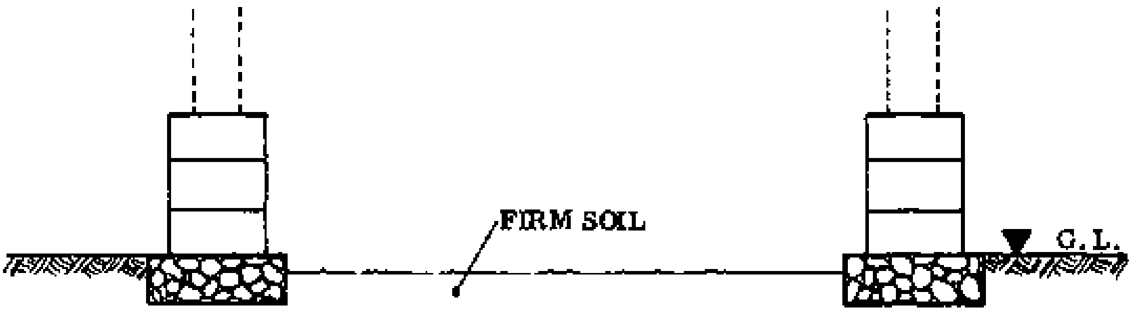


Fig. 2 TOP SOIL REMOVED

The bottom layer consists of small rocks, stones or broken sandcrete blocks. The second layer consists of smaller stones. Coarse gravel is used for all the remaining layers, up to about 6 cm below the tops of the footings. The last 6 cm or so is filled with fine sand, which seals off the surface so that no cement is wasted during the floor construction.

As can be seen in Fig. 3, the structure of the hardcore filling becomes denser and finer with each layer, starting from the bottom to the top. This is the correct way to protect the floor from the penetration of moisture.

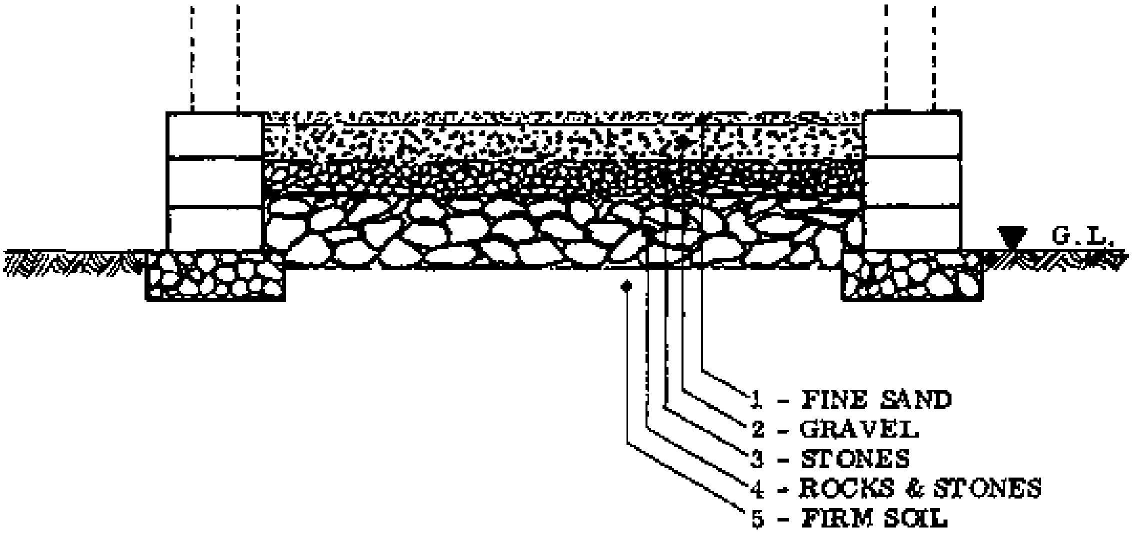


Fig. 3 HARDCORE FILLING

All layers are compacted with rammers. The coarse gravel can be watered down to ensure proper compaction and to ease the work. If there is a tractor available, it may be used to move the fillings and to speed up the heavy work.

NOTES:

PLINTH COURSE

The plinth is a slightly thicker course at the base of a wall or a column; often made of a more durable material than the rest of the wall or column.

In Rural Building, the plinth commonly consists of only one sandcrete course. The plinth course forms the first course of the rising wall immediately above the footings, and it is 1 cm wider than the landcrete blocks (Fig. 1). This 1 cm difference is evident from the inside face of the wall, but it is covered when the wall is plastered.

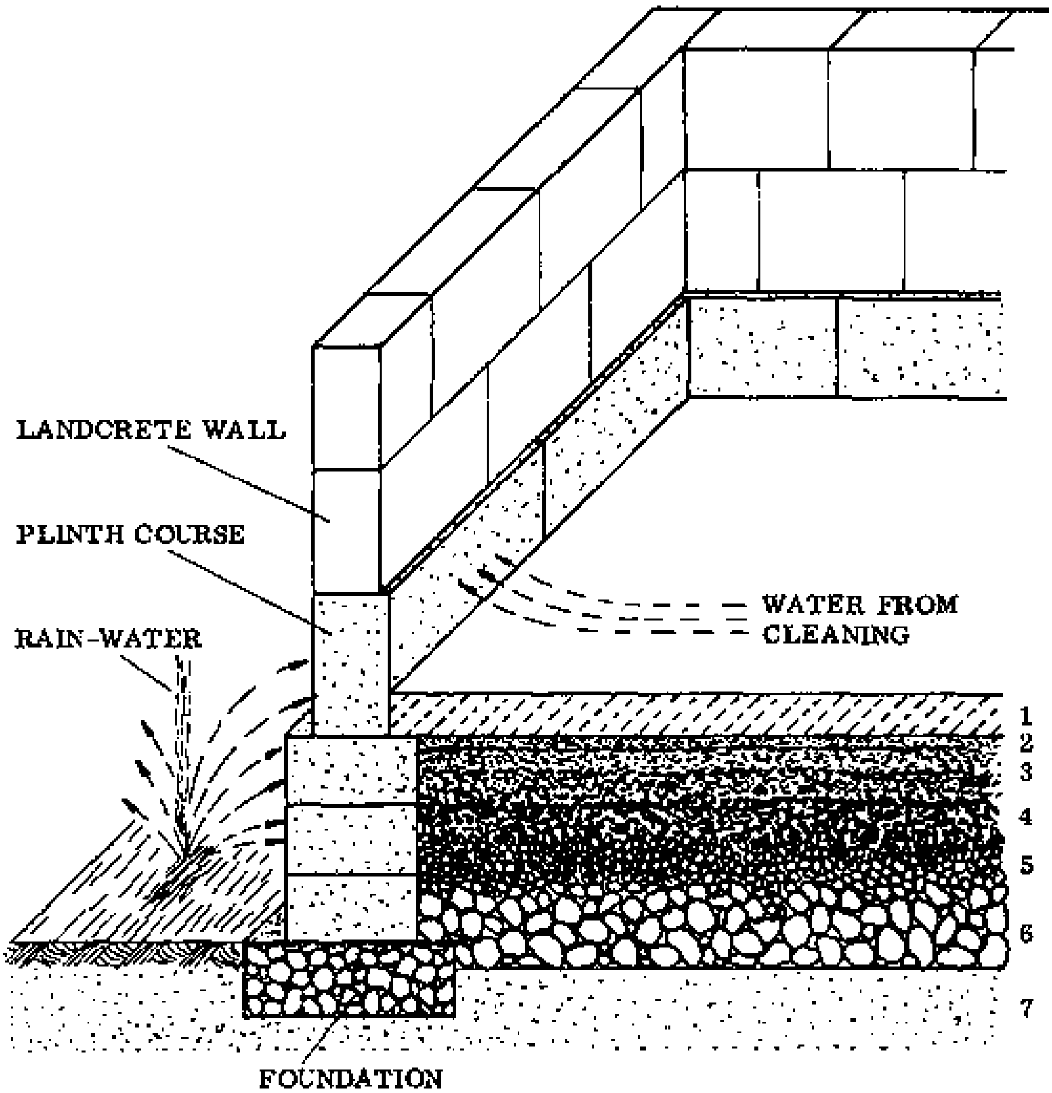


Fig. 1

1 – CONCRETE FLOOR
2 – FINE SAND
3 – FINE GRAVEL
4 – COARSE GRAVEL
5 – SMALL STONES
6 – ROCKS & STONES
7 – FIRM SOIL

Function of the plinth course

The plinth course raises the landcrete blocks above the finished floor level so that they cannot be penetrated by moisture (from outside by rain, from inside by water used for cleaning, etc.).

Although the landcrete blocks can withstand a skin–deep penetration of water for a short time, they must be protected against the long–lasting influences of the rainy season.

The most affected part of a building is always at the foot of the walls. Rain–water coming from the roof splashes up against the wall and creates a dirty strip about 60 cm in height, which is seen all along the footings. This area is more exposed to penetration by water than the rest of the wall, but the landcrete blocks are raised by the plinth course well above the endangered zone.

The illustration on the opposite page shows the possible paths which the water can take when penetrating the structure.

NOTES:

OPENINGS

An opening is a space in a wall left open for a door or a window. The first openings to be made in walls are the door openings.

Door openings

Before the plinth course is built, the door openings are marked in their correct positions on the footings.

In Rural Building, the door frames are usually made and set into place on the footings before the plinth course is built against the frames (Fig. 1).

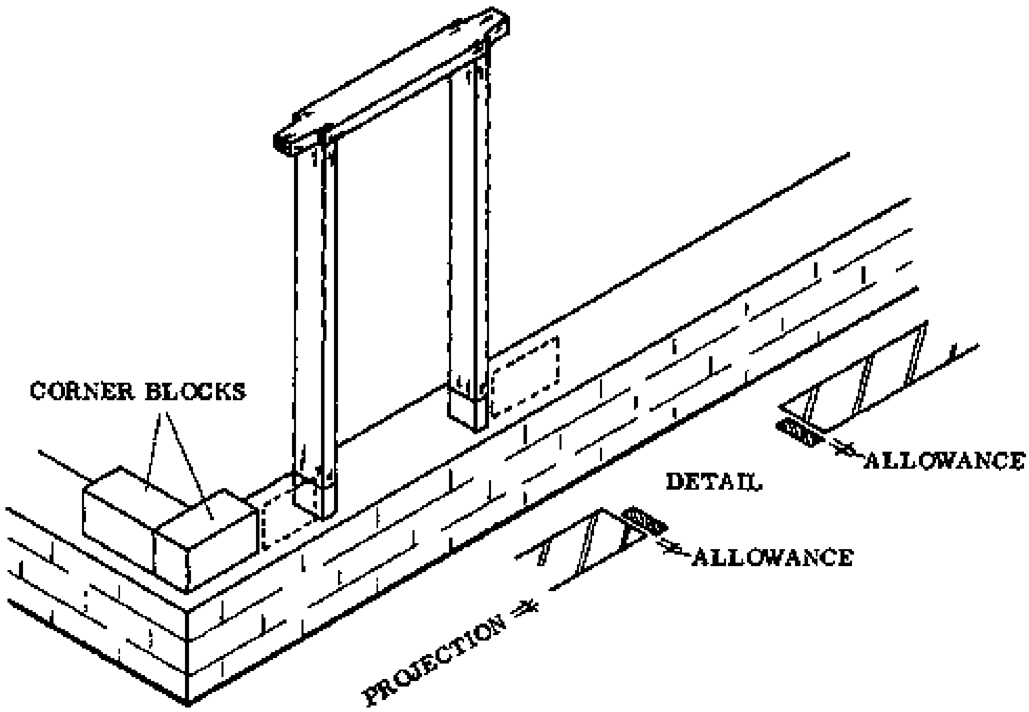


Fig. 1

If for some reason the door frames are to be installed later, the jambs of the openings (Fig. 2) are built up as described in the chapter on stopped ends, page 22.

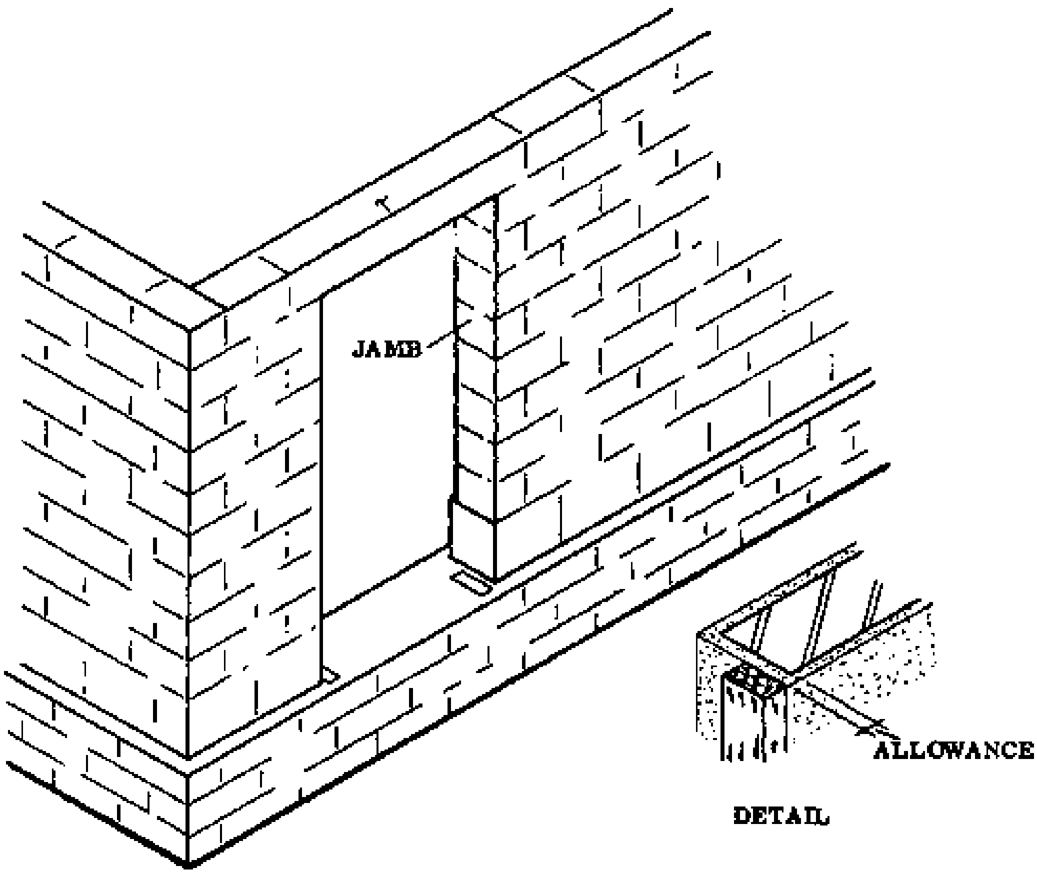


Fig. 2

A jamb is the portion of wall, or wall face, at the side of an opening. The jambs are built a little wider than the outside measurement of the frame (Fig. 2) so that the frame can fit into the wall opening.

Walling then continues until the window cill level is reached. This is the height where the window openings are set.

Window openings

The window frames are set and braced before the walling between them is completed. If the frames are to be set later, the window openings must also be built a little wider than the frames, so that the frames can be fitted in later.

In case the opening is to be filled with a decorative grille (Reference Book, page 193) or ventilation blocks (Reference Book, page 195), it is advisable to complete course by course including the special blocks.

This is done because it is easier than putting the decorative blocks into an opening later, and it provides the openwork screen blocks with more stability within the wall during construction.

NOTES:

SCAFFOLDING

A scaffold is a temporary structure which supports workers and materials during building and other work. It can be made of steel, aluminium, timber or bamboo.

According to their functions, there are three main types of scaffolds:

- Working scaffolds
- Protecting scaffolds

– Supporting scaffolds

Each type may be erected separately and serve only one purpose. Some situations however, require a combination of two or even all three types.

Working scaffolds

As the name indicates, the working scaffold is used for working from. It holds the worker at a height which enables him to comfortably complete walls etc. when the construction has proceeded to a level that makes it difficult to work from the ground. The following is a description of two simple scaffolds used to complete walling between door and window frames. Protecting scaffolds, supporting scaffolds and a number of more complicated scaffolds and their construction will be treated in the Construction Books.

– BLOCK SCAFFOLD: This is the lowest and simplest working scaffold. It is used to raise the worker a bit higher to make it easier to build the wall up to the actual scaffold height of 1,5 m. Set the sandcrete blocks on solid, level ground and lay one or two boards across them (Fig. 1).

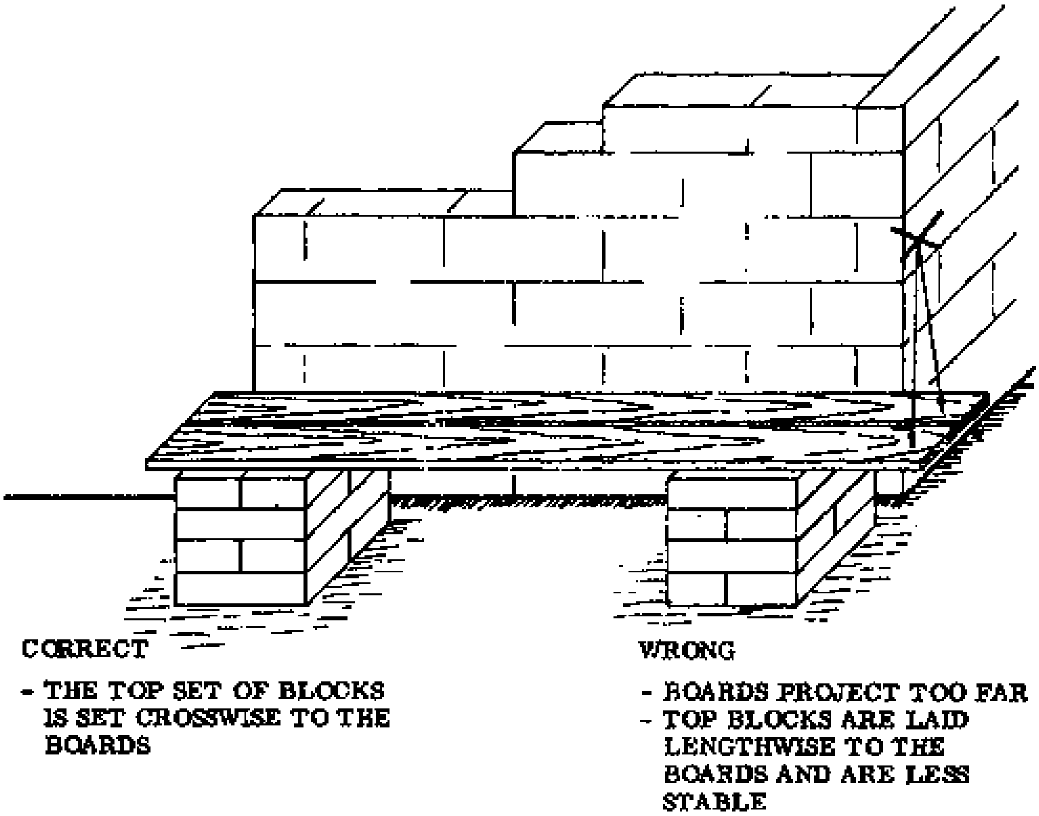


Fig. 1

– TRESTLE SCAFFOLD: This is a low–level scaffold, consisting of wooden trestles covered by two or three boards (Fig. 2). A trestle is a horizontal beam of wood with two legs on each end. Two or more of them are used to support the boards. Set them on firm, level ground, no further than 1,5 m apart. The height of the trestles can be from 75 to 100 cm. Small quantities of blocks and mortar can be kept on the platform. This scaffold enables the worker to continue walling up to lintel height, and to erect the formwork of the lintels.

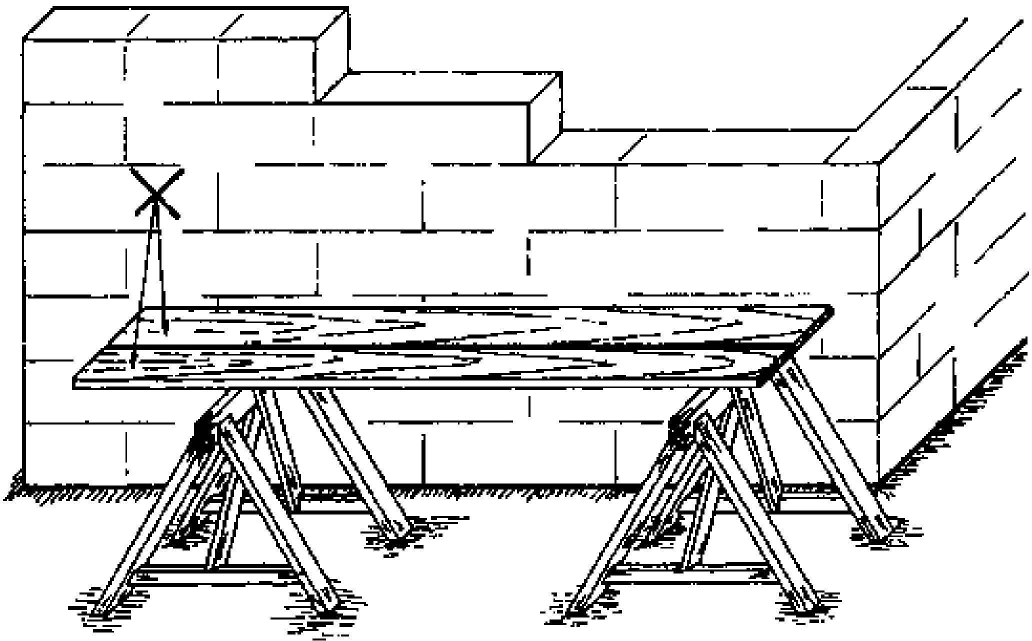


Fig. 2

NOTES:

Ladders

A ladder consists of two lengths of wood, metal or rope, called rails; which are connected at a certain distance from each other by rungs (Fig. 1).

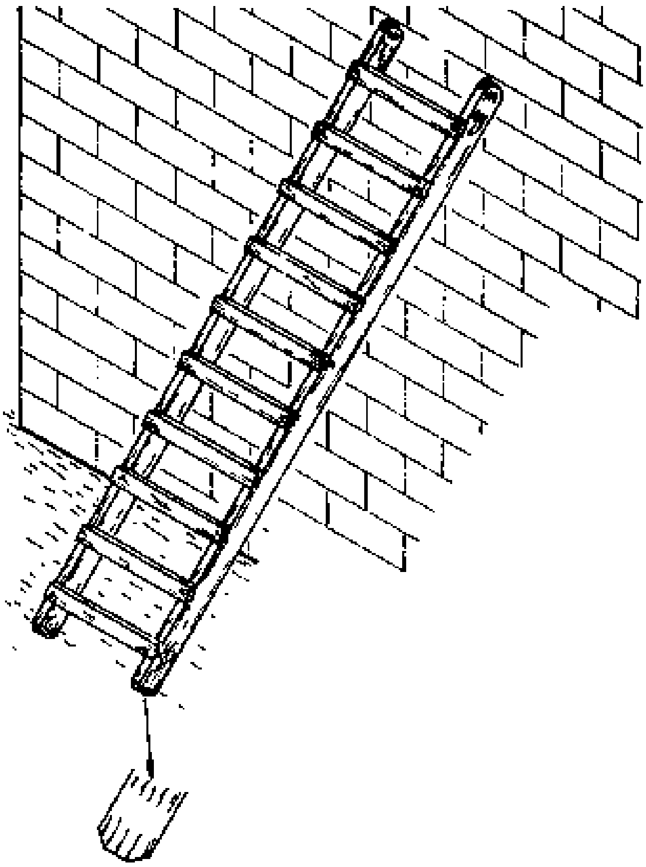


Fig. 1

Ladders are used to climb and descend scaffolds, walls, etc. during the construction of a building, and to do light maintenance work from later. Since such a piece of equipment is needed not only during the construction but also later in and around the house, it should be made from sound timber in a proper way so it can be used as a permanent ladder.

– CONSTRUCTING THE LADDER: Both the rails and rungs are made out of Odum. The dimensions of the two rails are 5 × 7,5 × 325 cm, while the ten rungs are 2,5 × 5 × 75 cm. The wood should be straight grained and planed to the above sizes.

Round the top ends of the rails where they touch the wall and cut off the foot ends as shown in Fig. 1, with a 45 degree bevel from each side. To prevent splinters and help the hands to move safely up and down the rails, round off all the edges. Incidentally, when climbing or descending ladders, keep your hands off the rungs. Grip the rear edge of the rails.

The over–all width of 75 cm gives an inside width of 65 cm which is wide enough to hold two scaffold boards on the rung. Later we will discuss making a ladder scaffold, in the Construction Book.

The distance of 30 cm between the rungs must not be exceeded, as a wider spacing would make it difficult to climb the ladder.

The rungs are inserted in notches cut in the rails, and fastened by using 75 cm nails as shown in Fig. 2.

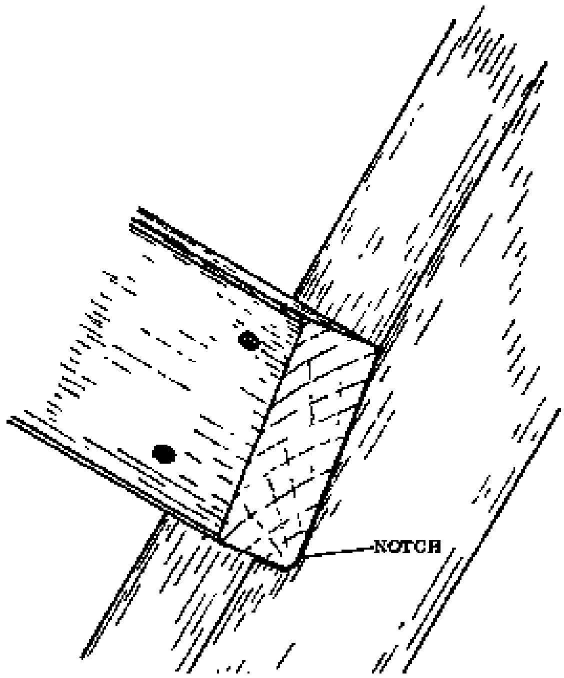


Fig. 2 ENLARGED DETAIL

Sometimes ladders are reinforced by fastening iron rods, threaded at both ends, through both rails behind the first, centre, and last rungs. The rods are held in place by nuts on the threaded ends.

– NOTE: A good ladder should be treated with oil or another preservative. Dried–out wood is the greatest threat to the safeness of the ladder. Always keep ladders in the shade when they are not in use.

NOTES:

BRIDGING OPENINGS

To bridge something means to connect the two sides or parts. This can be done in building with a structure of wood, stone, block work, steel or concrete. The essential thing is that the door and window openings must be safely bridged so that the walls above or other members of the structure cannot collapse and damage the house or the people inside.

Methods of bridging

There are various ways of bridging an opening. Which one of these is used depends on the distance to be bridged, the shape of the opening and the materials available.

One method which was common in former times was to make the openings so small that a single stone could be laid across them (Fig. 1). Openings which are low enough can also be bridged by inserting supporting blocks arranged like a “V” (Figs. 2, 3, & 4). This method is still common in the dry areas of Africa.

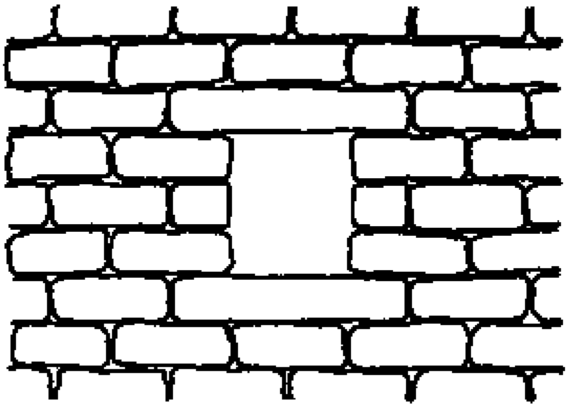


Fig. 1

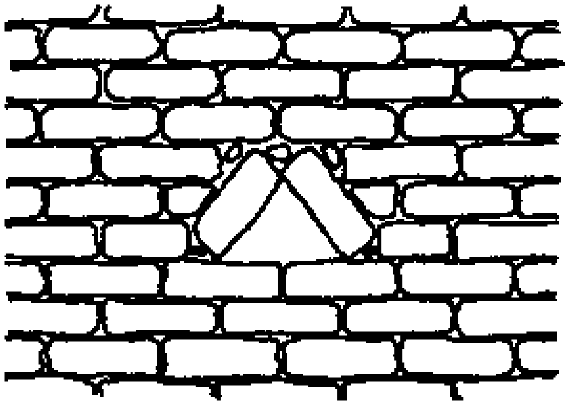


Fig. 2

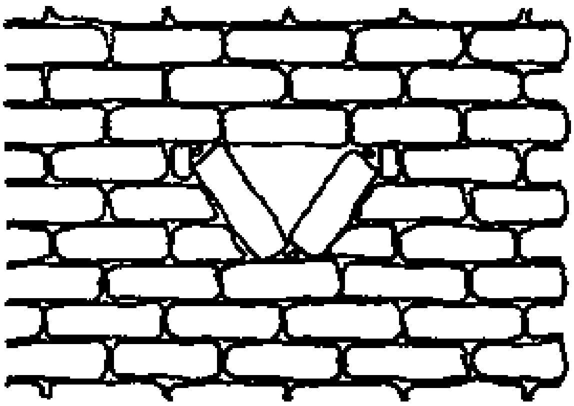


Fig. 3

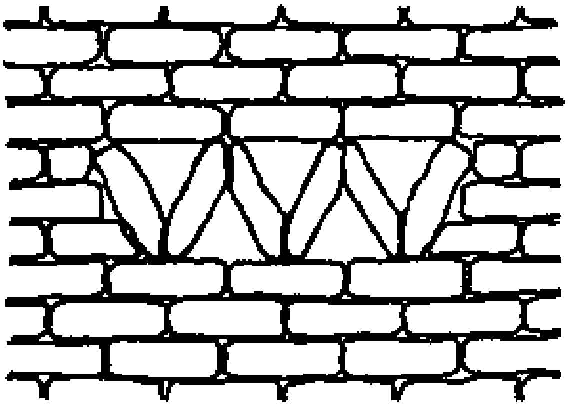


Fig. 4

The wider an opening becomes, the more difficult it is to bridge. Builders from many parts of the world eventually learned that if the blockwork remains closed above an opening, both sides of the wall will support each other, maintaining stability. This knowledge was often applied not only to bridge openings but also to construct roofs. The technique was to let each course overlap the one below until the blockwork met at the top and the two sides bonded into each other (Fig. 5).

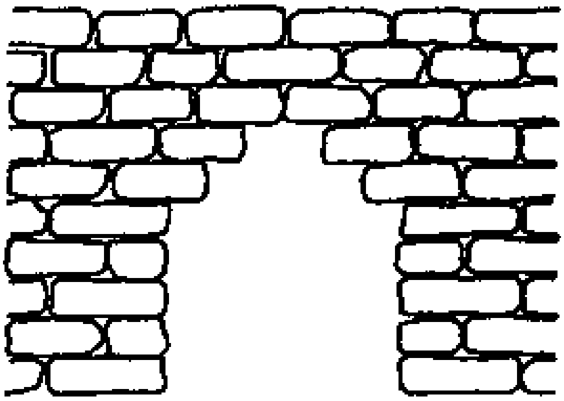


Fig. 5

From this simple method, arches were the next development. They are much stronger and have a more attractive appearance (Fig. 6).

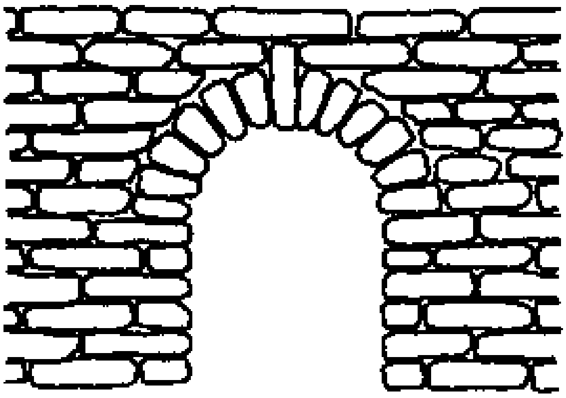


Fig. 6

Lintels were introduced in order to produce a square opening into which a frame could be fitted.

NOTES:

Built−up wooden lintel

A lintel, whatever material it is made from, is a horizontal member of the structure which bridges an opening (Fig. 1).

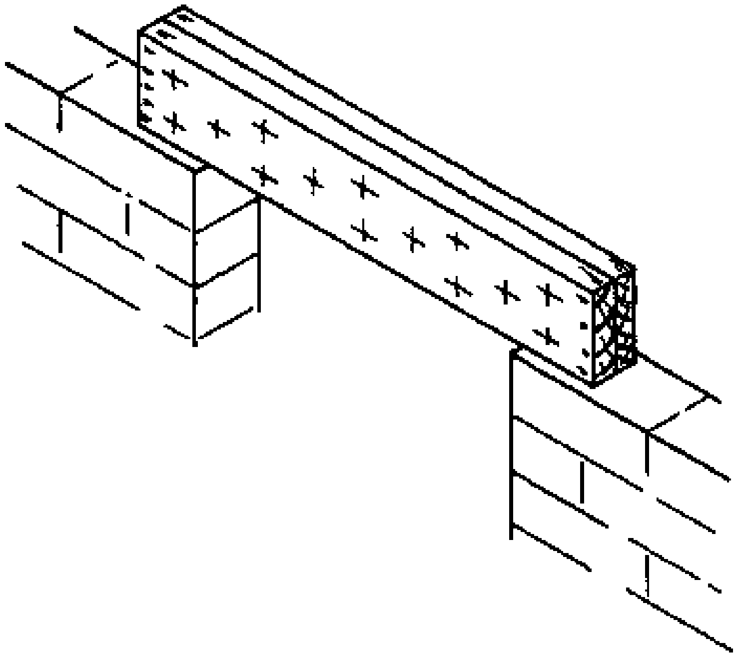


Fig. 1 BUILT−UP WOODEN LINTEL

Its function is to distribute the weight of the blockwork above and any other loads to the supporting walls. With a lintel the opening of the door or window can be lower than with an arch, and it is also easier to fit a frame into the opening.

For short−span openings such as doors and smaller windows which have no additional loads above, the wooden built−up lintel can be employed.

This lintel consists of two or more hardwood boards which are nailed, bolted or screwed together (Fig. 1). In order to save materials when a wider lintel is required, the boards are sometimes connected with spacers between them (Fig. 2).

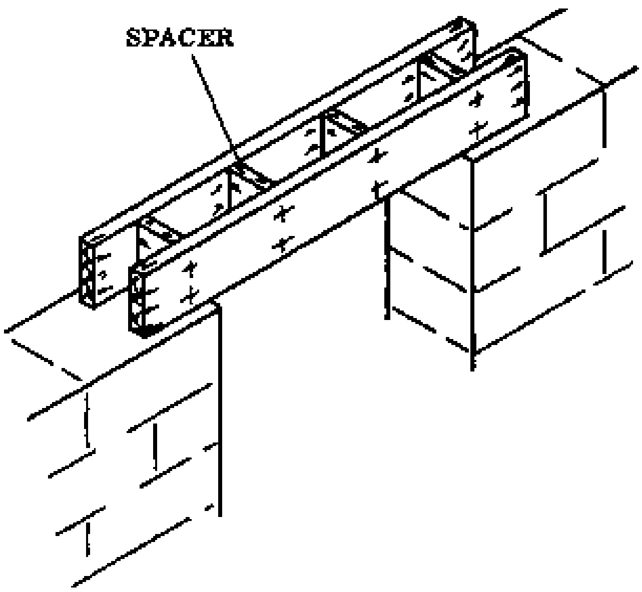


Fig. 2 WIDE BUILT−UP WOODEN LINTEL

For long−span openings and in situations where additional loads are present, arches or reinforced lintels are used.

Reinforced concrete lintel

Like the human body which is strengthened by bones, reinforced concrete is made stronger by the steel bars or metal netting embedded in it.

It is known that concrete alone can withstand enormous pressures, but if it is exposed to tensile stresses it will break (Reference Book, pages 168 & 169). Fig. 3 shows that a long board supported only on its ends will bend if weight is set on it. Similarly, a pure concrete lintel will try to bend under a heavy weight, but because the concrete is not flexible this will result in cracks forming across the soffit face, or even in collapse (Fig. 3).

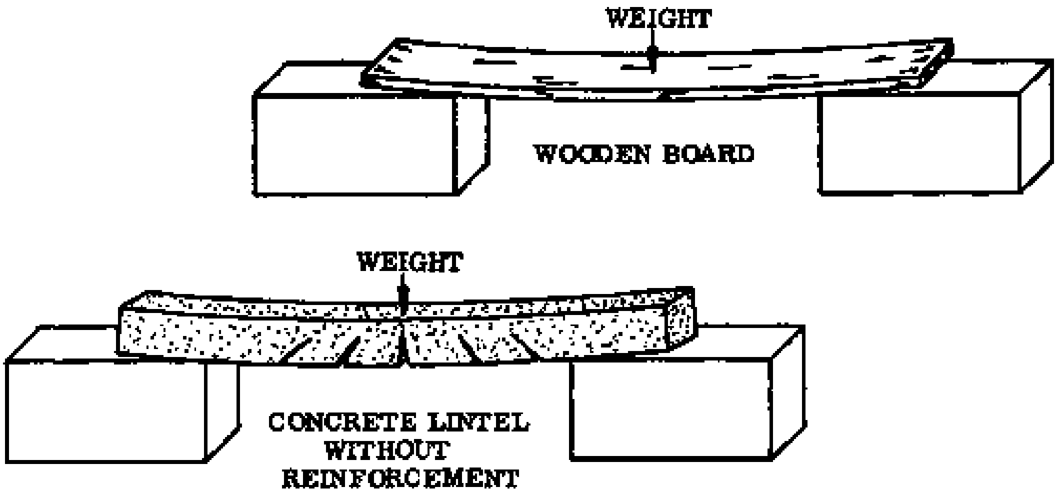


Fig. 3

To prevent this, reinforcement bars are embedded in the concrete if the lintel is expected to receive tensile stresses. The combination of concrete and steel does the job where one of them alone would not work: the concrete resists all pressure while the embedded steel resists all stresses.

The reinforcement for a lintel consists of several members with different diameters, shapes and functions. The members are often assembled beforehand in the form of so−called cages (see Fig. 1).

NOTES:

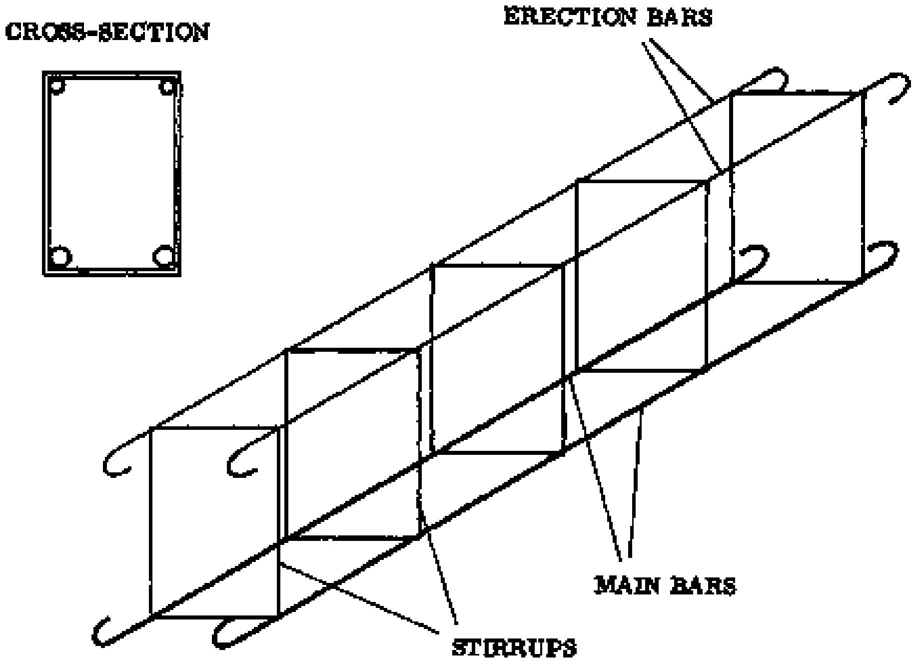


Fig. 1 REINFORCEMENT CAGE

– REINFORCEMENT CAGE: A typical reinforcement cage is shown in Fig. 1. The lower bars are the main bars. They are normally 12 mm in diameter be cause they do the actual strengthening of the lintel. The upper bars are thinner and are called erection bars. Since their main function is to hold the cage together, their diameter is only 6 mm. The square–shaped pieces are called the stirrups. They hold the main bars and the erection bars in position. All the different members are bound together with binding wire.

– CUTTING: All reinforcement bars have to be carefully measured and marked off before they are cut. A well equipped building site will have two different sized bolt cutters available. One is to cut the bars ranging from 4 to 10 mm in diameter and one is for bars up to 19 mm. If bolt cutters are not available, a hacksaw or a chisel may be used instead (Reference Book, page 19).

– BENDING: The bars are bent with the aid of the bending plate which is fixed on the work bench; and the bending bars (Reference Book, page 23). Each diameter of bar has to be bent with a specific size of bending bar.

– The bending is done according to a certain radius (this refers to the sharpness of the bend) in order to prevent overstraining and cracking of the bar (this will be explained in more detail later). The stirrups for the cages may be bent around a peg that has the same diameter as the main bars.

– BINDING: The members must be bound together in order to ensure that the bars remain in the correct positions while the concrete is being poured. Binding wire is bound around pieces at the connections (Figs. 2a & 2b). The wire should be stretched taut and then twisted tight with the pincers.

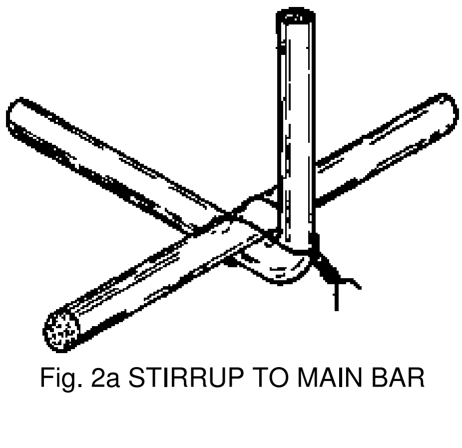


Fig. 2a STIRRUP TO MAIN BAR

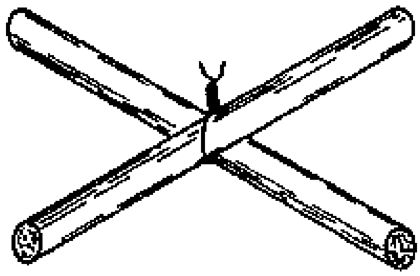


Fig. 2b BINDING OF CROSSING BARS

– NOTE: Examine the bars before you use them to make sure that they are free from paint, grease, loose scale or mud. Slight rusting will do no harm, but any loose rust should be removed.

For additional information on concrete and reinforcement steel, see the Reference Book, Materials and Products sections.

NOTES:

Formwork for a reinforced concrete lintel

The form is simply a temporary box into which the freshly mixed concrete is cast and kept until it has hardened. The inside shape of the box will be the outside shape of the concrete member.

All parts and members of a formwork used for casting reinforced concrete lintels are shown in Fig. 1 on the opposite page. The parts are nailed together in such a way that they can easily be taken apart after the concrete has hardened.

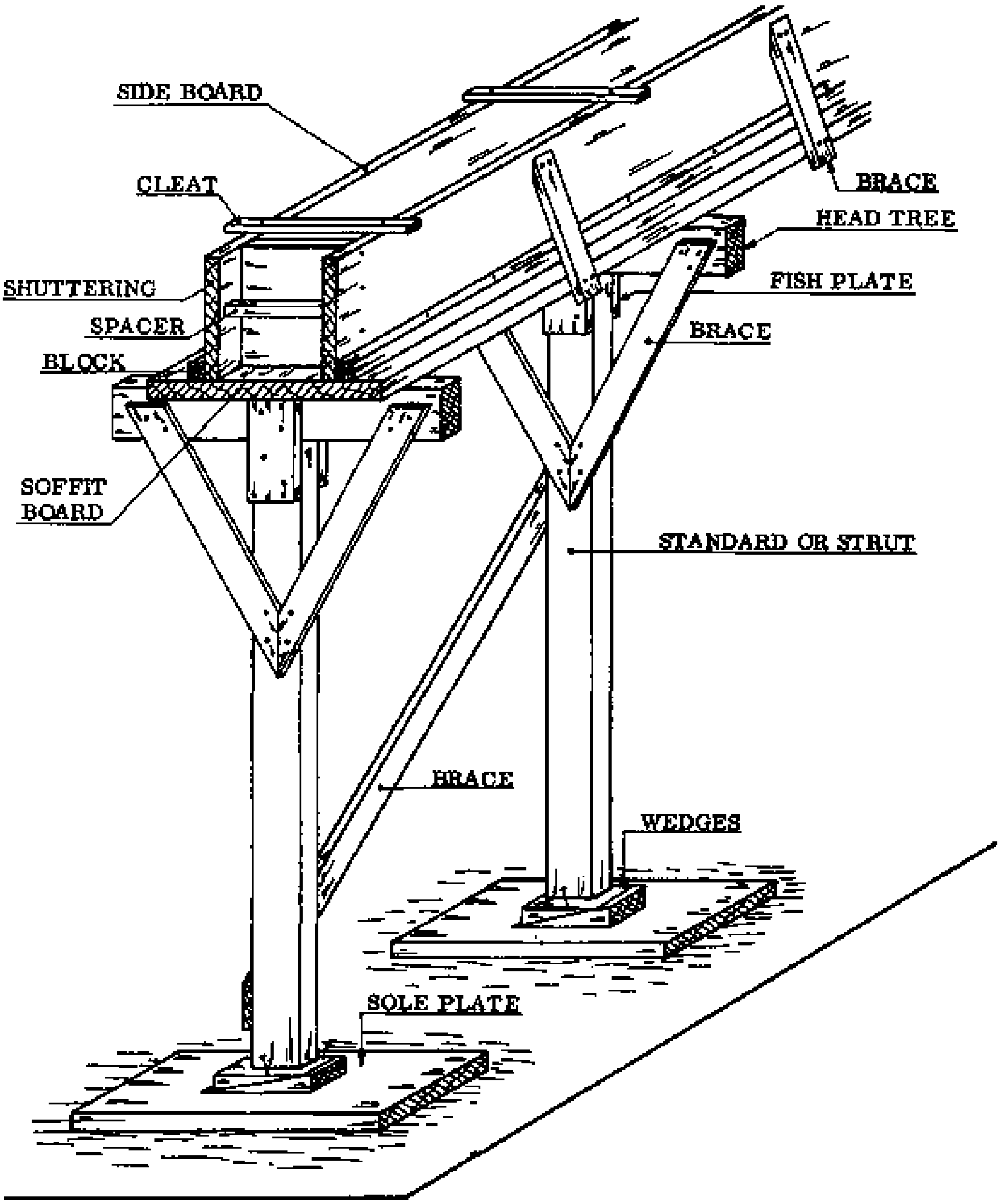


Fig. 1

Formwork is made of wood or metal and consists of two structural parts: the shuttering and the strutting.

– SHUTTERING: The shuttering is the actual shaping part of the formwork which is in direct contact with the concrete. Usually Wawa boards are used for shuttering because they are soft and light–weight, thus easy to work with.

– STRUTTING: The strutting is the supporting and bracing part of the formwork. It keeps the shuttering in position and supports both the shuttering and the concrete inside it until the concrete has set hard. Odum boards are usually used for the strutting because they are harder and stronger than the Wawa.

– CONCRETE COVER: Concrete cover, also called clear cover, is the thickness of concrete between the surface of the concrete and the nearest reinforcement bar enclosed in the concrete (Fig. 2).

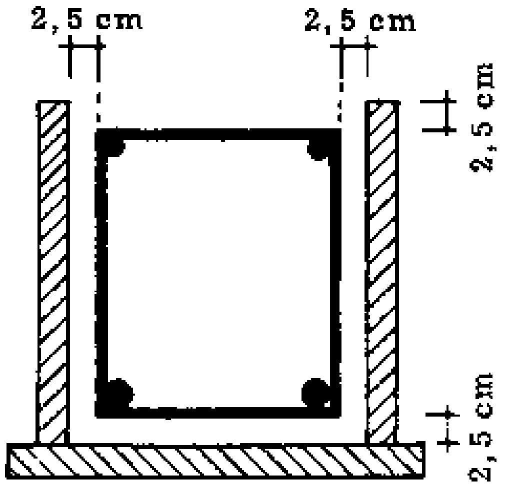


Fig. 2 CLEAR COVER

When the formwork is ready, the reinforcement cage is set into it. Spacers are attached to the bottom side of the stirrups (Fig. 3). These ensure that the reinforcement bars are correctly positioned within the concrete. The spacers are made beforehand out of cement mortar to the dimensions specified for the concrete cover thickness. A short piece of binding wire should be pressed into the fresh mortar of the spacer, so that it can be fixed properly on the rod.

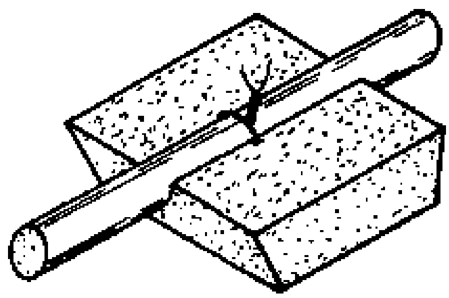


Fig. 3 DOVETAILED SPACER

There must also be spacers on the sides of the cage, to hold the stirrups away from the side boards of the shuttering.

– NOTE: When casting concrete, take care that the cage remains in position and that the concrete is well compacted around the reinforcement bars.

NOTES:

Casting reinforced concrete lintels

Concrete lintels are made in two ways. They are either cast–in–situ or they are precast.

– CAST–IN–SITU: This method is the most common one in Rural Building. The lintel is cast in situation; in the place where it is needed (Fig. 1). The advantage of this method is that no soffit board is needed for the form, because the head of the door frame acts as the bottom of the form, provided that the frame has been installed already. A further advantage is that any roof anchorage, if needed here, can easily be inserted into the reinforcement cage at the correct position.

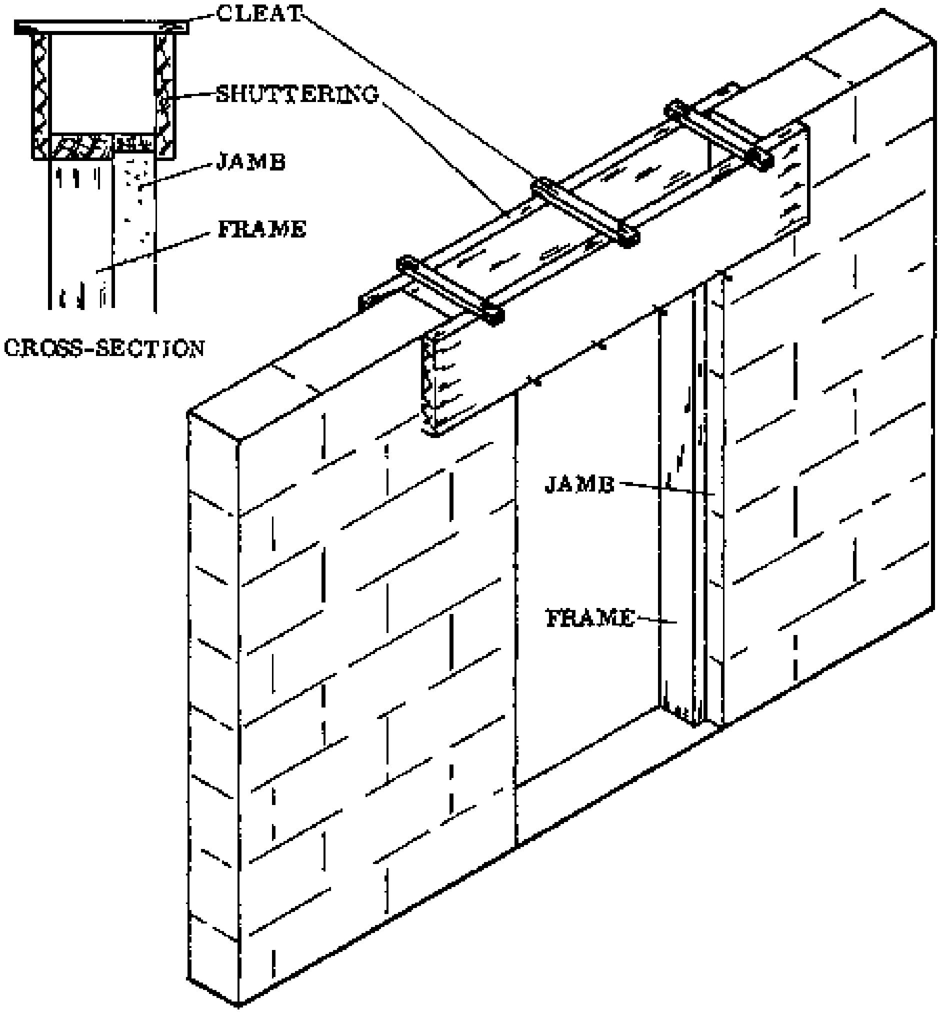
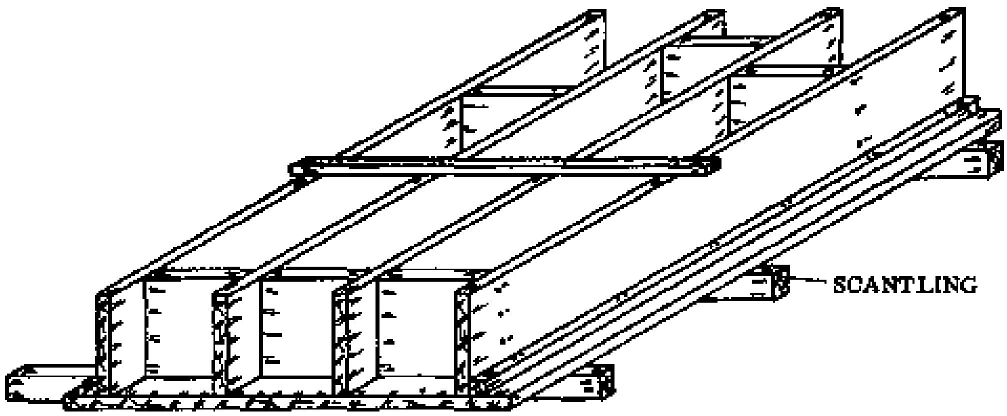


Fig. 1 CAST–IN–SITU

– PRECAST: A precast concrete lintel is a lintel which is made in advance. The formwork is on the ground and the concrete is cast there. When the construction reaches lintel height, the concrete lintel has set hard and can be set into position. The advantage of this method is that it saves time, since the wall above can be completed immediately after the lintel has been laid (Reference Book, page 137).

If several lintels have to be made, a form like the one shown in Fig. 2 can be used.



FORM FOR SEVERAL LINTELS OF DIFFERENT LENGTHS

Fig. 2 PRECAST

– NOTE: Precast concrete lintels must be marked on their top face with the letter "T" to ensure that they are placed in the correct position and not upside–down.

– PREPARATION OF THE FORMWORK: No matter which of the above methods is used, the formwork has to be prepared before the concrete is cast. This involves cleaning dirt and dust from the surfaces which will be in contact with the concrete, and watering or oiling them.

The formwork must be completely sealed so that no gaps remain for the cement paste to escape. This would result in voids and weak concrete.

– COMPACTION: The concrete is filled into the formwork in layers, and compacted by tamping with an iron rod or the trowel. Tapping lightly on the formwork with a hammer also helps to consolidate the concrete.

– CURING: When the concrete is starting to get hard, the lintel must be kept wet and covered. This process is called curing and must be continued until the concrete is completely set and the formwork can be removed.

NOTES:

– STRIPPING: Stripping refers to the removal of the formwork; this has to be done carefully to avoid causing shocks or vibrations.

After the formwork is removed, clean all the parts of it and remove the nails. Stack the different parts neatly to keep them from getting bent or warped.

– STRIPPING TIME: This is the period between the casting of the concrete and the time the formwork can be stripped off. During this time the formwork containing the fresh concrete must not be disturbed, so that the concrete can set hard without any cracks forming in it.

Depending on the size, shape and position of the concrete member, the stripping time varies from 4 to 28 days.

NOTES:

ROOFS

Anchor beam

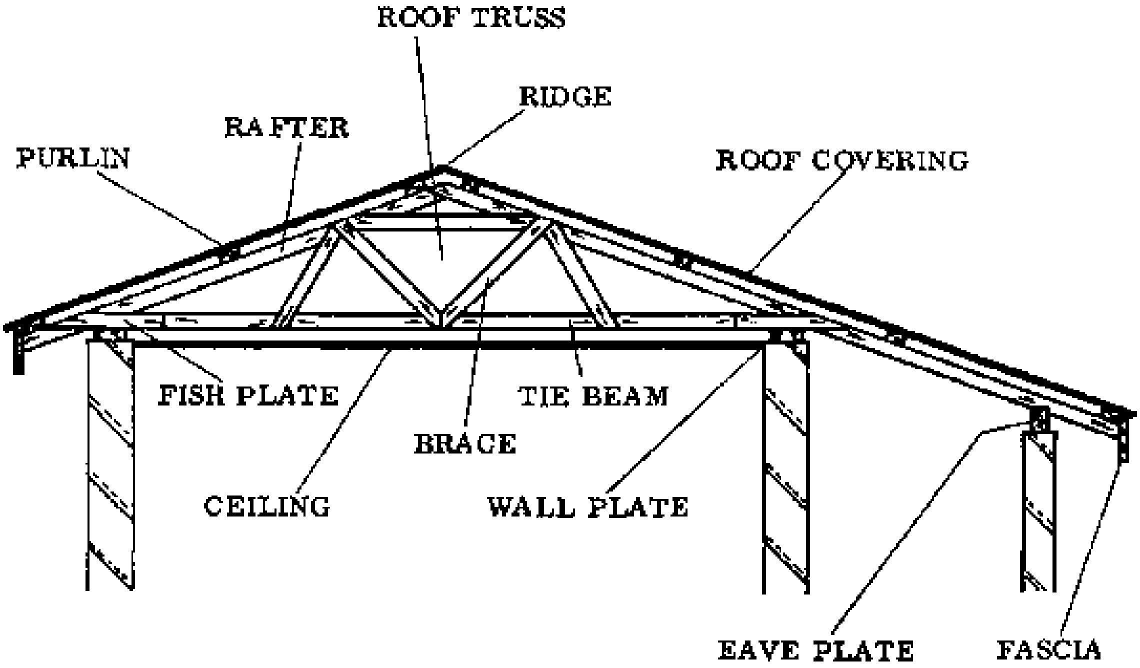
When the walling above the lintels is completed, the top of the wall may be covered with a strip of reinforced concrete, all around the outside walls of the house. This is the anchor beam, where the roof construction is anchored. It is also known as the ring beam or concrete belt.

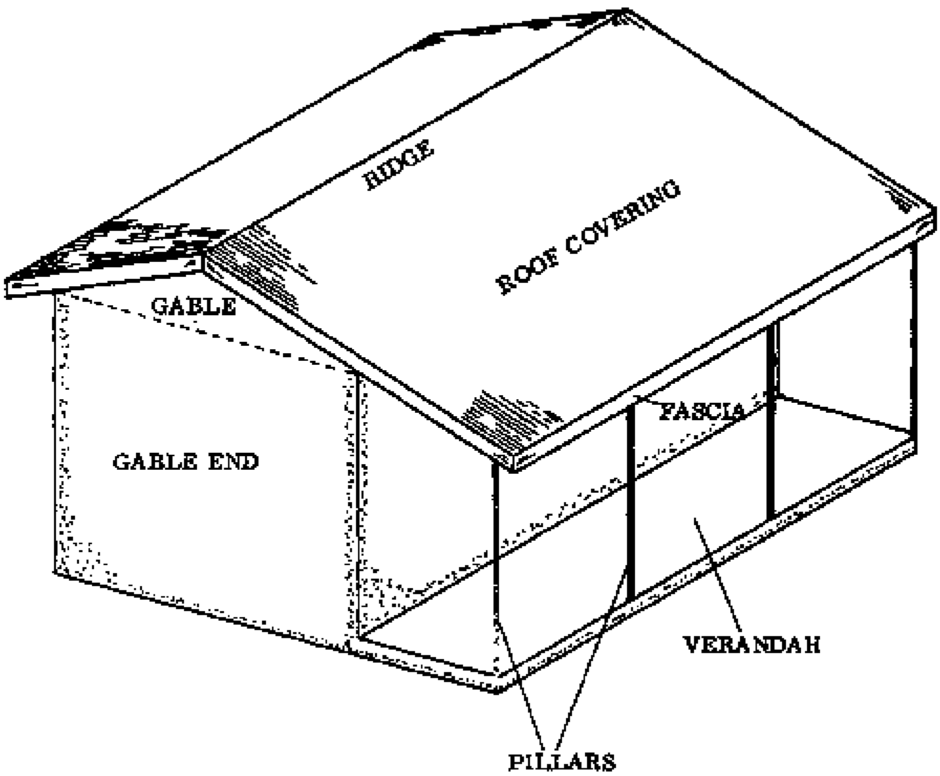
Wall plate

For smaller spans, the Rural Builder can install a wooden wall plate instead of an anchor beam. Both of these are explained further in the section on roofs in the Construction Book.

Terms

On this page and the next page, most of the parts and members of the roof construction are mentioned. The details of roof construction are dealt with in the Construction Book.





NOTES:

PLASTER – RENDER

Plaster and render are mortars with different mix proportions; they are applied to walls to protect the blocks from weather etc.

Internal surfaces are plastered; the mortar used is called plaster. External surfaces are rendered; the mortar is called render.

Functions of plaster and render

Since most of the wall consists of landcrete blocks, it has to be rendered to make it weatherproof, and to protect the blocks against rain which otherwise quickly damages them. The ideal rendering will prevent water from penetrating, will be free from cracks and will stick tightly to the wall. At the same time, the appearance of the building is improved.

The function of plaster is to give the inside walls a smooth, plain finish so that the rooms both look nice and are easily cleaned. No gaps or holes should remain for insects, spiders, etc. to find shelter in. Wet areas such as bathrooms, showers, kitchens and toilets, are plastered to protect the landcrete blocks from moisture penetration. In addition, the plaster serves as a protection against fire in buildings which are made out of a wood skeleton covered with mud (a common construction in southern Ghana).

Application

The application of the plaster can be done with one coat or two coats. Generally one coat work is done, but two coats may sometimes be required, for example when the wall is very uneven and a thick plaster coat is needed to cover the irregularities.

Sometimes a spatterdash coat is applied to the wall before the plaster, to give a good grip to the plaster. This is discussed on page 176; see also the Reference Book, page 29.

NOTES:

Plastering or rendering

Before the plaster or render is applied, the wall should be thoroughly checked to make sure that it is plumb and its surface flat. Holes and hollow parts should be filled in, and single projecting blocks must be chiselled off. The latter problem can often occur on the inside of walls due to irregularly made blocks.

The face of the wall should be free from loose dirt and dust, and it must be well dampened to reduce the absorption of moisture from the mortar.

On outside corners, so−called edge boards are fixed so that they project past the edge by a distance equal to the thickness of the coat to be applied (Fig. 1).

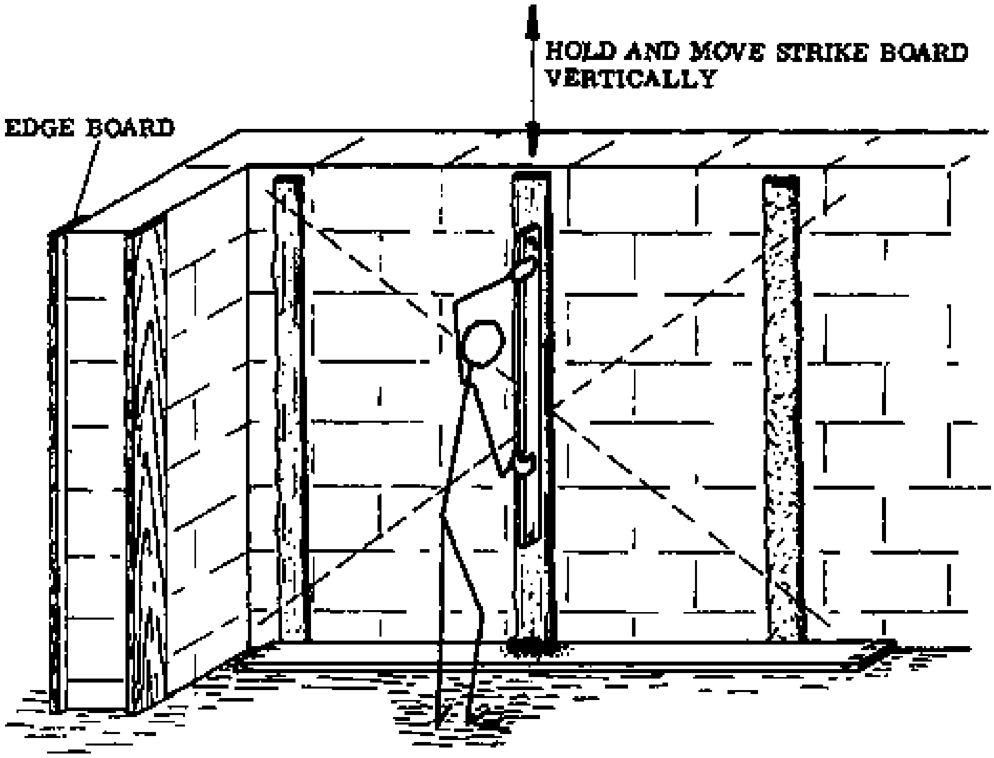


Fig. 1 PREPARATION OF SCREEDS

On inside walls and between edge boards, screeds are prepared according to the required thickness; they are situated as wide apart as the strike board (Reference Book, page 25) can readily bridge.

A screed is a strip of plaster or render which is carefully applied to the correct thickness to act as a guide for the strike board. In making the screeds, hold the strike board vertically and give it an up and down motion as you move it across, smoothing the screed (Fig. 1). The screeds will be flush with the finished surface and must be carefully plumbed and lined out (Fig. 1).

A board can be laid close along the bottom of the wall so that any mortar which is dropped can be picked up again, to avoid wasting material.

When the screeds are ready, the plaster can be applied as shown in Fig. 2. For this step the strike board is held horizontally and moved from side to side as it is pushed up the wall, smoothing the plaster.

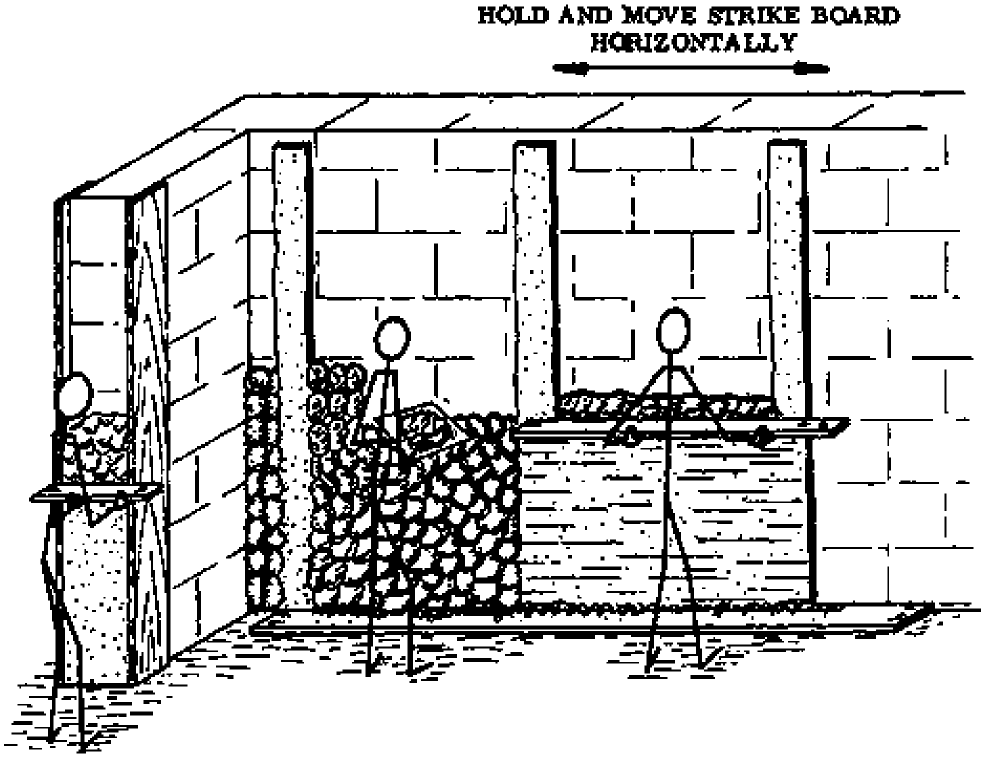


Fig. 2 APPLYING PLASTER

The aggregates

Regardless of where the sand for the plaster or render comes from, it must be clean and suitably graded (Reference Book, page 159, and pages 147 to 151).

Sand for rendering should be sharp and well graded, from fine to very coarse. The mortar may be difficult to apply, but nevertheless this is the best way to get a rendering that will not crack and let water in.

Sand for plastering should be well graded, from fine to fairly coarse; and for a finishing coat from fine to medium. Well graded sand reduces the drying shrinkage and cuts down the danger of cracking and crazing. Crazing means the formation of hairline cracks on the surface of concrete, plaster or render; usually it is caused by too much water in the mix, or by a too rich mix.

Mix proportions

In Rural Building, most of the mortars used for plaster and render are cement mortars, because lime is not always available.

The mix proportion for plaster ranges from 1:8 to 1:12, depending on the condition and grading of the sand. Both coats should have the same strength as far as possible if two coats are applied.

The mix proportion for render can vary from 1:6 to 1:10. It is generally agreed that the sides of the house which are exposed to rain should have a better mix. However, the mix proportion should never be better than 1:6, and should be adapted if possible to the strength of the background (Reference Book, pages 158 to 165).

Additional protective measures

When the plaster or render has set hard and has dried, it is advisable to paint the whole surface with emulsion paint (Reference Book, page 201).

If lime is available (Reference Book, page 152 and page 200) the walls are first white−washed to fill up the tiny holes in the surface. After this the emulsion paint is applied in two coats. The paint prevents water from penetrating into the plaster or render; reflects light and thus keeps the walls cooler, and gives the house an attractive appearance.

When emulsion paint has dried, it will not dissolve in water, so it can easily be cleaned with water and a soft brush.

− REMEMBER: Sand for plaster and render should be clean, properly graded and as coarse as is appropriate for the particular application.

Joints should be carefully raked out while the mortar is still fresh, so that the plaster or render can grip well. Another method is to apply a spatterdash to the wall to give a good grip to the plaster or render.

No coat should be richer than the coat underneath it. If you have to make two of different strengths, then the undercoat should be stronger than the finishing coat. Try to avoid making two coats of plaster or render, because it is difficult to get a good connection between the two coats. The spatterdash is not a coat, it is a background for the plaster or render.

NOTES:

Spatterdash

Spatterdash can be used to produce an attractive appearance, or it can be applied before plastering in order to make a good surface for the plaster or render.

Spatterdash is a wet, rich mix of cement and sand, called a slurry. This sand and cement is mixed to a proportion of 1:1,5 or 1:3. This slurry is thrown hard, or spattered, against the smooth block or concrete surface, and then allowed to harden (Fig. 1).

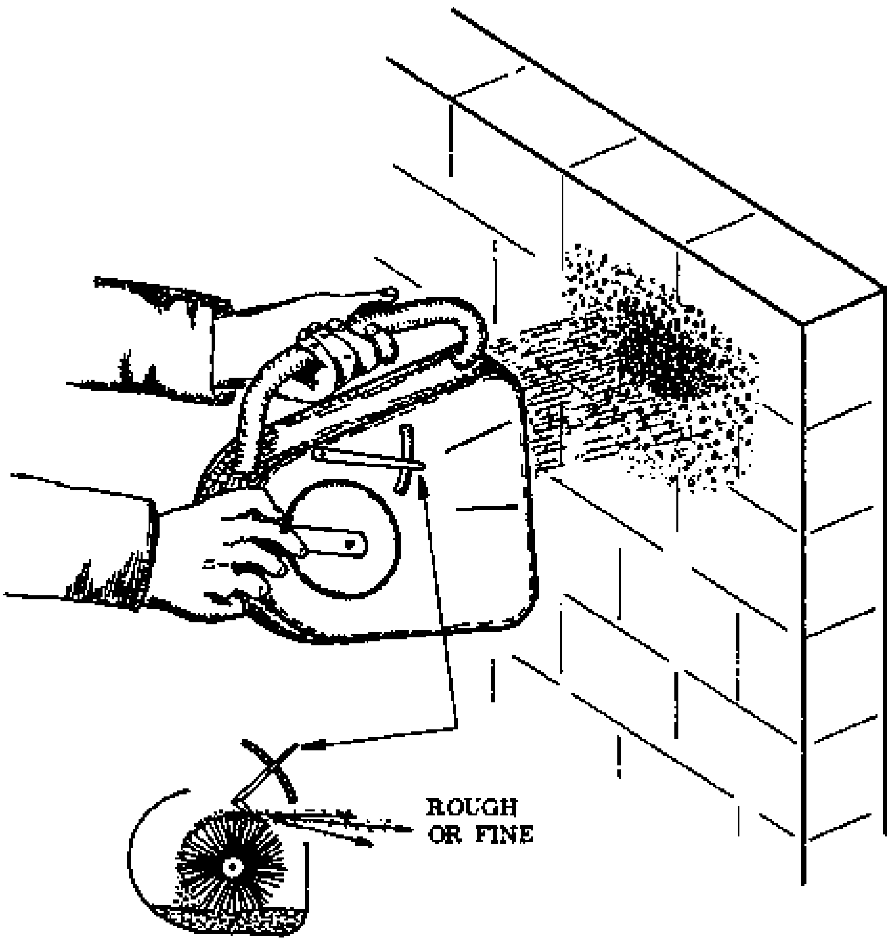


Fig. 1 & Fig. 2 FLICKER BAR

When you work with this hand operated machine (Reference Book, page 29), do not overload the machine with material. It is better to use small quantities at frequent intervals. All of the slurry must be used within 1 hour of the time it is mixed.

Do not set the flicker bar adjuster beyond the second notch when the machine is new. Only when the bar wears out should it be set to a lower notch (Fig. 2).

FLOOR CONSTRUCTION

The dry climate in the north of Ghana makes it advisable to construct the floor after the roof covering has been completed. This makes it easier to cure the concrete, and to make sure that the floor sets hard without cracking due to excessive drying. There are various methods to construct floors. In Rural Building the main ones are: one−course work, and two−course work.

One − course work

This means that the final surface finish is completed before the base layer has set hard. The result is a monolithic floor construction; which means that the floor throughout can be considered as one solid mass (Fig. 1). The advantage of this method is the short construction time, using a minimum of materials, and no separation between the top layer (screed layer) and the base layer.

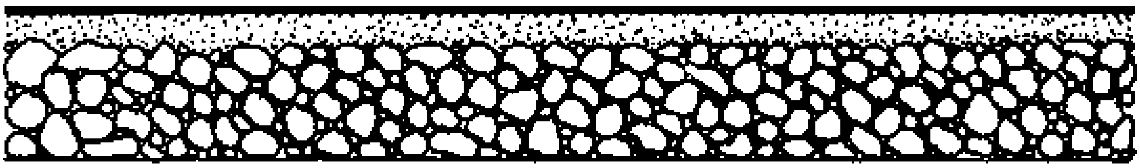


Fig. 1 ONE − COURSE WORK

Two − course work

This means that the base layer and the finish layer are constructed separately. After the base layer has set hard, a floor screed is applied. This is a fine−grained mortar layer, about 2 cm thick, laid to finish the floor surface (Fig. 2).

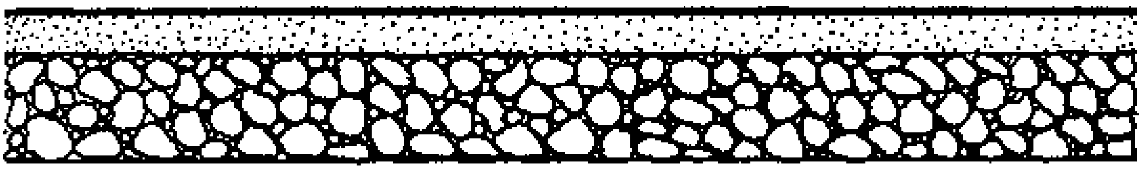


Fig. 2 TWO − COURSE WORK

The advantage of this method is that any faults in the base layer, such as cracks, can be covered. However, it takes longer to construct and requires more cement. Another disadvantage is that it can be difficult to get a good connection between the base layer and the floor screed. The base layer should be carefully treated with cement and water to form a good connection between the floor screed and the base layer.

Casting methods

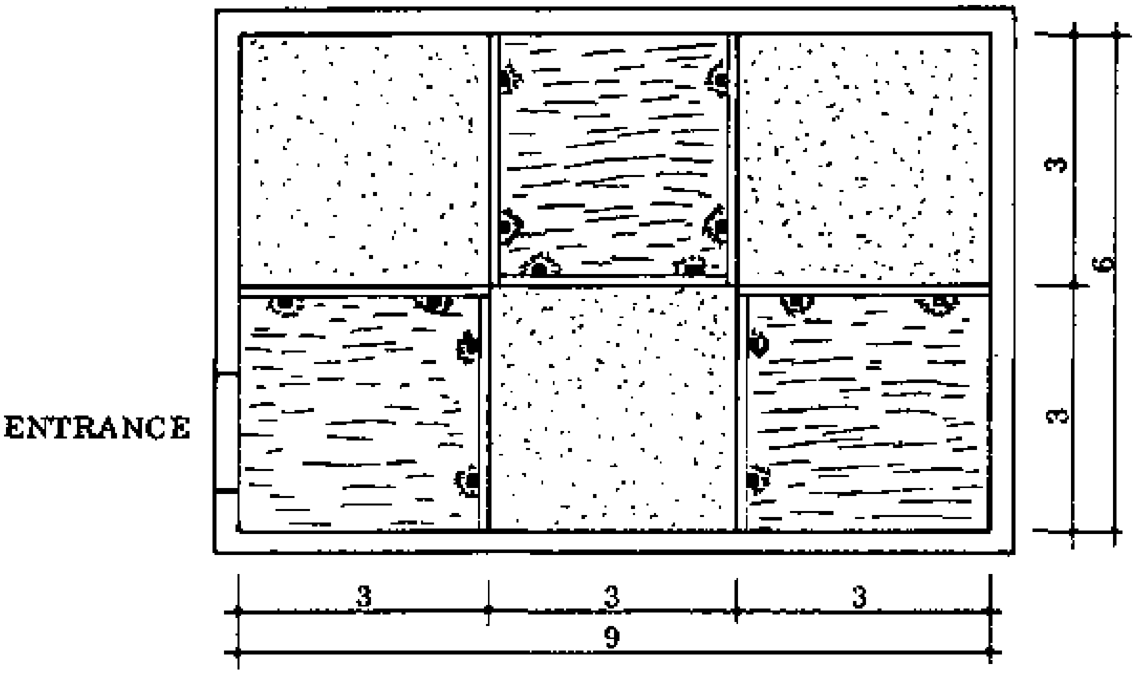
If a floor area is larger than approximately 10 square meters, the area should be divided into bays for concreting. A bay is one of several uniform divisions of a concrete floor which are cast at any one time.

The bays are separated by edge boards, which are laid and levelled to the required floor thickness. The edge boards act as a guide for the strikeboard to level off the concrete surface, therefore they must be laid and levelled with great care.

On the drawing below you can see the positions of the edge boards when the floor is divided into six bays. The boards should be arranged as shown so that the corners of the concrete bays will match each other when the floor is complete.

The division of the floor into bays helps to prevent the development of cracks due to shrinkage during the hardening process. The smaller the area, the less the shrinkage, and the fewer cracks will appear. Square−shaped bays are the best because all the sides will shrink by the same amount.

Bays also make the construction process easier. The bays are small enough to be cast, levelled and finished within a manageable time. The work can be interrupted to allow the already completed bays to harden. Then the edge boards are removed and the empty bays are cast, using the completed ones as a guide. Once you start casting a bay, it must be completed. Never interrupt a concreting process, as this can result in a faulty bond and the joint will always be visible. For the sequence of operations for casting a floor see Figs. 1 to 8 on the following two pages.



DIVISION INTO BAYS

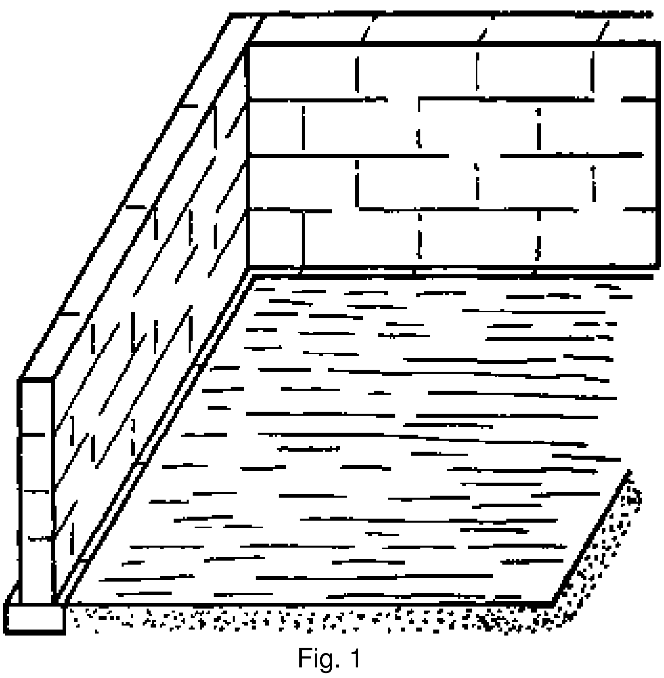


Fig. 1

– CLEAN THE AREA

– CLEAN THE EDGES OF THE FOOTINGS

– LEVEL THE AREA WITH A SHOVEL

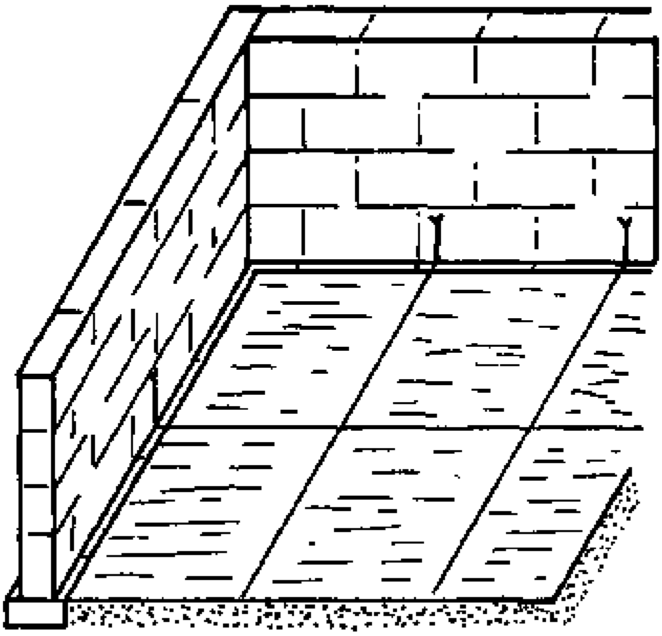


Fig. 2

– MARK THE BAYS ON THE WALLS

– SET OUT THE POSITIONS OF THE EDGE BOARDS ON THE GROUND

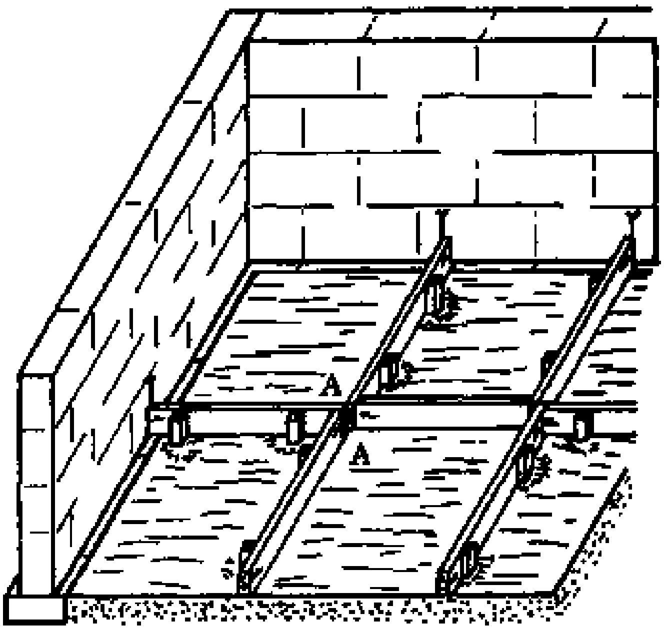


Fig. 3

– FIX THE EDGE BOARDS WITH PEGS

– LEVEL THE TOPS OF THE EDGE BOARDS

– THE CORNERS SHOULD MATCH (A to A)

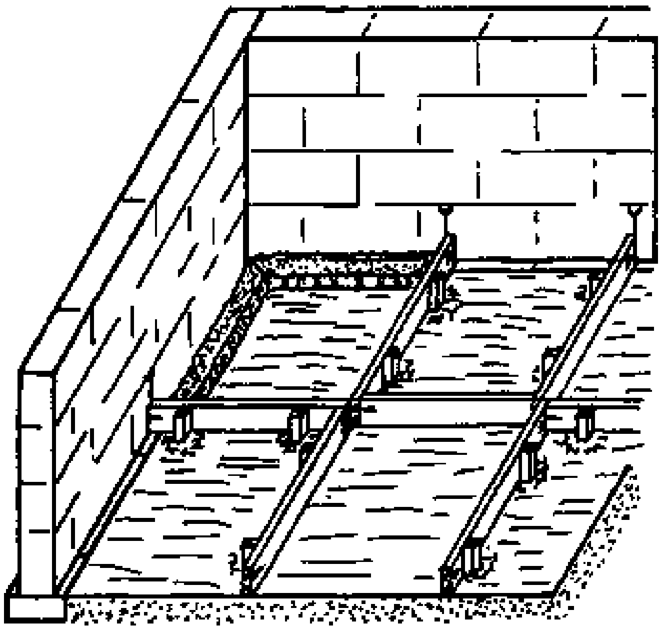


Fig. 4

– POUR GUIDE STRIPS TO THE HEIGHT OF THE BASELAYER

– LEVEL THE GUIDE STRIPS

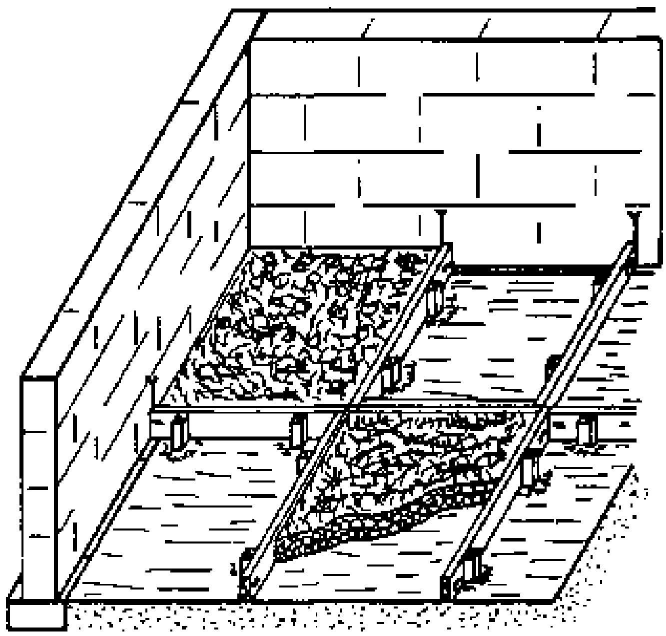


Fig. 5

– POUR THE BASE LAYER AND TAMP IT DOWN WITH THE RAMMER TO THE REQUIRED LEVEL

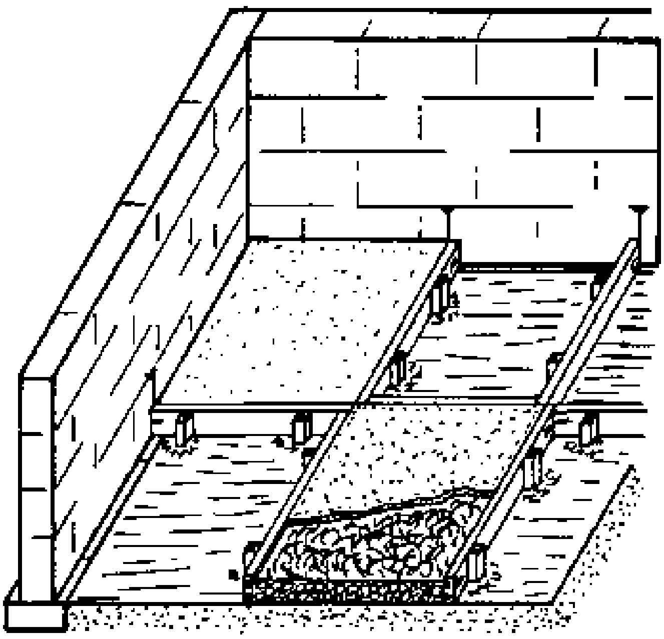


Fig. 6

– LAY THE FLOOR SCREED LAYER (FAIRLY DRY MIX) AND TAMP IT DOWN WITH THE WOOD FLOAT UNTIL MOISTURE COMES THROUGH

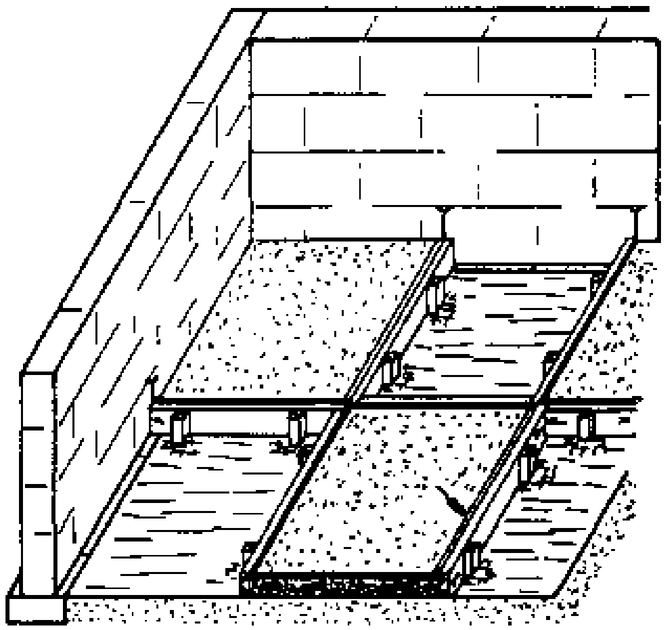


Fig. 7

– FINISH OFF THE TOP WITH THE TROWEL OR STEEL FLOAT

– MAKE A BEVEL ALONG THE EDGES FOR THE SHRINKAGE JOINTS (ARROW)

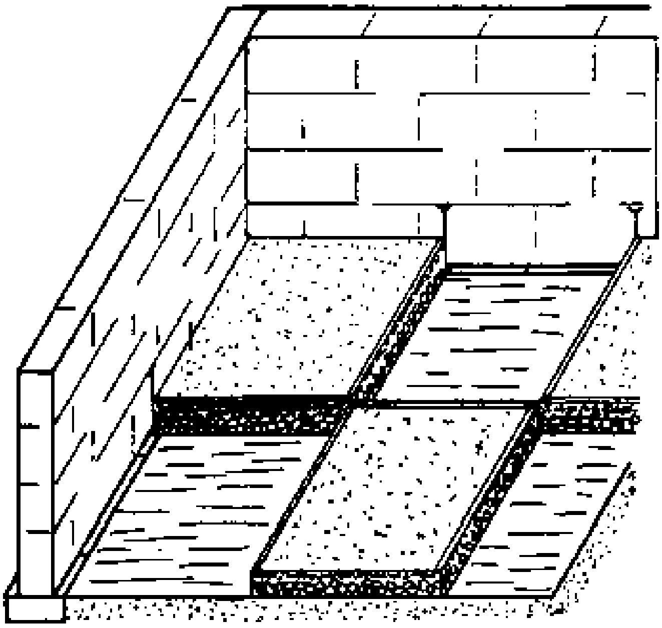


Fig. 8

– TAKE AWAY THE EDGE BOARDS AND PUT SAND ON TOP OF THE FLOOR

– WATER THE FLOOR REGULARLY

Shrinkage gaps

When one set of bays has hardened, the edge boards are carefully removed and the remaining bays can be cast. Shrinkage gaps are made between the adjoining bays. This is done by placing plastic or paper between the bays when the second set of bays is cast, so that the bays are kept separate from each other.

The shrinkage gaps allow the concrete bays to shrink a bit as they harden without cracking. This type of gap is used where the floor is not exposed to the sun or to great temperature changes; usually only for inside floors. Shrinkage gaps can be made in either one–course work or two–course work. A “V” is made along the top edges of the gap to improve the appearance of the floor (Fig. 1).

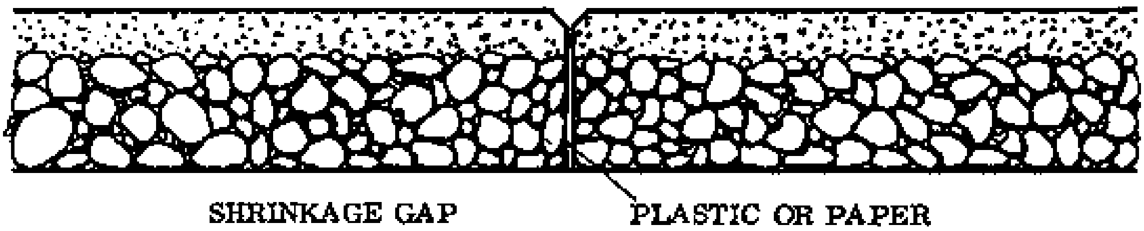


Fig. 1 SHRINKAGE GAP

Expansion gaps

Where the floor is exposed to the sun, as in a verandah floor or any concreted area outside the house itself, expansion gaps have to be made. In this case the edge boards are not removed until all the bays have been cast and hardened. The boards are then removed and the gap between the bays is filled with wet sand, and the floor screed is applied over the top (Fig. 2). Expansion gaps can only be made in two–course work.

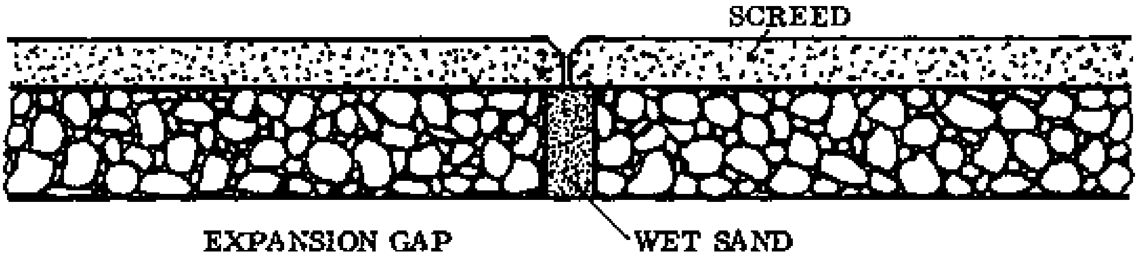


Fig. 2 EXPANSION GAP

The expansion gap allows the floor to expand and contract with the temperature changes without forming cracks. Expansion occurs when the floor is heated by the sun during the day, and shrinkage occurs at night when it cools down. Floors exposed to the sun should be divided into bays of no more than 5 square metres, and expansion gaps should be made in them. The floor screed must also be provided with a shrinkage gap; this should be located directly above the expansion gap in the base layer (Fig. 2).

A WORD FOR THE TRAINEE BEFORE ON–THE–JOB TRAINING

With the basic knowledge you have gained in this part of the course, you should now be prepared to go to a building site for on–the–job training.

Remember that so far you have covered only the first part of the course. You will still need to acquire much more knowledge and many more skills before you can be called a Rural Builder.

While you are working at the building site, remember that this time is also supposed to be a learning experience. If you want to learn, you have to ask questions about how and why certain things are done. If you can't get your questions answered at the time, write them down and bring them to your instructors for explanation. It is a good idea to keep a notebook; writing down in it the methods you applied at the building site, the time that a certain operation required, the materials used and how much was needed, and any ideas you have about how it could have been done differently.

You should occasionally review the information in this book, especially as it comes up on the job. Don't be afraid to use the book and to write notes in it; the notes which you make at this time can be very helpful to you later on, when you have finished the course and are working as a builder.

Rural Building – Construction

Table of Contents

Table of Contents

Table of Contents

Table of Contents

Rural Building – Construction

PREFACE

This official text book is designed purposely to meet the needs of trainees who are pursuing rural building courses in various training centres administered by the National Vocational Training Institute.

The main aim of this book is to provide much needed trade information in simple language and with illustrations suited to the understanding of the average trainee.

It is the outcome of many years of experiment conducted by the Catholic F.I.C. brothers of the Netherlands, and the German Volunteer Service instructors, in simple building techniques required for a rural community.

The National Vocational Training Centre is very grateful to Brothers John v. Winden and Marcel de Keijzer of F.I.C. and Messrs. Fritz Hohnerlein and Wolfram Pforte for their devoted service in preparing the necessary materials for the book; we are also grateful to the German Volunteer Service and the German Foundation For International Development (DSE) – AUT, who sponsored the publication of this book.

We are confident that the book will be of immense value to the instructors and trainees in our training centres.

DIRECTOR: National Vocational Training
Institute, Accra

INTRODUCTION TO A RURAL BUILDING COURSE

Vocational training in Rural Building started in the Nandom Practical Vocational Centre in 1970. Since then this training has developed into an official four year course with a programme emphasis on realistic vocational training.

At the end of 1972 the Rural Building Course was officially recognised by the National Vocational Training Institute. This institute guides and controls all the vocational training in Ghana, supervises the development of crafts, and sets the examinations that are taken at the end of the training periods.

The Rural Building programme combines carpentry and masonry, especially the techniques required for constructing housing and building sanitary and washing facilities, and storage facilities. The course is adapted to suit conditions in the rural areas and will be useful to those interested in rural development, and to farmers and agricultural workers.

While following this course, the instructor should try to foster in the trainee a sense of pride in his traditional way of building and design which is influenced by customs, climate and belief. The trainee should also be aware of the requirements of modern society, the links between the old and new techniques, between traditional and modern designs – and how best to strike a happy medium between the two with regard to considerations like health protection, storage space, sewage and the water supply. The trainee should be encouraged to judge situations in the light of his own knowledge gained from the course, and to find his own solutions to problems; that is why this course does not provide fixed solutions but rather gives basic technical information. The instructor can adapt the course to the particular situation with which he and the trainee are faced.

This course is the result of many years of work and experimentation with different techniques. The text has been frequently revised to serve all those interested in Rural Development, and it is hoped that this course will be used in many vocational centres and communities. It is also the sincere wish of the founders of this course that the trainees should feel at the completion of their training that they are able to contribute personally to the development of the rural areas, which is of such vital importance to any other general development.

We are grateful to the Brothers F.I.C., the National Vocational Training Institute and the German Volunteer Service for their assistance and support during the preparation of this course.

Bro. John v. Winden (F.I.C.)
Wolfram Pforte (G.V.S.)
Fritz Hohnerlein (G.V.S.)

LAY–OUT OF THE RURAL BUILDING COURSE

The Rural Building Course is a block–release–system course, which means that the trainee will be trained in turn at the vocational centre and at the building site. The period of training at the centre is called "off–the–job" training, and the period on the building site is called "on–the–job" training. Each will last for two years, so that the whole course will take four years and will end with the final test for the National Craftsmanship Certificate.

<u>BLOCK RELEASE SYSTEM</u>

YEAR	TERM 1	TERM 2	TERM 3
1	X	X	X
2	O	O	O
3	O	X	O
4	X	O	X

X = OFF–THE–JOB TRAINING
O = ON–THE–JOB TRAINING

The total "off–the–job" training period is approximately 76 weeks, each week 35 hours. During this training about 80% of the time is spent on practical training in the workshop. The remaining 20% of the time is devoted to theoretical instruction.

The total "on–the–job" training period is approximately 95 weeks, each week 40 hours. During this period the trainee does full–time practical work related to his course work. In addition some "homework" is assigned by the centre and checked by the instructors.

A set of books has been prepared as an aid to the theoretical training:

A – Rural Building, Basic Knowledge (Form 1)
B – Rural Building, Construction (Forms 2, 3, 4)
C – Rural Building, Drawing Book (Forms 1, 2, 3, 4)
D – Rural Building, Reference Book

All these books are related to each other and should be used together. The whole set covers the syllabus for Rural Building and will be used in the preparation for the Grade II, Grade I, and the National Craftsmanship Certificate in Rural Building.

BOOK INTRODUCTION

Rural Building Construction is your main construction book. It is built up in the same logical way that a house is built up: starting with the preliminaries of setting out and ending with the roof construction, hanging the doors, and the finishing.

Because of the structure of the training course, it might sometimes be necessary for the instructors to rearrange this sequence and treat certain working methods either earlier or later in the course (for example, plastering is done late in the construction of a building, but it might have to be treated quite early in the actual Centre training). In any case the instruction should follow the current Rural Building syllabus, and the instructor should pick out the chapters which need to be covered according to the syllabus.

There is room for the instructor to add his own ideas, knowledge and experiences concerning the local ways of building, and to adapt the lessons to the local circumstances. The trainee should be able to adapt the knowledge he has gained to the requirements of the rural areas.

In order to work with this text book, you should be familiar with drawing techniques so that you can understand the sketches and drawings. Don't be afraid to make notes and sketches in the book: the notes made here can be helpful to you again and again in your future building career.

– The tools and materials mentioned in this book are described and explained in the Rural Building Reference Book. Some figures essential for the Rural Builder are given in the Tables of Figures at the end of the Drawing Book.

– All measurements, figures and constructions given and explained in this book are made in accordance with the standard sizes of timber, steel, etc. which are commonly used in Ghana.

The appendix gives some basic designs and construction information for water filters, wells, sanitation systems, and a silo for improved grain storage.

BUILDING PRELIMINARIES

Site selection

When choosing the location of the planned building, the responsible builder will strongly advise his client to avoid building on valuable farm land, if possible.

Most Rural Builders come from farming communities; they are building for farmers, and they also do farming themselves. Thus they are very conscious of the land and know that good land should never be wasted by building on it.

Moreover, the Rural Builder is aware that there are a number of advantages in building on higher, stony areas not suitable for farming.

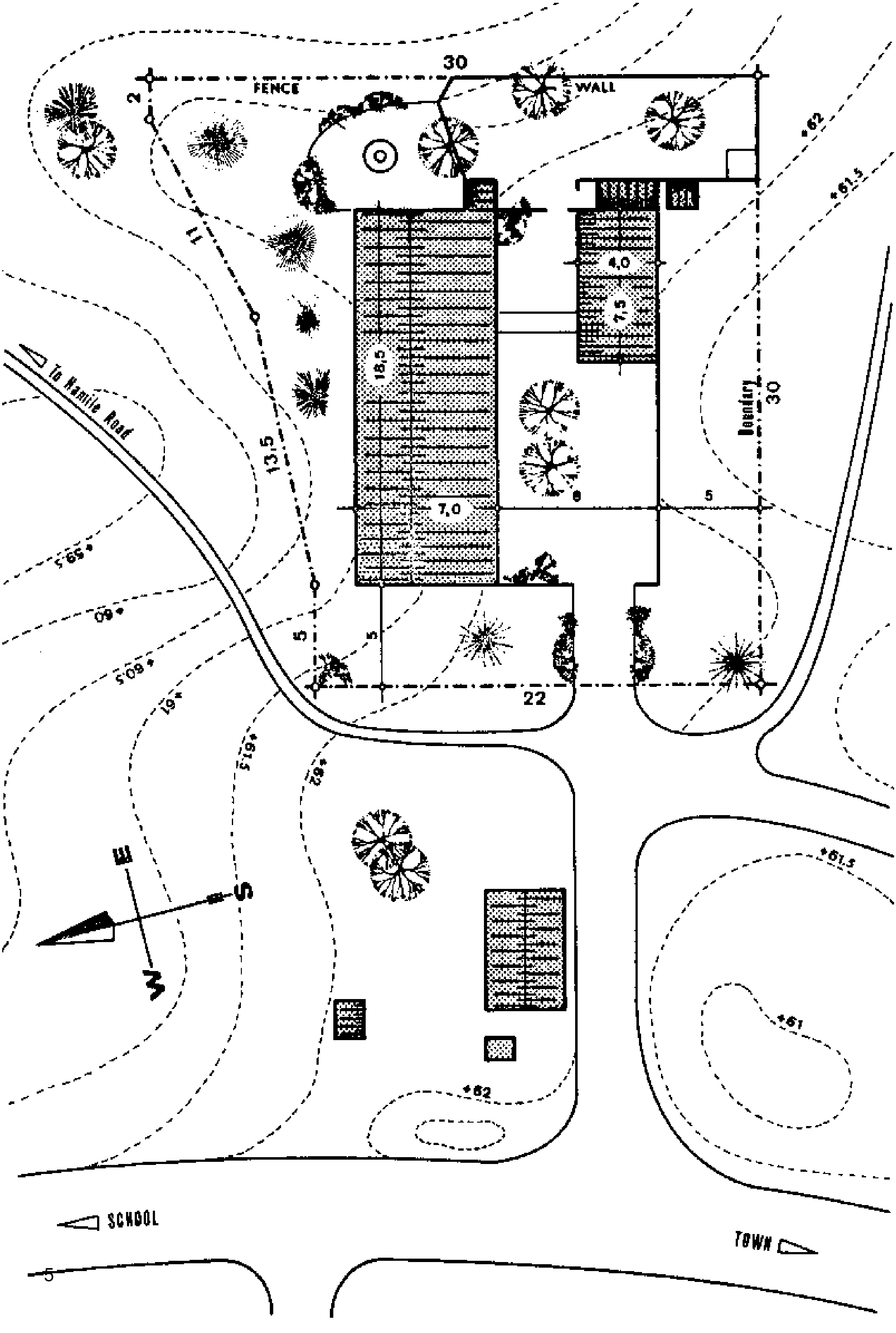
Some of the advantages are:

– The higher the building is situated, the healthier and more comfortable it will be to live in, because of the better ventilation and the reduced danger from dampness rising from the ground.

– Building materials such as stones and laterite are often available on the spot, and do not need to be brought from far away.

– The soil in higher areas is more likely to be the desired type to form a firm base for the house. This makes the construction of the foundations easier, and reduces the amount of building materials required, keeping the costs lower.

NOTES:


30
FENCE
WALL
2
11
13,5
18,5
7,0
4,0
7,5
5
5
5
22
30
Boundary
To Namile Road
+62
+61,5
+59,5
+60
+60,5
+61
+61,5
+62
+61,5
+61
+62
E
S
W
SCHOOL
TOWN

Location plan

When building a house or any other structure one must have certain information available, in order to arrive at the best and most economical result.

The most basic information is the location, size and nature of the plot. This is contained in the location plan, which shows the plot and the immediate surroundings in scale. The scale can be from 1:200 up to 1:1000, depending on the size of the project.

The plan outlines the shape of the plot and the dimensions of its boundaries, as well as the location of the future building. It should also show the nature of the area, because it is very important to know whether the site is sloping or if the ground is uneven.

Roads, drive ways and the positions of the bigger trees are also marked on the location plan (Fig. 1).

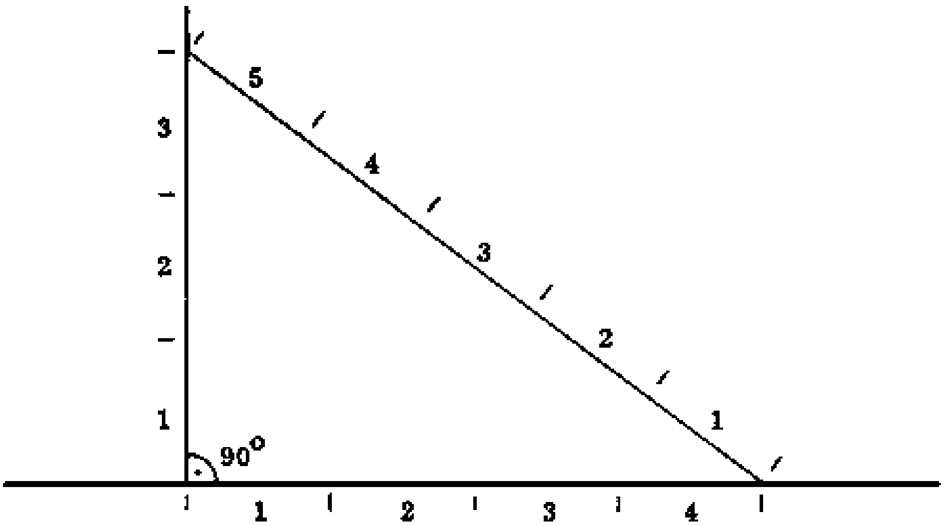


Fig. 1

In Rural Building, location plans are often not available, so in order to get the necessary information, both the client and the builder have to examine the plot thoroughly. Important matters such as the best position for the future building are discussed and decided on the spot.

When the site has been examined thoroughly and all the measurements and particulars have been obtained, the drawings for the house can be prepared.

– NOTE: Before the building can be started, all the required drawings have to be ready, and at the disposal of the foreman. Before you can prepare any drawings, you need to have all the particulars of the site.

NOTES:

Working drawings

The working drawings are the drawings which the builder uses before the construction starts and during the construction; to plan for materials requirements, to plan the work; and finally to carry out the construction according to the directions contained in the drawings.

The drawings include “plans”, “cross sections”, “elevations”, and “detail drawings”. They are all prepared in scales which are suitable to the particular drawing. The first three types of drawing have a scale of between 1:50 and 1:20.

– PLANS: A plan is a view that shows a certain layer or horizontal section of a building as if it were looked at from above (see Drawing Book, page 55). The plans usually include the “floor plan”, which shows the walls, positions of the doors and windows, etc. (Drawing Book, page 54); the “foundation plan” gives the dimensions of the foundations and footings; and the “roof plan” which shows the shape of the roof and its dimensions. The floor plan and the foundation plan are often combined into one drawing.

– CROSS SECTIONS: A cross section is a drawing which shows the inside of the structure, as if the building were cut into two (see the Drawing Book, pages 61 and 62). The exact position where the cross section is taken has to be shown on the plan.

– ELEVATIONS: These are the views of the building as it would look from the outside (see pages 59 and 60 in the Drawing Book).

– DETAIL DRAWINGS: These show members or portions of the structure in a larger scale than the other drawings; such as 1:10, 1:5, 1:2,5, etc. Detail drawings are made when:

- There is not enough space in the other drawings to clearly indicate all the required measurements.
- The member of the structure is too small to be properly shown in the other drawings.
- The member has a complicated shape and more views or cross sections are needed to explain it (see Drawing Book, page 84).
- Important construction hints have to be pointed out.
- The member is built up from several different materials.

The working drawings have to show the various materials used in the structure (see Drawing Book, pages 49 to 50). This enables the builder to make a list of the materials that will be required and the amount of each material (see the Reference Book, Tables of Figures, pages 234 to 240.

When this is done the builder can estimate the cost of the building and order the materials he will need. Ordering materials has to be done in advance so that the materials are there when they are needed.

Plot and site clearing

Once the planning work has been completed, the plot and site both have to be prepared for the setting out. The location plan shows exactly from which areas the trees, bushes, grass and stones must be removed. The ground is levelled. The part of the plot which is cleared will be the actual site that the future building will occupy, including a space of about 5 m all around the building.

One very important measure is to remove all the tree roots from the site area. If the roots remain, they will sometimes grow again and might damage the structure. This is particularly true with the roots of the neem tree.

Clearing does not mean that all the trees on the whole plot are removed. Beyond the 5 m clear space, as many trees as possible should be allowed to remain, because they will provide shade for the people using the building or living there.

Site organization

The first step in organizing the site is deciding where to make the driveway.

Next, choose the area where the building materials will be stored and arrange the storage facilities. Certain materials like sand and stones may have to be located, excavated, and transported to the site. This can be done as soon as the storage areas are located.

The building materials should not be stored too far away from the working place, nor should they be too close.

Space has to be provided for making blocks, and for mixing concrete and mortar. This also should not be too close to the future building.

The same applies to any temporary work sheds or storage sheds that are erected.

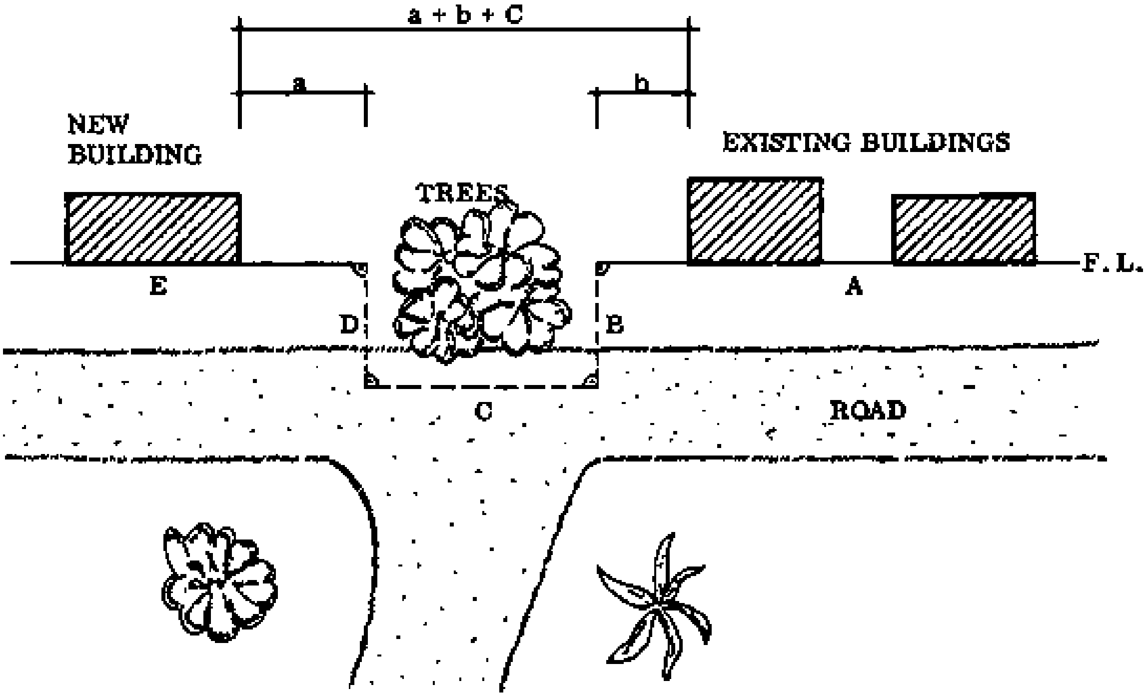


Fig. 2

NOTES:

Water supply

Any kind of building would be impossible without water. Therefore one of the main tasks of the builder is to provide a guaranteed supply of clean water.

Usually piped water is not available, so it is advisable to build a simple water tank, or else dig a well if this is possible (see the Appendix, pages 277 to 281).

The water tank should be located so that after construction is completed it can be used to store rain water collected from the roof. The best site will be close to either gable end of the house so that the rainwater from the gutters can be fed into the tank directly.

Investigate the possibilities for digging a well, as this would eliminate the need to transport water and thus cut down on unnecessary effort and cost.

SETTING OUT

Once the plot and site clearing is completed, the setting out can be done: first mark the frontline of the building and from there mark all the other lines using the 3–4–5 method described in the Basic Knowledge book, page 142.

However, not all sites are conveniently flat and level, and the Rural Builder will frequently face more difficult situations. While the construction of a right angle remains the same, the measurement of distances and the determination of directions might sometimes be difficult.

There is also the case where there are trees or other buildings which should remain, but which are in the way when we are making a particular measurement.

Interfering objects

Provided that you have mastered the 3−4−5 method, it is relatively easy to by−pass interfering trees or buildings in setting out: it only requires a bit more time to construct the additional angles (Fig. 1).

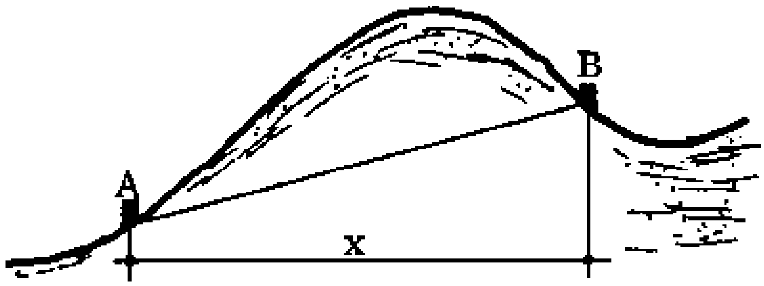


Fig. 1

Fig. 2 illustrates an example: the frontline of the existing buildings must be maintained in the new building, but it is difficult to set out directly because there are trees which are in the way. Rather than cut the trees down, we can by−pass them.

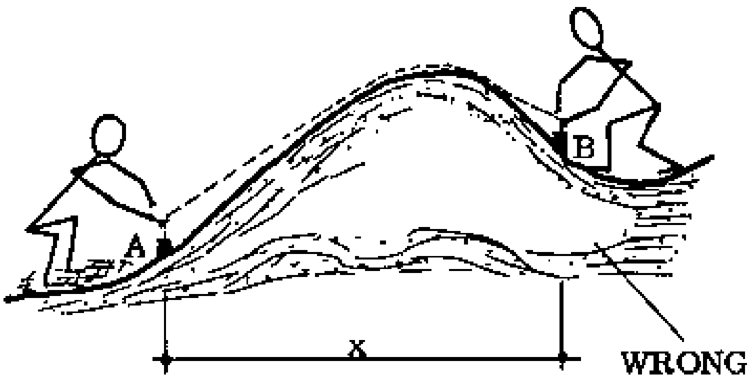


Fig. 2

From the frontline of the existing buildings (line A), set out line B, using the 3−4−5 method, perpendicular to line A. Then construct lines C and D using the same method, followed by line E which is the front line of the new building. Check that line C plus the distances “a” and “b” all add up to the total planned distance between the new building and the existing buildings (Fig. 2).

Uneven ground

Setting out on uneven ground, and particularly measuring distances, requires you to apply some simple geometry.

When we measure distances in setting out, we are actually looking for the horizontal distance between two points (Fig. 1, x). We don't measure the distance along a slope, because the house we want to build will not slope; it will have level floors and walls.

Since the ground is not flat, and the points are at different heights (point A is lower than point B), the horizontal distance between them has to be measured indirectly.

Fig. 2 shows two men trying to measure the distance between pegs A and B along uneven ground. Their result cannot be correct because the line they are holding is neither straight nor is it horizontal (measure “x” and compare it to the length of their line).

The men in Fig. 3 also fail to get the correct measurement. Their line is stretched taut and is therefore straight, but it is still not horizontal (measure “x” and compare it to the length of their line).

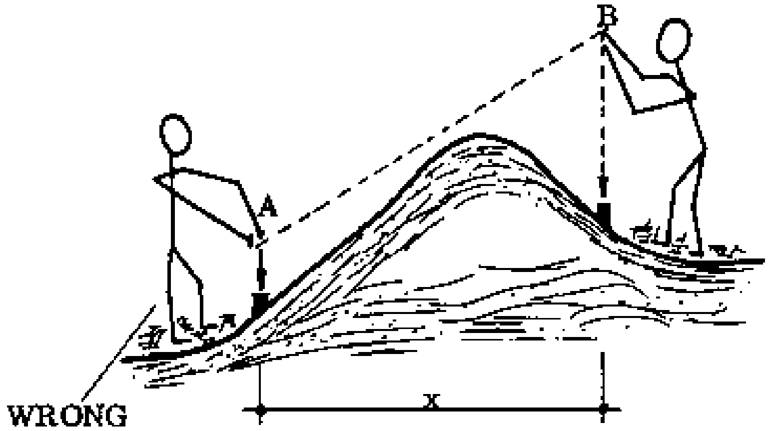


Fig. 3

In order to find the true horizontal length “x”, the line or tape measure has to be held horizontally and stretched taut so it is straight. Both ends of the line are kept vertically above the pegs A and B by means of plumb bobs (Fig. 4). This method as shown is a good rough method for short distances.

If a larger distance has to be measured, the work is carried out in intermediate steps of suitable lengths (Fig. 4).

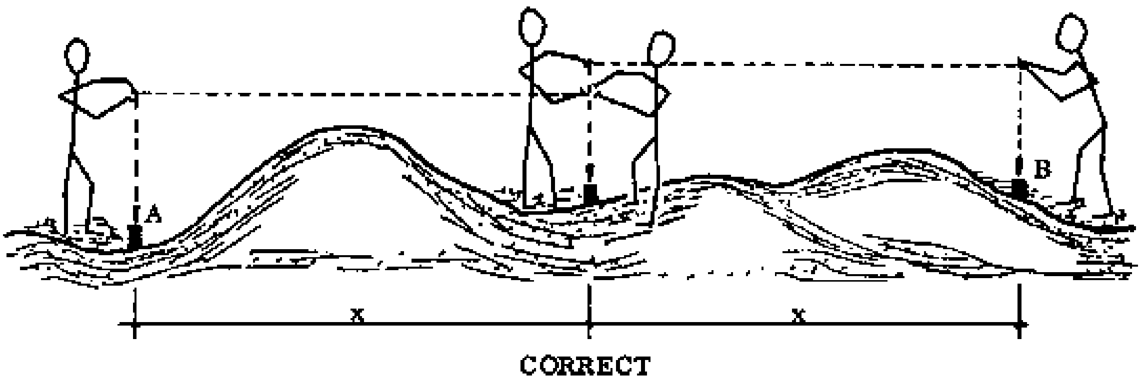


Fig. 4

For very large distances, the use of boning rods (Reference Book, page 25) can help to make sure that the different steps are in line and the total length measured is straight (Fig. 5). With the boning rods and a water level (Reference Book, page 25) you can also make sure that the whole distance is horizontal.

Use the water level to level between two boning rods; then any points in between can also be levelled by simply sighting along the boning rods (Fig. 5).

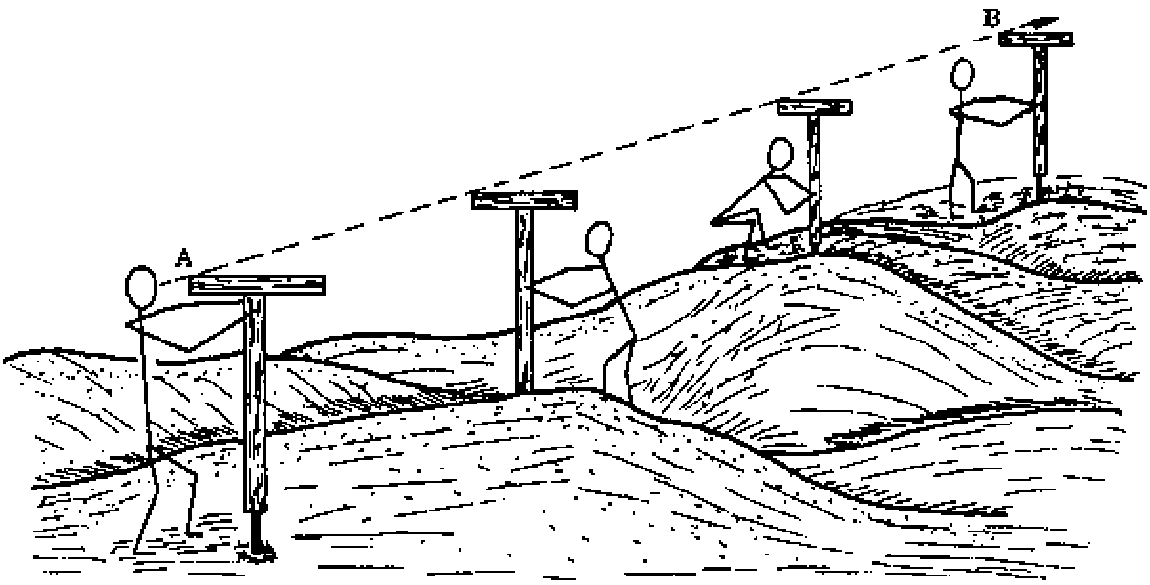


Fig. 5

NOTES:

Sloping sites

Setting out and measuring distances on sloping sites is simply the same procedure as explained in the section on uneven ground.

The work is carried out in steps (Fig. 1), with the line always held horizontally when measurements are taken.

The length of each section depends on how steep the slope is. The steeper the slope, the shorter the section, while slightly sloping areas allow longer sections (Fig. 1).

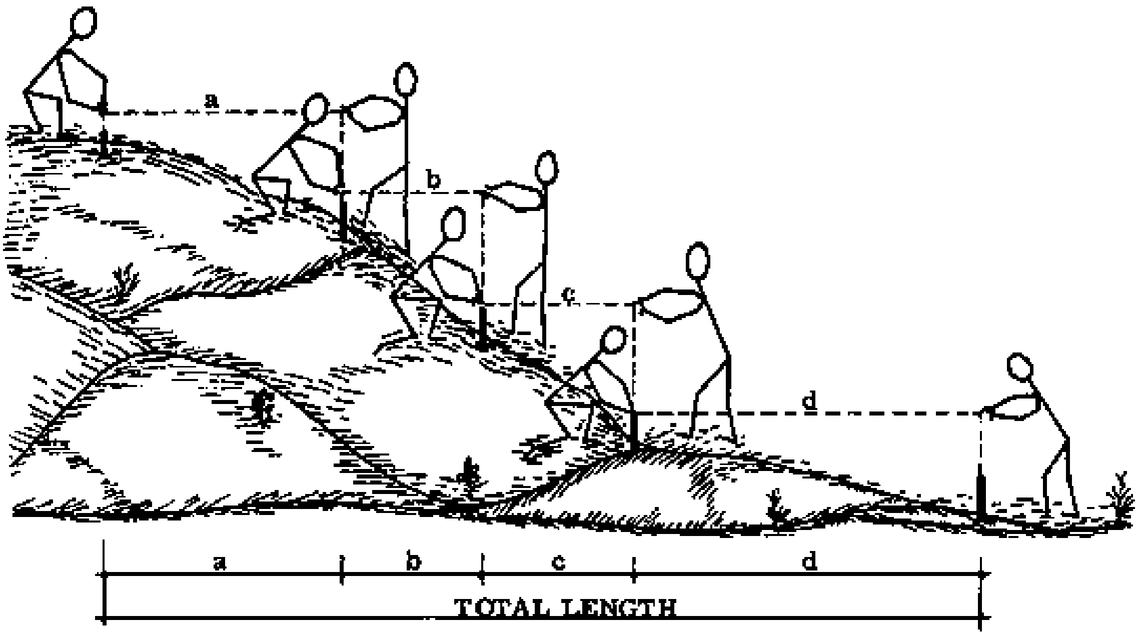


Fig. 1 MEASURING A DISTANCE ON A SLOPING SITE

The construction of a right angle according to the 3–4–5 method is the same on a slope, as long as all the lines involved are straight. To see that this is true, take your try square and turn it around in your hands. You will observe that whatever the position of the try square, the angle is always the same, because the sides of the try square remain straight.

Even on a site which slopes in two or more directions (Fig. 2) it is possible to construct a right angle as long as the lines are straight and do not touch the ground. The pegs may have to be different lengths, in order to keep the lines off the ground.

Keep in mind that on sloping sites all lines stretched between the pins do not represent the horizontal length (unless they are also levelled) but only the future positions and directions of the walls, etc. (Fig. 2, see also Figs. 1 to 4 on the previous page).

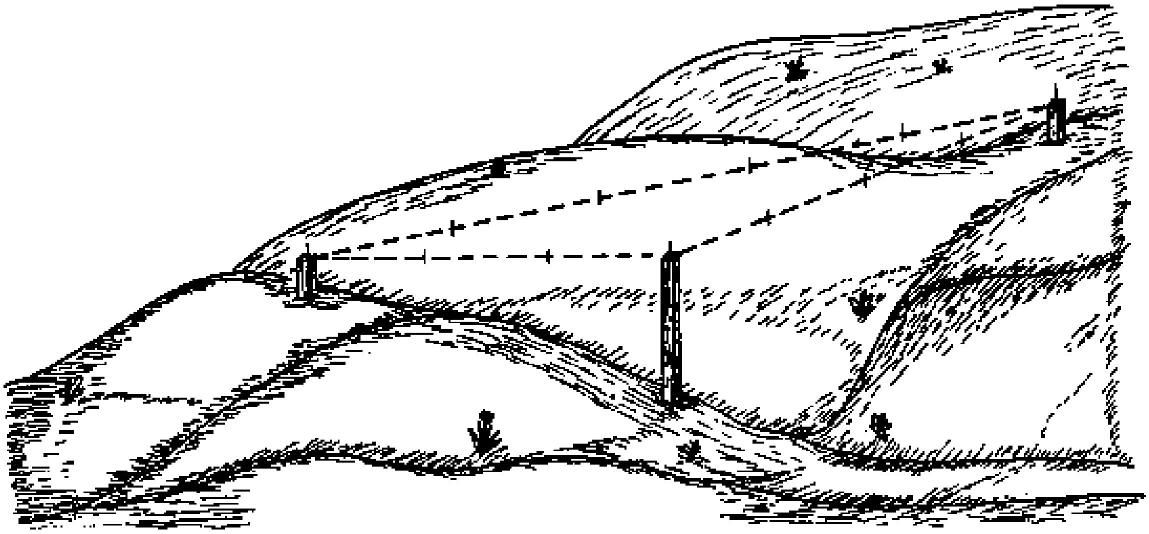


Fig. 2 3–4–5 METHOD ON A SLOPING SITE

The Rural Builder knows that the decision to build on a sloping site can have expensive consequences. There are some advantages such as easier sewage disposal, but the disadvantages are usually greater (Drawing Book, page 103).

NOTES:

Profiles

When the positions of the corners of the building are known, and the distances between them, then we can mark the positions and widths of the foundations as well as of the footings and plinth course.

This marking should be carried out in a relatively permanent way, so that it is accurate for a longer period. We do this by using profiles. A profile is a simple, temporary structure which maintains the correct locations of the various marks.

The profile consists of a board nailed flatwise on top of two pegs which are set in the ground, at a height of about 60 cm (Fig. 1). This height is necessary to lift the line well above the footings, so that later the plinth course can be marked from the profile.

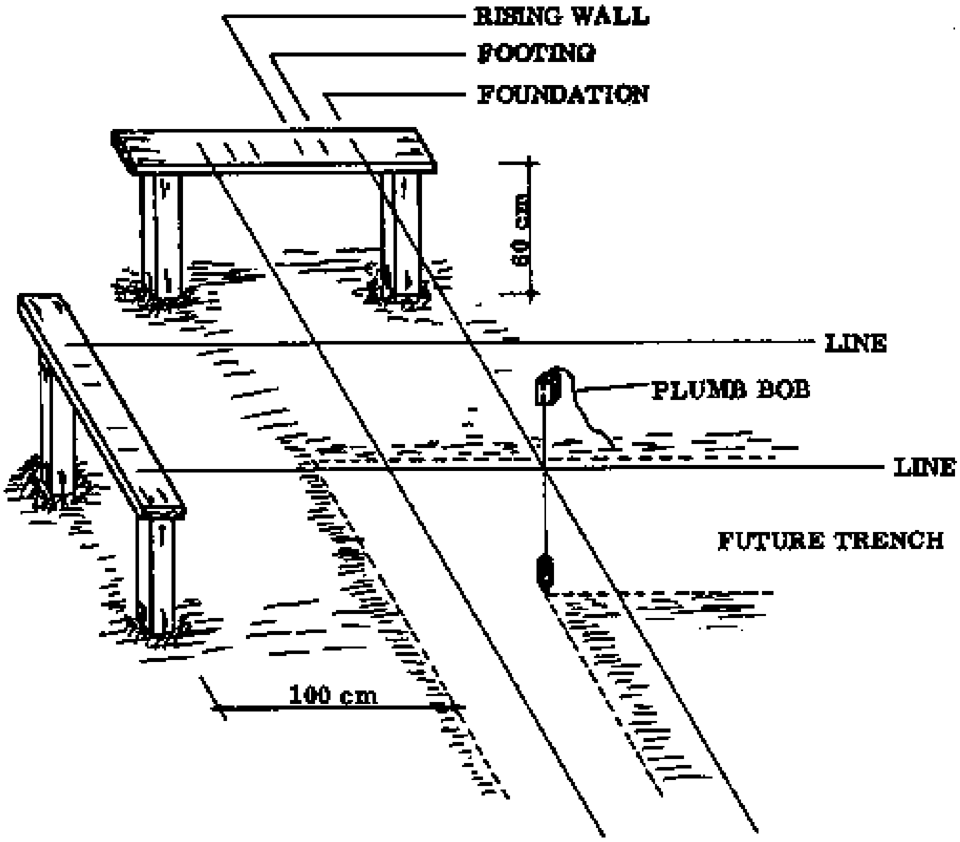


Fig. 1 MARKING THE POSITION OF THE FOUNDATION ON THE GROUND

If the soil is too hard to drive the wooden pegs into, then specially made iron pegs designed to receive a profile board can be used (Fig. 2). If these are not available, plain iron rods can be used, although they are less accurate since the lines are fixed directly onto the rods.

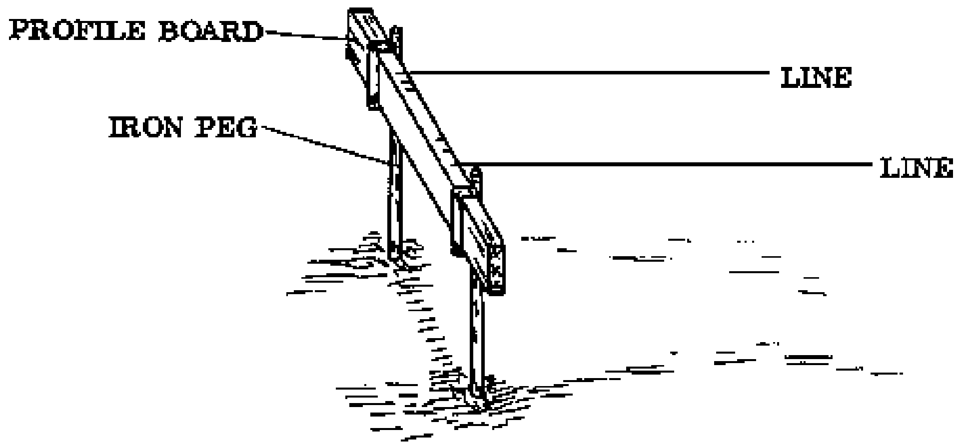


Fig. 2

At the corners of the building, two boards are used, to mark in two directions (Fig. 3). To mark off the dividing walls, one board is used at each end of the future wall (Fig. 3).

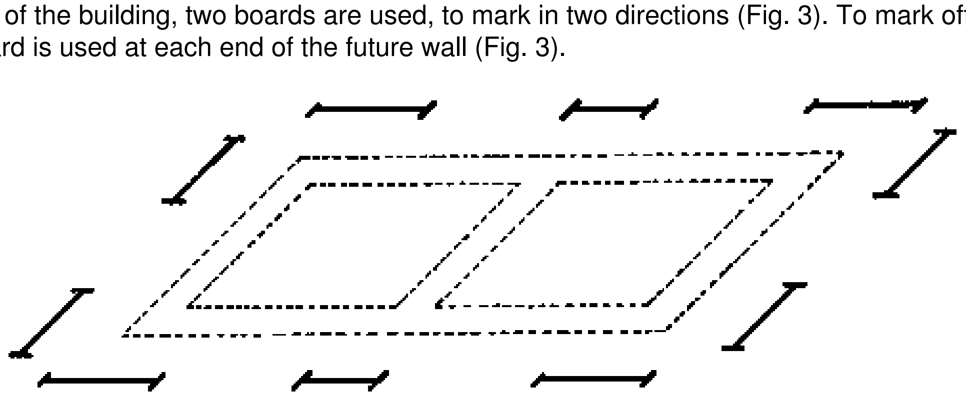


Fig. 3 POSITIONS OF THE PROFILE BOARDS

The profiles are erected at a distance of about 1 m from the outside edge of the foundation (Fig. 1). Permanent divisions are marked on the boards to indicate the width of the foundations and the thicknesses of the footings and rising walls. The marks may be either saw−cuts or short nails, so that lines can easily be fixed to them as they are needed.

The positions of the foundations are then marked on the ground by plumbing down from the lines stretched between the profiles (Fig. 1).

FOUNDATIONS

The stability of all buildings depends largely on the load−bearing capacity of the ground under them. As far as Rural Building is concerned, all hard soils are suitable for building. Soft soils, and those soils which become very soft and turn into mud when wet, are not suitable.

If a building is erected on the wrong kind of soil or if the foundations were constructed incorrectly, the building might settle unevenly, tilt or slide, or even collapse.

This can be avoided by selecting the right site for the building and by adapting the foundation construction to the soil conditions and the nature of the building.

Types of foundations

The most common forms for foundations in Rural Building are:

− SINGLE FOUNDATION: This is for columns, pillars and poles, if they are detached from the building (Fig. 1).

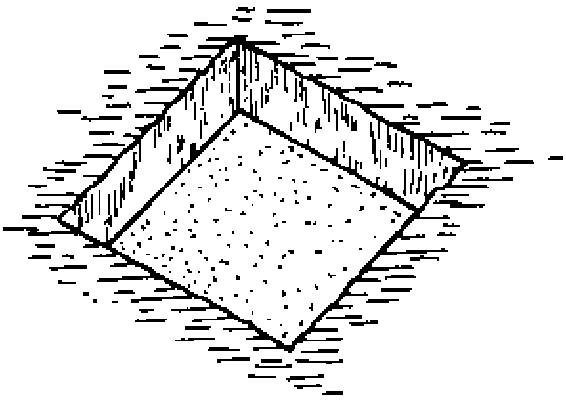


Fig. 1

− STRIP FOUNDATION: This is the most widely used foundation for walls (Fig. 2).

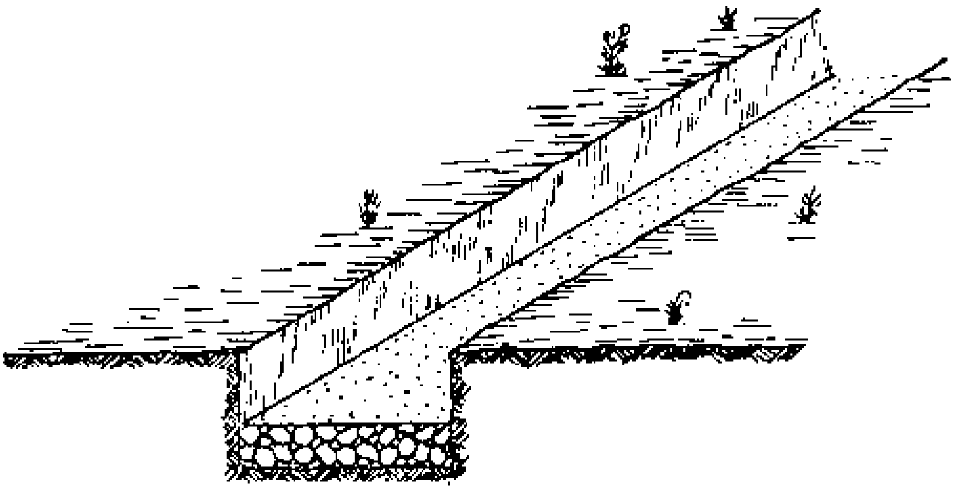


Fig. 2

− SLAB FOUNDATION: This is used for water tanks and septic tanks (Fig. 3).

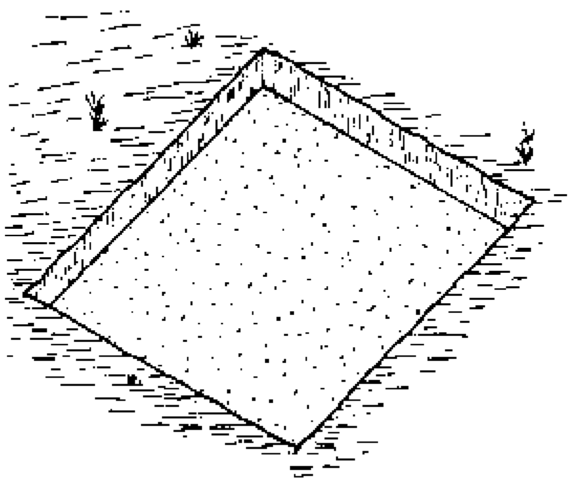


Fig. 3

− STEPPED FOUNDATION: On sloping sites the so−called stepped foundation must be used, which is in fact just a special form of the strip foundation (Fig. 4).

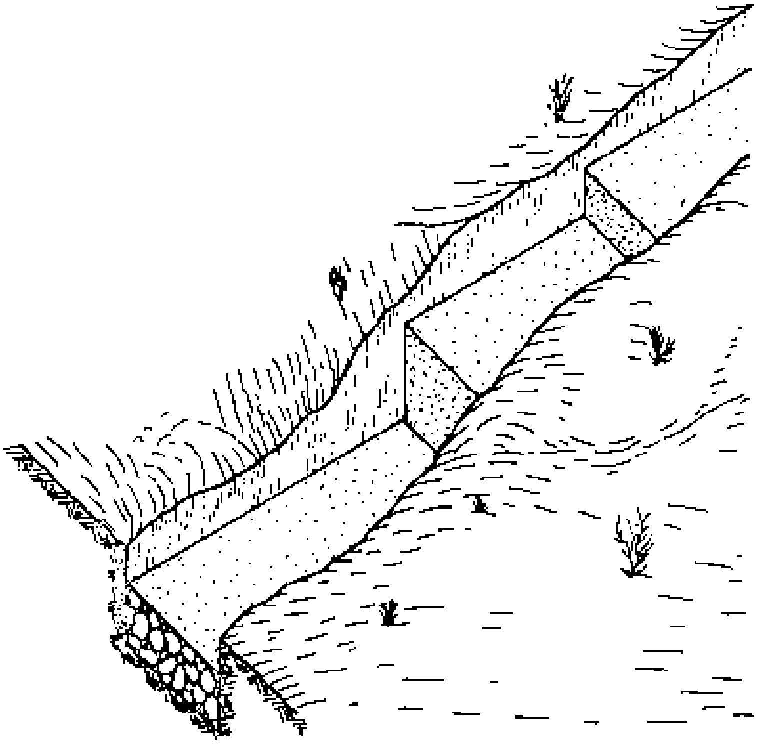


Fig. 4

NOTES:

Functions of the foundation

A foundation has to be constructed in a way that it can fulfill the demands that the building structure places on it. These are:

– To provide a solid, level base for the building
– To receive loads from the structure above
– To distribute the loads onto the ground over a larger area
– Thus, to prevent uneven settling of the building.

The above demands are met through the correct choice of dimensions, materials, and constructions for the foundation.

Dimensions for strip foundations

Many years of building experience in northern Ghana have proven that the dimensions for concrete foundations shown in Fig. 1 are sufficient, provided that the structure consists of only a ground floor and it is built upon firm soil.

A simple rule is: the depth of the foundation should be no less than the thickness of the rising wall; while its width should be no less than 3 times the thickness of the rising wall (Fig. 1).

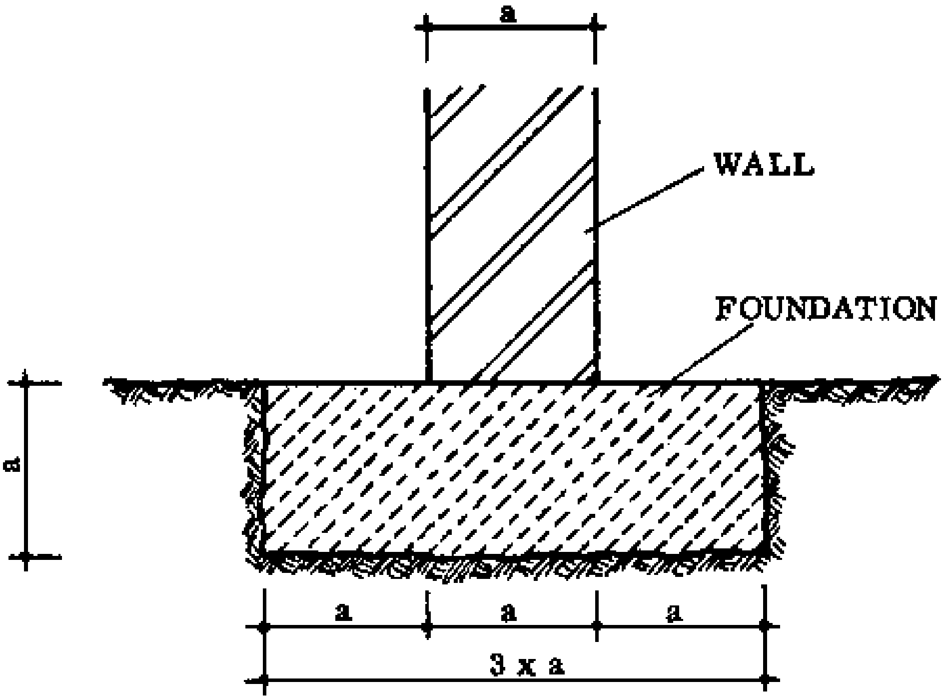


Fig. 1

Lower walls (not exceeding 2 m in height) which do not carry loads can be built on smaller foundations; these should be at least 30 cm wide and 15 cm deep (Fig. 2).

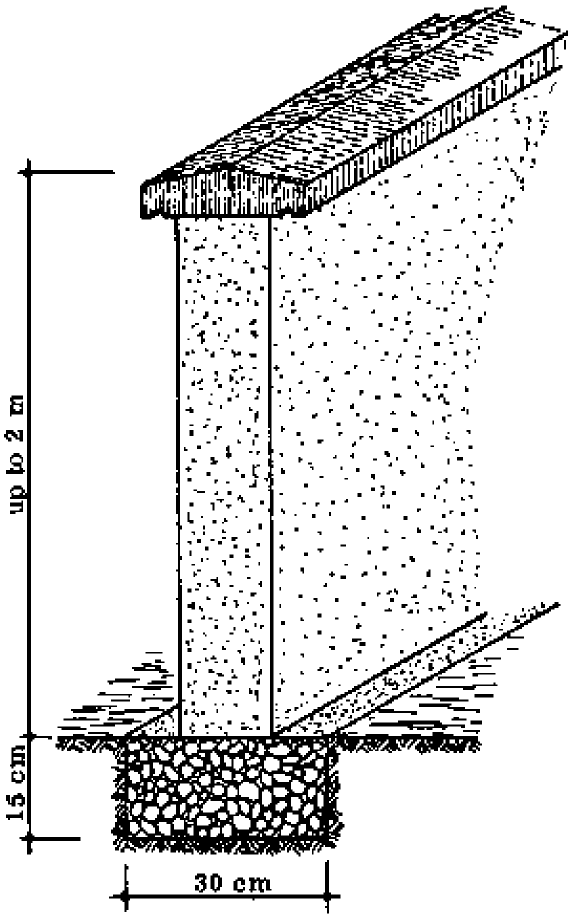


Fig. 2

Foundations which carry very low walls (less than 1 m high) such as decorative openwork screen walls enclosing verandahs, may be reduced to no less than 20 cm wide and 10 cm deep (Fig. 3).

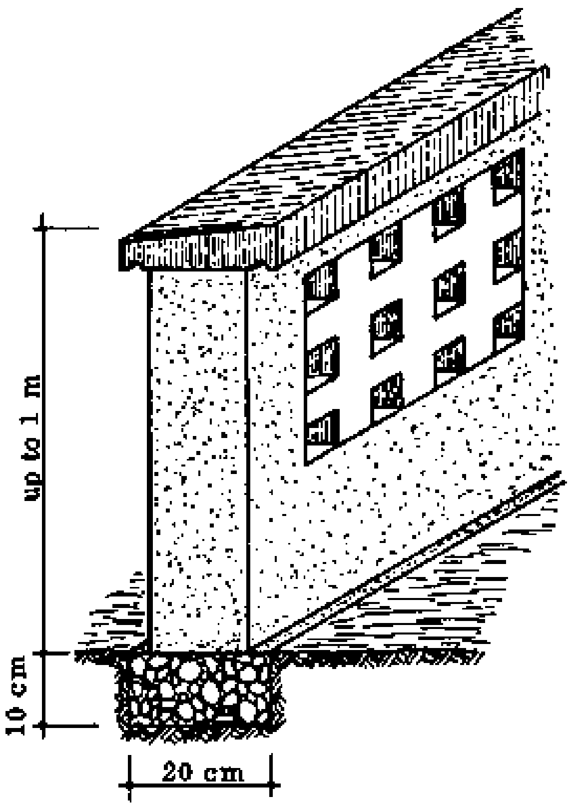


Fig. 3

NON–CONCRETE FOUNDATIONS

Although most foundations in Rural Building are made of concrete, there are situations where the choice of another material would be practical and economical. Some of the common alternatives to concrete foundations are:

- Rubble and boulder foundations
- Ashlar masonry foundations
- Laterite rock foundations
- Artificial stone (brick and sandcrete block) foundations.

In certain areas of the world, the first two types of masonry were formerly widely used: not only foundations but also footings, plinths and even rising walls were made out of stones. Due to the increased use of cement worldwide, and the improved concrete technology, stone masonry became uneconomical to build with because it takes more time and labour. Eventually the use of some of these types of masonry disappeared.

However, cement can be very expensive and it makes sense to return to the use of local materials when possible.

Rubble and boulder foundations

This kind of foundation is preferred on stony sites where rubble, rocks and boulders are found in large quantities, and where the soil is firm enough to permit its use.

This foundation saves building materials such as cement and timber for formwork, but it takes more time to construct and requires some skill.

As shown in Fig. 1, as far as possible very large stones are used, and the spaces that remain between them must be filled up with spalls. Spalls are smaller stones used to fill up the voids left in boulder masonry, in order to save cement mortar.

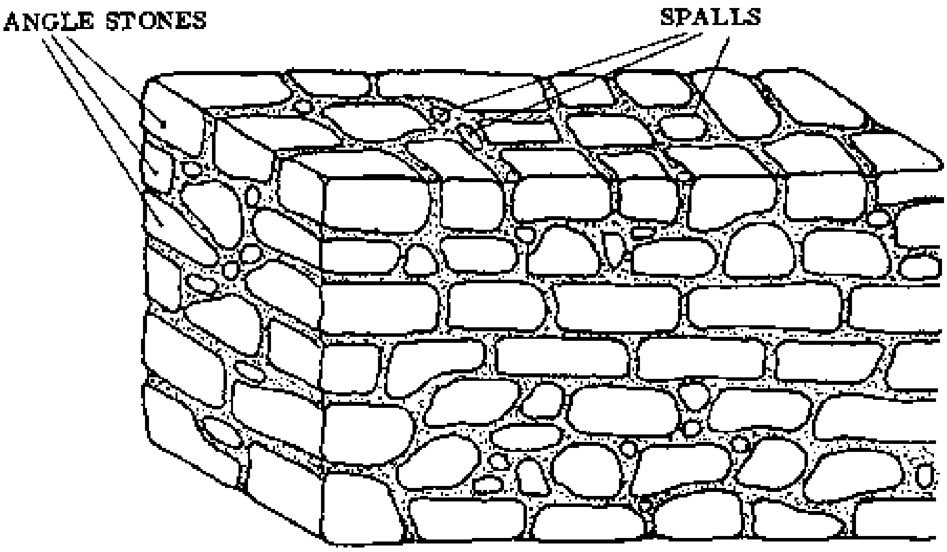


Fig. 1

The stones are used in their raw state, but the boulders forming the quoin should be shaped a bit more regularly to form a secure corner bond. The first course is laid in mortar, not directly onto the bare ground. It is usually impossible to construct regular courses because of the irregular shapes of the stones.

If the foundation is made of a porous rock like laterite rock, it is advisable to plaster both the inside and outside faces to prevent dampness from penetrating. Otherwise only the outside face is plastered.

The excavation for the trench is made a little wider than the foundation (Fig. 2) so that the plaster can be applied right down to the bed of the first course. Coarse gravel or broken stones can be used later to refill the space when the plastering is finished. This prevents the erosion of soil along the foundations, especially under the eaves of an overhanging roof.

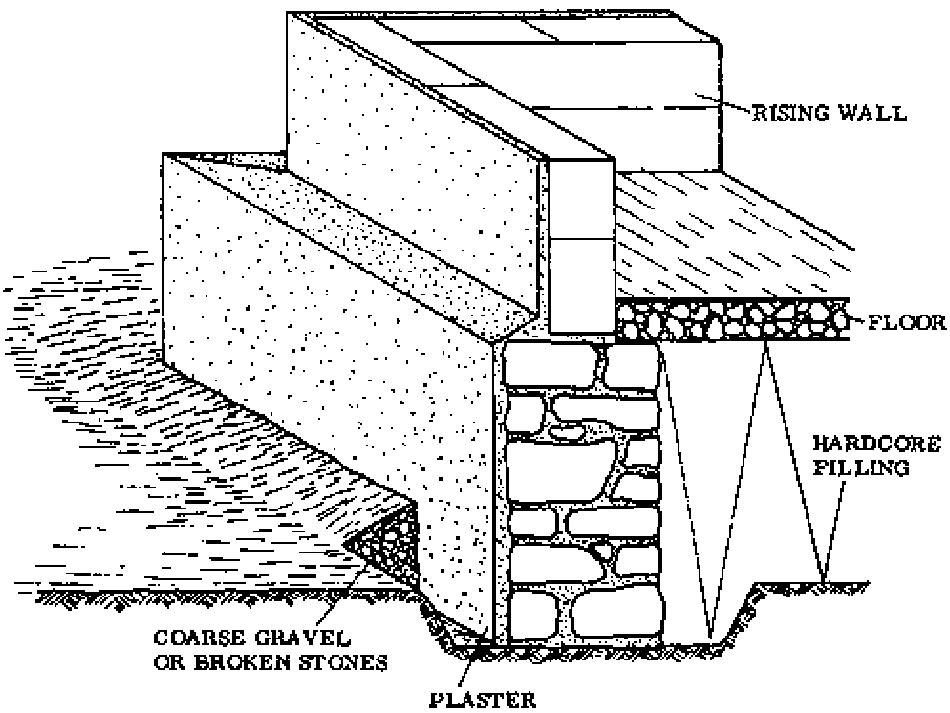


Fig. 2

NOTES:

Ashlar masonry foundations

In this type of masonry, the stones are “dressed” before they are used in the structure. To dress stone means to cut and shape it, and it is done to make the stones fit together better. There are four different types of ashlar masonry, depending on how much dressing is done and how the stones are put together. These are:

- Rough stone masonry
- Hammer−dressed ashlar masonry
- Broken range masonry
- Range masonry.

These are listed according to the increasing amounts of stone dressing and stone arrangement required for each method.

− ROUGH STONE MASONRY: This sort of masonry consists of natural stones which are shaped only slightly along their bed faces, or not shaped at all. As in boulder masonry, regular courses are not seen because of the irregularly shaped stones (Fig. 1).

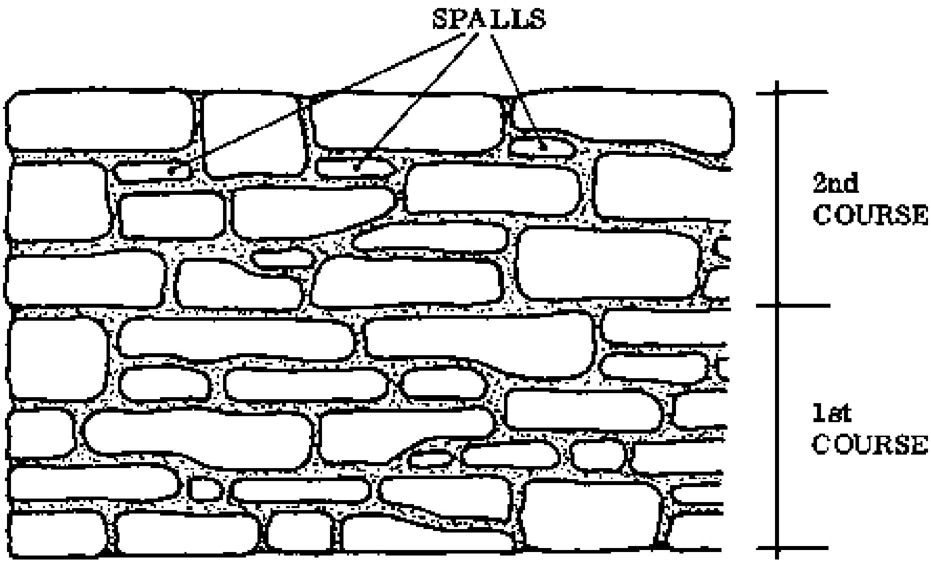


Fig. 1 ROUGH STONE MASONRY

− HAMMER−DRESSED ASHLAR MASONRY: As the name implies, the stones used for this type of masonry are roughly shaped with a hammer, so that the stretcher and header faces are approximately square to each other.

The stones are laid in regular courses but the thickness of the stones may vary within one course (Fig. 2).

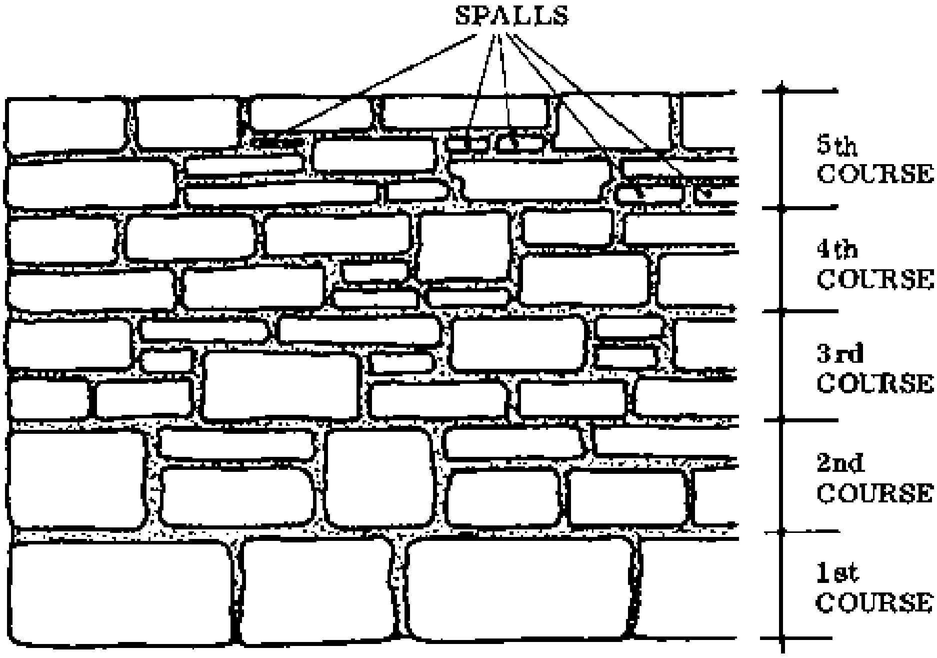


Fig. 2 HAMMER−DRESSED ASHLAR MASONRY

NOTES:

− BROKEN RANGE MASONRY: The stones of this masonry are accurately shaped with the club hammer and cold chisel (Reference Book, page 15) so that all the faces are square to each other. The bond should not contain joints more than 3 cm thick. The height of the stones may vary within a course, and the height of the courses may also vary, with the result that the courses are continuous for only short distances (Fig. 1).

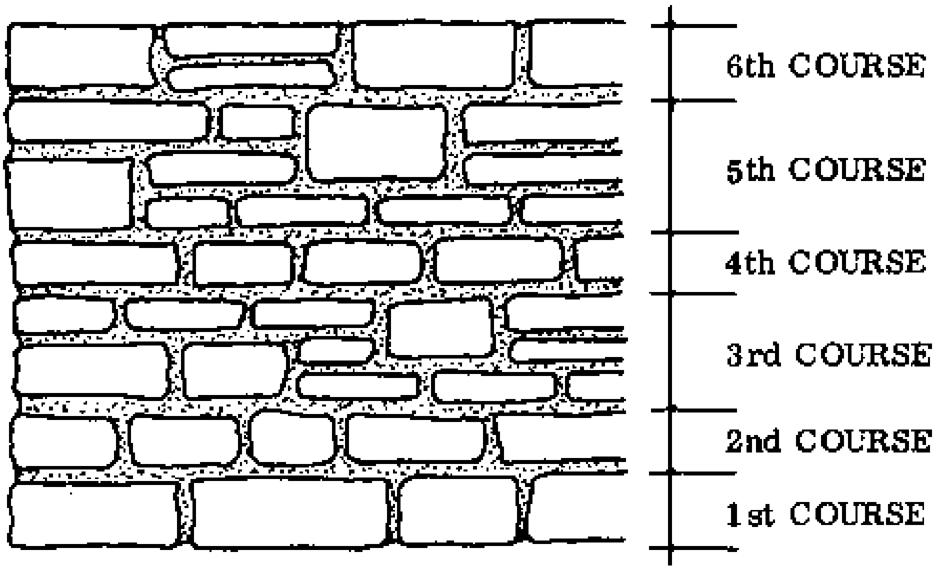


Fig. 1 BROKEN RANGE MASONRY

− RANGE MASONRY: The accurately squared stones are laid in courses, and each course is uniformly thick throughout its length. However, the courses are not all necessarily all the same thickness (Fig. 2).

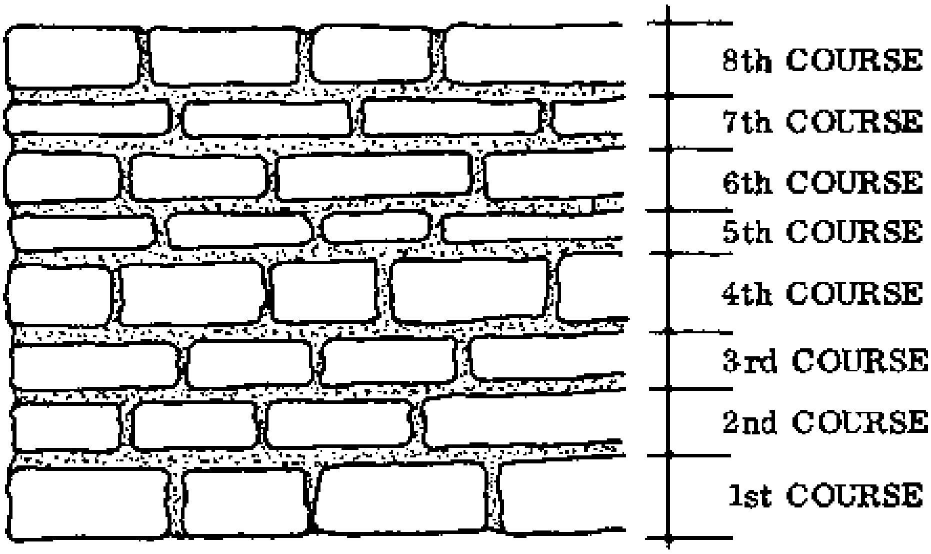


Fig. 2 RANGE MASONRY

Bonding principles

The following rules are observed for all four ashlar masonry techniques, regardless of how much dressing is done on the stones.

– Observe the structure of the rock, and if possible lay the stone in the way it has “grown”. For example, if the stone appears to have horizontal layers, it should be laid so that the layers are flat.

– Never lay stones edgewise.

– The stones should overlap each other as far as possible; avoid making any continuous cross joints between two courses (Fig. 3).

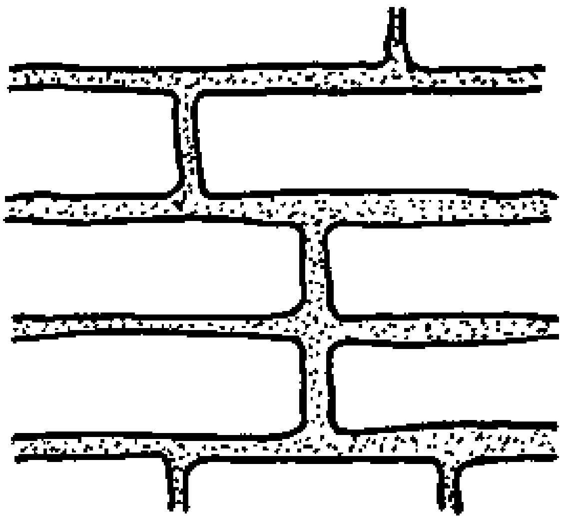


Fig. 3 WRONG!

– Also avoid making a group of continuous cross joints in one course (Fig. 4), as this creates an unpleasant appearance and an impression of a separation. A better arrangement is shown in Fig. 1.

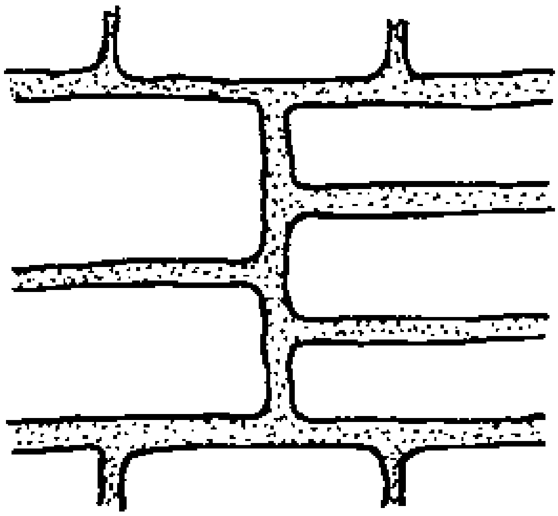


Fig. 4 WRONG!

– Fill up the bigger voids between stones with spalls, to save mortar.

– If ashlar masonry is used as a foundation, the first course is always laid in mortar, not directly on the ground.

– In case the foundation is combined with the footings and the plinth course, all ashlar masonry must be coursed and levelled at a height not exceeding 1,5 m, and preferably every 50 cm.

NOTES:

Laterite rock foundations

Many areas of northern Ghana offer the opportunity to work with a highly suitable building material; namely laterite rock.

In structure and colour it appears similar to laterite soil, and although it is rather porous and comparatively soft when freshly dug from the earth, it gradually becomes hard and rock–like when it is exposed to the air.

Laterite stone has been used for many sorts of masonry because it is readily available, easily shaped, and strong.

Its only disadvantage compared with concrete is that it takes time to excavate the stone and shape it into blocks.

However, taking all the factors into consideration, there are some cases where laterite rock represents the most economical choice for building material.

Although the stone can be given any convenient shape, the dimensions of blocks made from laterite stone should preferably be 14 x 30 x 46 cm, which allows proper bonding with all sorts of masonry. Accordingly, the dimensions of half–blocks are 14 x 30 x 22 cm; for 3/4 blocks, 14 x 30 x 34 cm; and for 1/4 blocks, 14 x 30 x 10 cm (Fig. 1).

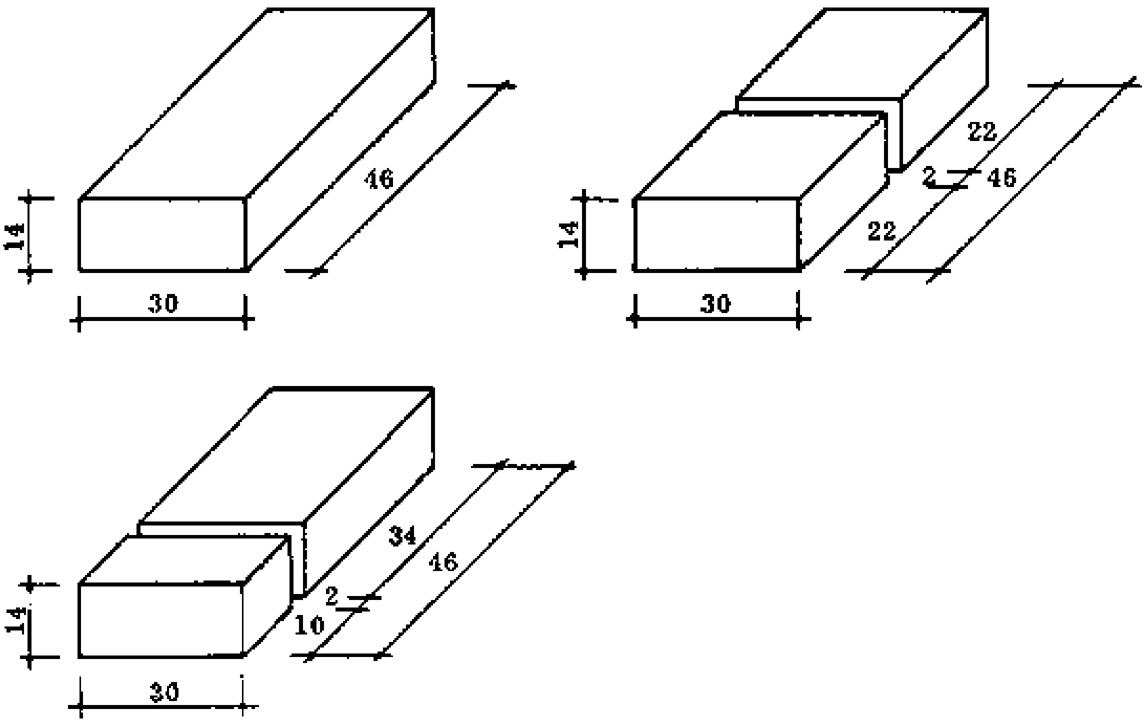


Fig. 1

When blocks of laterite stone are used for footings, they are laid in stretcher bond, flatwise, which results in a footing which is 30 cm thick instead of 23 cm when sandcrete blocks are used (Fig. 2).

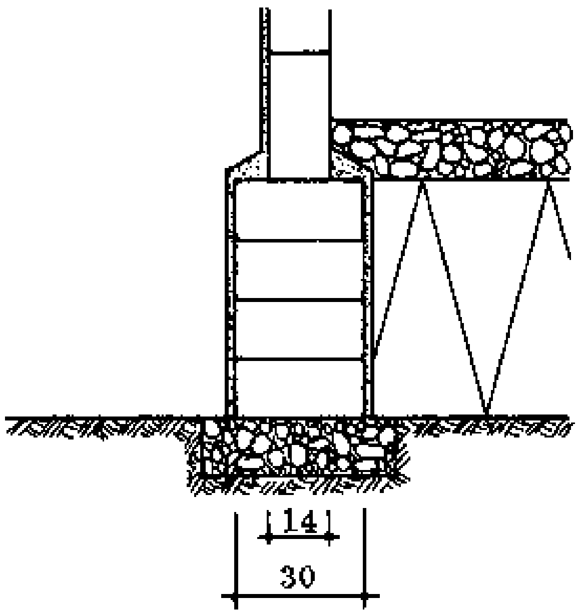


Fig. 2

Foundations can be built out of laterite stone blocks; the blocks are laid in header bond, with a minimum of two flatwise courses (Fig. 3). Foundation and footings can be combined as shown in Fig. 4, which allows the erection of stronger outside walls.

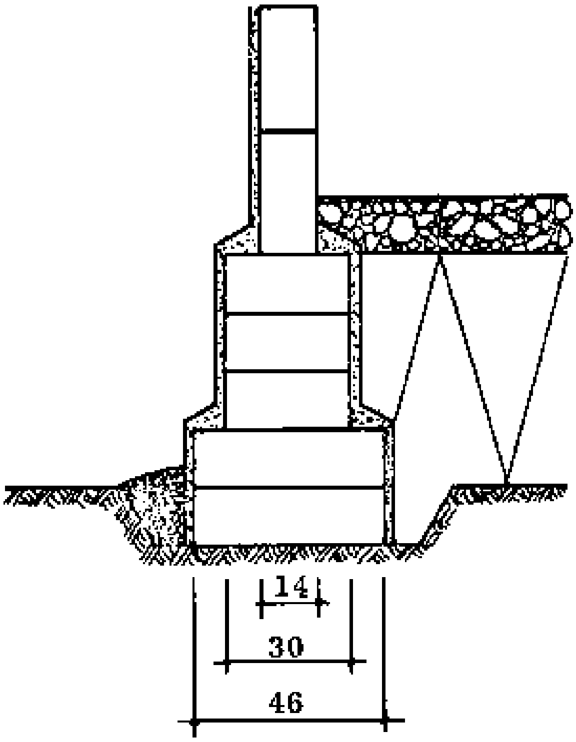


Fig. 3

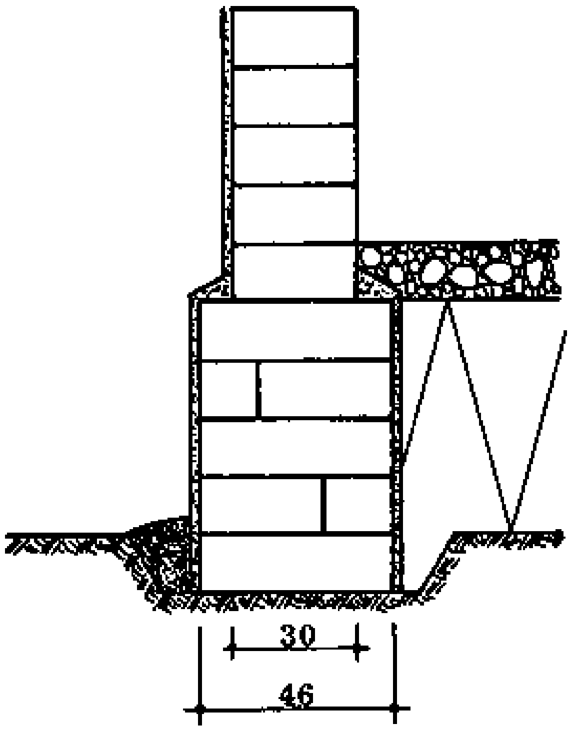


Fig. 4

Since the laterite stone is porous, the foundations should be plastered on both the inside and outside faces.

NOTES:

Artificial stone foundations

As far as Rural Building is concerned, there are only two artificial stone products of importance for foundations: bricks and sandcrete blocks.

Both products are seldom used for foundations in northern Ghana. We don't use bricks because, while the clay is available to make them, it would take too much firewood or other fuel to fire the bricks. Concrete or laterite stone blocks are usually more economical to use than sandcrete blocks.

– BRICK FOUNDATIONS: Brick is one of the oldest known artificial stones; it is made from clay which is shaped, dried, then fired in a kiln. The usual dimensions of a brick are 7,1 x 11,5 x 24 cm, a size which results in a masonry containing many joints, but which allows the construction of most complicated bonds.

Foundations made out of bricks must be at least 5 courses high and carefully laid in cross bond or English bond (Fig. 1). Note the different arrangements of the alternating courses.

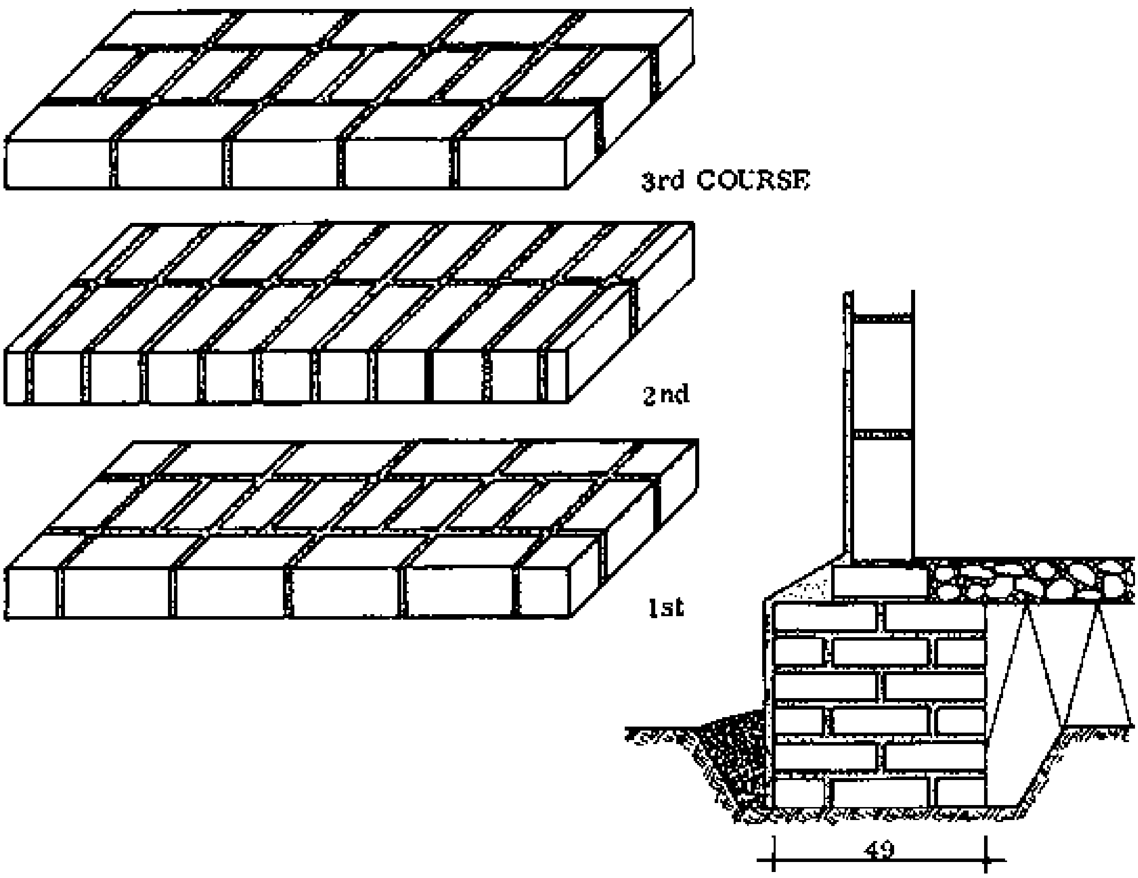


Fig. 1 BRICK FOUNDATION

– SANDCRETE BLOCK FOUNDATIONS: In an area where there is a lot of sand available but no broken stones, gravel or laterite rock, etc., one may be forced to use sandcrete blocks to build the foundations. The mix proportion for these blocks should be no less than 1:8, and the blocks themselves should be laid in header bond, as seen in Fig. 2.

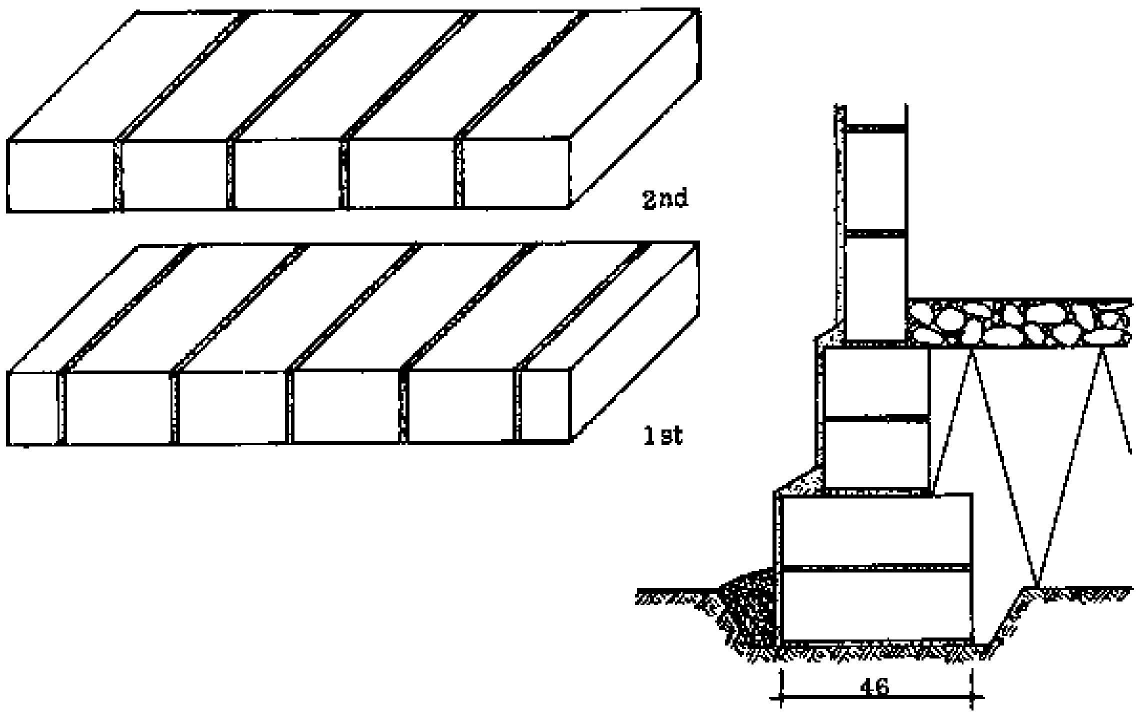


Fig. 2 SANDCRETE BLOCK FOUNDATION

NOTES:

CONCRETE FOUNDATIONS

Excavating the foundation trenches

After the setting out is complete, including marking the positions and widths of the foundations on the ground, the lines are removed from the profiles or pins and the excavation work is started.

All the topsoil and as much as possible of the soft soil and light soil is removed, and brought to a place where it can either be used immediately or kept for a future dry season garden.

In most cases soils of a firm consistency and good load bearing capacity are found at depths ranging from 15 to 25 cm, which is deep enough for the construction of foundations for a rural dwelling place (Fig. 1).

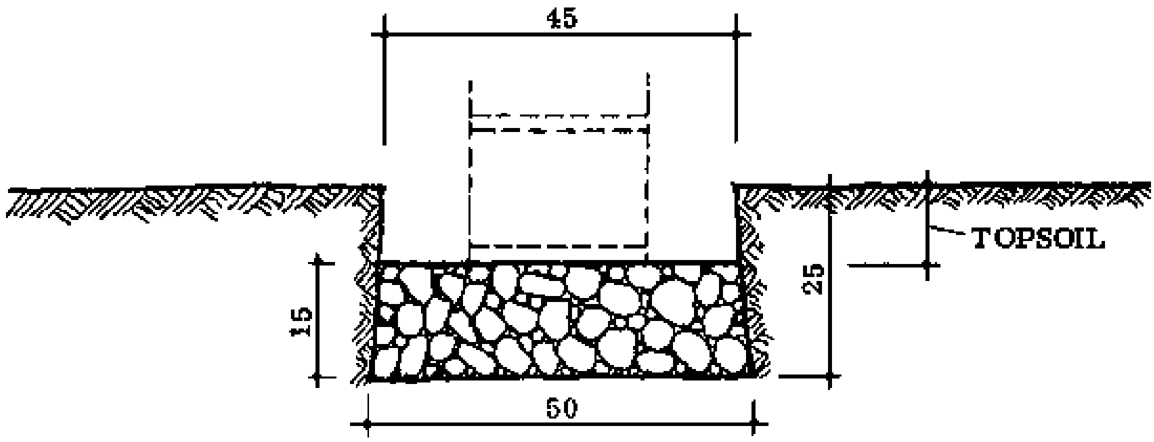


Fig. 1

There are of course exceptional cases where the rock is close to the surface, or even at the surface, which makes the work easier; or the opposite situation of very deep soft soil, which is a problem.

In areas where there is light or heavy rock close to the surface, the thickness of the foundation can be reduced, but to no less than 5 cm thick. The surface of the rocks should be roughened if necessary to provide a good grip, and cleaned before the concrete is cast. These areas are usually rich in stones, so one should check out the possibility of making boulder foundations. The boulder foundations can also be carried out as a stepped foundation if necessary, following the contours of the rocky surface (Fig. 2).

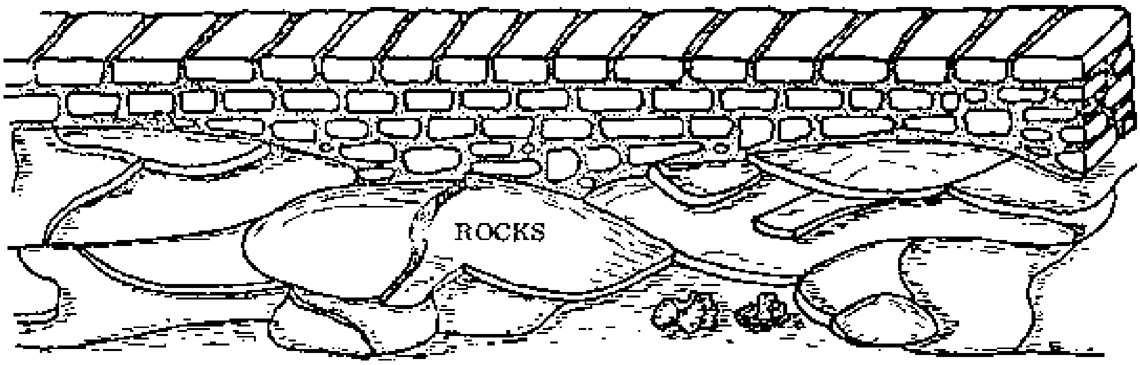


Fig. 2

Very deep soft soil is a problem, and it requires special measures. In general, all excavations should be continued until a layer of good firm soil is found. When a depth of 60 cm is reached and the soil is still too soft, the excavation work is stopped.

Instead of digging deeper, widen the trench to at least 60 cm. This increases the total area on which the structure rests, with the result that the pressure on the soil underneath is distributed over a wider area.

Fig. 3 shows that the thickness of the widened foundations must be increased to 30 cm, because of how the foundation material distributes the pressure of the wall above.

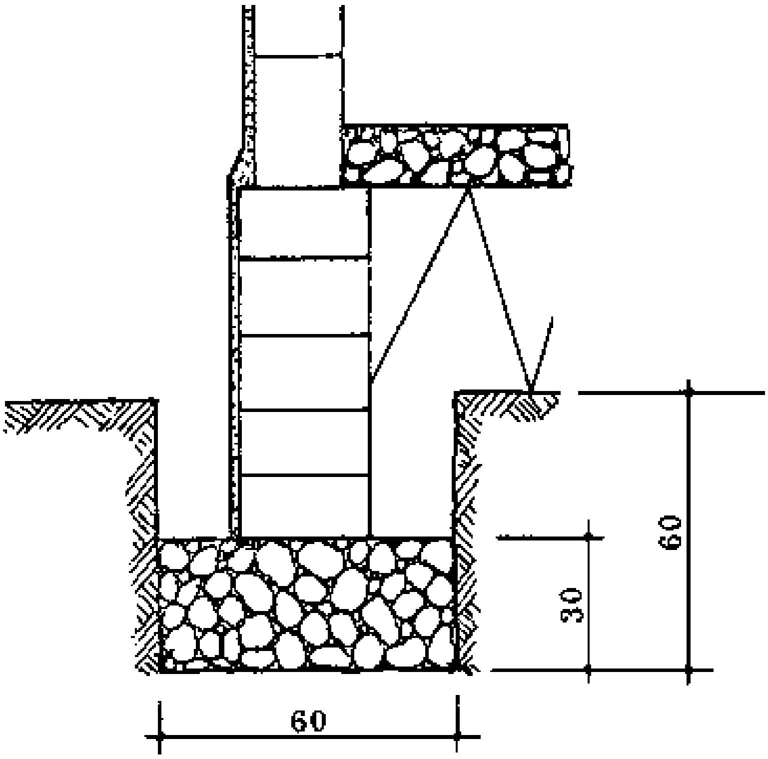


Fig. 3

In order to save concrete, put bigger stones, rubble or boulders into the foundation; it should preferably be flush to the ground surface (Fig. 4).

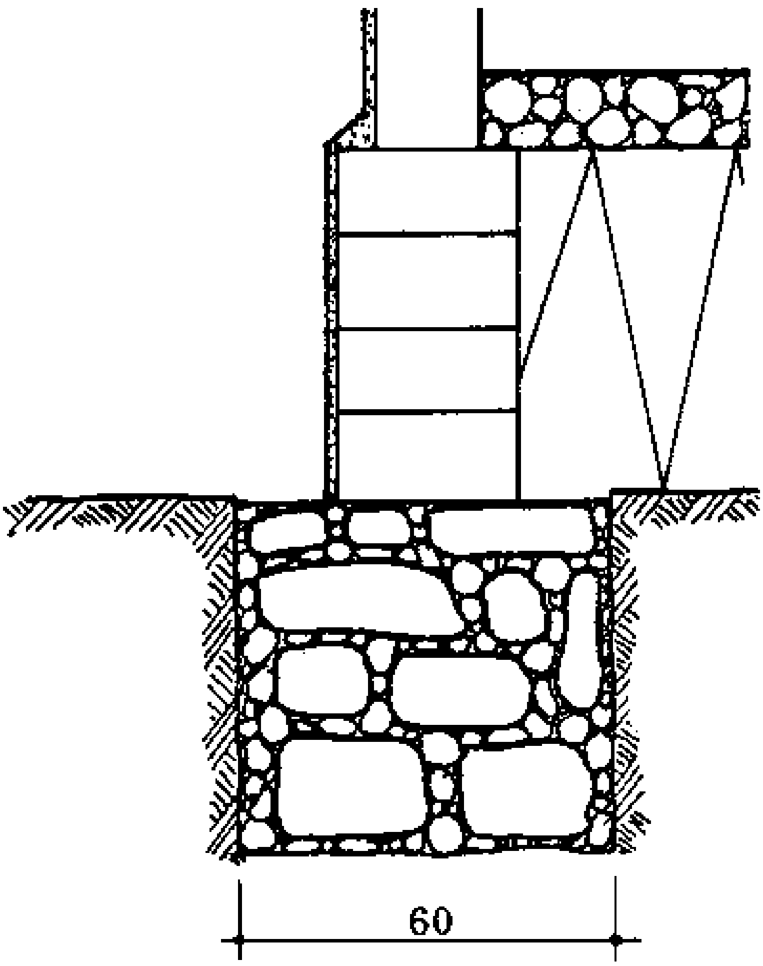


Fig. 4

– SOFT POCKETS: During the excavation work it sometimes happens that the character of the soil changes unexpectedly: spots or pockets of soft soil are found in the firm soil. These may be natural deposits or man–made holes that have gradually filled in. The load bearing capacity of the soil is reduced in these places.

If the area is relatively small and runs across the trench, it is advisable to reinforce the concrete foundation covering the pocket with a network of crossed iron rods (Fig. 1). The rods should be long enough to bridge the soft part and project past it on both ends to anchor securely in the foundation which is supported by firm soil.

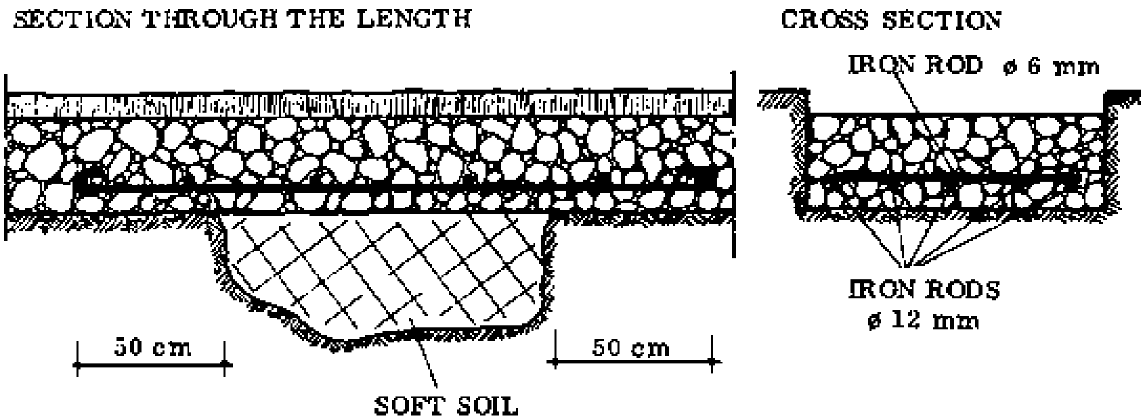


Fig. 1

In case the area is too wide to be reinforced in this way, the soft soil is removed and the hole is refilled with compacted layers of boulders, stones, and sharp sand; or with concrete, thus improving the load bearing capacity (Fig. 2).

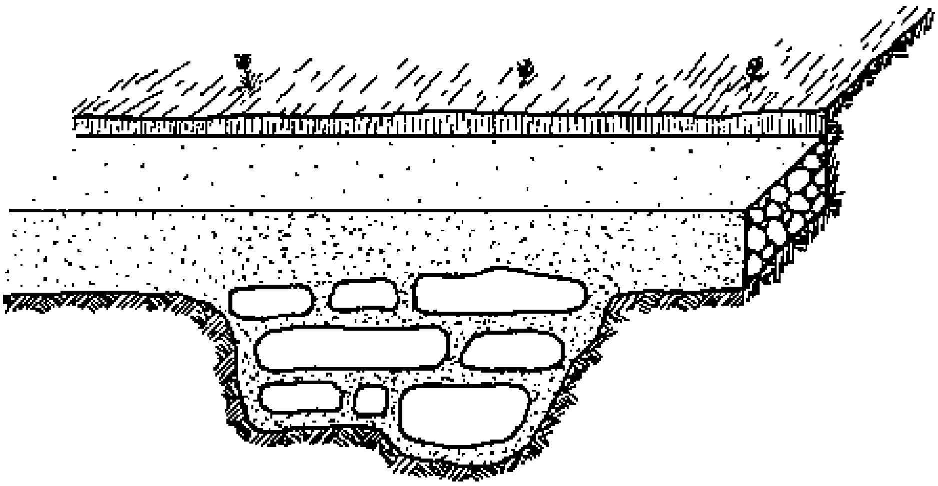


Fig. 2

When the foundation has to cross a very wide section of soft soil, that section of the foundation has to be made wider and deeper than the rest (see the previous page).

– SHAPE OF THE TRENCHES: Although it is generally accepted that the ideally shaped foundation trench has walls that are at right angles to the levelled bot tom of the trench (Fig. 4), it is often observed that unskilled or even skilled workers tend to dig trenches which are incorrectly shaped. Special attention should be given to this problem during excavations in harder soils, because the more difficult the digging, the more likely it is that incorrectly made trenches will result (Fig. 3).

Fig. 3

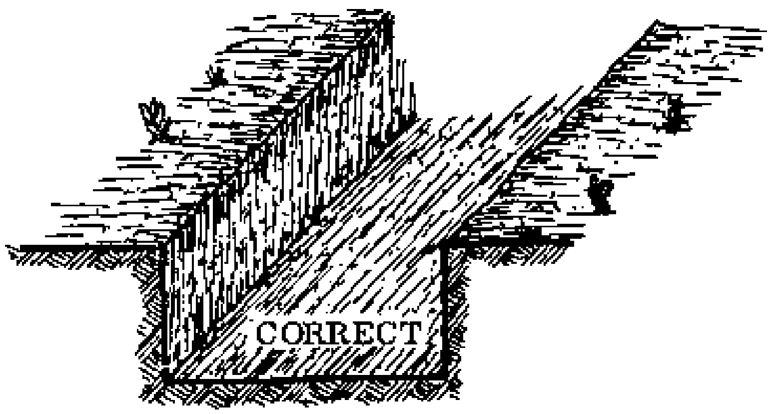


Fig. 4

Experience has shown that it is best to ask the workers to make the trenches a bit wider at the bottom, to ensure that the minimal width of the foundation is maintained everywhere (Fig. 5).

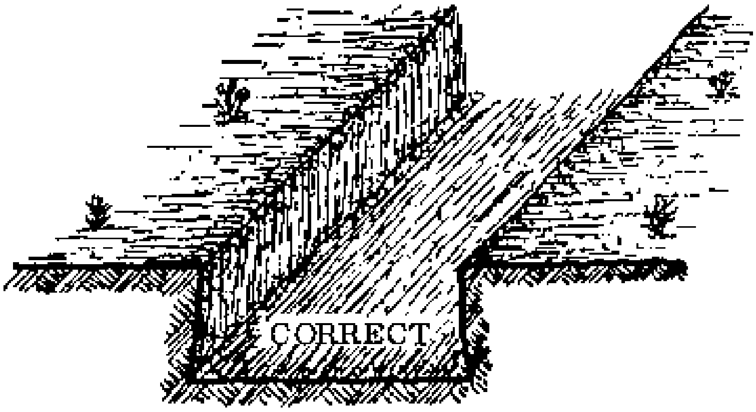


Fig. 5

NOTES:

Measurements of stepped foundations

The number, length and height of the steps in the foundation depend on the shape and steepness of the ground contours. To make it easier to construct the footings later and to save materials, the skilled builder will adapt the length and height of the steps to fit with the type of blocks that will be used for the footings.

Fig. 1 shows a common stepped foundation made of concrete, and footings built of sandcrete blocks. It can be seen that the concrete thickness is 15 cm throughout, while the steps are different lengths.

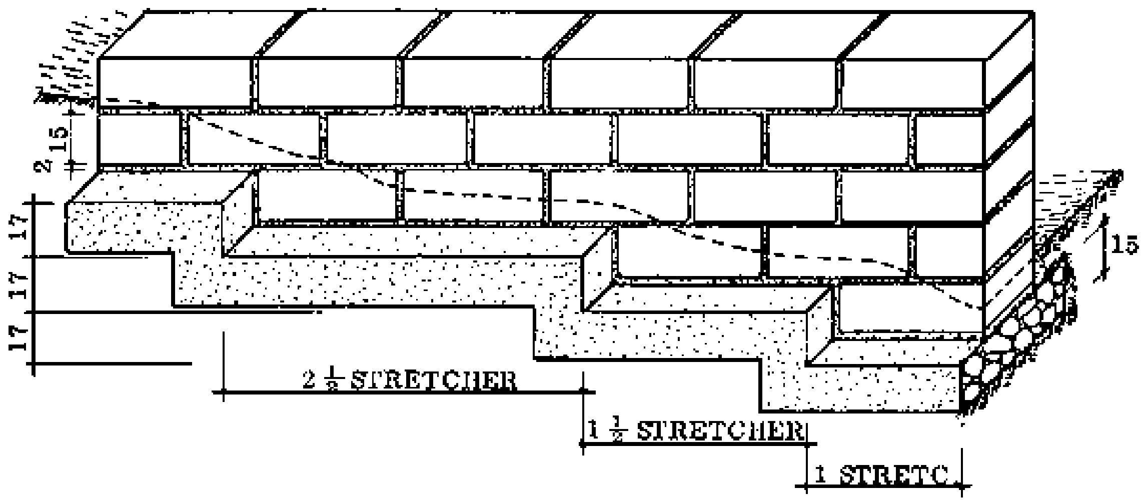


Fig. 1 STEPPED FOUNDATION WITH SANDCRETE FOOTING

– HEIGHTS OF THE STEPS: The height of each concrete step is always the thick ness of a sandcrete block, plus the thickness of the mortar bed; making 15 cm plus 2 cm equals 17 cm.

In case the steps have to be steeper, the height of the step is always a full multiple of 17 cm: 34, 51 cm, etc. so that 2 or 3 courses of sandcrete blocks can fit on the step (Fig. 2).

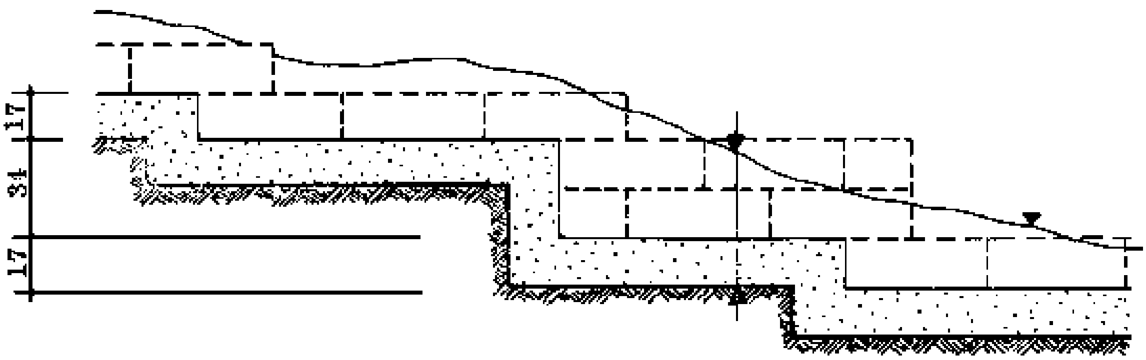


Fig. 2 STEPPED FOUNDATION WITH 2 COURSES ON ONE STEP

– LENGTHS OF THE STEPS: All masonry is supposed to be built in half–block bond. Accordingly, the minimum length of a step is half a block plus the joint: 22 cm plus 2 cm equals 24 cm; or for longer steps, a full multiple of this: 48 cm, 72 cm, 96 cm and so on.

If the foundation is to be constructed with laterite stone blocks (Fig. 3), the height of one step is reduced to 16 cm, that is 14 cm for the block plus 2 cm for the joint. The lengths of the steps are the same as for sandcrete blocks.

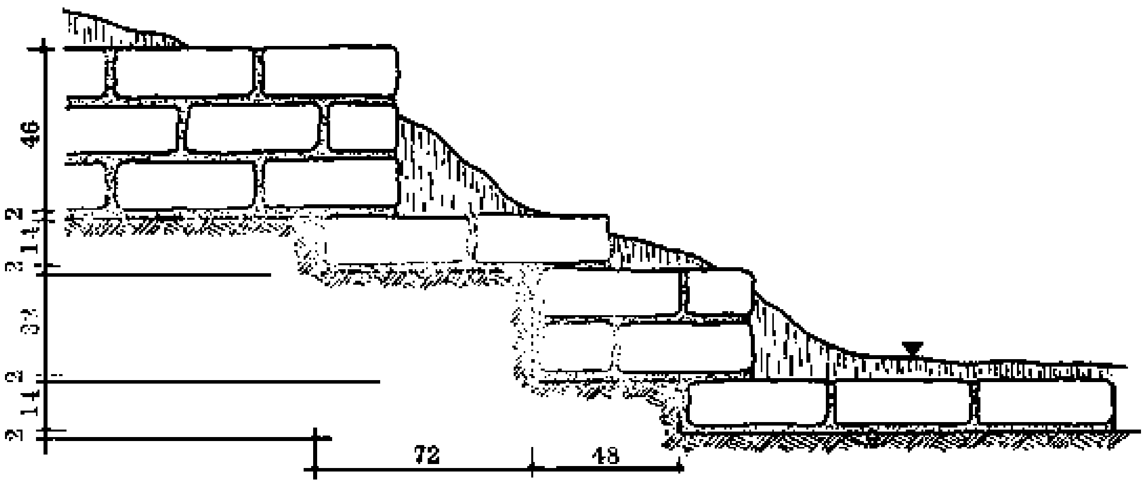


Fig. 3 STEPPED FOUNDATION WITH LATERITE STONE

The actual construction of a stepped foundation and its footings must always be started from the lowest step, to prevent bonding mistakes.

NOTES:

Levelling the trenches and marking the foundation depth

The bottoms of all foundation trenches must be perfectly level, not only in the length but also across the width. Otherwise the building may settle unevenly, which can cause cracks in the structure or even a complete collapse.

This is why a foundation on a sloping site must be constructed in steps (Fig. 1) instead of taking a course parallel to the slope of the ground.

An improperly constructed foundation can result in a building that is a danger to the people living in it, and also a possible loss of valuable property.

When the trench has been excavated and roughly levelled, the next step is to determine the depth of the foundation concrete and at the same time, to level the bottom of the trench more exactly.

This is done by inserting iron or wooden pegs in the trench so that they project from the bottom by a distance equal to the depth of the foundation (Fig. 1). The distance between the pegs should be no further than the straight edge can bridge, so that it is possible to level between them using the straight edge and spirit level. Trenches can be levelled more accurately over longer distances by using the water level.

The triangular pattern of the pegs is necessary to obtain a level surface: if the distances A−B and B−C are level, then A−C must also be level (Fig. 1).

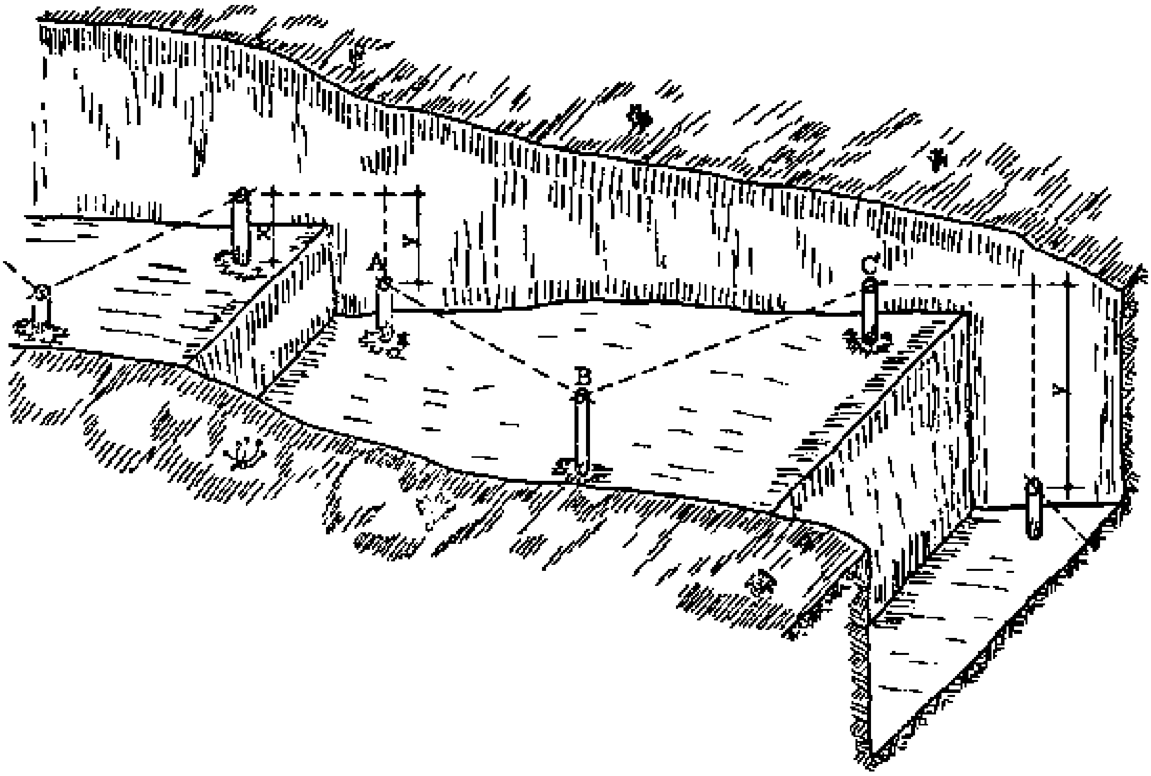


Fig. 1

x = DEPTH OF FOUNDATION CONCRETE
y = HEIGHT OF STEPS (BLOCK PLUS JOINT)

NOTES:

When the tops of the pegs are level, we can measure how far each peg sticks out from the bottom of the trench, and thus check whether the trench bottom is also level. High areas are skimmed off with a shovel, while hollows are filled with concrete. Never refill hollow areas with excavated soil, as this might lead to uneven settling of the foundation.

NOTES:

Mix proportions

The correct mix proportions for foundation concrete should generally be determined through the calculations of an engineer. Since this is usually not possible in Rural Building, the Rural Builder can decide the mix proportion with the help of the Tables of Figures, Reference Book, page 234. The data given there and the following hints are approximate values and are intended as a guide. The general range for the mix is from 1:10 to 1:15.

− For small projects like single dwellings, stores, etc., a mix proportion of 1:15 is sufficient because the total weight on the foundation is not so great.

− Bigger buildings like two−storeyed houses, halls or churches require a better mix proportion of 1:12.

– Elevated water storage tanks, bell–towers and other large heavy structures should be based on foundations mixed in a proportion of 1:10.

Preparations before casting

If the ground is dry, the foundation trenches have to be wetted down before the concrete is cast. This helps to reduce the absorption of moisture from the concrete by the soil. Take care that the sides of the trenches are also thoroughly wetted.

After the foundation concrete is mixed (Reference Book, pages 161 to 163), it has to be transported to the trenches, either in buckets, headpans or wheelbarrows. All transportation of the concrete has to be done without too much delay or vibration, as this could lead to the aggregates becoming separated. If wheelbarrows are used, the paths should be covered with boards to reduce vibration and to make it easier to push the wheelbarrows.

It is a good idea to provide a wheel stop (Fig. 1) beside the trench. This helps to ensure that the concrete is emptied right in the middle of the trench and does not take along dust and dirt from the sides of the trench. A board can be used to protect the opposite side of the trench (Fig. 1). This is not necessary when the concrete is picked up with a shovel from the wheelbarrow.

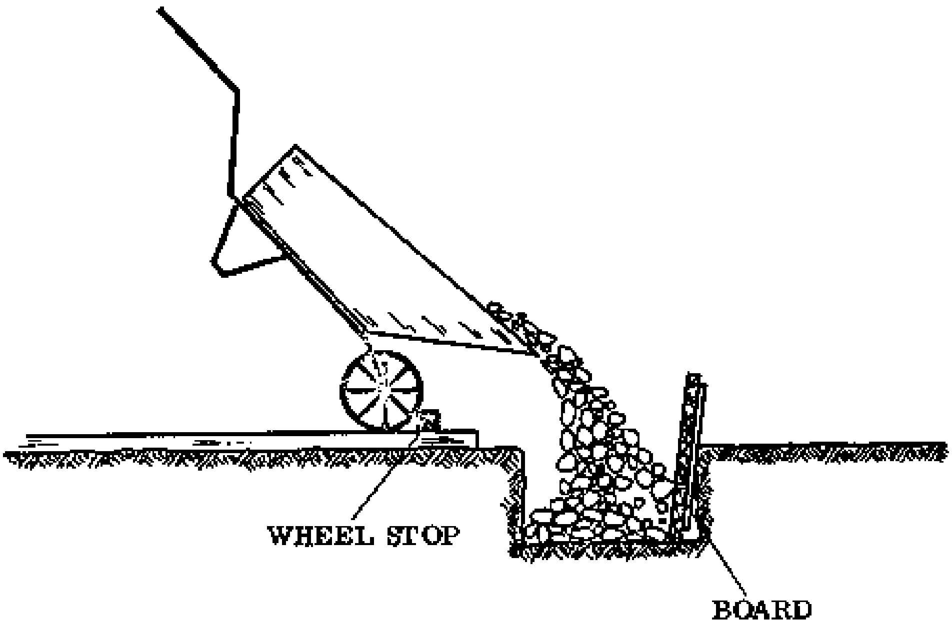


Fig. 1

NOTES:

The containers in which concrete is transported should be kept wet, so that no concrete sticks to the container when it is poured.

NOTES:

Casting

The concrete must be cast systematically so that the compacting and levelling follow immediately after it is poured in the trench. The headpan loads or wheelbarrow loads are deposited in an orderly way, not just dumped anywhere in the trench (Fig. 1).

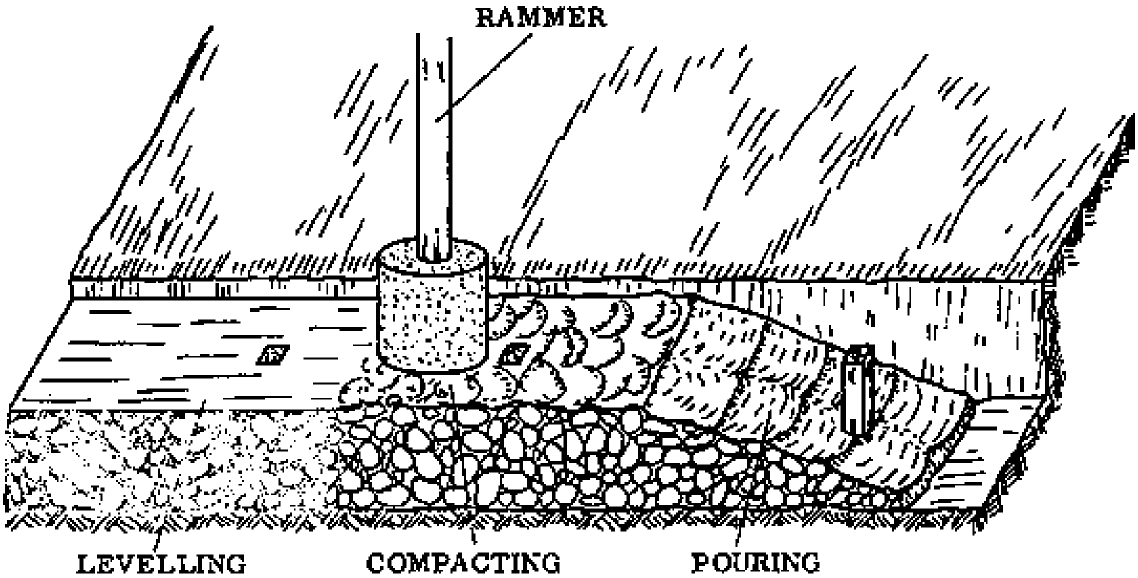


Fig. 1

Do not cast foundation concrete in sections with spaces in between, as this can lead to disturbances of the hardening process when the gap is filled up later. Always start from the far end of the trench and work your way closer to the mixing area. Two groups of workers can cast foundations on different sides of the building at the same time.

– COMPACTION: The concrete must be well compacted so that no air voids re main. Since foundation concrete has a rather stiff consistency, to compact it requires the use of heavy rammers (Reference Book, page 19).

The concrete is applied in layers no more than 15 cm deep, and each layer is compacted with the rammers. Pay special attention to compacting the corners and the outside edges. Stiff concrete should be compacted until its surface becomes wet.

Do not be tempted to compact the concrete just roughly, or to add water to ease the work. The production of a good foundation is a hard job, but only hard work will result in a good quality foundation.

– STEPPED FOUNDATION: In casting the vertical parts of a stepped foundation, pieces of board are used as shown in Fig. 2. These are fitted into recesses cut in the side of the trench. The width of the board is the same as the height of the step (Fig. 2).

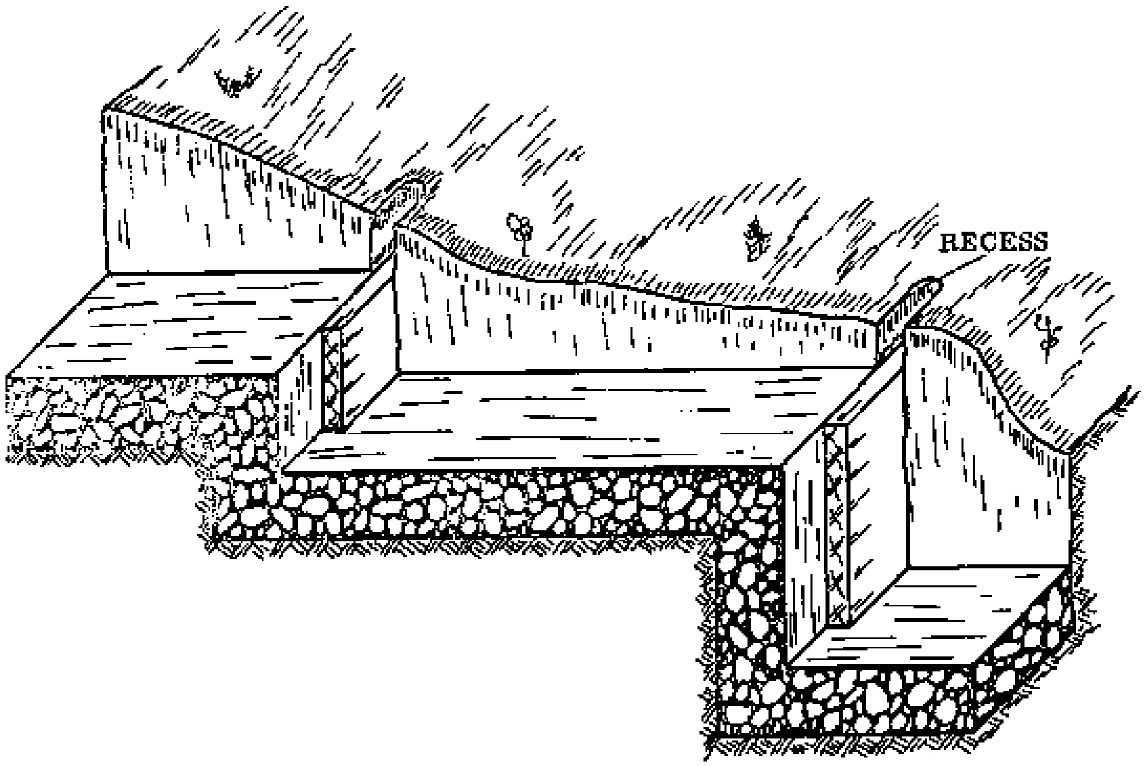


Fig. 2 CASTING A STEPPED FOUNDATION

NOTES:

Levelling the foundations

As soon as the foundation is compacted, the top has to be levelled flush with the top of the pegs. For this purpose a strike board is used.

If the compaction has been carried out correctly, the levelling should be fairly easy as there is not much concrete left to strike off.

All wooden pegs have to be removed and the holes filled with concrete, while the iron pins may remain if these were used.

As soon as the hardening process starts, as can be seen by the dull and dry looking surface, the area where the footing course will be set must be slightly roughened with the blade of a trowel, to provide a good grip for the mortar (Fig. 1).

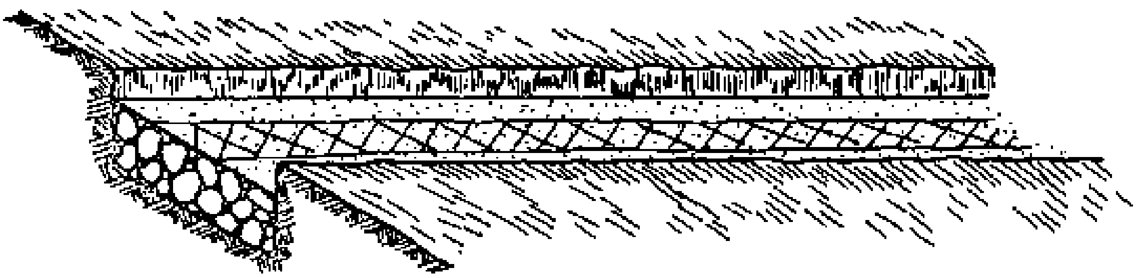


Fig. 1

Curing

If the concrete is disturbed during the hardening process, serious defects may be produced.

Freshly cast concrete must therefore be covered with empty cement bags, straw, mats, boards or moist sand to protect it against:

– The rain, which can wash out the cement paste, leaving the non–bound aggregate behind (Fig. 2).

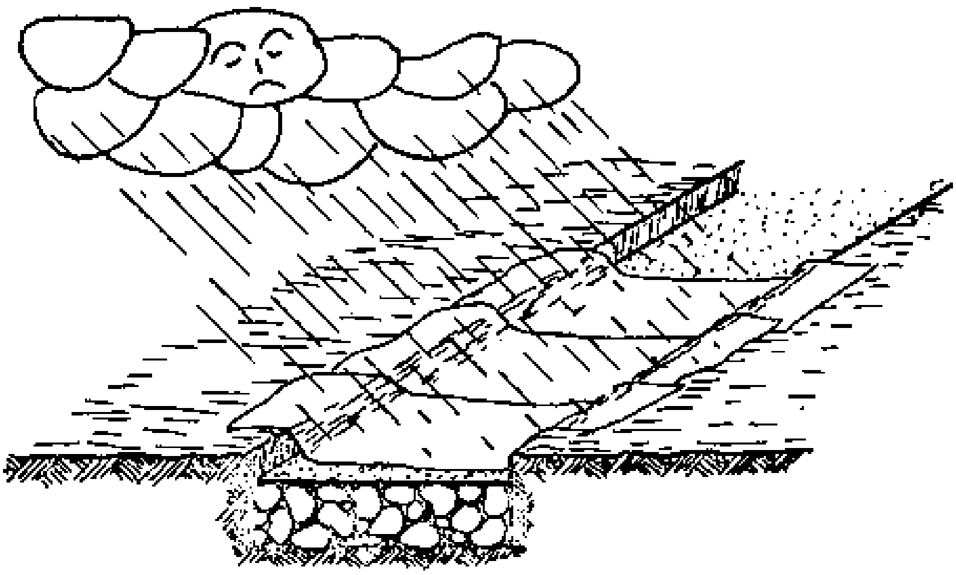


Fig. 2

– The sun, which can "burn" the surface of the concrete, so that although the concrete looks cured, under the surface it has not set hard enough (Fig. 3).

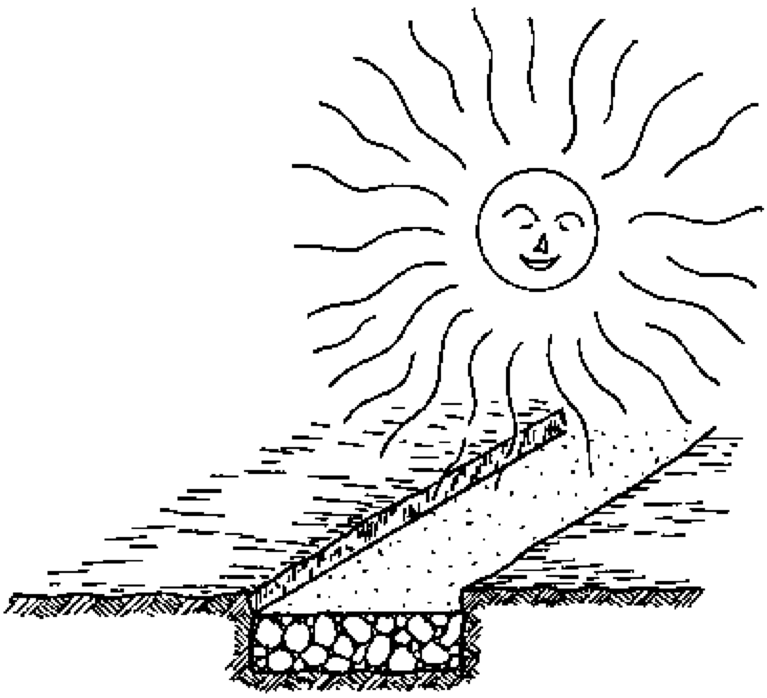


Fig. 3

– The wind, which can dry up the surface, resulting in cracks due to excessive dryness and shrinkage: especially during the harmattan season (Fig. 4).

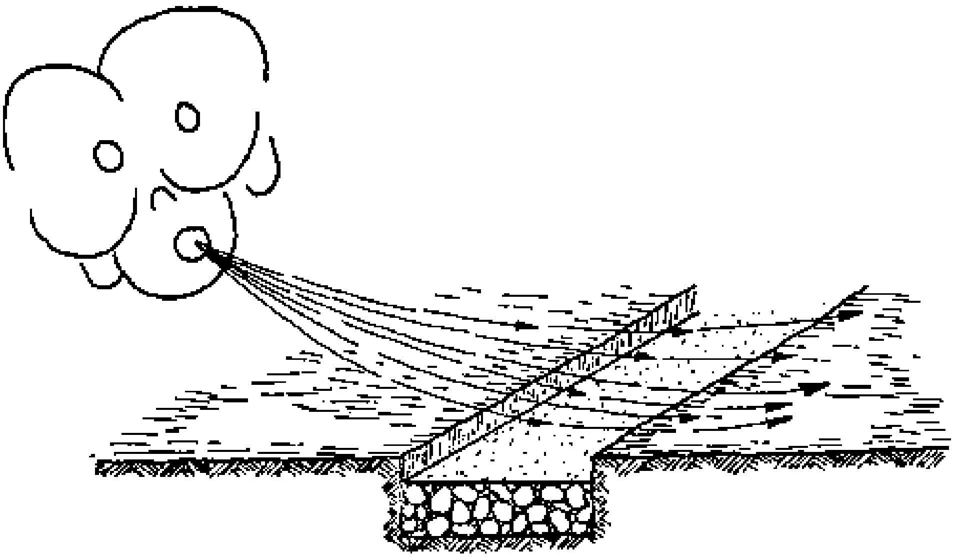


Fig. 4

– The dirt, which may get on the surface and interfere with the grip of the footings.

Any vibration near the hardening concrete could cause cracks and destroy the internal structure of the concrete. Don't continue with any excavation work, etc. near the just–completed foundation.

Once the surface has set sufficiently hard, the concrete must be wet down and kept wet for three days.

NOTES:

FOOTINGS

The projecting courses at the foot of a wall, between the rising wall and the foundation, are called the footings. If there is no wider concrete foundation, the combination foundation/footing is called a footing (see Foundations, page 25).

Functions of the footings

Since the footings form the link between the rising wall and the foundation, the demands on them are similar to those set on the foundations. These are:

– To provide a solid, level base for the walls
– To receive loads from the structure above
– To distribute the loads onto the foundation (or the ground).

In addition, the footings have to:

– Raise the floor high enough above ground level to prevent moisture from rising through to the floor, and to keep the landcrete blocks of the rising wall dry.

As far as Rural Building is concerned the last function is the most important one.

Materials and measurements

The most common material used for footings is sandcrete blocks, laid flatwise in a half−block bond. The courses are 23 cm thick and 17 cm in height, and they are laid in the centre of the foundation strip.

In order to effectively prevent moisture penetration, three courses should be laid above ground level, thus raising the soffit of the floor to a height of 51 cm above ground level. This is the minimum for all bedrooms and living areas.

Only in cases where the building is not to be used as a dwelling place for people, for example a store or a shelter for animals, may the footings be built to a lower level.

The use of boulder or laterite rock masonry is preferred as this can save considerable amounts of cement. The dimensions of such footings will be the same as those of sandcrete footings, when the laterite rock blocks are cut to the same dimensions as sandcrete blocks.

− COMPARE: Fig. 1 shows a building with no footing. The floor is at ground level and water can easily enter. The building in Fig. 2 rests on a footing and the floor is raised above ground level, so it will be drier and thus healthier to live in, and also less likely to collapse since the mud walls are kept drier.

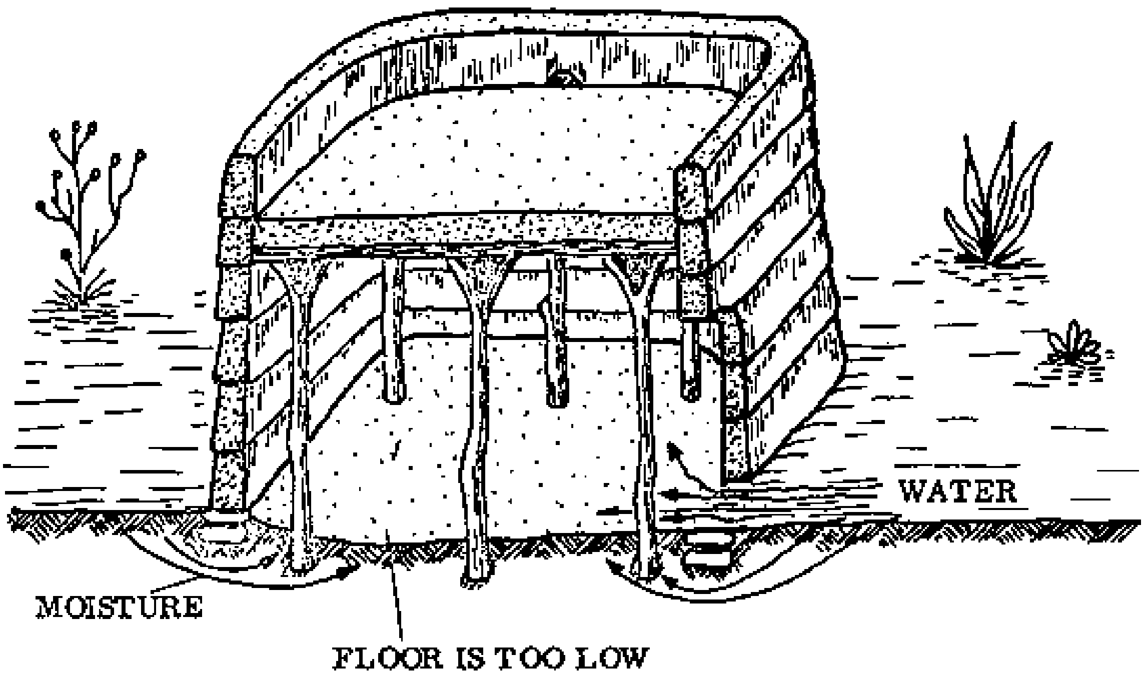


Fig. 1 BUILDING WITHOUT FOOTING

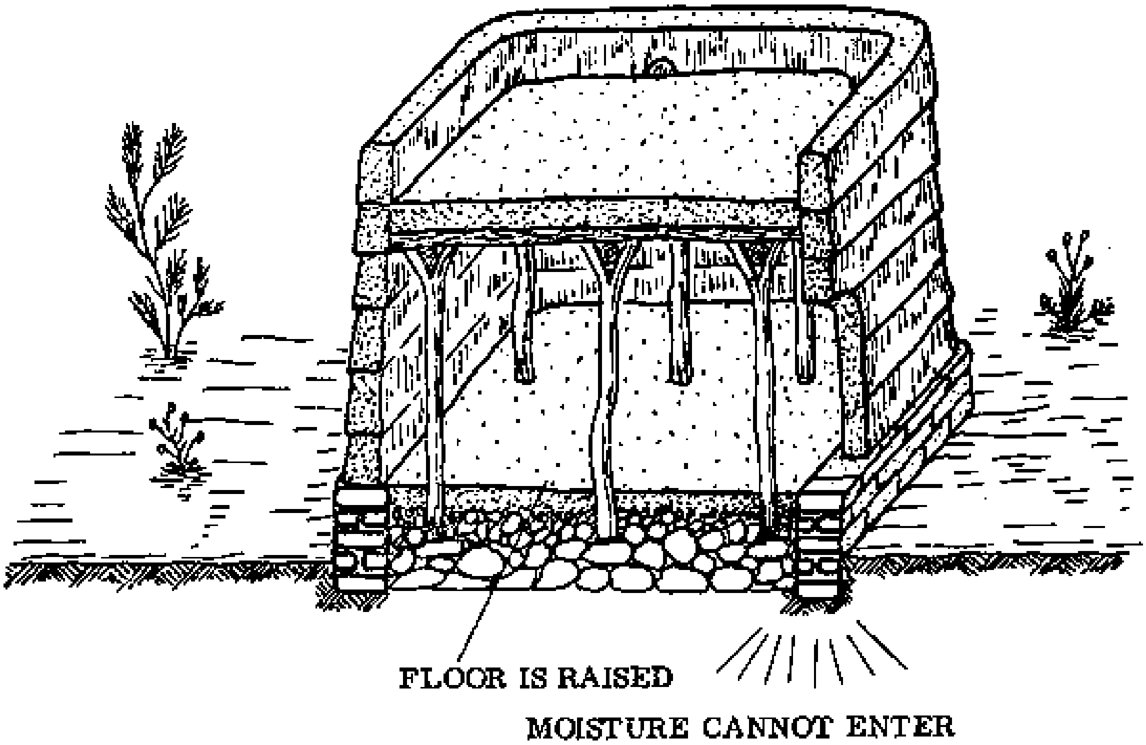


Fig. 2 BUILDING WITH FOOTING

SPECIAL BONDS

Special bonding problems occur at quoins, T–junctions and cross junctions where walls of different thicknesses meet. These situations are frequently found in connection with the footings. They may also occur in other masonry.

An example where footings with different thicknesses meet is in the construction of a verandah. This is because the footing courses under verandahs are laid edgewise instead of flatwise, in order to save material. This is possible because there are no great loads on the verandah footings.

The bonding problem arises from the fact that the dimensions of common sandcrete blocks make it difficult to form a bond between the edgewise courses and those laid flatwise. Fig. 1 shows that two courses laid edgewise do not exactly correspond with three courses laid flatwise: there is a 1 cm difference in height.

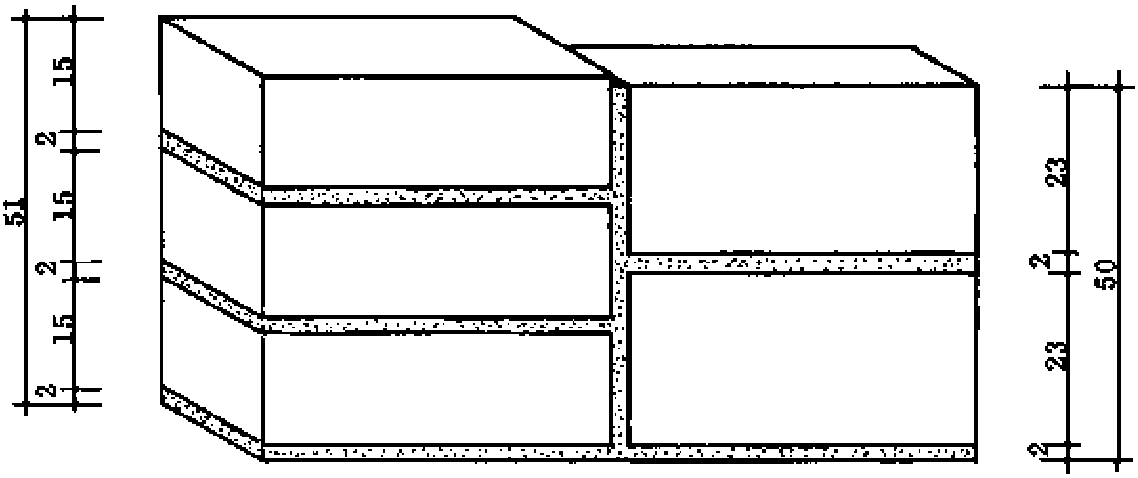


Fig. 1

Footing blocks can be specially made to dimensions that will show a better correspondence, so that bonding is easier and less block–cutting is needed to make the bonds. Fig. 2 shows four flatwise courses of specially made blocks, 10,5 cm thick, which correspond perfectly with two courses laid edgewise. Thus bonding is made easier.

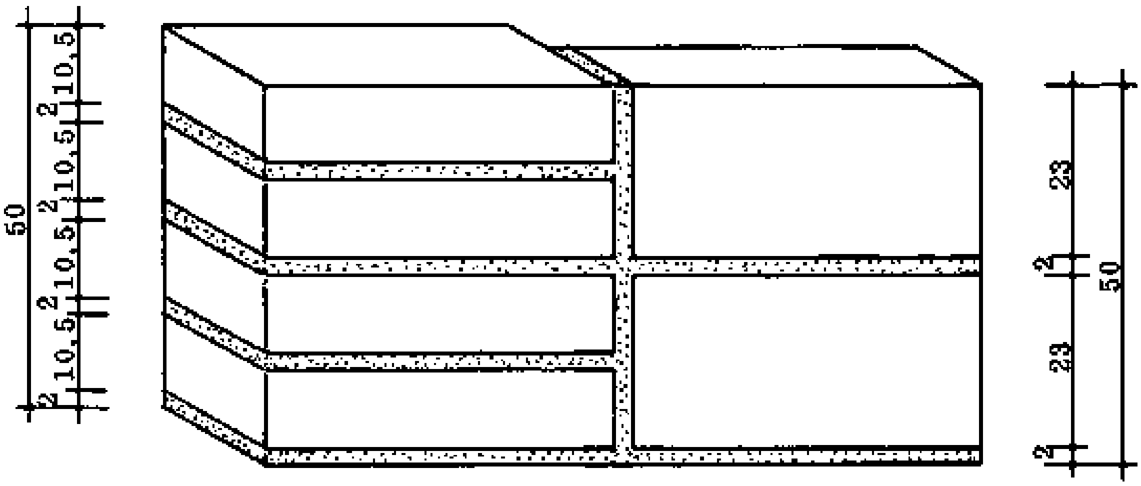


Fig. 2

The verandah footing may be kept in line with the outside face of the wall footing (Fig. 3), or in line with the rising wall (Fig. 4) which results in a recessed footing (see Drawing Book, pages 65, 66, and 90).

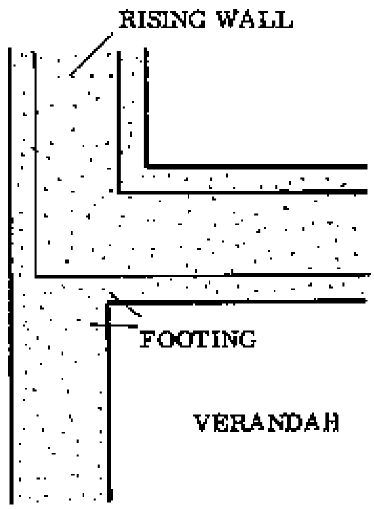


Fig. 3

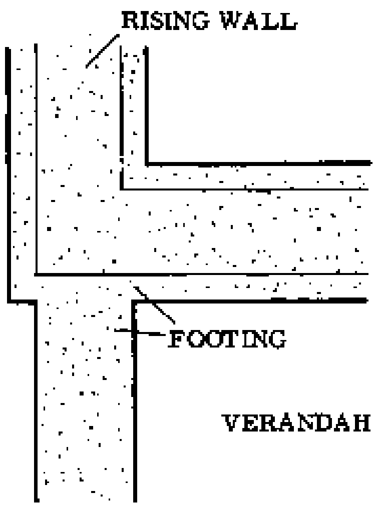


Fig. 4

Each type of block can be used with either a recessed footing or a flush footing. Therefore there are four possible situations:

– Common sandcrete blocks in a flush footing
– Common sandcrete blocks in a recessed footing
– Specially made sandcrete blocks (10,5 cm thick) in a flush footing
– Specially made sandcrete blocks in a recessed footing.

NOTES:

Different wall thicknesses at a quoin

This situation occurs when a verandah is closed at one end with a wall, or where a "loggia" is made. A loggia is a room which has one side open to the courtyard, garden, etc. (Fig. 1). The footings which carry walls have to be regular flatwise footings, while the footing on the open side can be constructed with the blocks edgewise, since it does not carry any wall.

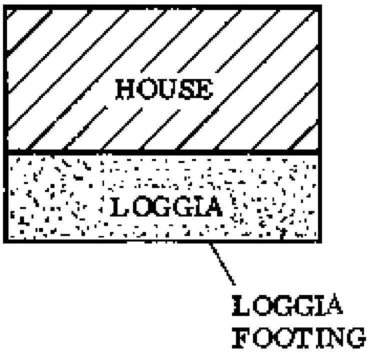


Fig. 1

– COMMON BLOCKS, FLUSH TO OUTSIDE: Fig. 2 shows that both quoin stretchers of the edgewise courses (blocks A and C) have to be cut to an odd shape to fit together with the flatwise quoin header of the second course (block B). In order to maintain the half–block bond, block B has to be cut to a length of 39 cm.

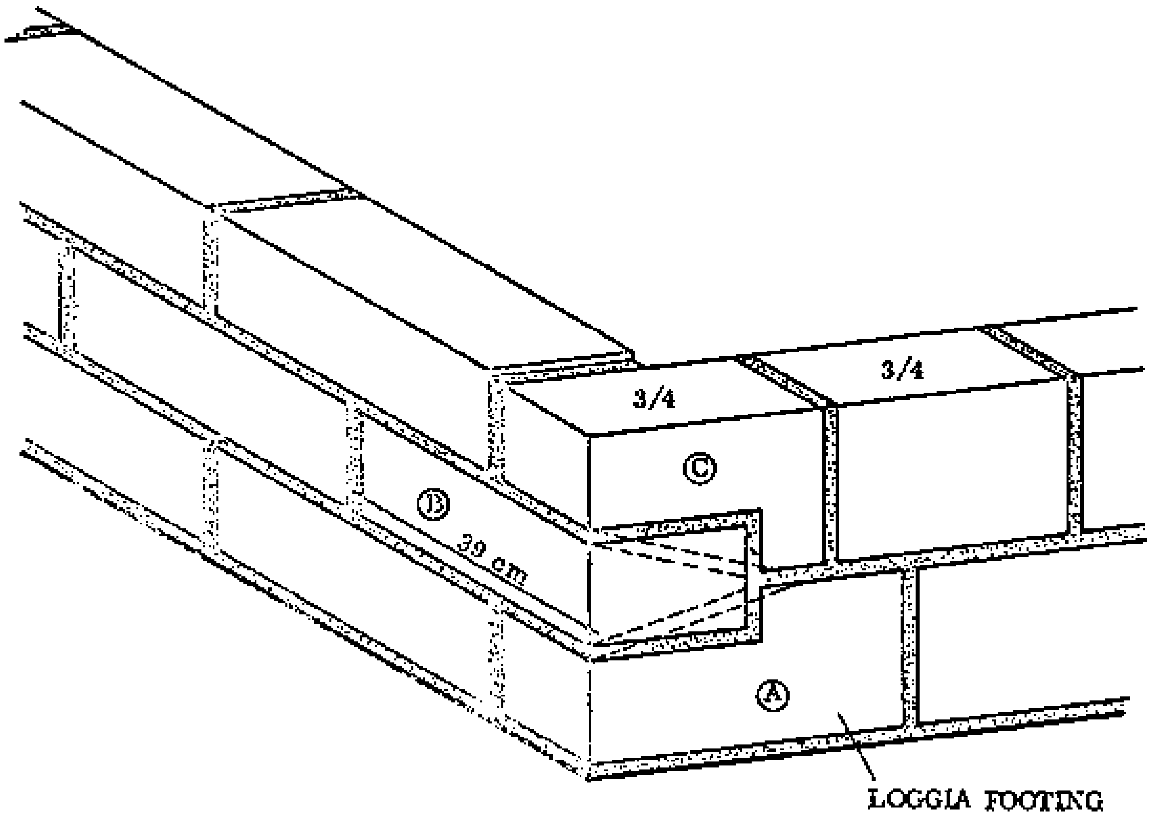


Fig. 2

– SPECIALLY MADE BLOCKS, FLUSH TO OUTSIDE: If specially made blocks are used, it is not necessary to cut them to odd shapes, and the bond is easy to make as well as more economical (Fig. 3).

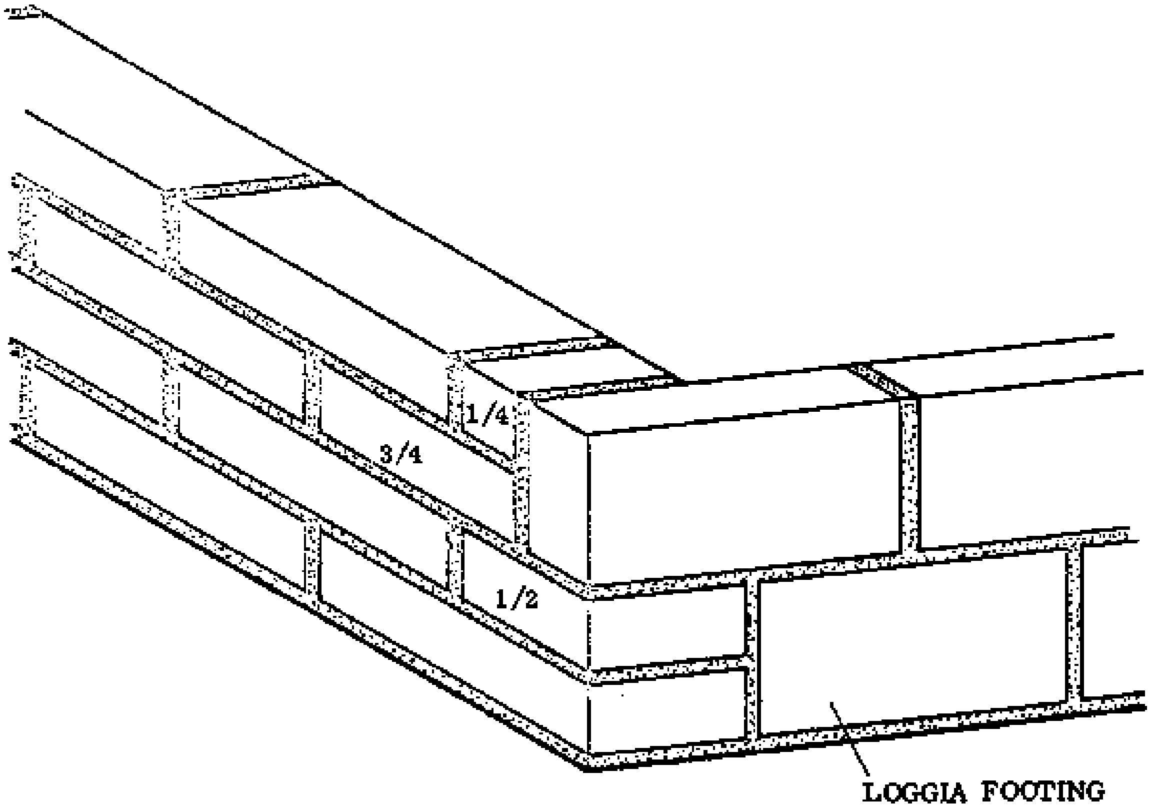


Fig. 3

A corner bond in which the edgewise courses are set back (recessed) in order to be in line with the outside of the rising wall does not make sense and it is therefore not shown here. It is best to apply one of the arrangements above, or to make the whole structure stronger by laying all the corner blocks flatwise (Fig. 4, below).

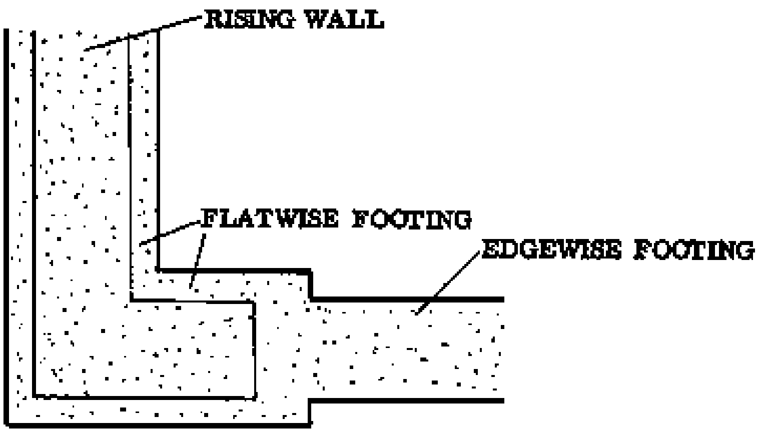


Fig. 4

– NOTE: It is best to avoid making these bonds with common blocks: use specially made blocks instead if possible, because it is extremely difficult to cut the odd shaped blocks (Fig. 2, blocks A and C) to the ideal shape without breaking them. If specially made blocks are not available, the common blocks can be given a wedge shape where they intersect, as indicated in Fig. 2 by the broken lines. This shape is easier to cut without breaking the blocks.

Different wall thicknesses at a T–junction

In Rural Building we are mostly concerned with those T–junctions in which a course of edgewise blocks meets either a corner ("A" below) or a wall ("B" below) of flatwise blocks.

Situation "A" occurs for example when a verandah is built flush with the corner of the house; while situation "B" will occur if the verandah meets the wall of the house away from the corner.

There are also possible situations where a flatwise course meets a corner or wall of edgewise blocks, but these situations are not common in Rural Building.

Here we discuss four methods which can be used in situation "A", depending on the type of blocks available and on whether the edgewise course will be recessed or flush to the outside of the flatwise courses. Two methods are given to deal with situation "B".

– SITUATION "A", COMMON BLOCKS, OUTSIDE FLUSH: As with the corner bond using common blocks (previous page), this bonding problem can only be solved by shaping the first blocks of both courses of the thin wall so that the second course of the thick wall can be bonded (Fig. 1). This requires precise and careful cutting.

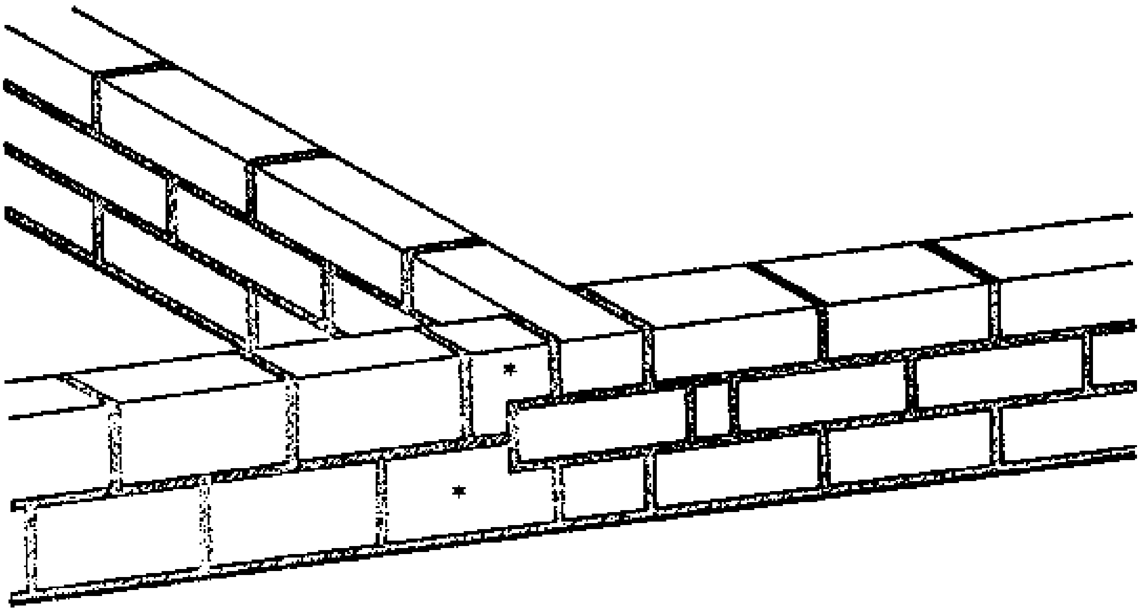


Fig. 1 SITUATION "A" – COMMON BLOCKS, OUTSIDE FLUSH

– SITUATION "A", SPECIALLY MADE BLOCKS, OUTSIDE FLUSH: Bonding be comes simpler and more economical when these blocks are used. Fig. 2 shows that there is no material wasted since the 1/4 block which is left from cutting the 3/4 block will be used in the fourth flatwise course.

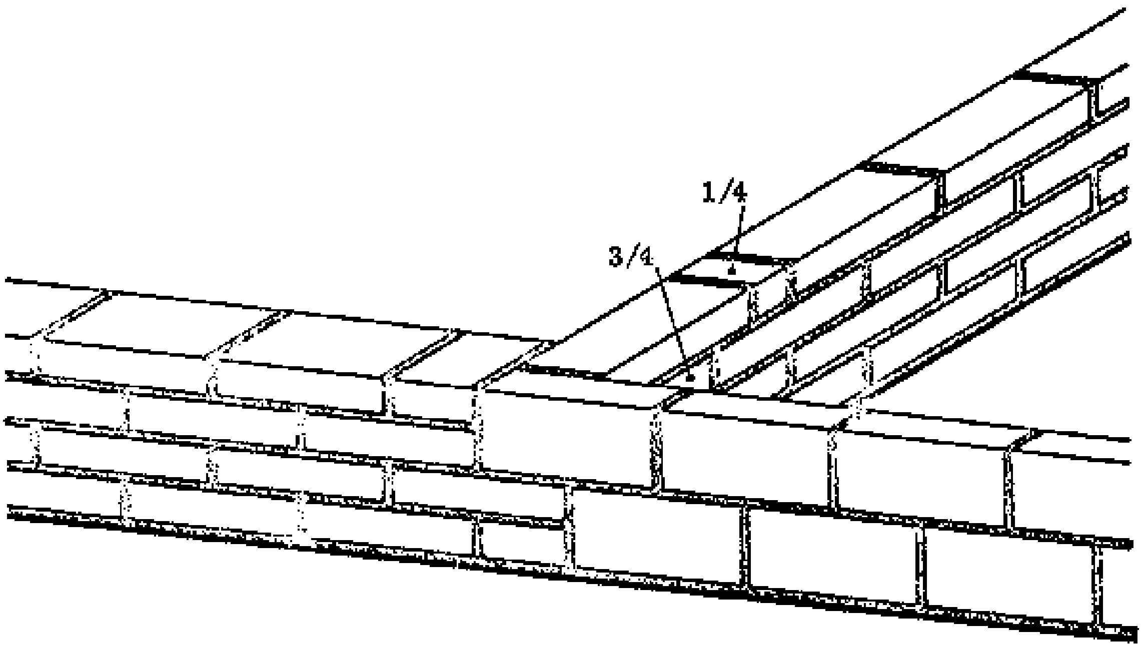


Fig. 2 SITUATION “A” – SPECIALLY MADE BLOCKS, OUTSIDE FLUSH.

SITUATION “A”, COMMON BLOCKS, RECESSED: This bond is almost the same as the first method above, except that the stretcher of the second flatwise course projects on both sides in the direction of the thin wall (Fig. 3, broken lines). After the mortar has set hard, the projecting corners are chiselled off.

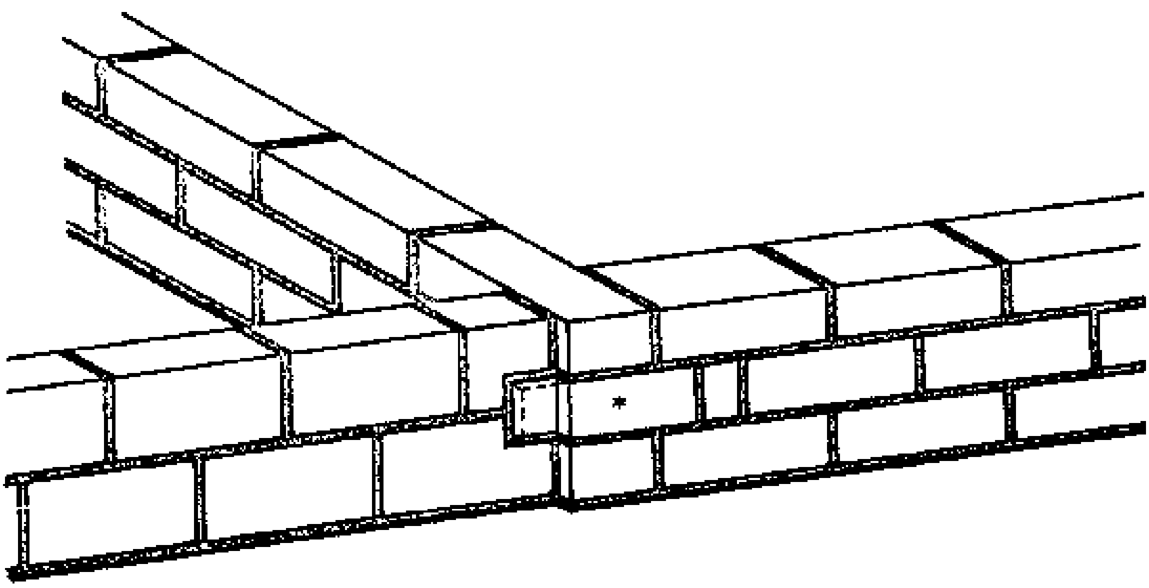
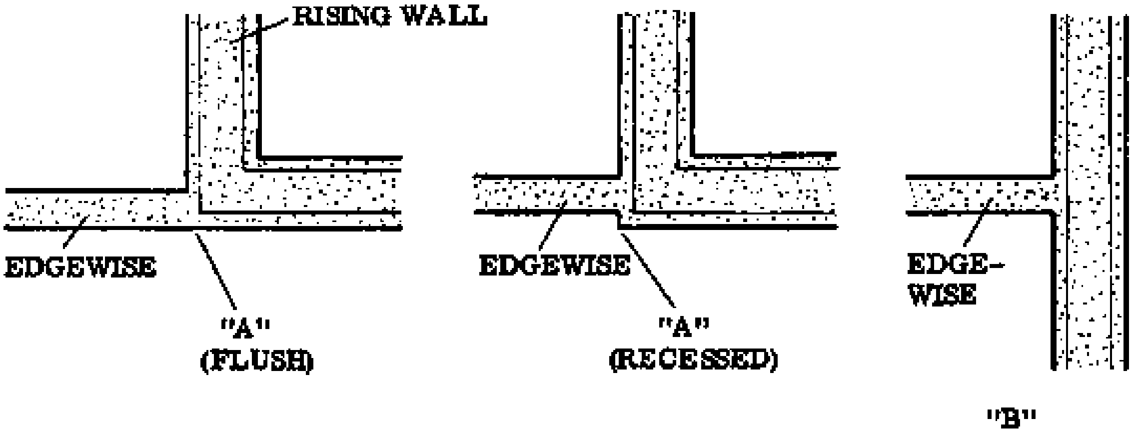


Fig. 3 SITUATION “A” – COMMON BLOCKS, RECESSED

– SITUATION “A”, SPECIALLY MADE BLOCKS, RECESSED: In this case we can use the same bond as in the second method (Fig. 2, last page). The 3/4 block and the full block above it have to be shortened by 4 cm. This will reduce the in side overlap of the junction, but that cannot be helped.



– SITUATION "B", COMMON BLOCKS: Again, here it does not make sense to talk about making a recessed thin wall: as at a quoin, the edgewise course will always be flush with the outside face of the flatwise footing course.

Fig. 1 shows that here again we find the same problem which always arises when common blocks are used in a bond between different wall thicknesses. The first blocks of the two edgewise courses have to be cut to odd shapes.

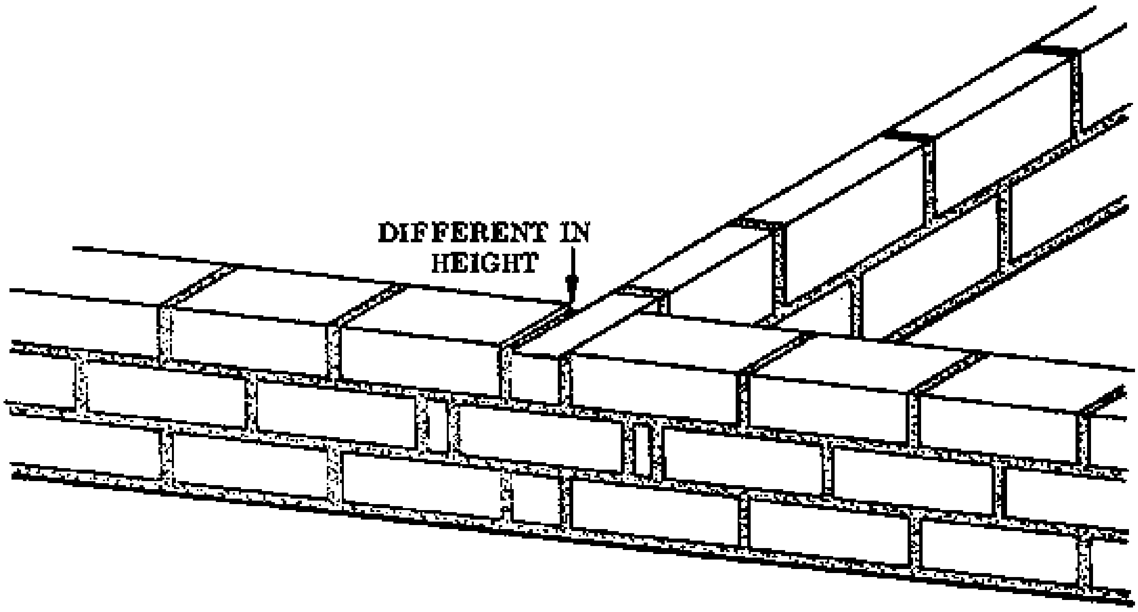


Fig. 1 SITUATION "B" – COMMON BLOCKS

– SITUATION "B", SPECIALLY MADE BLOCKS: When this bonding method (Fig. 2) is compared with the last method, it is clear that once again the specially made blocks are the best choice.

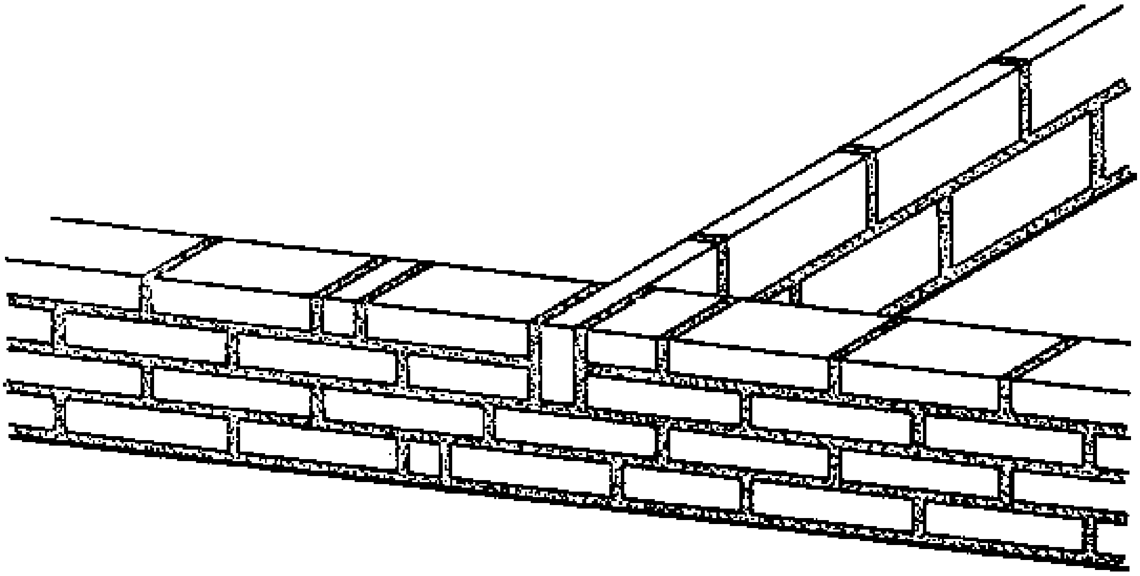


Fig. 2 SITUATION “B” – SPECIALLY MADE BLOCKS

NOTES:

Different wall thicknesses at a cross junction

There are four possible situations for a cross junction with different wall thicknesses. The one which is described here is the most common in Rural Building. This situation occurs when the end of a verandah joins the wall of the house and is in line with an inside wall (Fig. 2, below). This means that the footing blocks are laid flatwise in three directions, and edgewise in one direction.

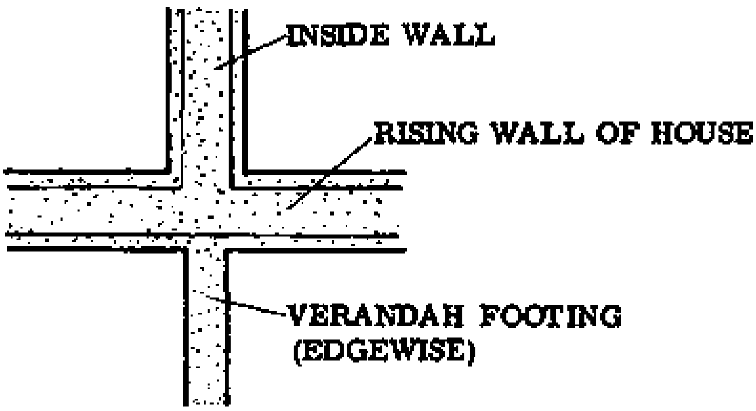


Fig. 2

– COMMON BLOCKS: The first course of the thin wall is bonded into the thick one by a 3/4 block (block A) which must be shaped in such a way that the second course of the thick wall can overlap it (block B). Block A is followed on one of its stretcher sides by a 1/2 block, while all other directions are continued with full blocks (Fig. 1a shows the first courses).

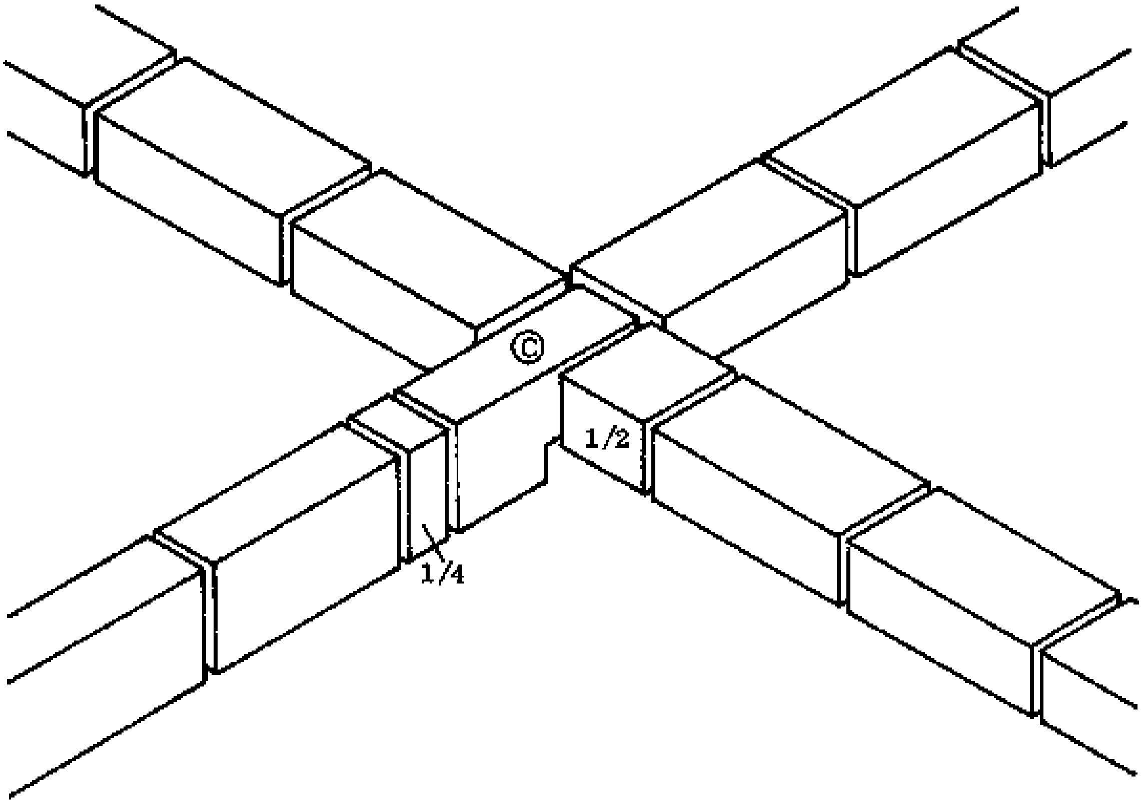


Fig. 1a 1st COURSE

In order to maintain the half−block bond, the second course of the thick wall must contain a block which is 18 cm long, and another 42 cm long; the latter overlaps the 1/2 block below. Don't forget that the first cross joint following the stretcher overlapping the thin wall is 3 cm wide, or else the first two cross joints are made 2,5 cm wide (Fig. 1b).

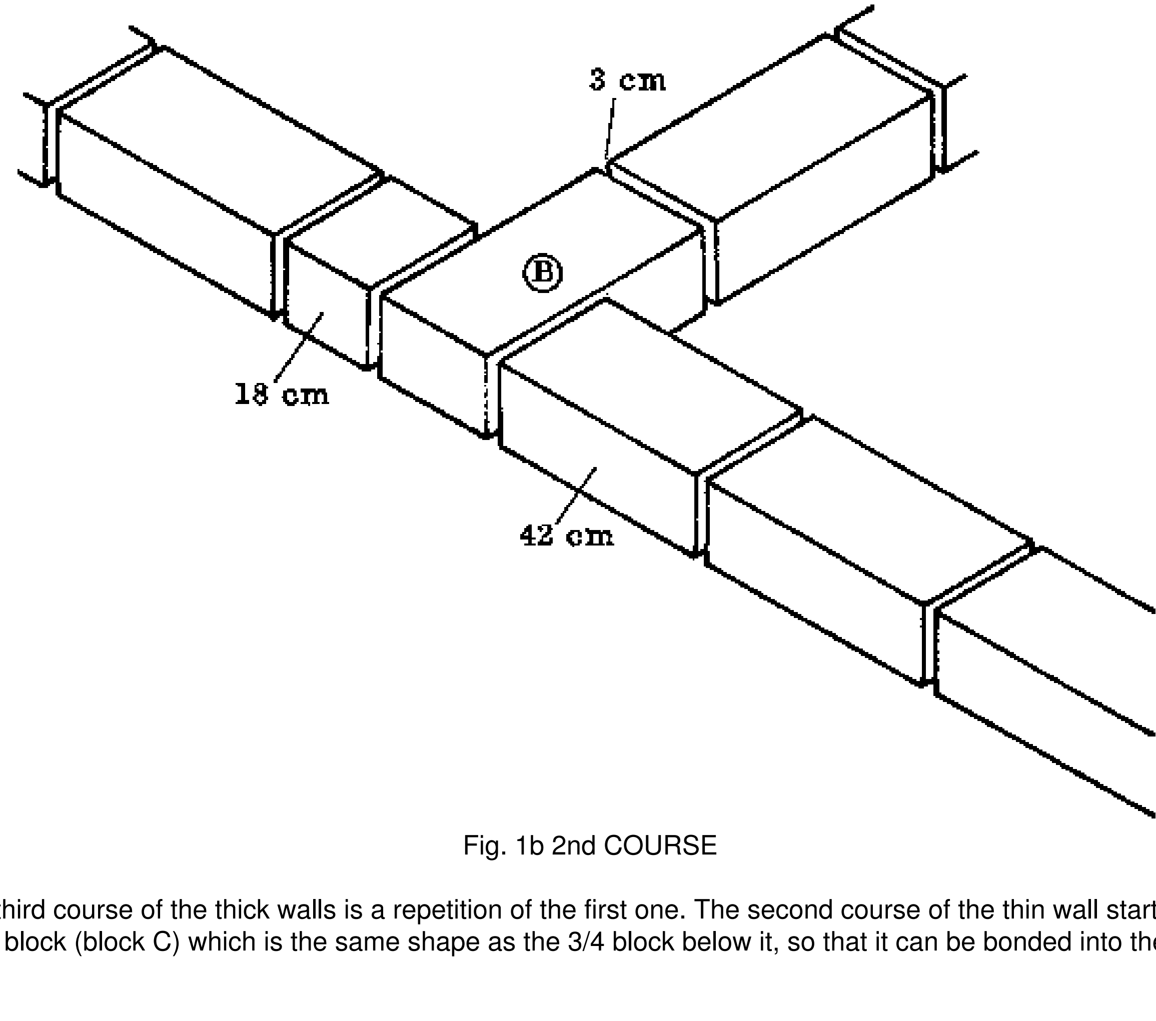


Fig. 1b 2nd COURSE

The third course of the thick walls is a repetition of the first one. The second course of the thin wall starts with a full block (block C) which is the same shape as the 3/4 block below it, so that it can be bonded into the thick wall. It is followed by the 1/4 block which was left over from the first course. Note that the thin wall remains 1 cm lower than the other walls, unless the mortar beds in the thin wall are both made 2,5 cm thick (Fig. 1c).

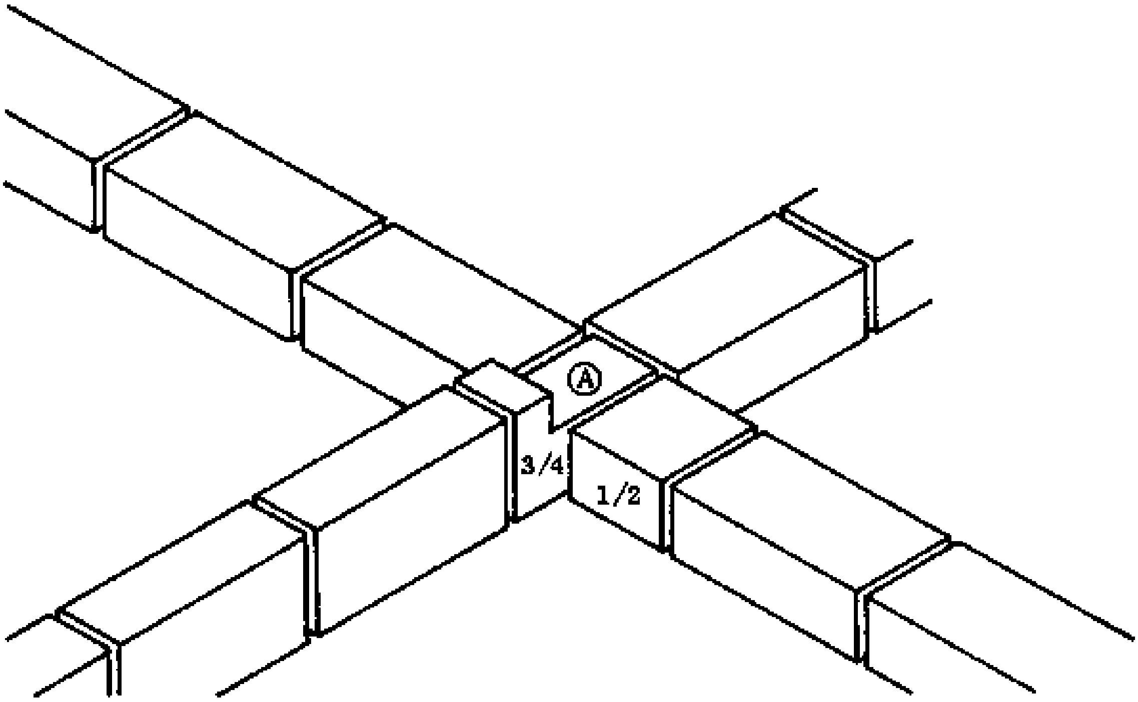


Fig. 1c 3rd COURSE

A disadvantage of this bond is that the overlap across the thin wall is rather short. This problem is not fully solved by using the specially made blocks.

– SPECIALLY MADE BLOCKS: The first course of the thin wall is bonded into the first two courses of the thick one by using a full block (block A). The first cross joint following this block is made 3 cm wide, or else the first two cross joints are made 2,5 cm wide. The first course of the thick walls continues with a 1/2 block (block B) in the direction of the thin wall, and with a 1/2 block (block C) either to the right or left side of the cross. The second course of the thick walls starts with full blocks where there are half–blocks below, and with a half–block which is above the full block of the first course (Fig. 1a).

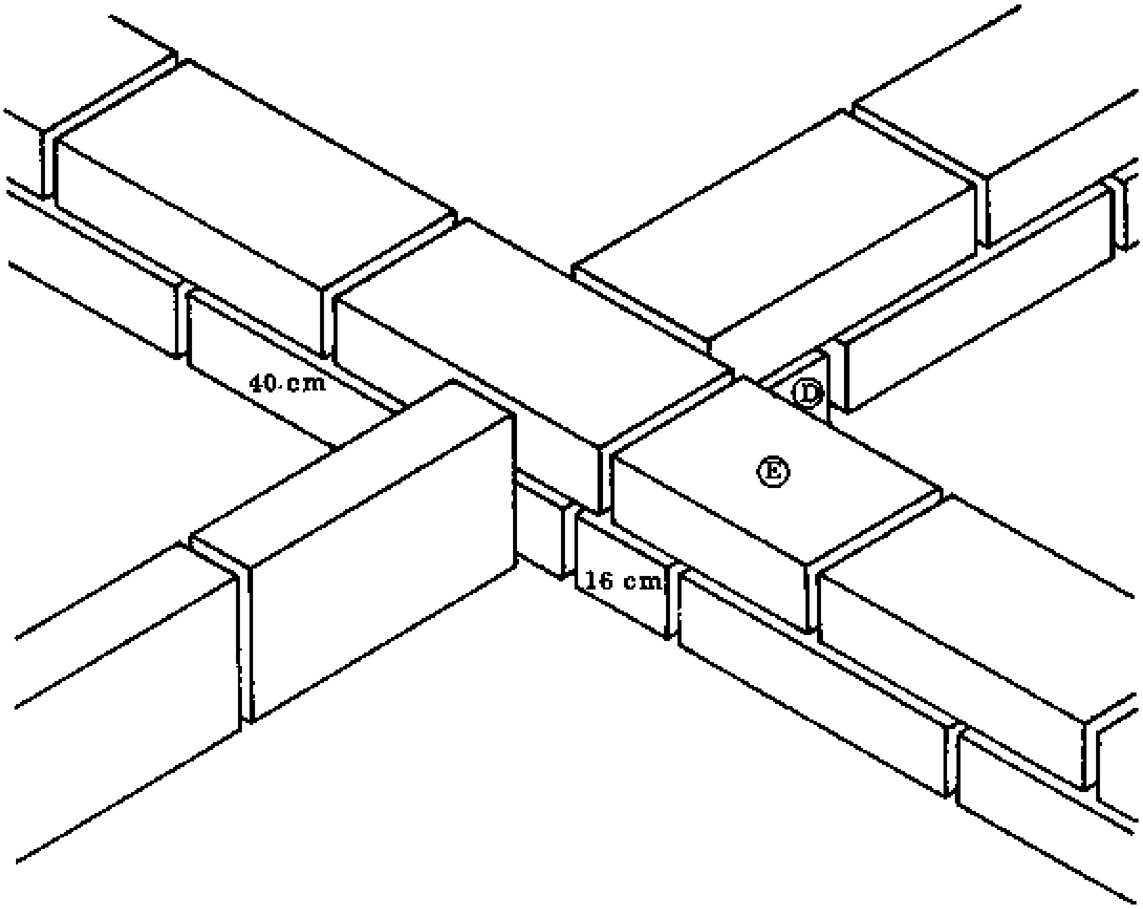


Fig. 1a 1st COURSE

The third course of the thick walls starts with a full block (block D) covering three cross joints. A block of 16 cm in length is placed beside this, above the full block; and a block of 40 cm length is placed on the other side, above the 1/2 block. The second edgewise course and the fourth flatwise course consist of full blocks, with the exception of a 3/4 block (block E) overlapping the 16 cm block below by 10 cm (Fig. 1b).

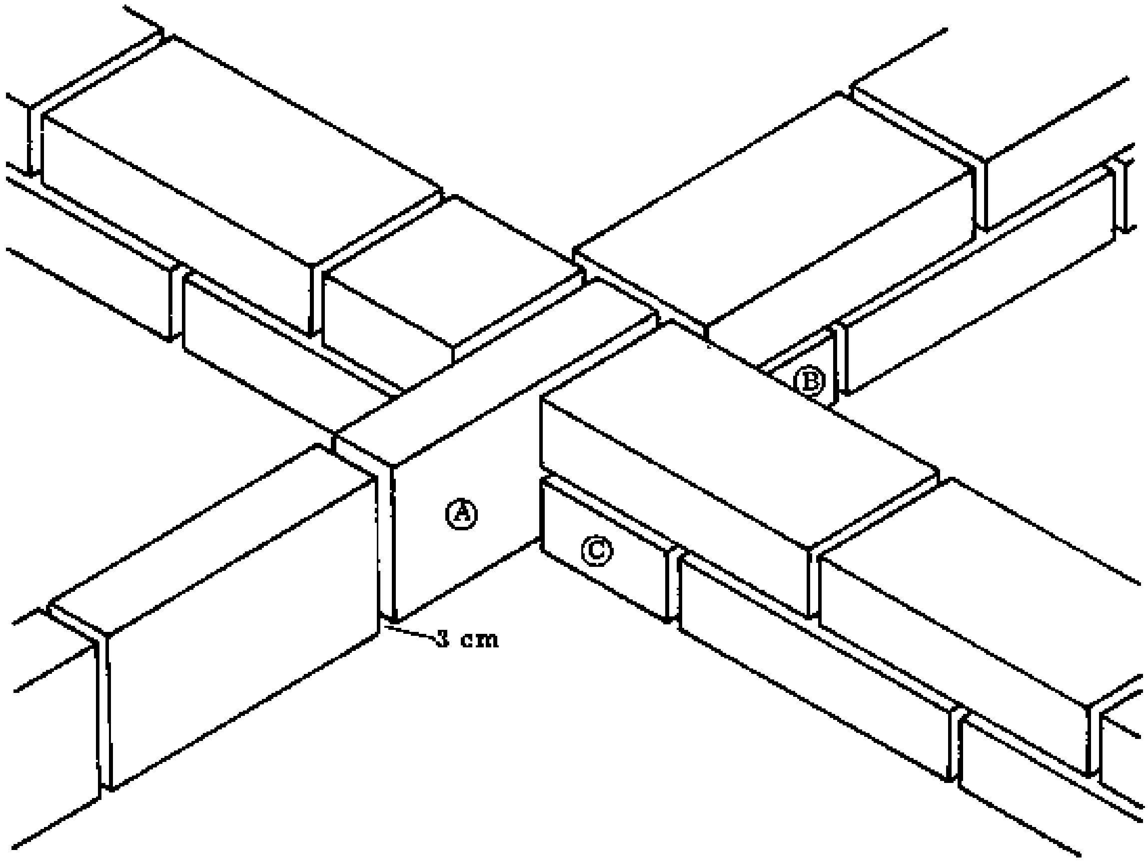


Fig. 1b 2nd COURSE

This cross junction bond, even with the use of the specially made blocks, still does not provide a very good overlap.

NOTES:

– STAGGERED BOND WITH SPECIALLY MADE BLOCKS: A simple but good masonry bond can be achieved by staggering the bond. This means that the thin wall is shifted to either side of the crossing thick wall. The distance between the two centre lines of the walls will be about 19 cm (Fig. 1a).

The first course of the thin wall is bonded into the thick one by using a full block. The two courses on the left side of this almost form a quoin, while the courses on the other side are completed in the normal way. Apart from the 1/2 block in the second course, only full blocks are needed (Fig. 1a).

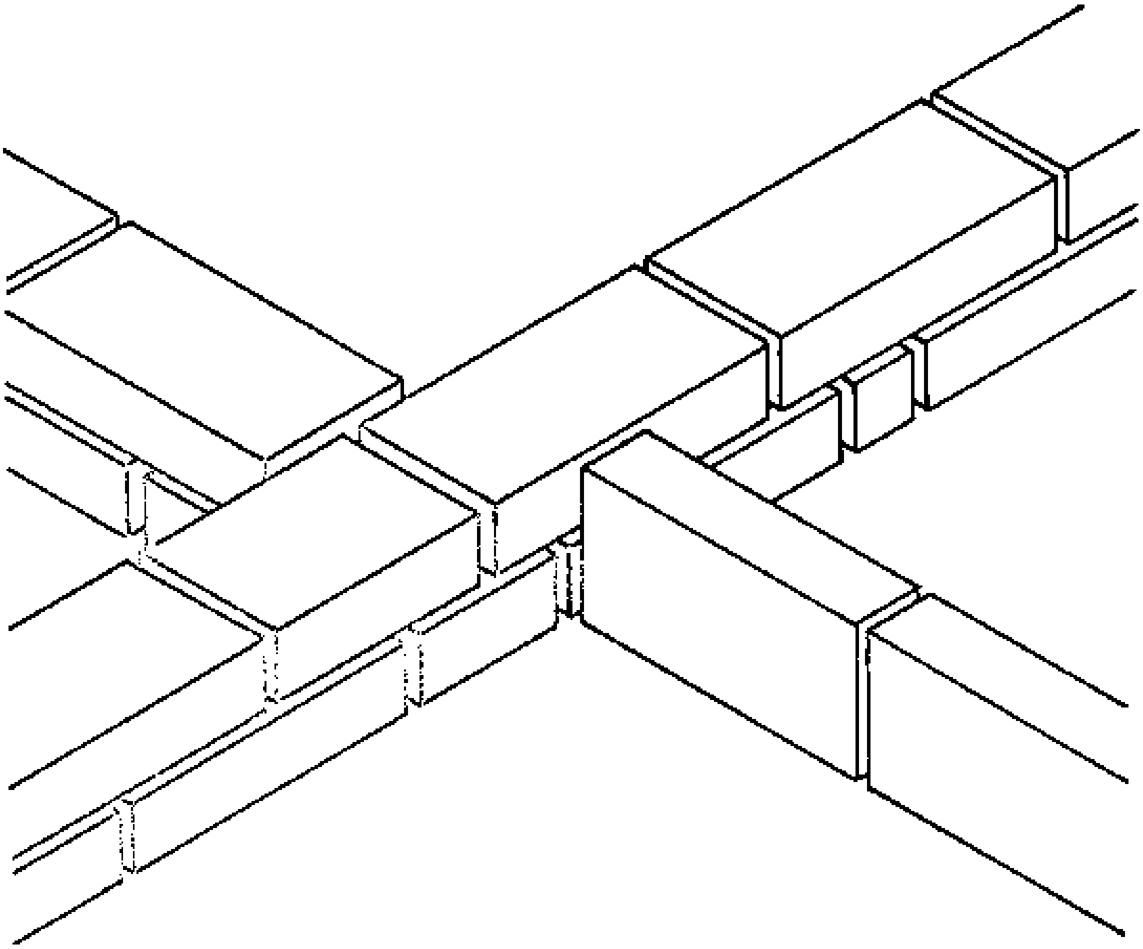


Fig. 1a 1st COURSE

The third and fourth courses of the thick wall are bonded as if in a T–junction, except that the 1/4 block of the third course is placed further away from the junction, to avoid having too many cross joints in the junction area (Fig. 1b).

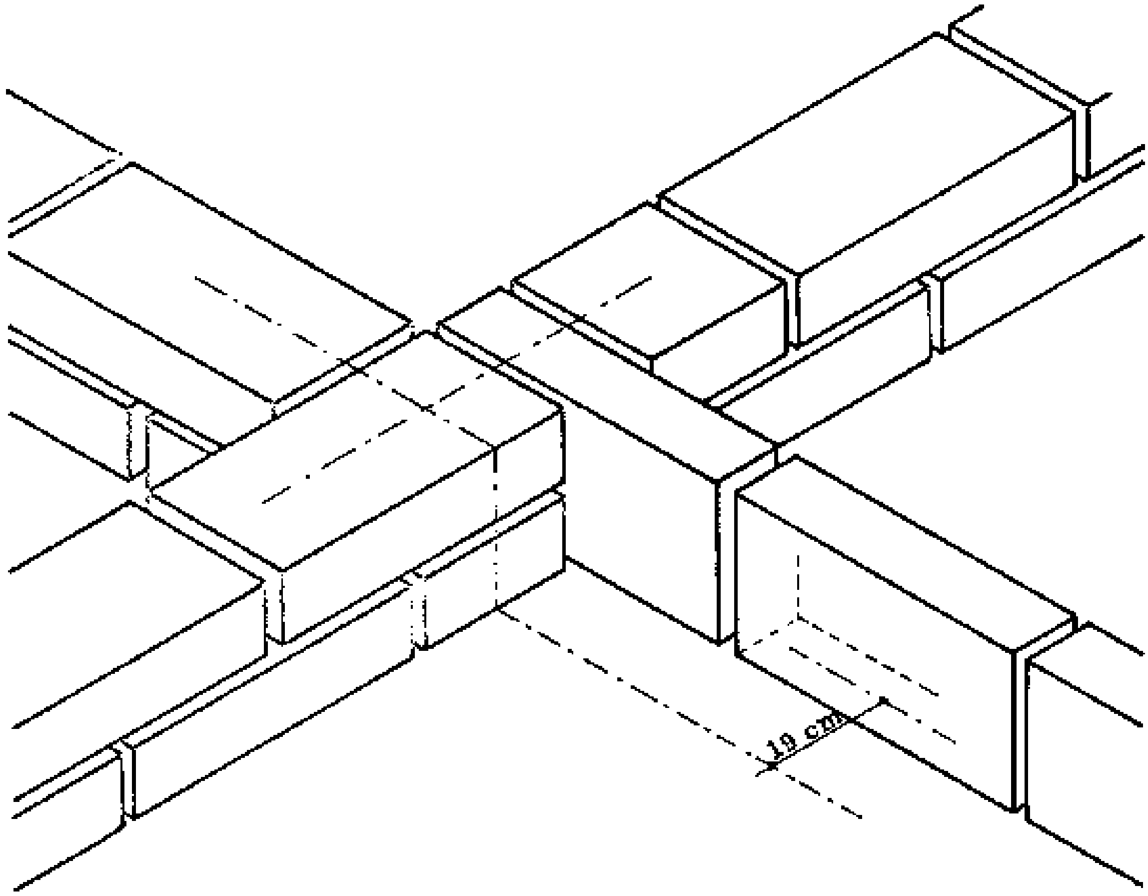


Fig. 1b 2nd COURSE

– NOTE: By planning ahead and doing a little extra work in setting out, you can avoid complicated and costly constructions.

For footings where there will be junctions between flatwise and edgewise blocks, it is always better to use specially made blocks which are 10,5 cm thick. These allow proper bonding, are more economical, and avoid the necessity for constructing junctions between two edgewise courses and three flatwise courses.

Cross junctions between different wall thicknesses should be avoided because the bonding is difficult and the overlap is poor. A staggered bond is preferred in those cases where a simple T–junction cannot be made instead of the cross junction.

NOTES:

HARDCORE FILLING

Functions of the hardcore filling

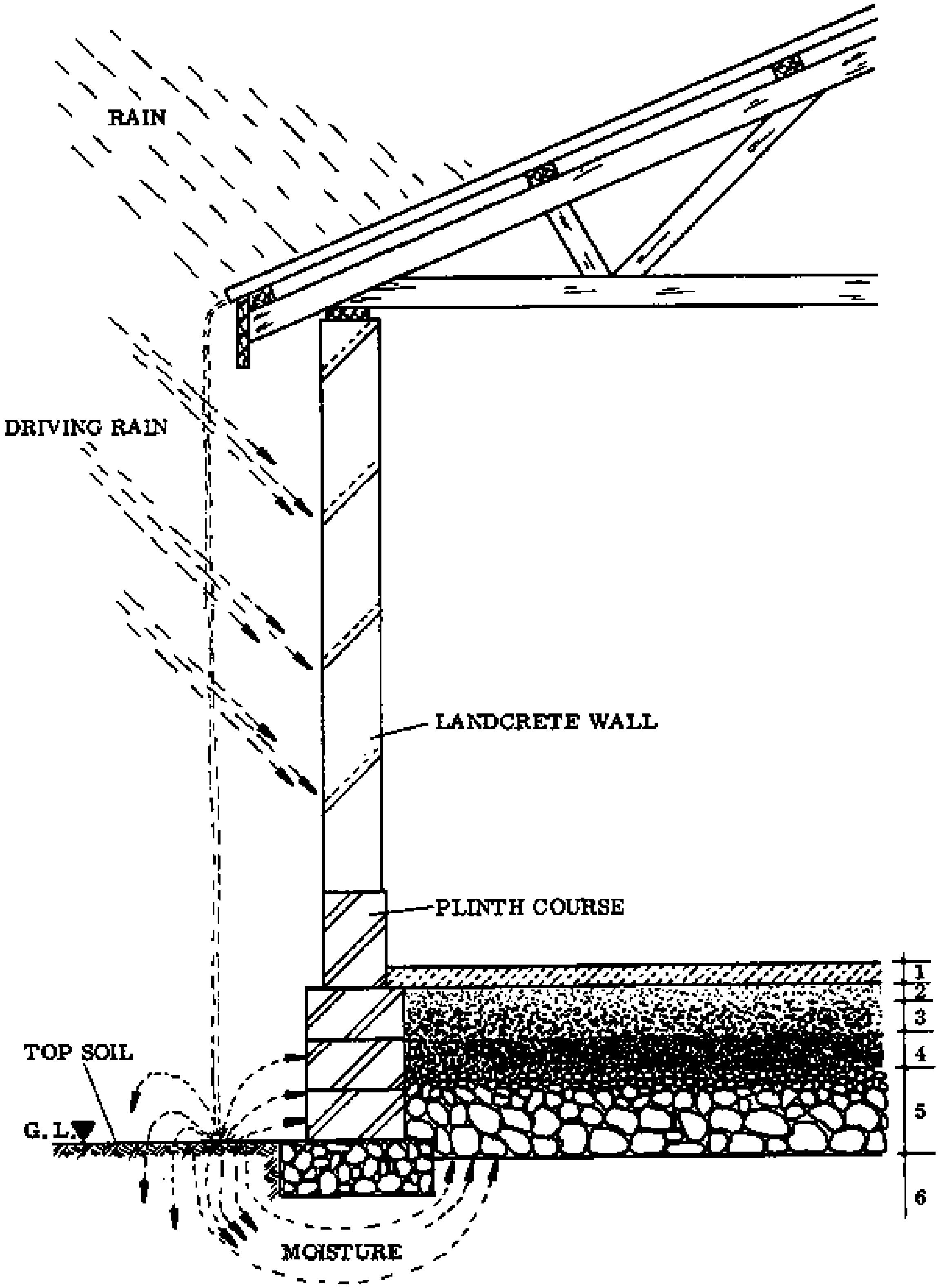
The two main functions of the hardcore filling are:

- To support the concrete floors, including all loads imposed on the floors
- To raise the floors high enough above ground level to prevent dampness from penetrating.

The hardcore has to be made from hard, solid materials which are arranged in such a way that moisture is not able to rise through them to the floor.

Materials and arrangement

All topsoil is removed before the hardcore is applied. Then the filling is applied in layers no more than 15 cm thick. Each layer is compacted thoroughly before the next one is added. The hardcore filling occupies the space between the subsoil and the tops of the footings (Fig. 1).



THE HARDCORE FILLING PREVENTS MOISTURE FROM RISING UP TO THE FLOOR

1 = CONCRETE FLOOR
2 = FINE SAND
3 = FINE GRAVEL
4 = COARSE GRAVEL
5 = ROCKS & STONES

6 = FIRM SOIL

The first layer consists of rocks, stones and broken sandcrete blocks. These are no smaller than fist−size and no bigger than 15 cm in diameter. The stones for this layer are preferably set into place by hand, according to their shape, in order to fit them together.

For the second layer we use broken stones which are about half the size of a fist. The following layers are formed of smaller stones, coarse gravel, or gravelly laterite soil; up to about 6 cm below the tops of the footings.

The last 6 cm to the top of the footings should be filled with sand or laterite soil to seal the surface of the hardcore, in order to keep the cement paste from the floor from leaking downwards.

− BACK−FILLING: If the foundation consists of stone masonry, the extra space left inside the foundation trenches has to be filled in before the hardcore is done. If the space is more than about 30 cm wide, it is best to use hardcore to fill it. If less, rammed soil will be sufficient.

The outside of the trench excavation has to be refilled with gravel, to prevent erosion around the foundations (Foundations, page 19).

Never be tempted to fill up the site with soil underneath the hardcore, even on a sloping site: even if the soil is compacted it will still settle and cause the floor above to settle and crack. The hardcore should rest directly upon the subsoil.

Compaction of the hardcore

All the layers are normally compacted by hand with heavy rammers. This exhausting work can be made easier by using heavy iron or concrete rollers, or by driving a tractor several times over the hardcore to compact it.

Wet down the gravel and sand layers as they are filled in. This not only reduces the dust in the air but also makes compaction easier and ensures a dense layer.

Sometimes the building schedule allows construction to halt during the rainy season. If so, then it is a good idea to plan ahead in order to complete the hardcore filling before the rains come. This is done so the hardcore can be left open during the rainy weather to become very well compacted by the rain. However, it is still necessary to compact the layers of hardcore as they are added. The hardcore can be inspected from time to time during the rainy season, and any sunken areas can be filled up as they develop.

− NOTE: It is sometimes observed that a builder uses soil excavated from the foundation trenches to make the hardcore. This is convenient, but it is a bad procedure. The laterite soil acts as a sponge to draw moisture up from the subsoil into the building. The hardcore is made with a rock base because the rocks do not draw moisture upwards, so the building stays drier.

Gravelly laterite soils can be used for the layers just below the final layer, and fine laterite soil may be used for the final layer which seals the hardcore filling.

PLINTH COURSE

The plinth course forms the first course of the rising wall, immediately above the footings. Its sole function is to raise the landcrete blocks or sun−dried laterite blocks of the following courses high enough to protect them from moisture penetration.

The materials used for the plinth course should therefore be moisture resistant to some extent, such as natural stone or sandcrete blocks (Fig. 1, last page). It is known from experience that one plinth course is sufficient in northern Ghana, but there are situations where it is better to use a more durable material up to window cill level, especially in the rain−forest areas of Ghana.

In northern Ghana the rising landcrete walls are erected flush with the outside of the plinth course. In the south, however, it is advisable to lay the landcrete blocks flush to the inside of the plinth, so that thicker render can be applied on the outside to protect against moisture penetration.

POSITIONS OF DOOR AND WINDOW FRAMES

Before the plinth course is laid, the positions of the doors are marked on the footings.

If the door frames have been already made and painted they may now be set into place according to the marks. If the frames are not yet available, the plinth course and the rising walls can be erected anyway. In this case one must remember that the measurements given in the drawing are the outside measurements of the frame. Therefore the opening left in the wall must be about 1 cm wider on all sides, so that later on the frame can fit in (see Fig. 1).

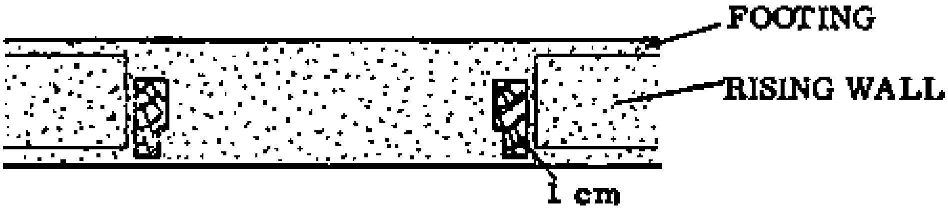


Fig. 1

The way the door and window frames are positioned in the surrounding masonry depends on the type of door or window, which way it opens, and whether mosquito−proofing and/or burglar−proofing will be installed.

Fig. 2 shows the most common position in which the frame is set flush to the outside of the render. The frame may be flush to both the inside and outside surfaces (Fig. 3), although the cill may project past the render on the outside face. Keep in mind the thickness of the plaster or render when you set the frame in the unplastered wall. The frame edge should be in line with the future plaster surface.

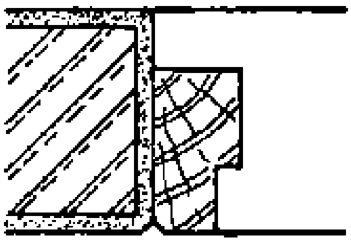


Fig. 2

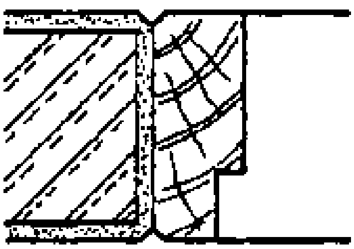


Fig. 3

Vibrations from opening and closing the door or window, as well as the shrinking and swelling of the frame, will cause cracks to appear in the plaster and even cause pieces of plaster to come off. To prevent this and to cover the unavoidable cracks, a V−joint is made wherever plaster or render is flush to the frame. This may be covered with a wooden strip (Fig. 4). It is incorrect to apply plaster or render directly against the frame (Fig. 5, arrow).

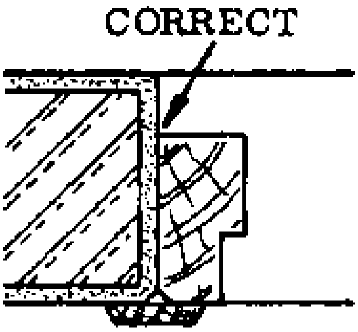


Fig. 4

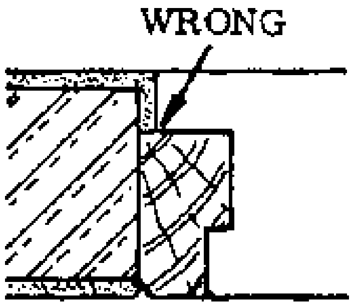


Fig. 5

DOOR FRAMES

Types of door frames

The door frame provides a secure attachment for the door. Depending on the type of door, its function, and its location, different types of door frames can be constructed. The most common door frame consists of three members (Fig. 1):

- – Two vertical members called posts (a)
- – One horizontal member called a head (b).

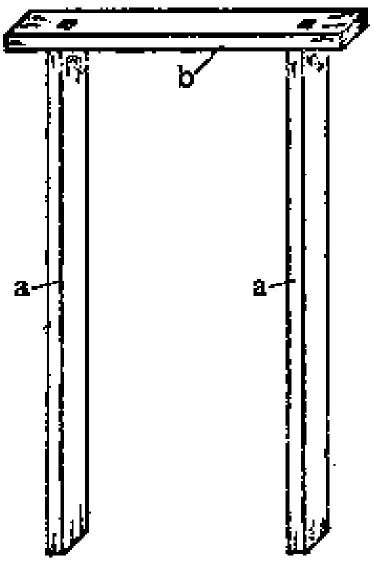


Fig. 1

When it is necessary for the door to fit tightly in the frame, it consists of four members (Fig. 2):

– Two posts (a)
– One head (b)
– One member on the floor, called the threshold (c).

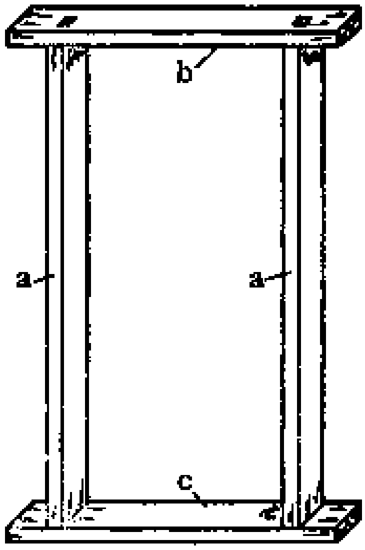


Fig. 2

When additional light or ventilation is needed for a room, a fanlight is added to the frame structure by adding one more member between the posts, called a transom (Fig. 3, d).

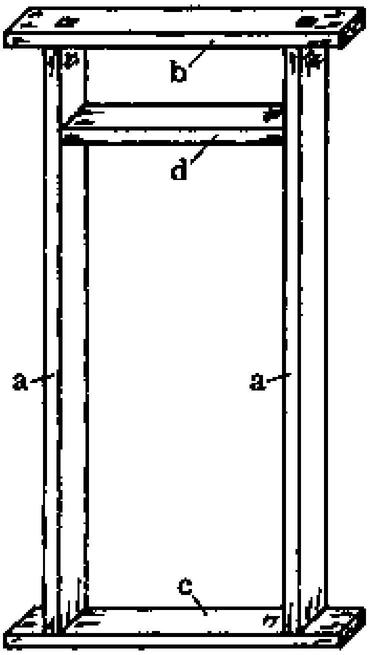


Fig. 3

Note that since the threshold is in direct contact with the floor, or even partly embedded in the floor, it is in special danger from attack by termites or fungus (Reference Book, pages 141 to 144).

– BEAD OR REBATE TYPE DOOR FRAMES: Each of the above door frames can be made either with beads (Fig. 4) or a rebated construction (Fig. 5).

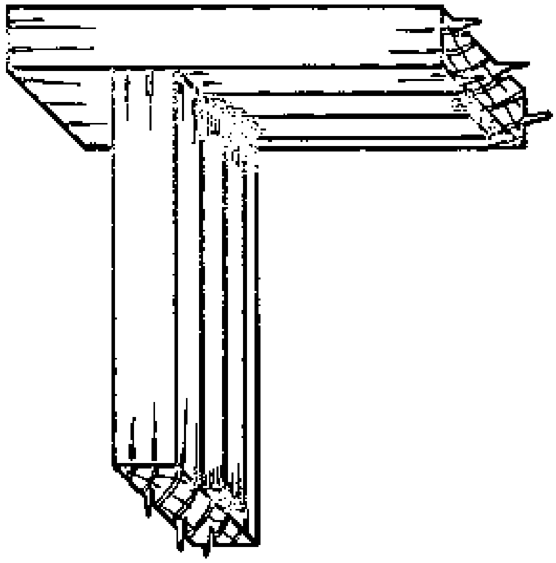


Fig. 4

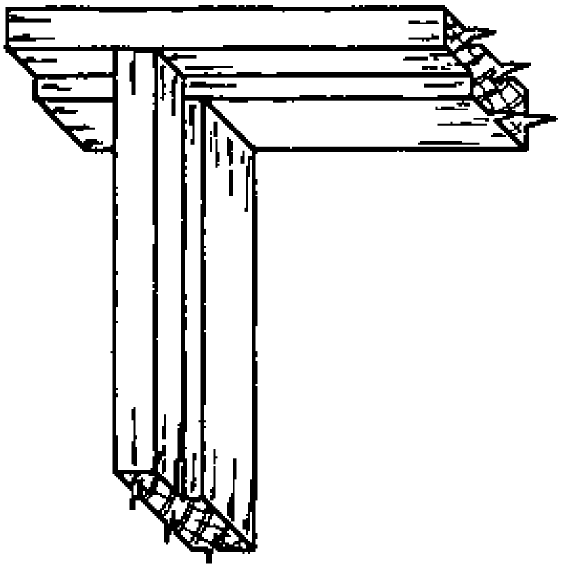


Fig. 5

Beads are preferred over a rebate for two reasons: the construction is easier, and it is possible to adjust the beads after the door is hung. Beads are always fixed into place after the frame is installed and the door is hung.

Rebates, however, do have a better appearance than beads, and no extra wood is required to make a rebated frame.

NOTES:

Joints for door frames

– JOINTS FOR DOOR FRAMES WITH BEADS: The joints for a door frame made with beads can be common mortice and tenon joints for box–like constructions. They may be either pegged, wedged or nailed (Basic Knowledge, pages 104 to 106, and 124; also Drawing Book page 43 and pages 67 to 71).

If a transom is required, it should be installed using a stub tenon joint to prevent water from penetrating the mortice (Basic Knowledge, page 122).

If a threshold is installed, a common mortice and tenon joint is used for it, but wedges should not be used since they might fall out. Pegs cannot be used either, because the threshold is too thin. This joint should be nailed.

– JOINTS FOR DOOR FRAMES WITH REBATES: If the door frame is made with a rebate, take care that the shoulders of the tenons are set out and cut correctly. One shoulder of the tenon is cut longer to fit the rebate (Drawing Book, pages 67 &68).

The thickness of the tenon is affected by the size of the rebate. If the rebate is 1/3rd or less of the width of the member, the tenon will not be reduced in size (Fig. 1). If the rebate is wider than 1/3rd of the member, the thickness of the tenon (and accordingly the mortice width) is reduced by the depth of the rebate (Fig. 2).

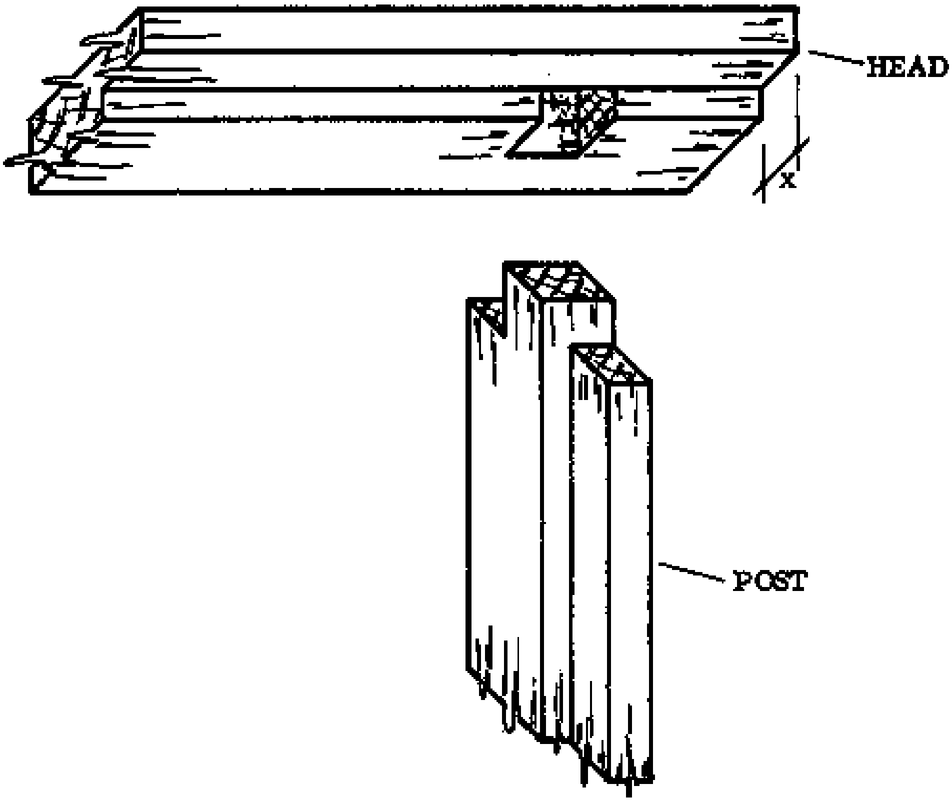


Fig. 1 WIDTH OF REBATE (x) 1/3 OR LESS

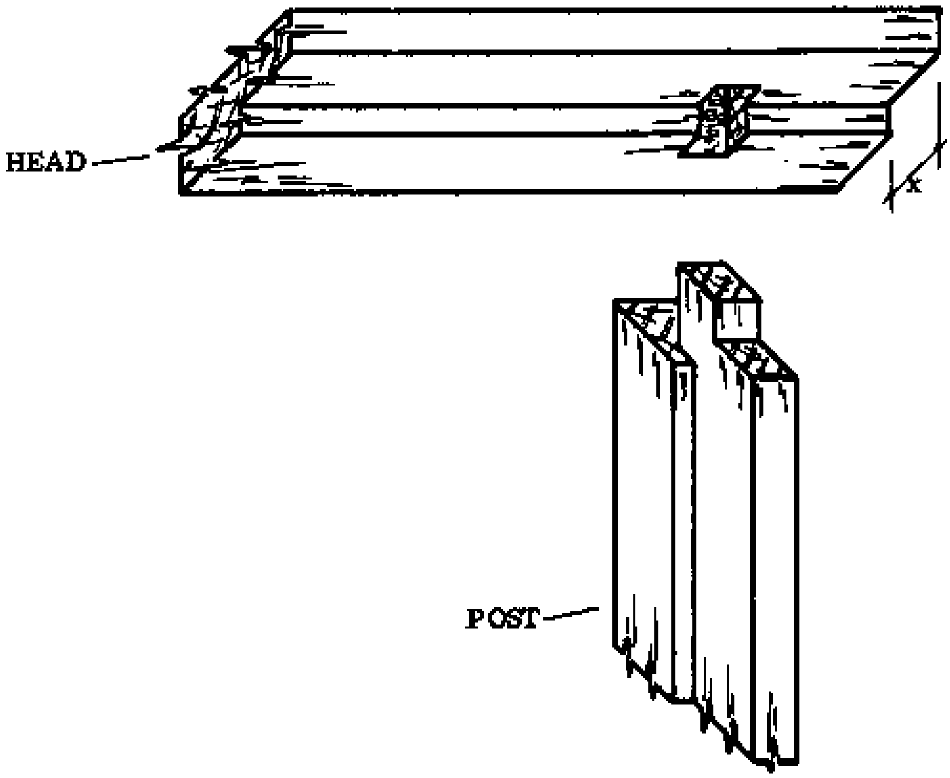


Fig. 2 WIDTH OF REBATE (x) MORE THAN 1/3

Besides these considerations, the construction of these joints will be the same as for any common mortice and tenon joints for box–like constructions.

NOTES:

Heads of door frames

– HORNS: In order to provide an additional attachment to the wall, the ends of the head and the threshold can project beyond the posts into the wall. This is especially necessary in mud walls.

These projecting parts can be shaped like horns (Fig. 1), or else the front corners can be cut off at an angle (Fig. 2). These shapes give a good appearance to the frame head when the frame is built into the wall.

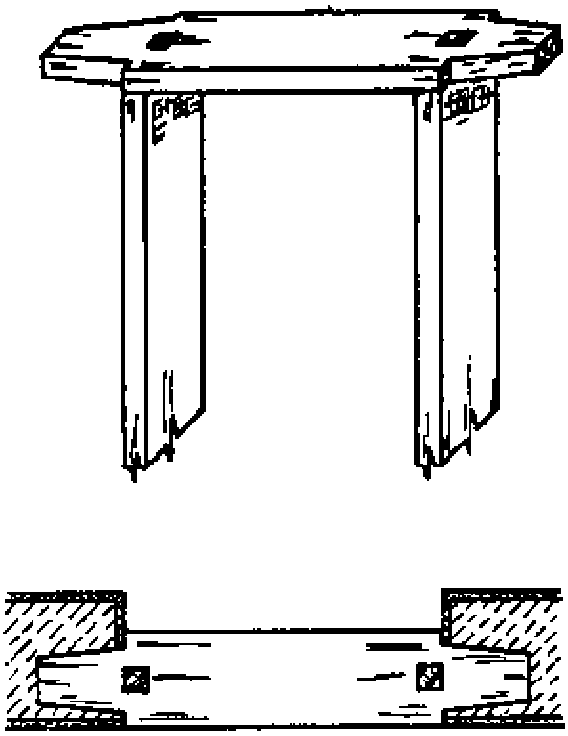


Fig. 1

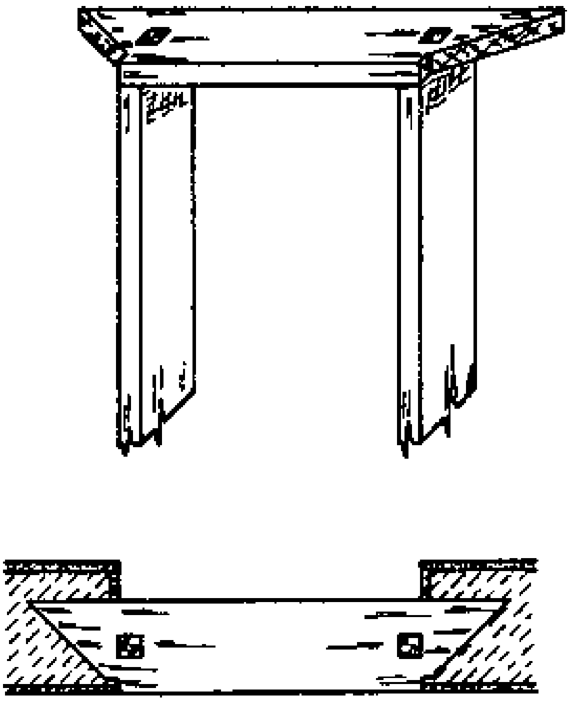


Fig. 2

– WEATHER STRIPS: If a door frame is to be installed in an outside wall, you need to take some extra precautions to prevent water from entering between the lintel and the frame head, and between the door itself and the door frame.

Weather strips (Fig. 3) can be fixed on the door head to keep water out. We will learn more about weather strips later in the book, in the section on window frame heads.

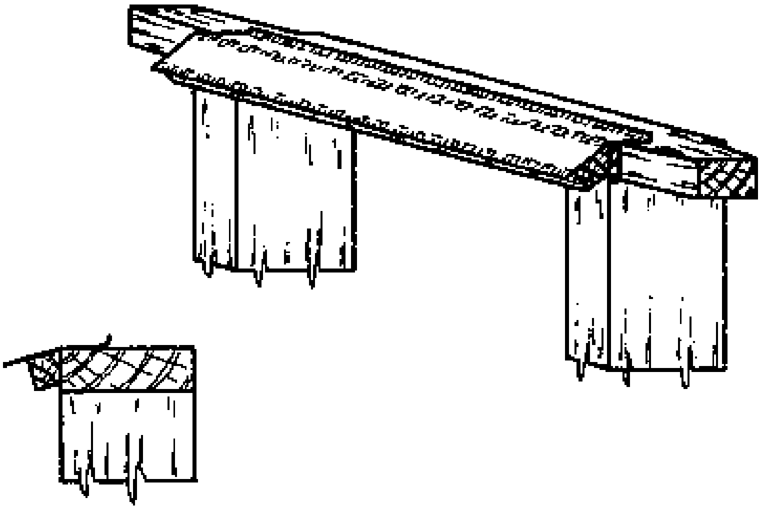


Fig. 3

– STEEL CRAMPS: These are pieces of mild steel rod which are fixed into the door posts (Fig. 1, next page). They are fixed about 60 cm apart; near the head, middle and foot of the frame.

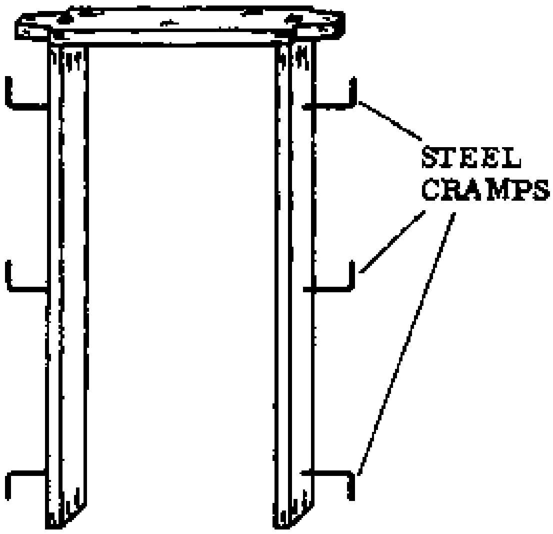


Fig. 1

The function of these cramps is to secure the frame rigidly to the blockwork. They are set in the posts in positions which correspond with the bedjoints of the blocks, so that they can be built into the bedjoints.

To fix the cramps in the door frame, drill holes in the posts. The holes should have a diameter a little smaller than the rods, and should not go all the way through the post. Bend one end of the rod to form a head (Fig. 2, next page) and knock the head into the post. Bend the other end to a right angle so it fits into the cross joint between the blocks (Fig. 2, next page).

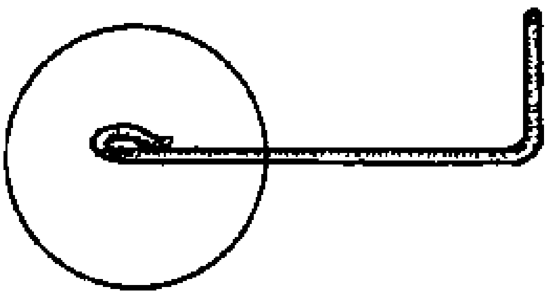


Fig. 2

NOTES:

Measurements for door frames

– MEASUREMENTS OF THE TIMBERS: Usually door frames are made of timbers which are about 10 cm wide and about 5 cm thick. If the posts are held in the wall by steel cramps, it is possible to reduce the size of the timbers to 7,5 by 5 cm. The cramps provide a good grip to the wall so the frame doesn't have a lot of stress on it. This means that the timbers can be made smaller and thus less costly. The cramps are made by cutting iron reinforcement rods.

The frame itself is always measured from inside face to inside face. Unless it is stated otherwise on the estimate, measurements given for door frames are always inside measurements.

– MEASUREMENTS OF THE FRAME WITH RESPECT TO THE MASONRY: To make the work easy, to avoid extra block–cutting, and to reduce waste, the outside measurements of the frames should correspond to the building unit measurement of the blocks used to construct the wall. For example:

> – The building unit measurement for landcrete blocks is 31 cm wide by 24 cm high.
>
> The outside height of the door frame will be 8 x 24 = 192 cm.
>
> The outside width of the door frame will be 3 x 31, minus 2 cm for one cross joint = 91 cm (Fig. 3).
>
> The steel cramps are also placed according to the building unit measurement of the blocks, so that they will fit into the bedjoints of the wall (Fig. 3).

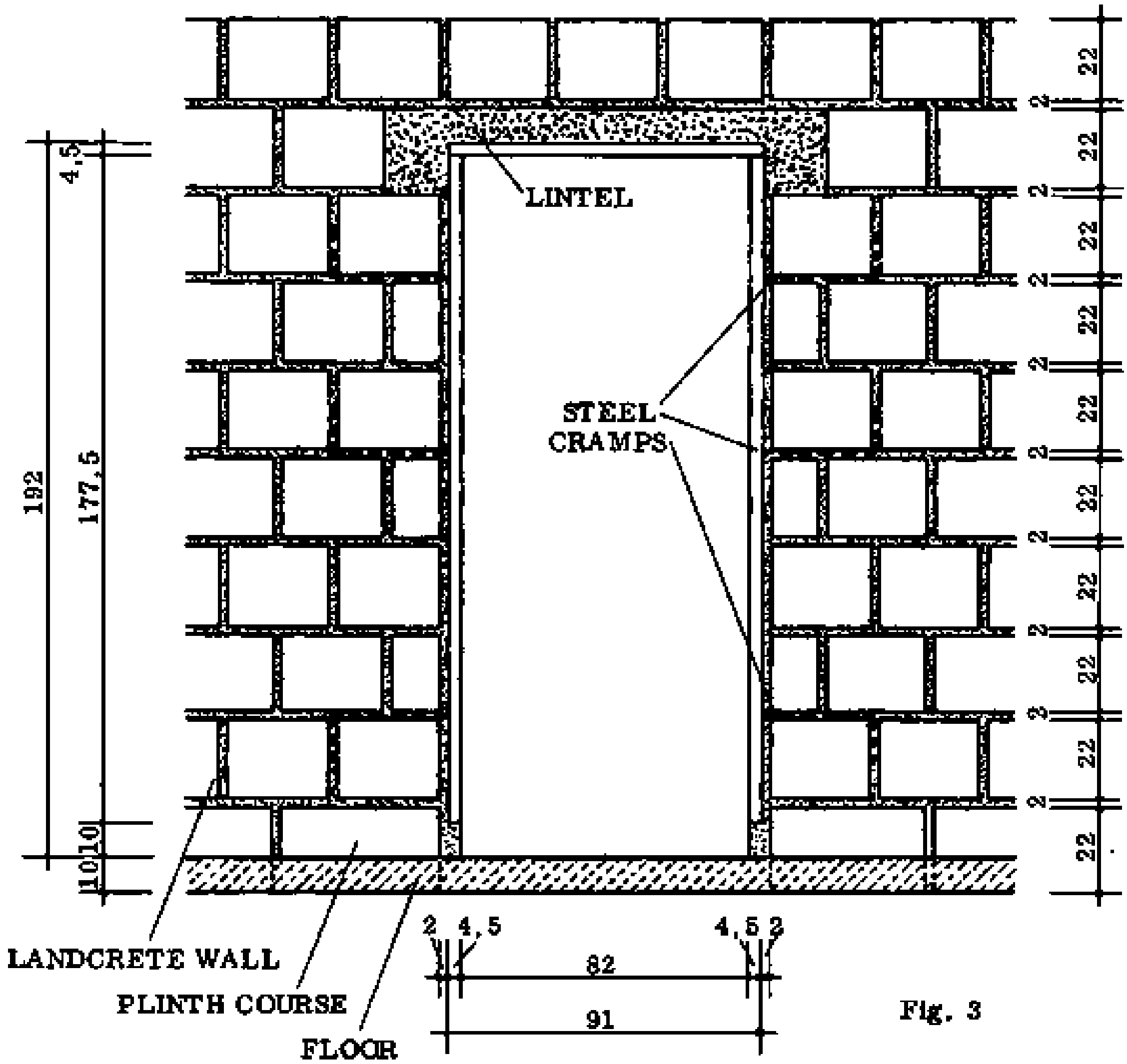


Fig. 3

NOTES:

Concrete shoe

In order to give a firm base to a door frame with no threshold, concrete “shoes” can be fitted on the posts.

To make the shoes, drive steel dowels into the bottom end of each post before setting the frame in the wall (Fig. 1). The projecting ends of the dowels are enclosed later by the finished floor and the shoe (Fig. 2).

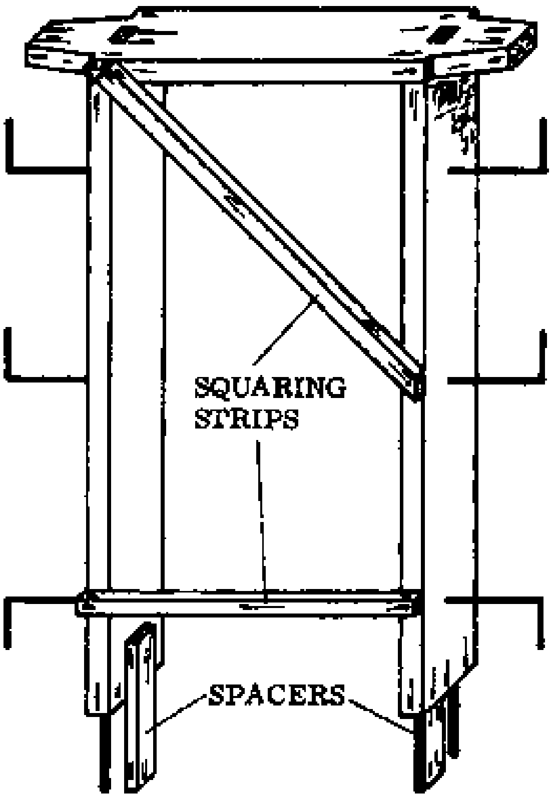


Fig. 1

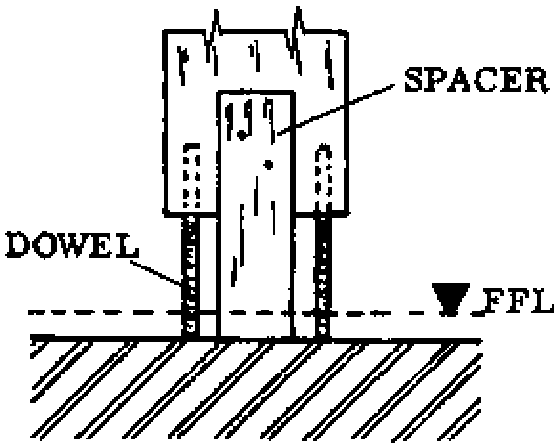


Fig. 2

Spacers are used to keep the frame at the correct height during the building operations (Fig. 1). The steel dowels are short pieces cut from reinforcement rods.

– ADVANTAGES AND DISADVANTAGES OF THE THRESHOLD (Fig. 3):

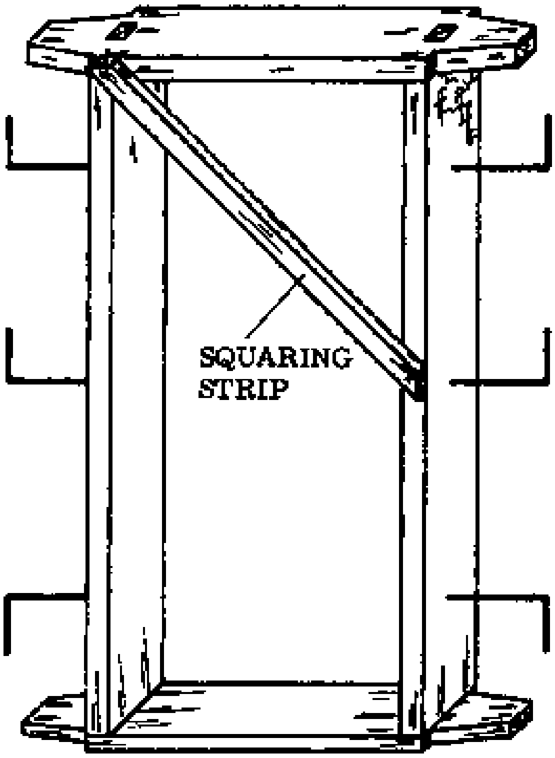


Fig. 3

advantages:

– The door closes tightly into the framework.
– If the threshold is thick enough, it can be made with a rebate.

disadvantages:

– The threshold is easily attacked by wood diseases or termites.
– More materials are needed.
– More joints have to be made, therefore construction is more difficult.
– Water can penetrate between the threshold and the finished floor (Figs. 4a & 4b).

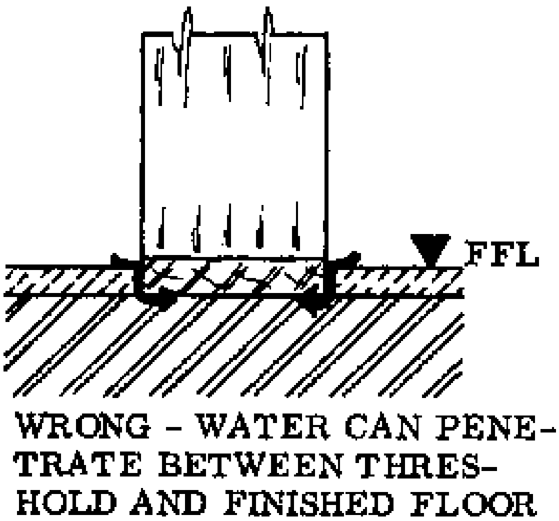


Fig. 4a

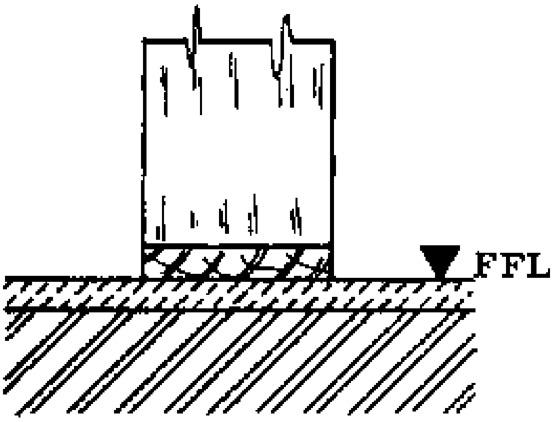


Fig. 4b

– ADVANTAGES AND DISADVANTAGES OF THE CONCRETE SHOE

advantages:

– The wood is not in direct contact with the floor, so there is less danger of attack by termites, etc.
– Less materials are needed.
– The shoe secures the doorframe to the floor.

disadvantages:

– The door might not close as tightly as with a threshold.
– If the frame is not well braced during the building operations, there may be a danger of distorting it while fixing it in place.

– SEQUENCE OF OPERATIONS FOR MAKING A REBATED DOOR FRAME WITH A CONCRETE SHOE: (see Drawing Book, page 67)

a. Study the drawing.

b. Prepare a cutting list.

c. Select the wood.

d. Plane the wood to the required sizes (as indicated on the cutting list).

e. Make the face marks.

f. Mark out the joints (take special care in marking out the shoulders of the tenons on the posts) and mark the length of the posts.

g. Mortice the head and rip the tenons at the posts.

h. Plane the rebate.

i. Cut the shoulders of the tenons.

j. Drill the holes for the steel dowels.

k. Clean up the inside edges.

l. Paint all the members with a primer, especially the joints.

m. Fix the steel dowels and the wooden spacers.

n. Drill the holes and set anchors at the correct places (steel cramps).

o. Assemble the frame with squaring strips.

p. Cut the horns to the required shape and paint them.

Take care when marking the lengths of the posts. They should be the length of the door; plus the upper joint, and minus the height of the concrete shoe.

– ASSEMBLING THE DOOR FRAME: To keep the door frame rigid and square during the various building operations, it needs to be braced. This bracing is done with squaring strips (Fig. 1, last page). These, strips are about 2 x 5 cm, and they are cut into the rebate or nailed to the face of the frame. They hold the frame square and keep the correct distance between the posts.

The proper steps for assembling a door frame are as follows:

a. Knock the frame together.

b. Place the frame, rebate side up, on the workbench.

c. Clamp the posts to the head (use sash clamps or the wedges on the bench).

d. Nail a squaring strip to hold the posts at the correct distance apart.

e. Test for squareness from corner to corner (diagonally).

f. With the clamp still in position, fasten the joints.

g. Cut and nail the other squaring strip diagonally from the head to the post (Fig. 1, last page). This holds the frame square.

h. Cut the posts to the required length.

i. Drill the holes for the steel dowels and fix them. They should be long enough to anchor into the concrete floor.

j. Nail wooden spacers into the inside of the rebate. These keep the frame at the correct height during the building operations (Figs. 1 & 2, page 70).

k. Finish off the frame. The priming coat of paint should be applied to the external woodwork before it is fixed in place.

When timber with a small section, for example 5 x 7 cm or 5 x 10 cm, is used for the posts, an extra squaring strip should be fixed horizontally in the middle of the frame. This prevents the pressure of the blockwork from distorting the frame.

Installing door frames

Frames which are improperly built–in can cause problems later, when the plastering is done or the doors are hung. Therefore we must give special attention to setting the frames properly.

A door frame should be fixed in such a way that the door can open flat to the wall. Otherwise, the door will form a lever to the frame, and the hinges will be forced out when the door swings wide open suddenly.

Door frames can be fixed in position either during the masonry construction or after the walling has been completed.

– SETTING FRAMES DURING MASONRY CONSTRUCTION: The first frames to be set are those of the outside walls. When the masonry work has been built to floor level, the door frame is placed in position according to plan and at the correct height, and held there by means of wedges (Fig. 1, a, next page).

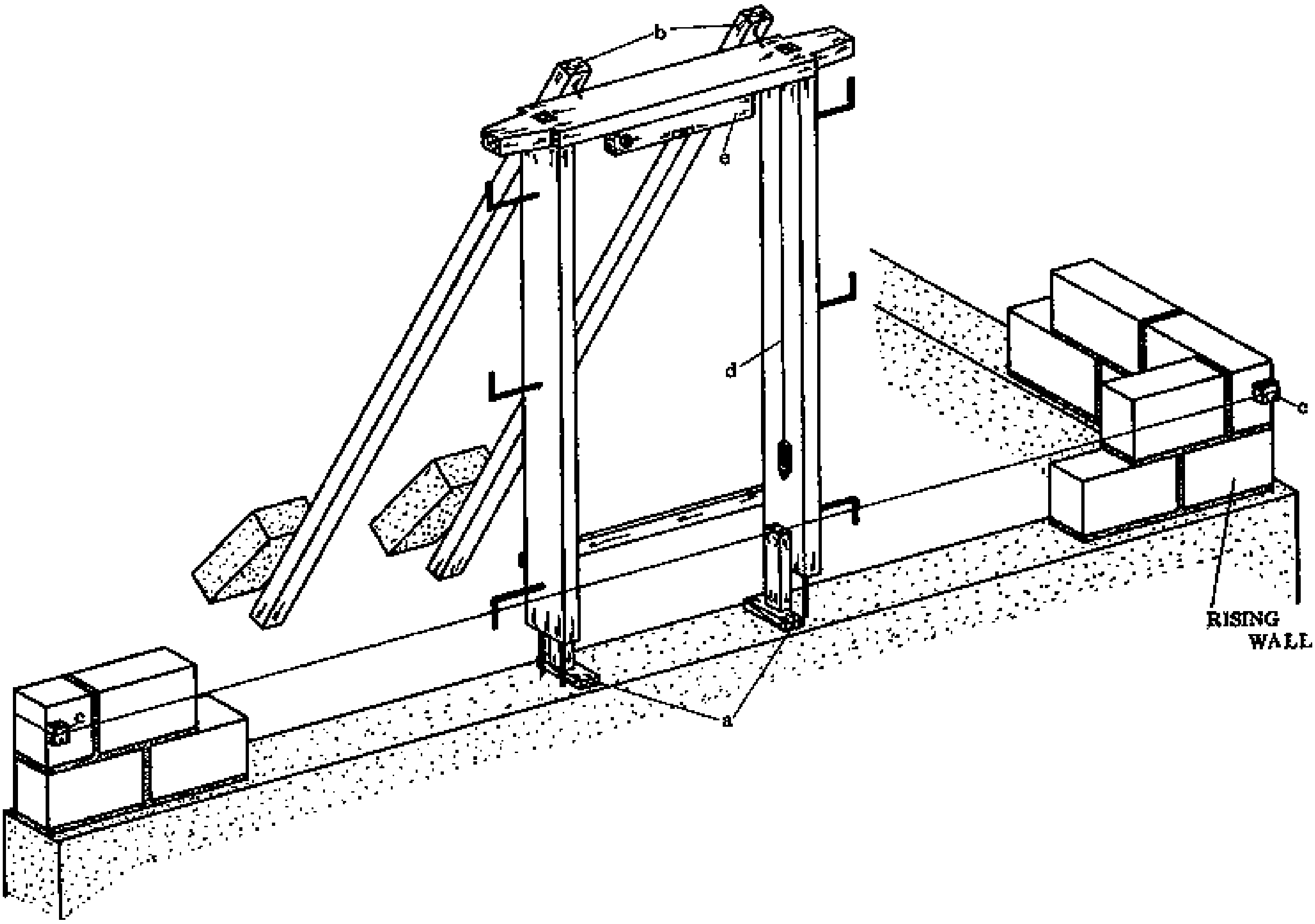


Fig. 1

To hold the frame in position during the following building operations, we use struts. These are braced against blocks on the ground and lean up to the head of the frame, where they are secured with two nails (Fig. 1, b, and Fig. 2, next page).

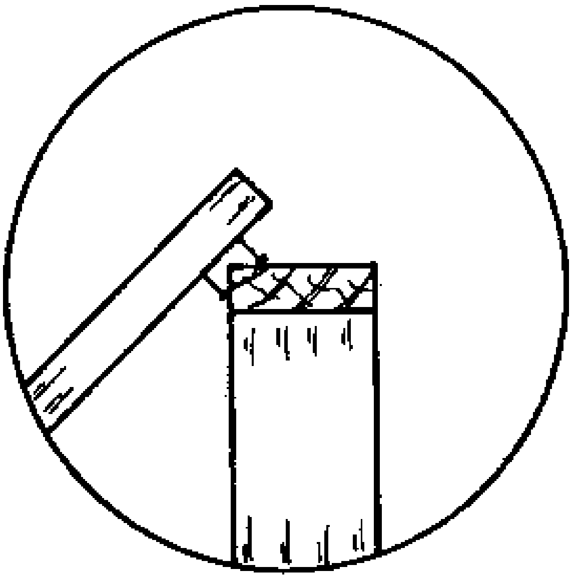


Fig. 2

The masonry line is used to align the frame with the face of the wall. The line is fixed at the two corners of the wall and two small wooden blocks are used to hold the line out from the wall by the same amount as the thickness of the future render layer; so that the line shows the position of the face of the render on the finished building (Fig. 1, c, next page).

The line should be free (not touching any frame or block) from corner to corner of the building. It should be separated from the frame faces by about a trowel's thickness (Fig. 3, next page).

Because the posts are long, the plumb bob is the best tool for making sure that the frames are straight and upright. Hold the bob at the inside top of the frame, so it has room to swing freely (Fig. 1, d). Check both posts (Reference Book, page 5)

To adjust the frame, the wedges are knocked a bit in or out, thus raising or lowering one post at a time until the frame is straight.

The face of the frame can be plumbed at the same time. To do this, step to one side of the frame and sight the edges of the post and plumb line. A helper should stand by the struts and either "give" or "pull" them until the frame is straight. Take care that the space between the face of the frame and the mason line remains correct (Fig. 3).

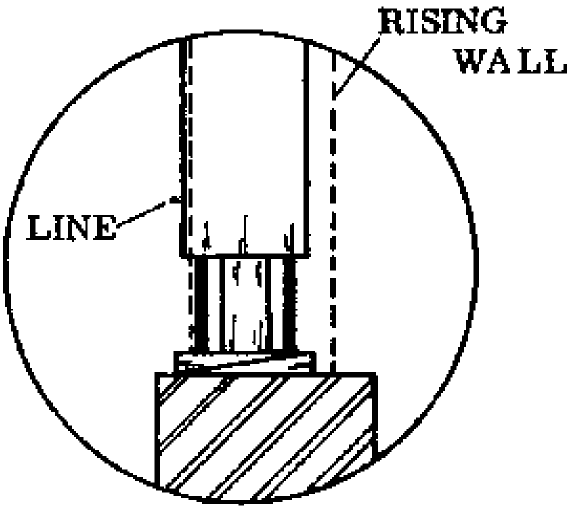


Fig. 3

As a final check, the soffit (underside) of the head can be levelled with a spirit level (Fig. 1, e).

– REMEMBER: Be sure that the face of the frame is in line with the mason line, not flush with the face of the blocks. When the building is finished, the render surface and the face of the frame should be flush.

Make sure that the frame remains at the correct height, so that the steel cramps can fit into the bedjoints and the frame does not get twisted.

After several courses of blocks have been laid, the frame should be rechecked to make sure that it has not become distorted by the blocklaying. Blocks should be laid on both sides of the frame at the same time, so that it does not get pushed out of plumb.

The struts and braces are taken off only when the blockwork has reached the head of the frame.

If more than one frame is erected, walk around the building and look from a distance to compare the frames with each other and make sure that they are all in the correct alignment.

– SETTING FRAMES AFTER THE WALLING HAS BEEN COMPLETED: In this method, the installation of the frames is postponed until the roof construction is complete, in order to reduce the risk of damage to the woodwork from the rain and sun.

Hardwood or plastic plugs (Reference Book, page 215) are driven into the bed–joints to serve as anchors for the frame. The frame is then put into position and nailed or screwed to the plugs.

NOTES:

WINDOW FRAMES

Types of window frames

The function of a window frame is to admit light and air into the building. The most common frame used in Ghana is the solid window type, consisting of an outer frame into which a casement or louvres are fitted.

The most common window frame consists of four parts (Fig. 1):

- – Two posts (a)
- – One head (b)
- – One cill (c)

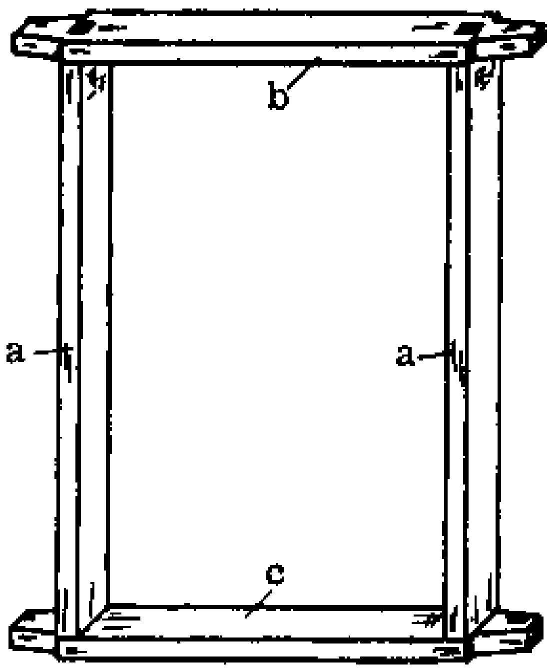


Fig. 1

When additional light and ventilation are needed, a fanlight can be added. The extra piece is called a transom (Fig. 2, d).

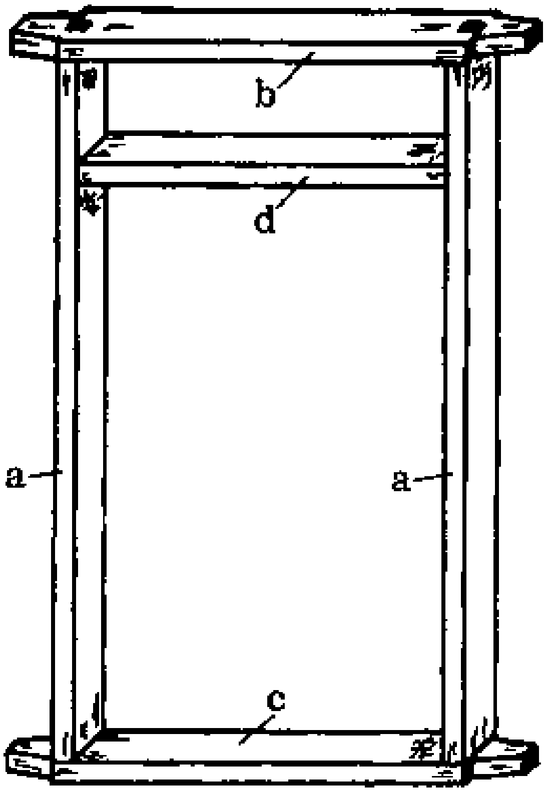


Fig. 2

If wider windows are required, a mullion (Fig. 3, e) can be added.

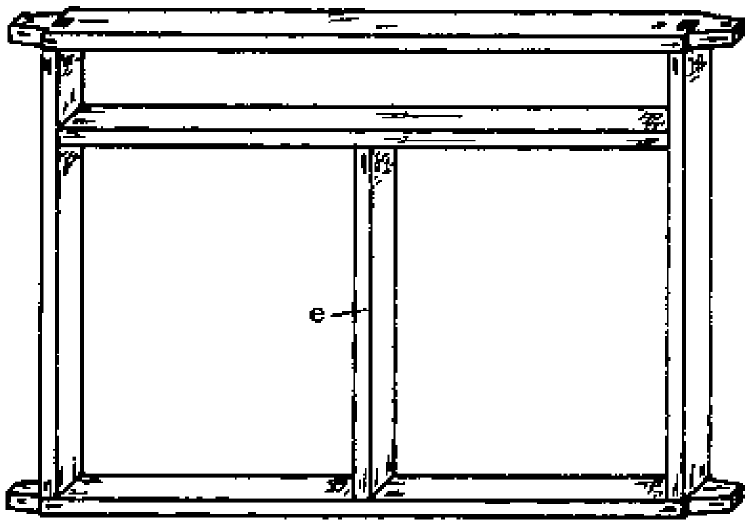


Fig. 3

Any of these frames can be made with a rebate or with beads, or with a combination of the two (Figs. 4 & 5).

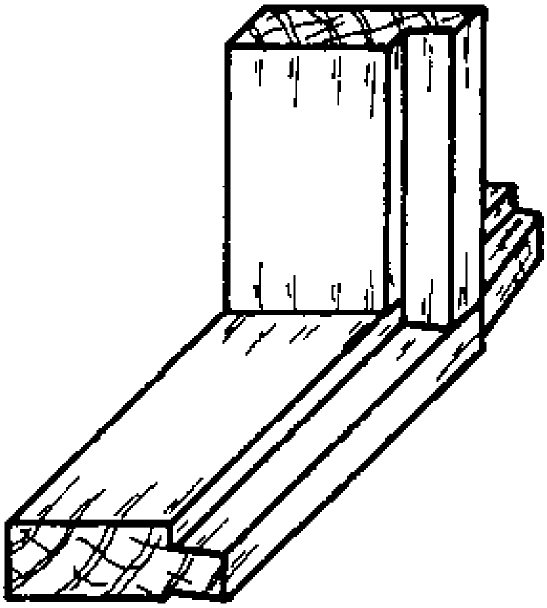


Fig. 4 WITH REBATE

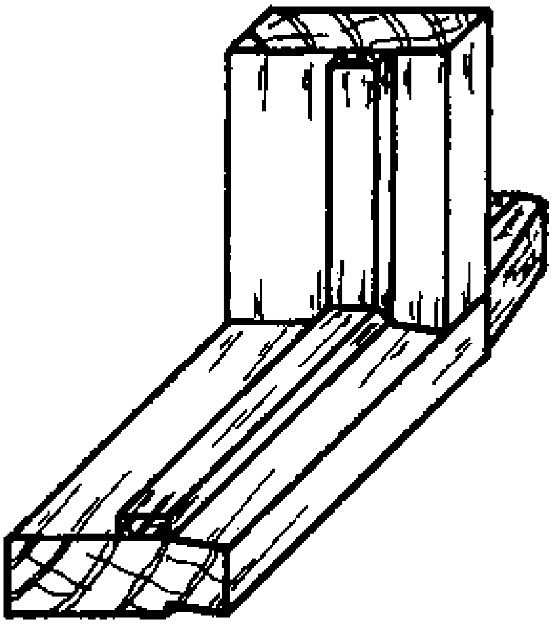


Fig. 5 WITH BEADS

For a list of the advantages and disadvantages of beads or rebates, see the section on door frames. If beads are used, they are fixed after the casement is installed, so they can be adjusted (see Drawing Book, pages 42 & 72).

Measurements of window frames

Before you start constructing a window frame, you have to decide:

– whether the window will have shutters, louvres or any other kind of closing;
– if there will be any burglar proofing, and if so what kind;
– if any mosquito proofing is required;
– and where the window will be installed (does it have to be opened frequently, for example).

All these factors can influence the kind and sizes of timber we use, and the size of the frame itself.

– REMEMBER: Window frame measurements which are given with no further explanation are always inside measurements.

NOTES:

– MEASUREMENTS OF TIMBER SIZES FOR WINDOW FRAMES: A very common size of timber used for window frames is 7,5 to 10 cm wide, by about 5 cm thick. This size of timber is readily available and relatively inexpensive. If large frames are required, the timber size should be about 15 cm by 5 cm.

– MEASUREMENTS WITH RESPECT TO THE CASEMENTS: The height and width of the window frame are partly determined by the kind of casements which will be used. If ready–made casements are used, the frame has to be the right size to fit them. If the casements are to be made, consider the timber sizes which are available and choose the size of the casements according to the size of the boards, to avoid waste.

– MEASUREMENTS WITH RESPECT TO LOUVRES: If glass louvres will be in stalled, their size will determine the height and width of the frame. Find out the size of the louvre first, then start making the frame, not the other way around. Mistakes here can be very expensive!

Also make sure that there is room enough to open and close the louvres and that the mosquito proofing, if present, does not interfere with them.

Louvre windows will be discussed thoroughly in one of the next lessons.

The type of burglar proofing which is chosen will also affect the construction of the window frame, and we will consider this in one of the later lessons.

Steel cramps

If steel cramps are used to hold the frames, they should be positioned to fit into the horizontal joints (bedjoints) of the walls (see Measurements of Door Frames section, page 69).

Joints for window frames

When you are marking out the joints, first decide whether the frame is to have a rebate or beads.

In general, the joints for window frames are the same as those for door frames (see the section on Joints for Door Frames, page 65).

NOTES:

– SEQUENCE OF OPERATIONS FOR MAKING A WINDOW FRAME WITH TRANSOM AND MULLION: The joint for the transom–mullion connection should be a stub tenon, to prevent water from entering the mortice at the top.

Take care when marking out and cutting the shoulder of the tenon where it meets the slope of the cill, so that they fit together exactly (Drawing Book, pages 46, 47, 70, 71 and 72).

a. Study the drawing.

b. Prepare the cutting list.

c. Select the timber.

d. Cut the timber to size.

e. Plane the timber to size and make the face marks.

f. Mark out the joints. Take special care in marking out the shoulders of the joints. The head, transom, and cill must be marked out together, as the two posts and the mullion must also be marked out together.

g. Mortice the head and cill, and make stopped mortices in posts and transom.

h. Rip the tenons for the transom, posts and mullion.

i. Rip the horns on the head and cill.

j. Prepare the rebate and throating if required.

k. Cut the shoulders of the tenons.

l. Smooth and clean up the inside edges.

m. Paint the frame with a primer coat, especially at the joints.

– ASSEMBLING THE WINDOW FRAME:

a. Place the frame on the workbench, with the rebated side up.
b. Fix the transom to the posts.
c. Fix the mullion to the transom.
d. Clamp the head and the cill to the posts and mullion.
e. Test for squareness at the four corners, and check the diagonals.
f. Cut and nail the squaring strips.
g. With the clamps still in position, fasten the joints.
h. Finish off the frame.

Cells of window frames

The cill should have a slope on the outside, to keep rain out of the building. This slope can be constructed by chamfering the cill (Fig. 1) or by a combination of chamfering and rebating (Fig. 2).

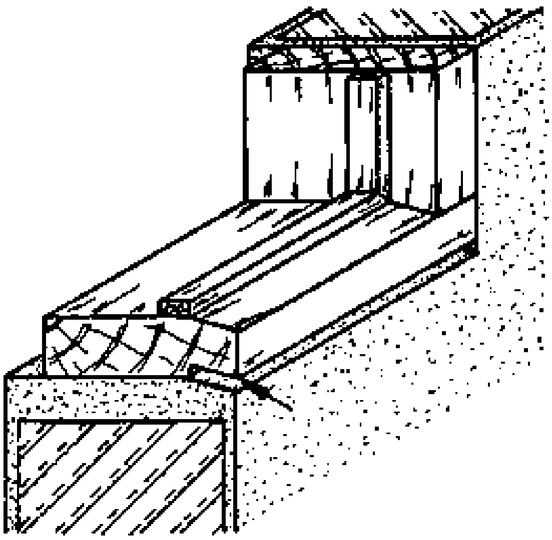


Fig. 1

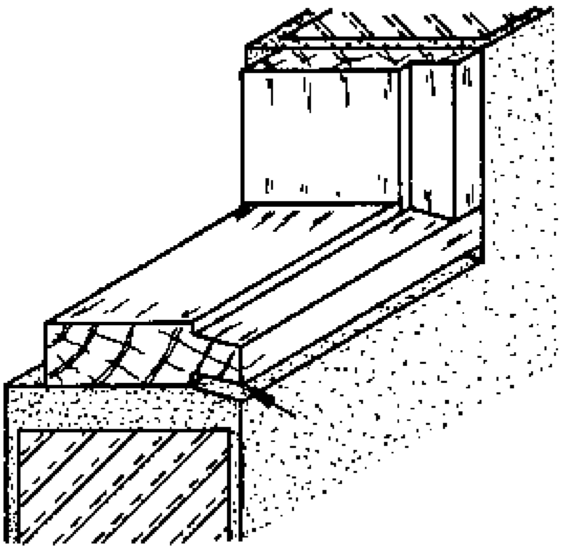


Fig. 2

It is important to prevent rainwater from entering the space between the cill and the wall, where it could cause the cill to rot. A throating at the soffit of the cill (Figs. 1 & 2, arrows) allows water to drip down instead of running back under the cill. The angle of the throating should be parallel to the slope of the cill.

Another way to keep water out is to fix a metal strip, called a drip, under the cill (Figs. 3a & 3b). The drip is fixed in a sawcut in the underside of the cill, so that the water which drips onto the metal will not run inwards. The slope of the metal comes to just inside the face line of the cill (Fig. 3b).

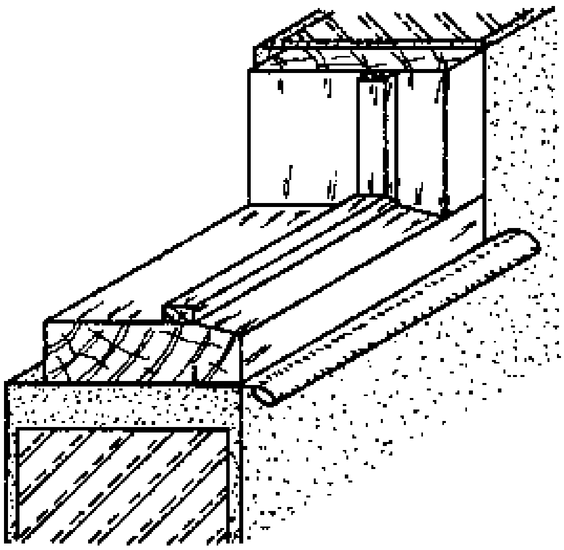


Fig. 3a

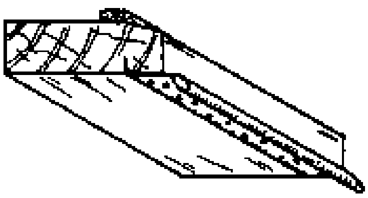


Fig. 3b

The metal strip should extend past the ends of the cill. If it does not, the water which runs down the posts of the frame will damage the render around this part at the corners of the frame.

It is also possible to combine the two solutions, by fixing a metal strip onto the throating.

Every cill should have some kind of protection to keep water from entering between the cill and wall. All cills must come out at least as far as the finish line of the render.

As an alternative to the wooden cill, the window can be constructed with a plaster cill. The posts are fitted with steel dowels and a concrete shoe. The construction is similar to that of a door frame with a concrete shoe (Fig. 4, also see Concrete Shoe, page 71).

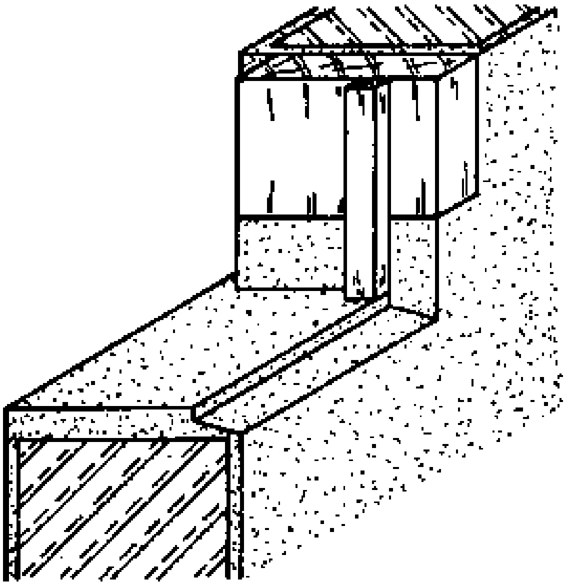


Fig. 4

NOTES:

Heads of window frames

Some protection must also be added at the head of a window frame to prevent any water from entering the space between the head and the lintel and causing damage to the wood. The simplest method is to fix a metal strip similar to the one on the cill. The part of the strip which is plastered over should be bent slightly upwards to prevent water from entering (Fig. 1a, arrow).

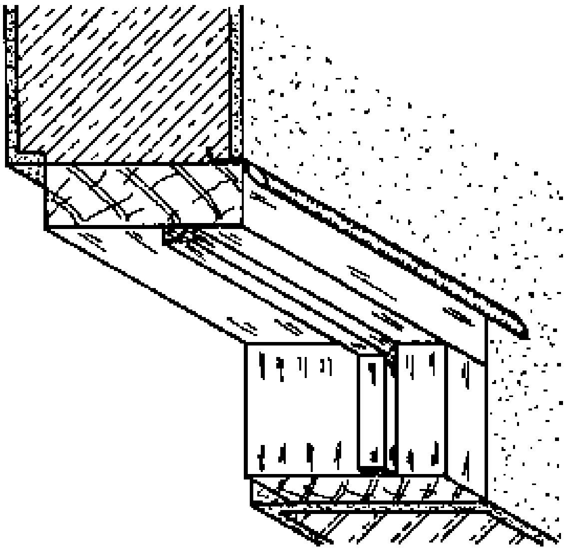


Fig. 1

Note that the line of nails is staggered so that the drip (or weather strip) is firmly secured to the head (Fig. 1a). Otherwise, movement of the strip during heavy rains or storms would probably loosen the render.

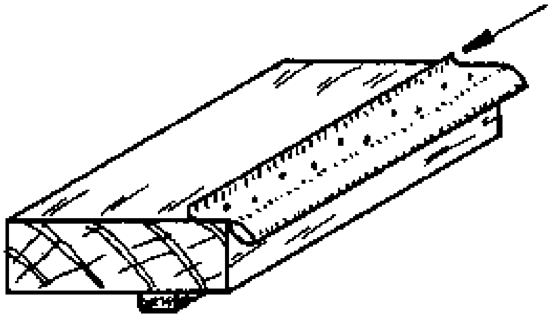


Fig. 1a

These metal drips may be put on when the frame is set up, or left until just before the rendering is done.

An alternative method would be to fix wooden battens, shaped as shown in Fig. 2, on the face of the window head. This method gives a more satisfactory appearance to the window frame.

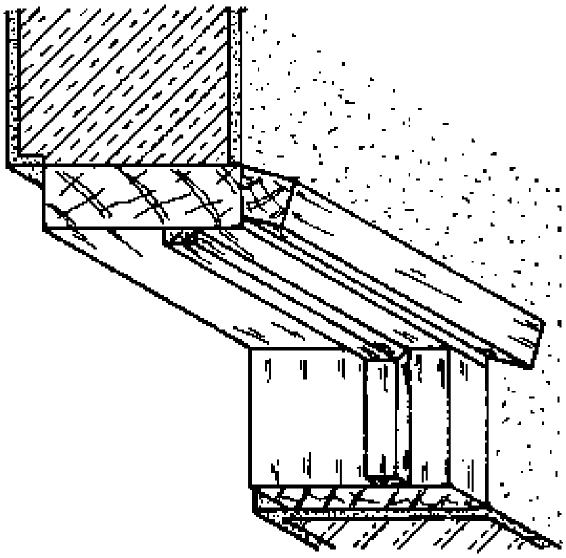


Fig. 2

A combination of both these methods is also possible (Fig. 3).

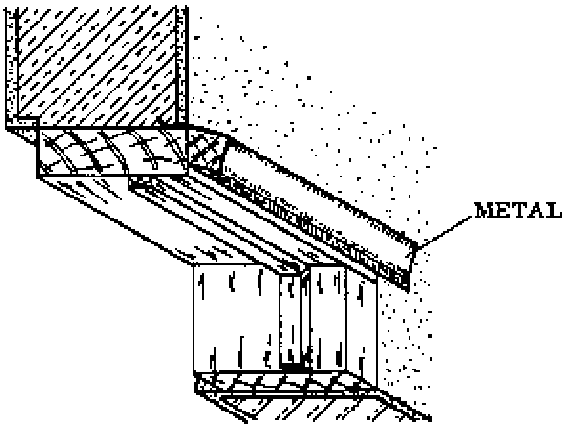


Fig. 3

The importance of fixing weather strips on both the cill and the head of the frame cannot be over−emphasized. They are easily overlooked during the construction of the building and one might be tempted to do a quick job and leave them out. But in the long run the strips will save money by preventing water damages to the wood and expensive repairs.

The same kind of protection can be applied to the heads of door frames.

The heads and cills of window frames can be provided with horns to give an additional secure fixing to the wall (see Heads of Door Frames).

NOTES:

Installing window frames

Installing window frames is similar to installing door frames (see Door Frames section). A window frame should be fixed in such a way that the casement can open flat to the wall, otherwise the casement will form a lever with the edge of the wall. This can cause the hinges to be forced out when the window is blown open by the wind.

Window frames can be installed either during the construction of the walls, or after the walling has been completed.

– INSTALLING THE FRAMES DURING THE WALL CONSTRUCTION: When the blockwork has reached window cill level, the frames can be set and aligned in the same way as a door frame. The chief difference is that in the window frame the horizontal members are usually longer than the vertical members, and for that reason more attention is given to levelling the head and cill of a window frame than to levelling the head of the door frame (Fig. 1).

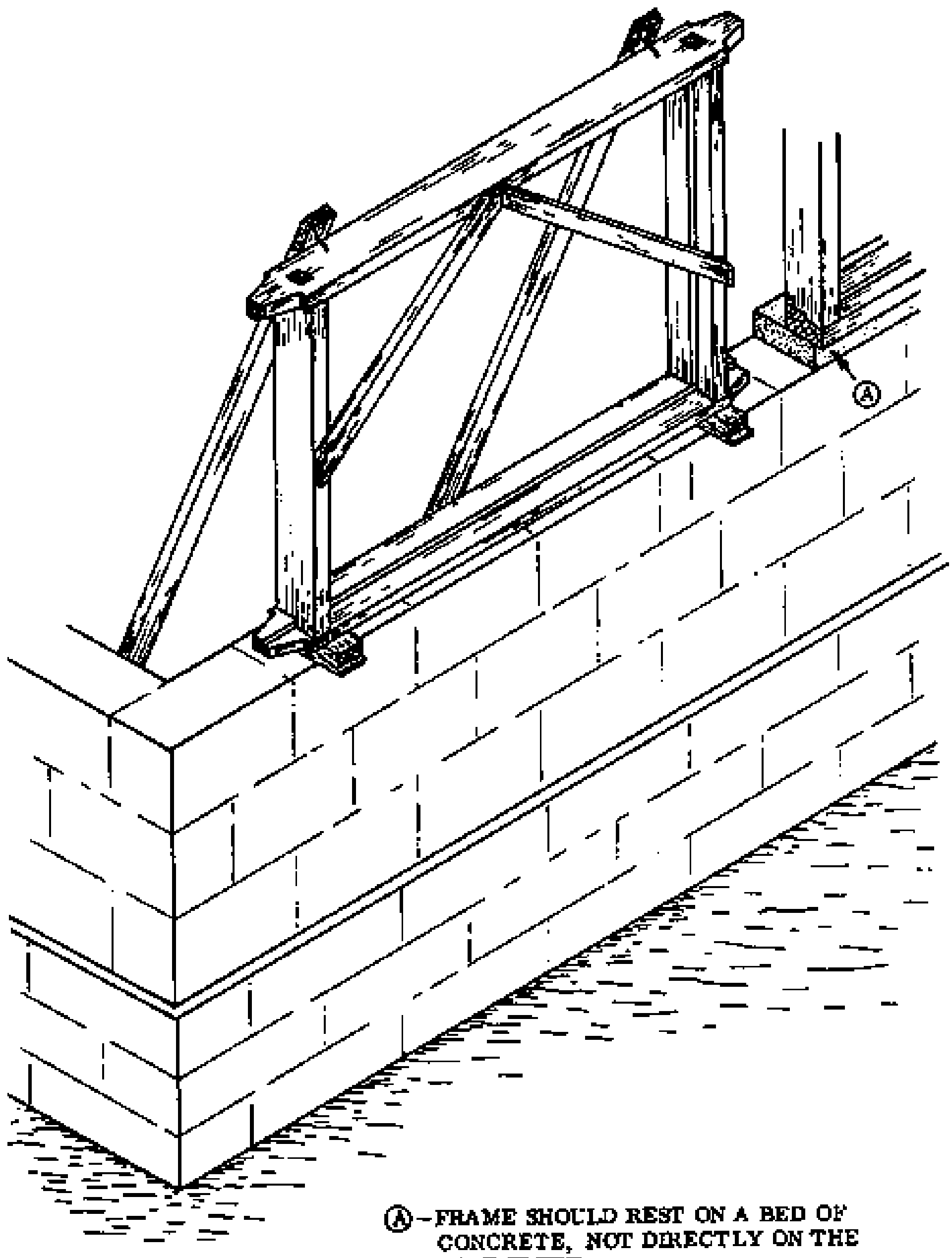


Fig. 1

If more than one frame is installed, check them by comparing from a distance to see if they are aligned, as with door frames.

– INSTALLING THE FRAMES AFTER WALLING HAS BEEN COMPLETED: This second method is not so commonly used, but it also has its advantages. In order to keep the frames clean, square and dry, they are kept in a store until the building is roofed. Openings are left in the blockwork to receive the frames, horns, and steel cramps. The frame is set into this opening and the steel cramps and horns are secured with mortar.

Sometimes hard wood or plastic plugs are used to secure the frame in the wall.

– NOTE: The window frame does not rest directly on the landcrete wall; this would provide a path for moisture to get into the landcrete and weaken or damage it. The window frame is set upon a bed of concrete or cement mortar (Fig. 1, A).

NOTES:

WALLING UP BETWEEN FRAMES

First mark the positions of the blocks on the outsides of the frames. Mark both the height of the blocks (Fig. 1, a) and the face line of the blockwork (Fig. 1, b). The face line of the blockwork will be inside the face line of the frames, because the faces of the frames must be flush with the finish line of the render.

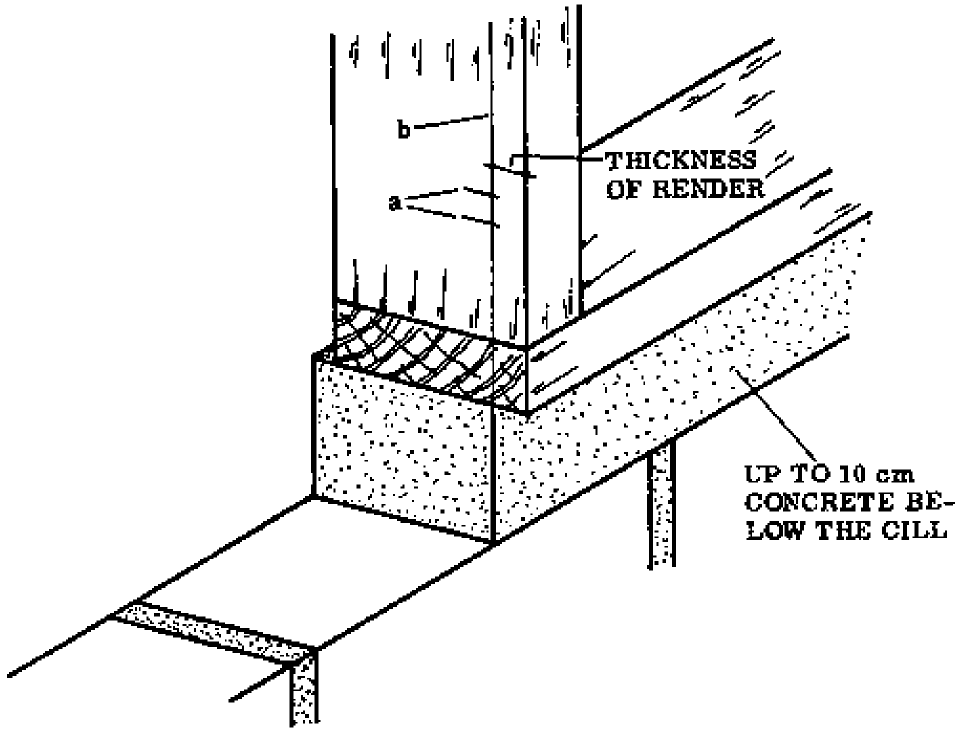


Fig. 1

– NOTE: The window frame does not rest directly on the landcrete blocks. This is because moisture could enter between the cill and the landcrete and get into the blocks, where it would cause them to swell and fall apart. To protect the landcrete blocks, the cill must rest upon a bed of concrete which can be up to 10 cm thick. By adjusting the height of this concrete bed, the anchorage irons and the heads of the frames can be brought into alignment with the bed joints of the blocks.

The first blocks laid are those which touch the frames. The courses in between are completed and aligned with the aid of either a straight edge, spirit level, or mason line, depending on the distance between the frames.

Pay special attention to the anchorage irons of the frames. Make sure that they are not just embedded in the bed joint; instead make grooves in the bed faces of both blocks, which can be filled with mortar to anchor the iron and to protect it from rust (Fig. 2).

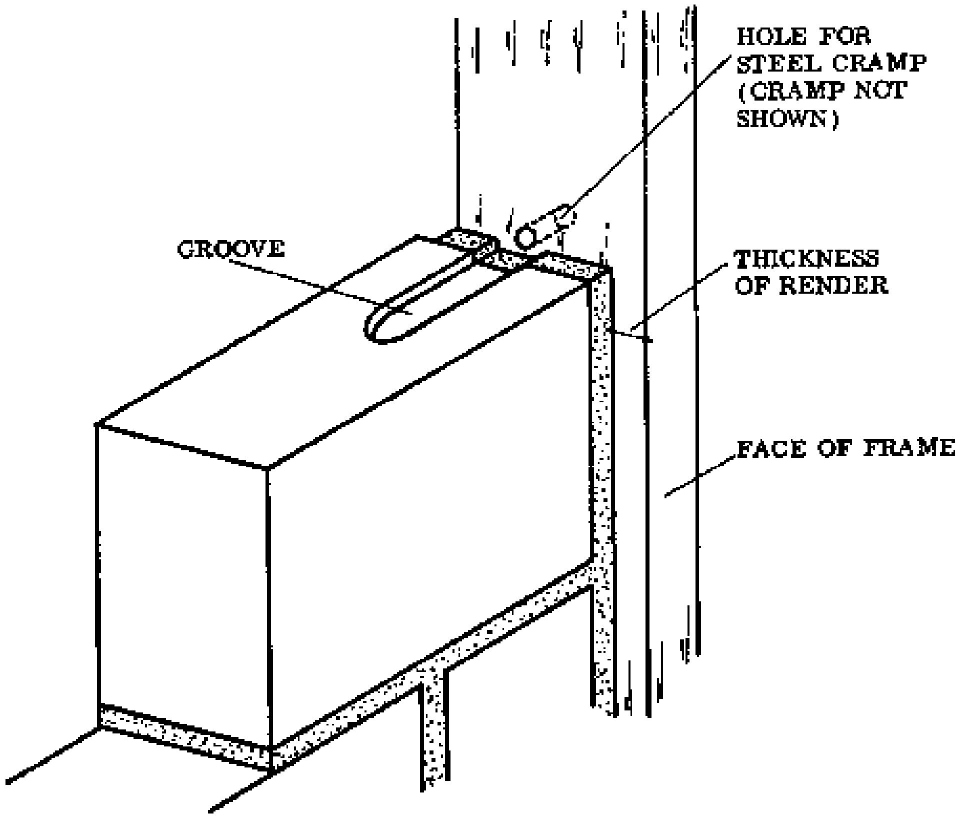


Fig. 2

MOSQUITO PROOFING

It is often necessary to install mosquito wire on doors and windows. The wire screen is normally attached with wooden beads directly onto the window frame. For louvred windows it is fixed on the outside. For casement windows which open outwards, the wire screen has to be attached on the inside or onto a separate framework which is hinged onto the inside of the frame.

A separate framework for the mosquito wire is commonly constructed on doors. Make this framework like a panelled door (this door and its construction are described in one of the following sections, under Doors). Use one or two braces in the framework to keep the door rigid. Often a spring is attached to the wire door to keep it in the closed position.

BURGLAR PROOFING

It is practically impossible to keep burglars out of a house when the occupants are away, but it is at least possible to make the house burglar proof to the extent that burglars cannot enter without making considerable noise and so alerting people in the area.

Types of burglar proofing for windows

– One of the most common methods is to fix mesh wire or expanded metal directly onto the frame, in a way that it cannot be torn off without making consider able noise or using a special cutting tool. Use strong beads to attach the wire to the frame and plenty of screws or nails (Fig. 1).

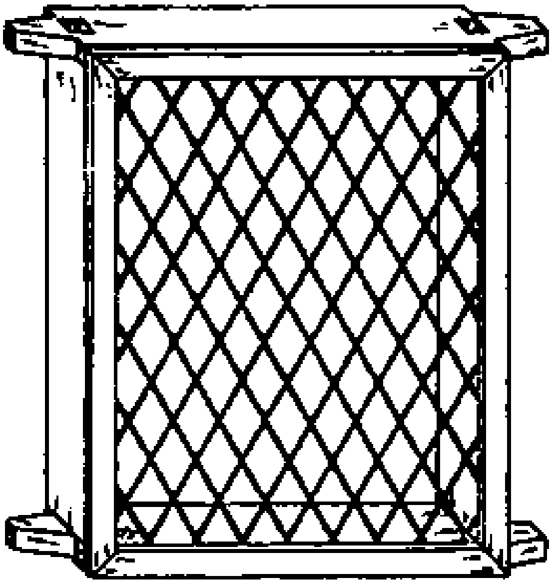


Fig. 1

– Sometimes burglar proofing is made from welded iron rods in different patterns and fixed directly into the wall around the window. It should be anchored well and deeply enough so that it cannot be pulled out (Figs. 2 & 2a).

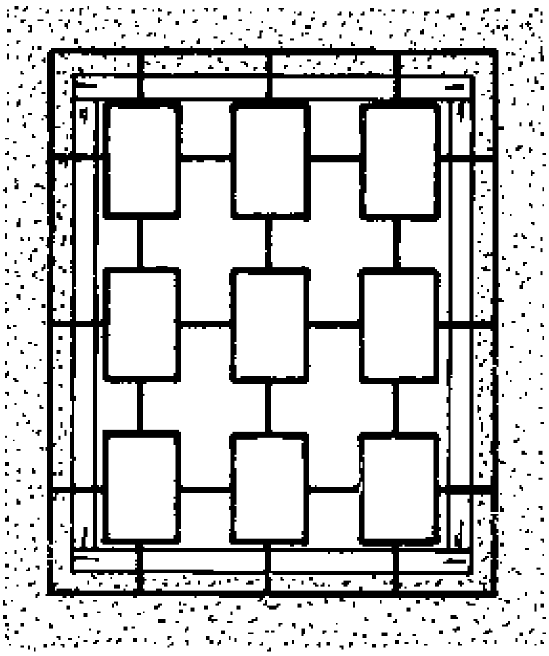


Fig. 2

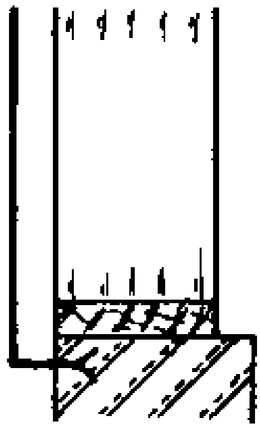


Fig. 2a

– Another way to make a window safer is to fix iron bars horizontally into the frame. This must be done during the assembly of the frame. If some of the bars stick out at the sides of the frame, they can also be used as an additional anchor for the frame in the wall (Fig. 3). If the span between the posts of the window is large, the horizontal bars may need to be reinforced by having vertical bars welded onto them, so that they cannot be bent up or down to allow the burglar to enter.

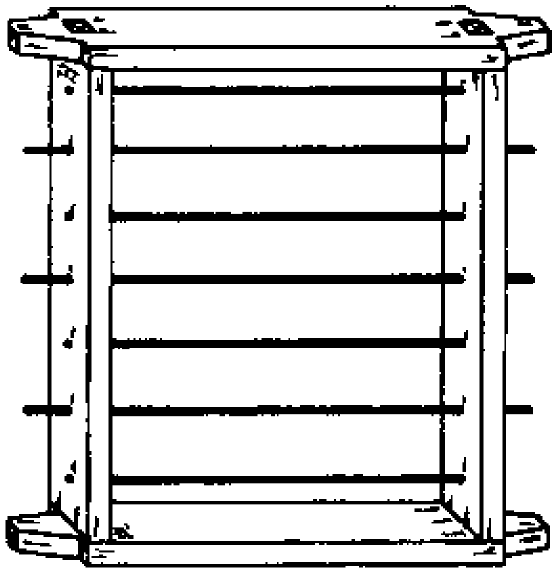


Fig. 3

The bars can also be applied to windows fitted with louvres. In that case, the iron bars are placed between the louvre glasses (Fig. 3a). They must be placed in such a way that they will not obstruct the louvres when they are opened.

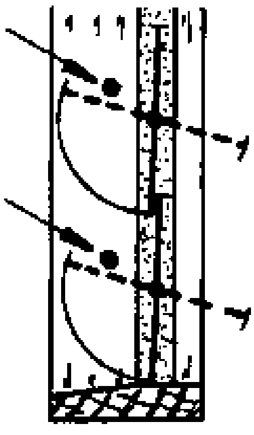


Fig. 3a

– A relatively inexpensive and reliable burglar proofing is the wooden type. During assembly of the frame, this burglar proofing is installed into mortices made in the head, cill and posts of the frame. The separate pieces are fitted together with halving joints in a crosswise pattern (Fig. 4).

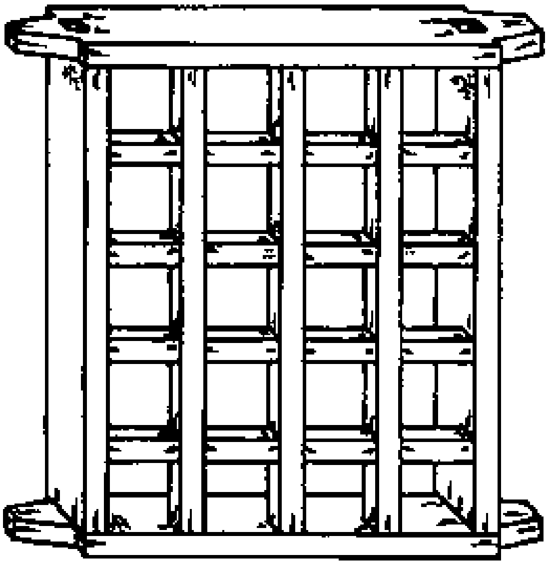


Fig. 4

If outward–opening casements are installed in a frame, install the burglar proofing on the inside face of the frame. Leave a small opening in the burglar proofing for the hand to pass through in order to open and close the window.

For louvred windows the burglar proofing is always installed on the outside.

DOORS

The door is an essential part of the building structure. It must have the right proportions: not so large that it weakens the wall of the building, and not too small either. People, goods, and equipment, according to the uses of the building, have to be able to pass through the door easily.

Types of doors

In Rural Building, doors are classified as follows:

– Ledged and battened doors (Fig. 1)

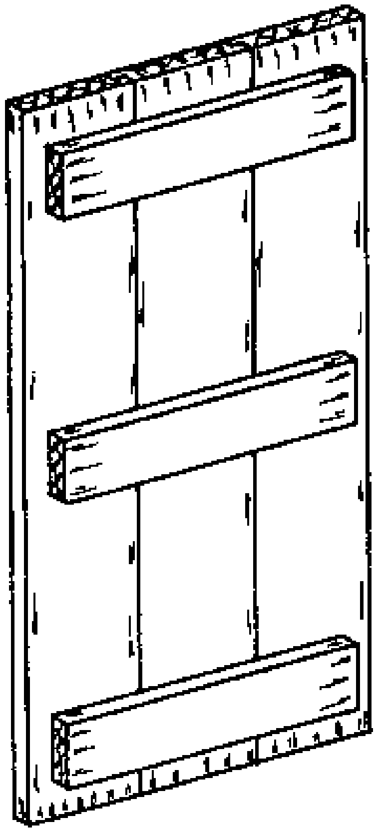


Fig. 1

– Ledged, braced and battened doors (Fig. 2)

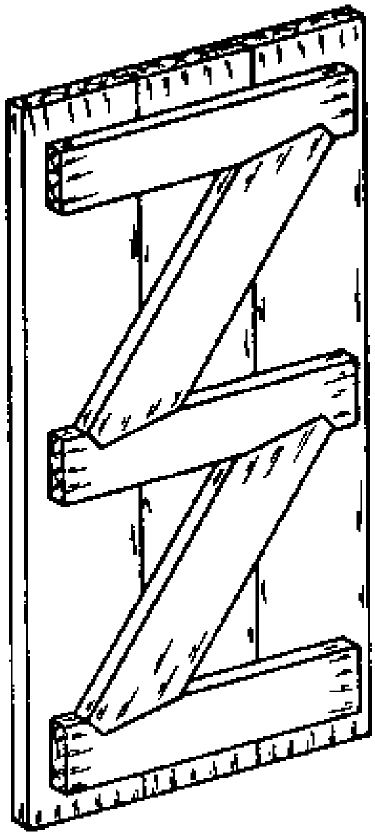


Fig. 2

– Panelled doors (Fig. 3)

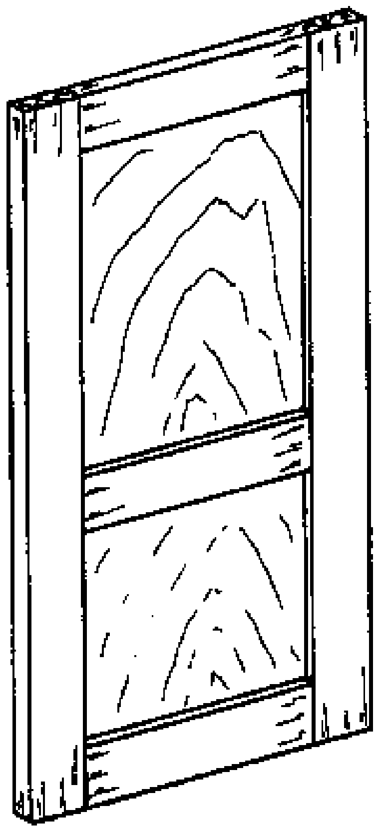


Fig. 3

– Flush doors (Fig. 4)

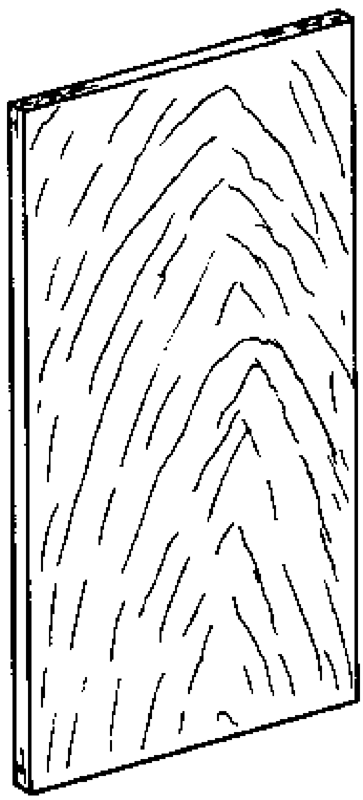


Fig. 4

For an outside door which is exposed to rain and sun, it is best to choose a weather resistant door like a battened or panelled door. If the door is protected inside the building then a flush door made of plywood will be satisfactory.

Sizes of doors

The size of the door depends on:

– Where it will be used (entrance doors will naturally be slightly larger than other doors, and bathroom doors will be a bit smaller)

– The materials which are available (plan the door according to the sizes of wood and plywood which are available).

A common door size is 198 cm by 76 cm. This is wide enough to allow most sizes of furniture to pass through. Nearly all modern furniture has one dimension which is 76 cm or less: a standard table, for example, is 76 cm high.

Living room and bedroom doors are sometimes larger for reasons of ventilation.

Position of the door

Outside doors should always open to the outside. This makes them more weatherproof and easier to open in case of an emergency such as a fire, when you want to get out quickly.

Try to position the door so that you cannot look directly into the room from the outside.

Finishing treatment of the door

All doors should be painted or varnished, or preserved in some way. A good paint job preserves the door from decay and reduces shrinkage and swelling, thereby lengthening the life of the piece (Reference Book, pages 200 & 201).

Paint is especially important for flush doors. They should be well painted and the edges of the door should be soaked in paint.

Ledged and battened doors

These doors consist of vertical boards called battens (Fig. 1, a) which are nailed or screwed to the horizontal members, called ledges (b). Often the battens are a–bout 15 to 18 cm wide and 2 to 3 cm thick. Doors made with narrow battens like these have a better appearance.

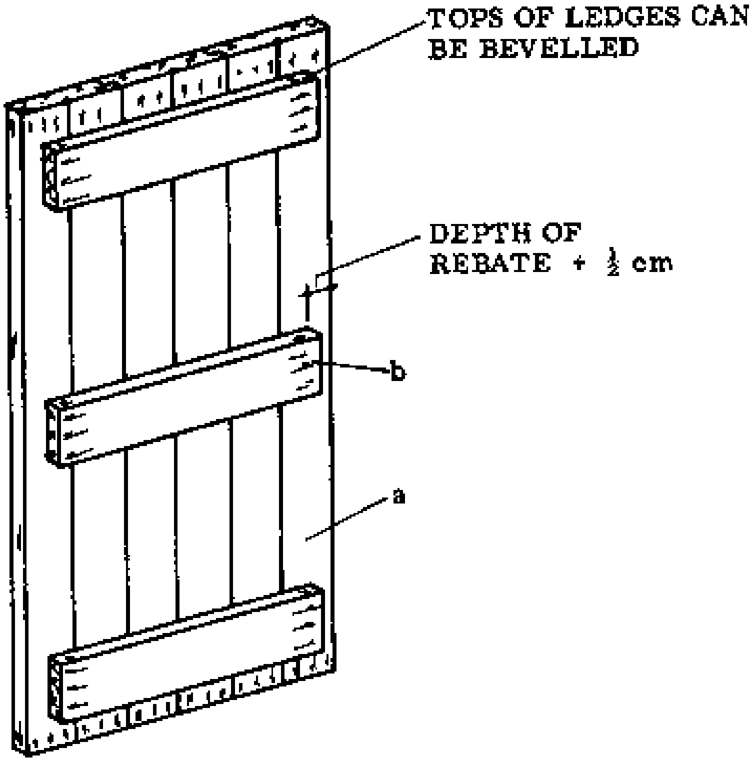


Fig. 1

Because of the climate in the northern part of Ghana, here it is better to use boards which are up to 30 cm wide. These wider boards are less likely too twist and warp at the ends (Fig. 2). The boards should be well seasoned so that they won't crack at the ends.

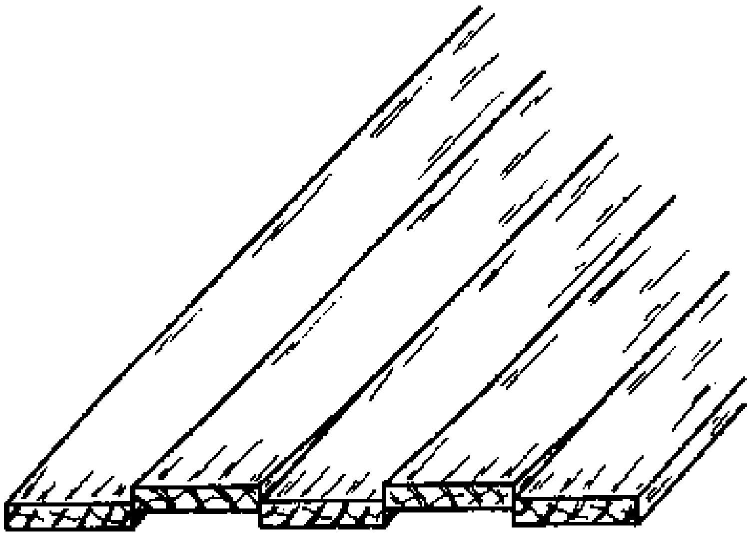


Fig. 2

The width of this door is usually the width of 2 1/2 or 3 boards (Figs. 3 & 4).

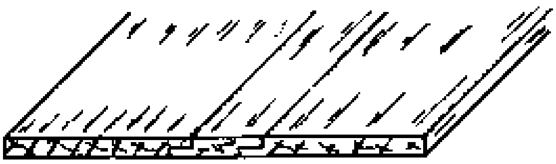


Fig. 3 2 1/2 BOARDS

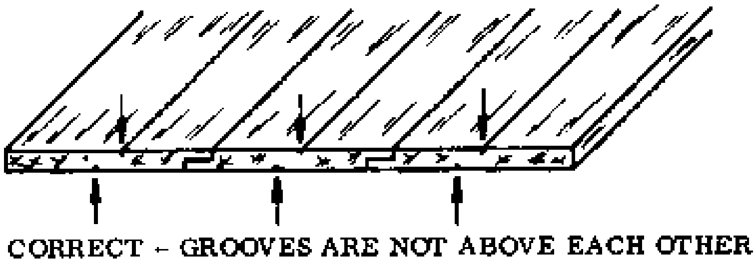


Fig. 4 3 BOARDS

Grooves can be made in the wide battens, to produce a pleasing appearance as if the door were made with narrow battens (Fig. 4). The grooves should not be made from both sides of the door at the same spot, above each other, because this will make the door weak (Fig. 5).

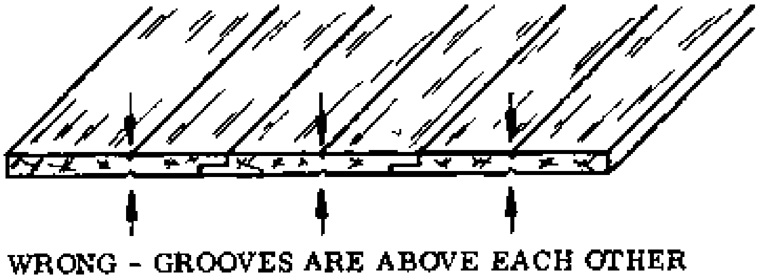


Fig. 5

The ledges should be as long as possible to prevent cupping of the battens, and to provide a solid attachment. The length of the ledges will be the width of the door minus the depth of the two rebates or beads in the door frame, and minus a 1/2 cm allowance on each side (Fig. 1). The ledges are usually 2 to 3 cm thick. When this construction is used for an external door, the tops of the ledges should be bevelled (Fig. 1).

The ledged and battened door is the simplest type of door. It is often used for narrow openings. It is relatively cheap to construct, but unfortunately it tends to sag because of its weight.

NOTES:

– JOINTS FOR LEDGED AND BATTENED DOORS: We use special types of joints to connect the battens of this door. These joints are known as matchboarding joints.

A matchboarded door will have a good appearance even when the boards have shrunken and the joints are opening. Matchboarding joints are not glued like ordinary widening joints (Basic Knowledge, pages 130 to 136). They are left loose so that shrinkage can take place, and the battens are held together by the ledges.

In Rural Building we use two different matchboarding joints: the loose tongued joint (Fig. 1), and the rebated joint (Fig. 2).

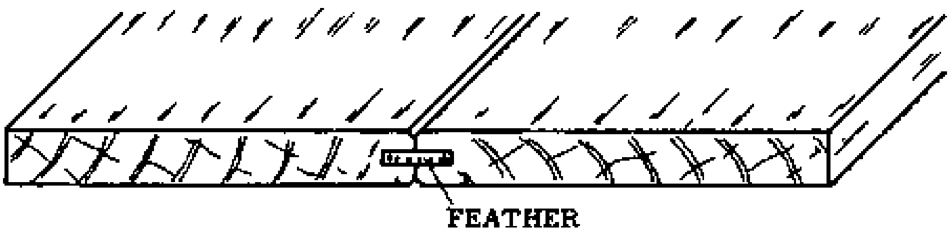


Fig. 1

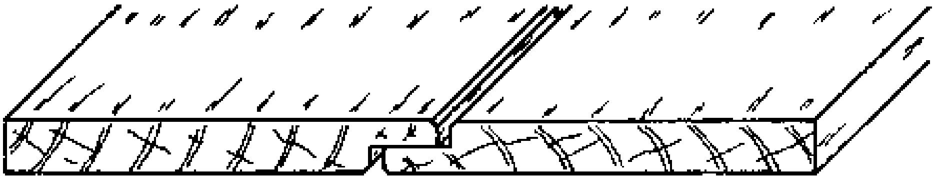


Fig. 2

The loose tongued joint has a tongue made of plywood. It is glued into only one side of the groove so that shrinkage can take place (Basic Knowledge, page 134).

There are several possible ways to make the rebated joints used in battened doors (Fig. 2).

When you assemble this joint, put a strip of wood in between the battens with the same thickness as the gap you want. This keeps the gap between the battens open as the door is assembled.

Any batten–type door made during the rainy season should be assembled with the matchboarding joints closed. If the door is assembled during the dry season, then the joints should be kept open (Fig. 2, also see Reference Book, pages 129 to 130). There should be enough allowance between the battens to allow them to swell up to 5% of the width of the board (for a 30 cm board size the gap will be up to 1 1/2 cm). If this is not done the door will start to warp when it swells in the rainy season.

– SEQUENCE OF OPERATIONS FOR MAKING A (NAILED) LEDGED AND BATTENED DOOR:

a. Study the drawing.

b. Prepare the cutting list.

c. Select the wood.

d. Cut the timber to the right size, leaving a 1 cm allowance in the length of the battens for finishing off.

e. Plane the timbers to size. Mark the boards (Basic Knowledge, page 88).

f. Plane the matchboarding joints.

g. Paint or varnish the edges of the battens.

h. Fit the battens together. Use a wooden or metal sash clamp to hold them.

i. Mark the positions of the ledges.

j. If the door is to be an external one, bevel the tops of the ledges.

k. Paint or varnish the inside faces of the ledges and battens.

l. Nail the ledges lightly to the battens (Fig. 3, previous page).

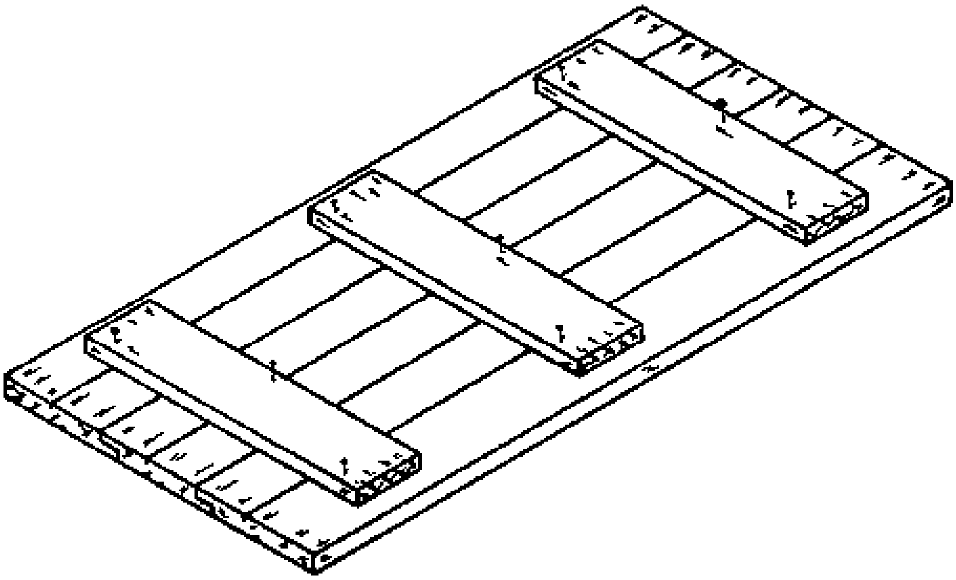


Fig. 3

m. Turn the door over put three pieces of wood under the ledges for support during nailing (Fig. 4, previous page).

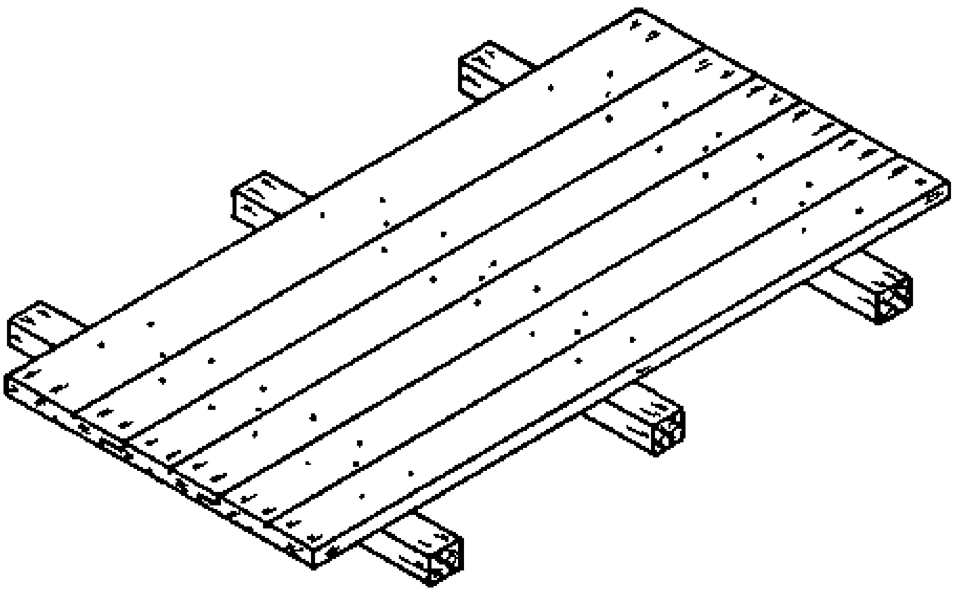


Fig. 4

n. Drive the nails through the battens and ledges and punch the heads under the surface of the wood.

o. Turn the door over and clench the nails. Remove the nails used in step “1” to nail the ledges lightly to the battens.

p. Cut off and level the battens at the top and bottom.

– REMEMBER: To avoid splitting the wood, always blunt the nails and drive them in a staggered pattern (Fig. 4, previous page). Clench all the nails to prevent them from being pulled out if the wood warps or swells. For clenching, the nails have to be long enough to go through the wood and out the other side by about 5 mm (Basic Knowledge, pages 92 to 94).

Ledged, braced and battened doors

This is a ledged and battened door to which braces have been added to prevent sagging (Figs. 1 & 2). These braces must slope upwards from the hinge edge of the door, and they are housed with a skew notch into the ledges (Drawing Book, page 73).

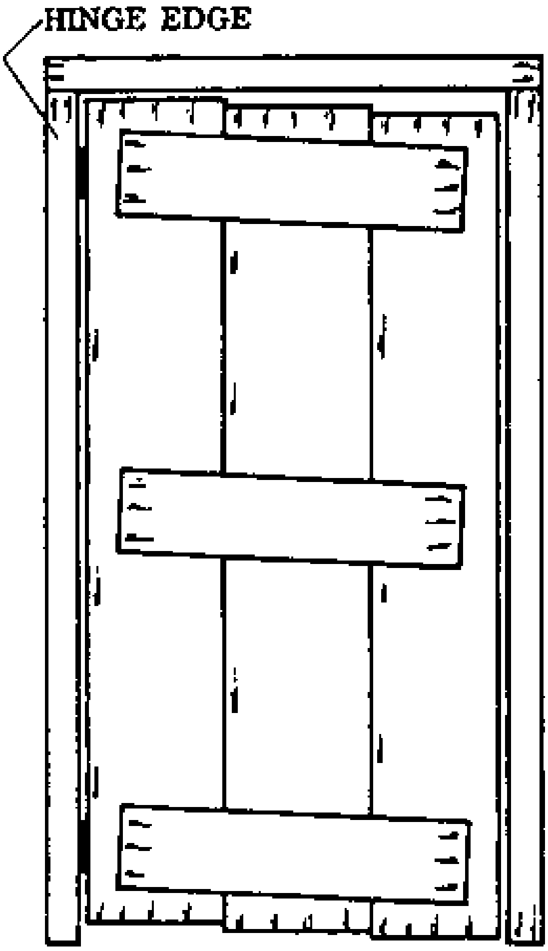


Fig. 1 NO BRACES – DOOR MAY SAG

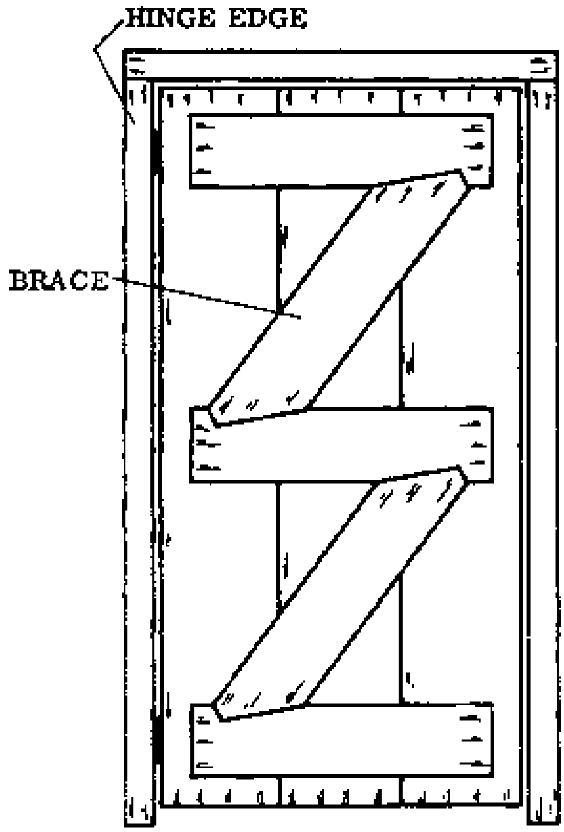


Fig. 2 BRACES PREVENT SAGGING

The skew notch helps to distribute the force from the weight of the door, so that the ledges have an even pressure on them. To achieve an equal distribution of the force, the angle of the short shoulder of the skew notch has to bisect (divide in two) the angle between the ledge and the brace (see Fig. 3, angle “x” = angle “y”).

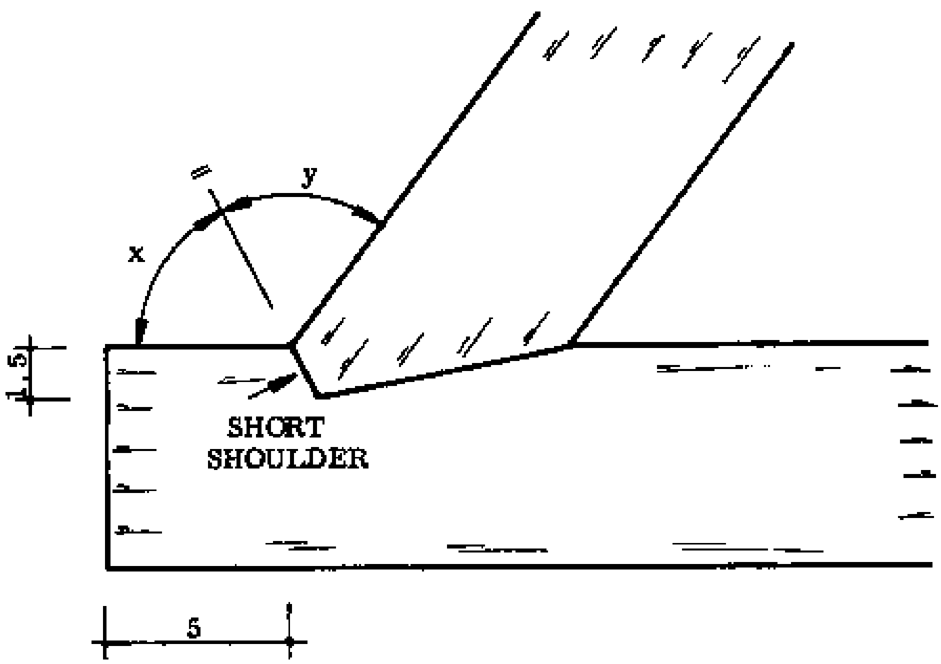


Fig. 3

The skew notch should start from a point 5 cm from the end of the ledge, to prevent shearing off. The depth of the skew notch will be 1,5 cm (Fig. 3).

This type of door construction may be used for large openings because of its greater strength.

The sequence of operations to make this door is the same as for the ledged and battened door. The braces are fitted to the door after the ledges are nailed lightly to the battens (step “1” in the construction).

– SEQUENCE OF OPERATIONS FOR MAKING A (NAILED) LEDGED, BRACED AND BATTENED DOOR: Proceed in the same manner as for the ledged and battened door,' until you reach step “1”. Continue as follows:

m. Place the braces on top of the ledges (Fig. 1).

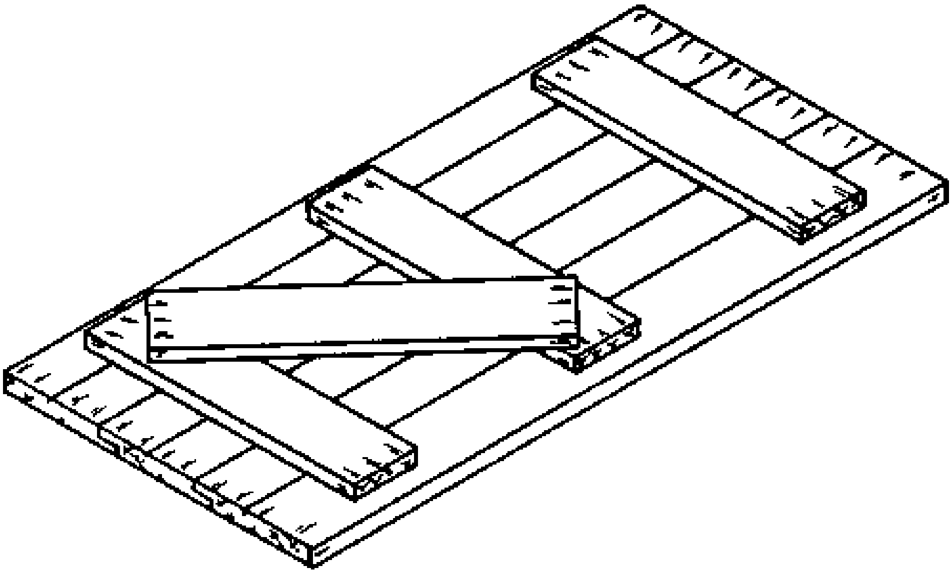


Fig. 1 (m)

n. Mark out the skew notches on each end of the braces.

o. Cut the braces according to the marks.

p. Place each brace in position and mark out the positions on the ledges (Fig, 2).

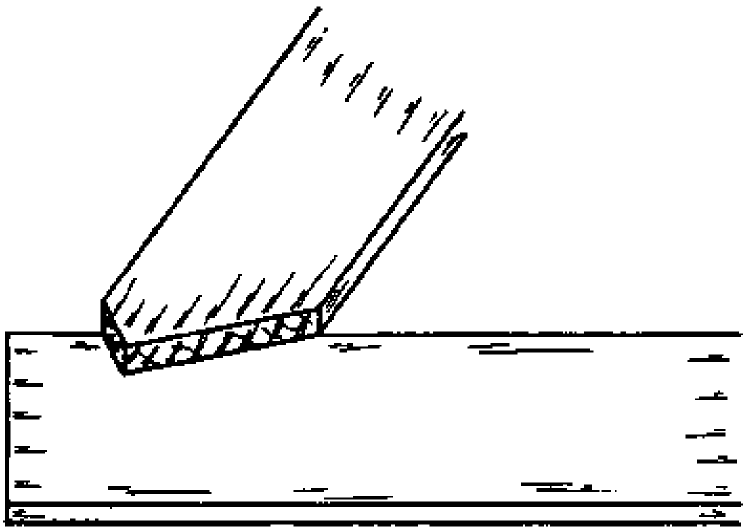


Fig. 2 (p)

q. Chisel the notches in the ledges (Fig. 3).

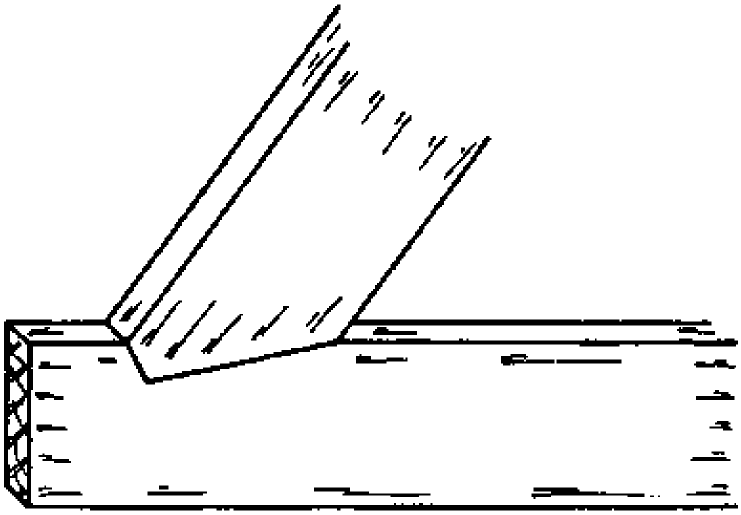


Fig. 3 (q)

r. Paint the skew notches.

s. Nail the braces lightly to the battens.

t. Turn the door over and place three pieces of wood under the ledges for support during nailing.

u. Drive nails through the battens, ledges and braces, and punch the nail heads under the surface.

v. Turn the door over and clench the nails. Remove the nails which were used to hold the braces and ledges lightly to the battens in step “s”.

w. Cut off and level the battens at the top and bottom.

NOTES:

Panelled doors

These doors (Fig. 1) consist of a frame made up of stiles (a), a top rail (b), a bottom rail (c) and sometimes an intermediate rail (d). Into this framework a plywood panel (e) is fitted. This panel may fit into a groove or a rebate (Drawing Book, pages 75 to 78).

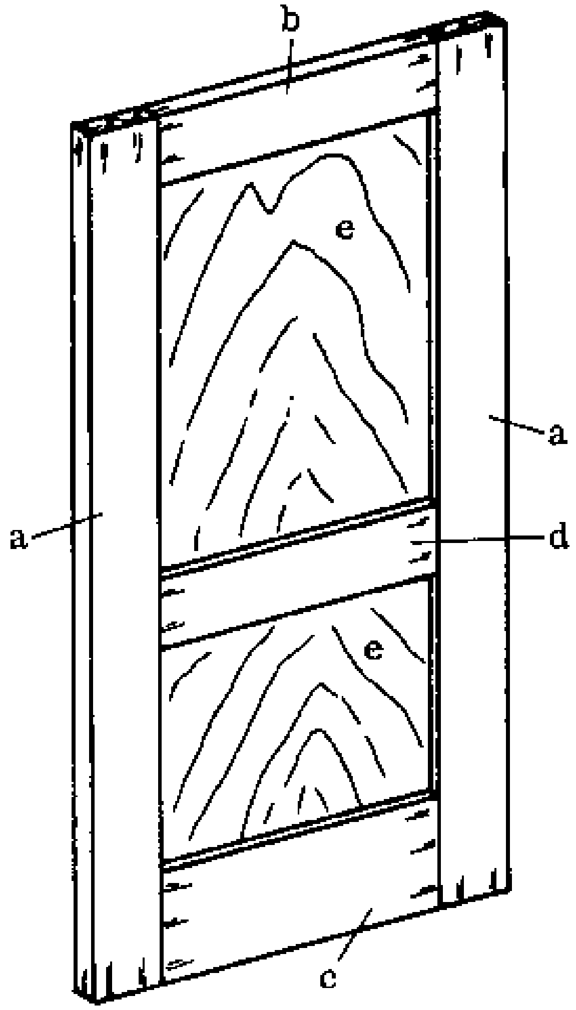


Fig. 1

– GROOVED–IN PANEL: This construction can be used only on doors which will be protected from the rain. If water enters the groove, it will not be able to dry out and can cause the plywood to rot (Fig. 2).

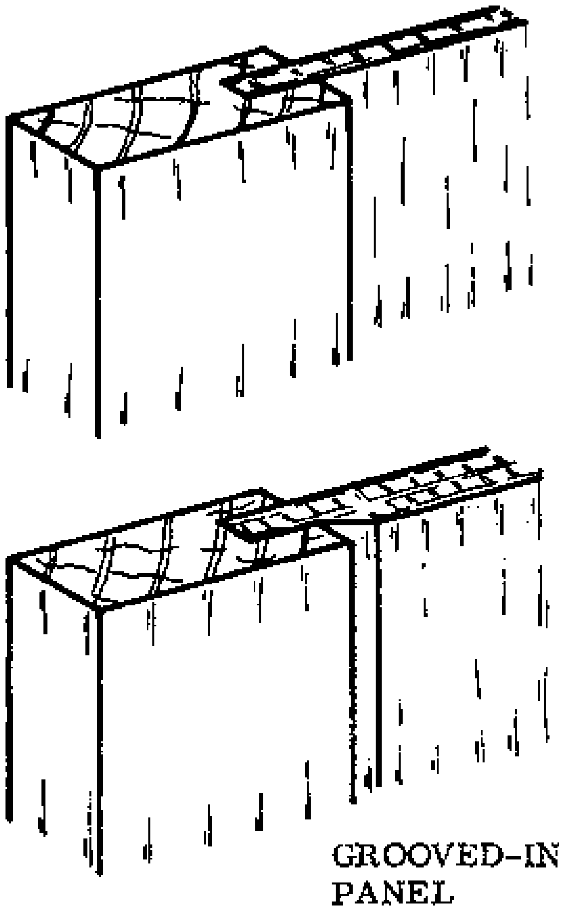


Fig. 2

If the door will be painted or varnished, the edges of the plywood panel and the inside of the grooves should be treated before the door is assembled.

The depth of the grooves is usually 1/3rd of the thickness of the members. The grooves are made as explained in the Basic Knowledge book, page 136.

The joints for this kind of door will be a haunched stub tenon for the top and bottom rails (Fig. 4), and a stub tenon for the intermediate rail (Basic Knowledge, pages 118 to 122). Note that the width of the tenon has to be reduced by the depth of the groove (Fig. 4, arrow) and the mortice is reduced accordingly.

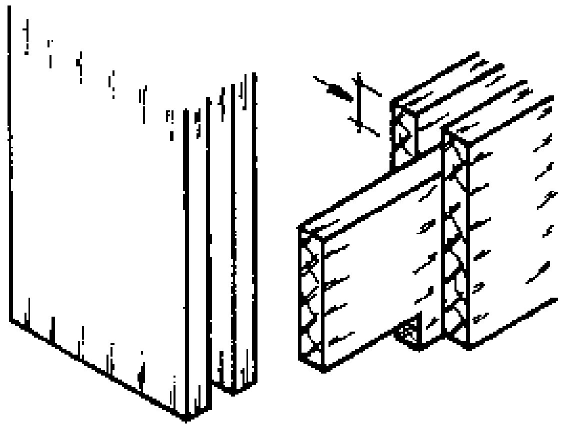


Fig. 4

– REBATED FRAMEWORK: When the panel will be fixed after the frame is assembled, a rebated framework is used. A rebate is made in the frame and the panel is secured with beads (Fig. 3).

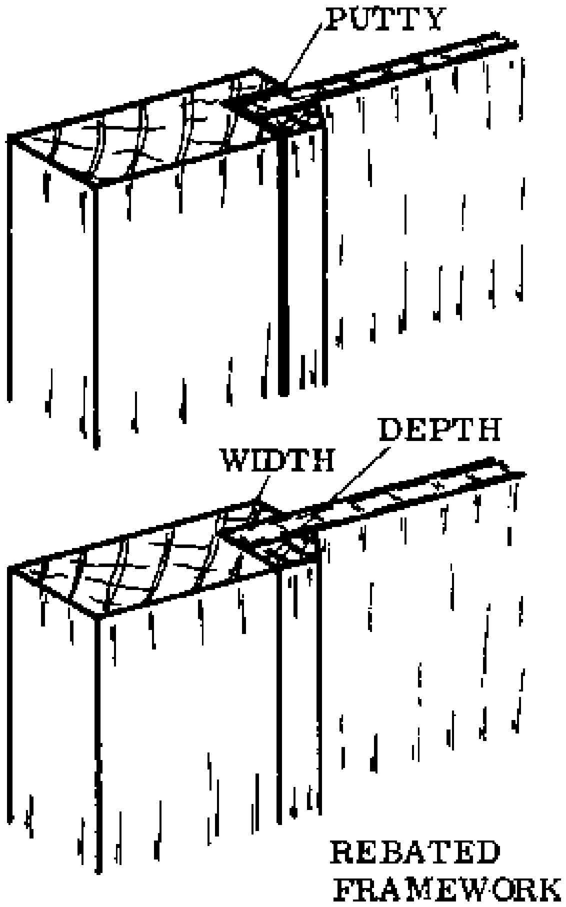


Fig. 3

Unlike the grooved–in panel door, this door can be used in places where it is exposed to rain. In that case, the plywood is set in putty so that water cannot penetrate inside, and the tops of the intermediate and bottom rails should be bevelled. The beads are also set in a thin layer of putty, then secured with nails.

If the door will be painted or varnished, the joints, edges of the plywood, rebates and beads all have to be painted before assembly.

The width of the rebate is usually 1/3rd of the thickness of the frame member, and the depth is usually 2/3rds of the thickness of the member (Fig. 3).

The joints for this kind of door will be haunched stub tenons for the top and bottom rails and stub tenons for the intermediate rail. Note that one shoulder of the tenon has to be longer to fill the rebate (Fig. 5, a). The widths of the tenon and mortice have to be reduced by the size of the rebate (Fig. 5, b; also Drawing Book, page 78, and Basic Knowledge, pages 118 to 120).

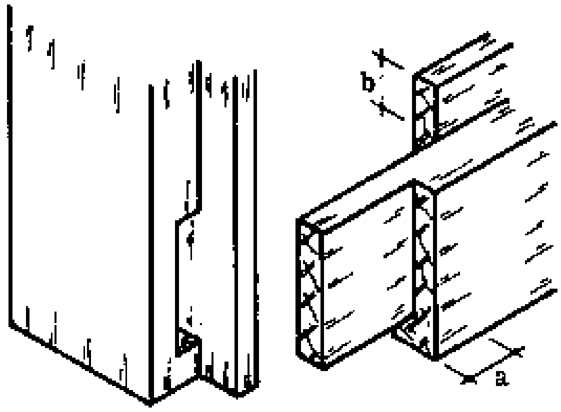


Fig. 5

NOTES:

– TIMBER MEASUREMENTS FOR PANELLED DOORS:

Stiles and top rail – 3 to 4 cm thick, 10 cm wide
Intermediate rail – 3 to 4 cm thick, 10 cm wide
Bottom rail 3 to 4 cm thick, 15 to 20 cm wide

– HOW TO PREVENT A PANELLED DOOR FROM SAGGING: Very often panelled doors will sag after a certain length of time. This is due to the joints drying out and loosening, and to the weight of the door.

The key to the door's ability to resist sagging is the plywood panel. For this reason the panel must be properly secured and fit tightly into the frame.

The tenons must also be well secured. If we can prevent the joints from opening we prevent the door from sagging. A good method of securing the joints is to nail through the joint and pinch off the heads of the nails. They should only be long enough so that they can be punched under the surface but do not come through the other side of the frame (Fig. 1b).

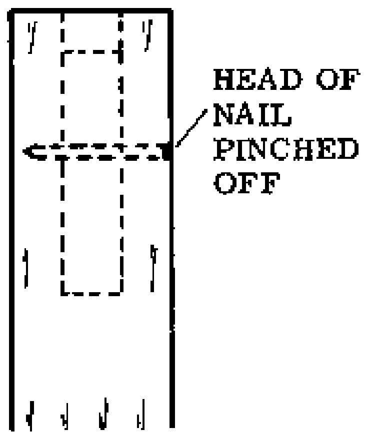


Fig. 1b

Note the staggered positions of the nails in Fig. 1a on the left. This prevents the nails from splitting the wood.

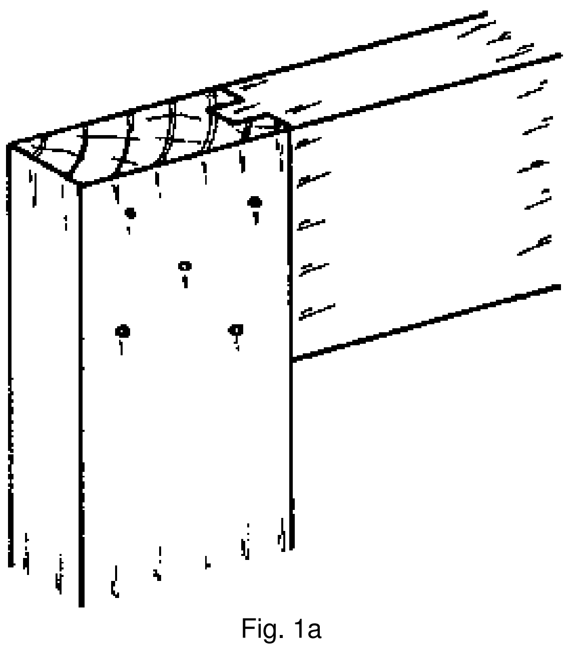


Fig. 1a

On the hinge stile of the door, the joints tend to pull apart at the lower edge. To prevent this, fix strips of sheet metal at the top hinge corner and at the lower corner opposite from the hinge stile. Use small nails to fix the metal (Fig. 2).

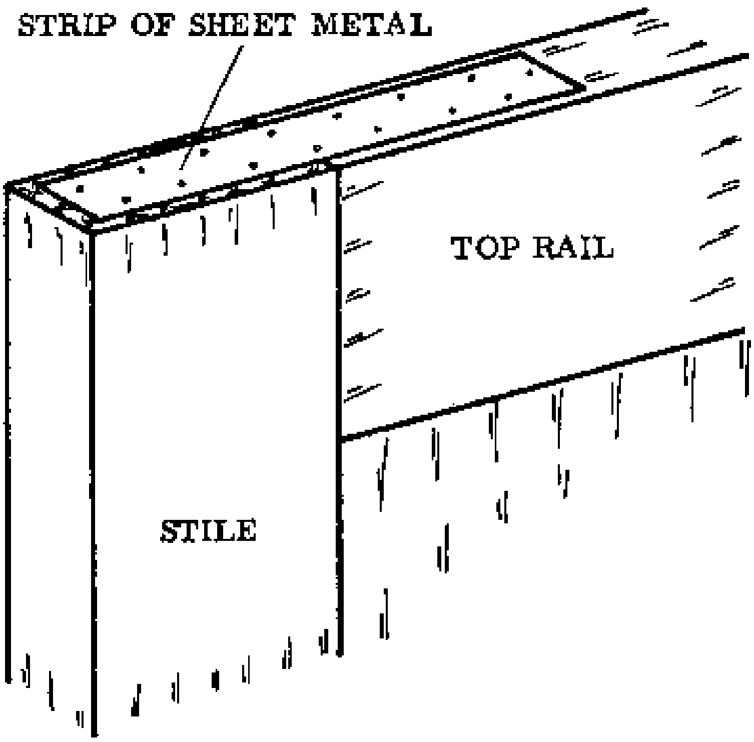


Fig. 2

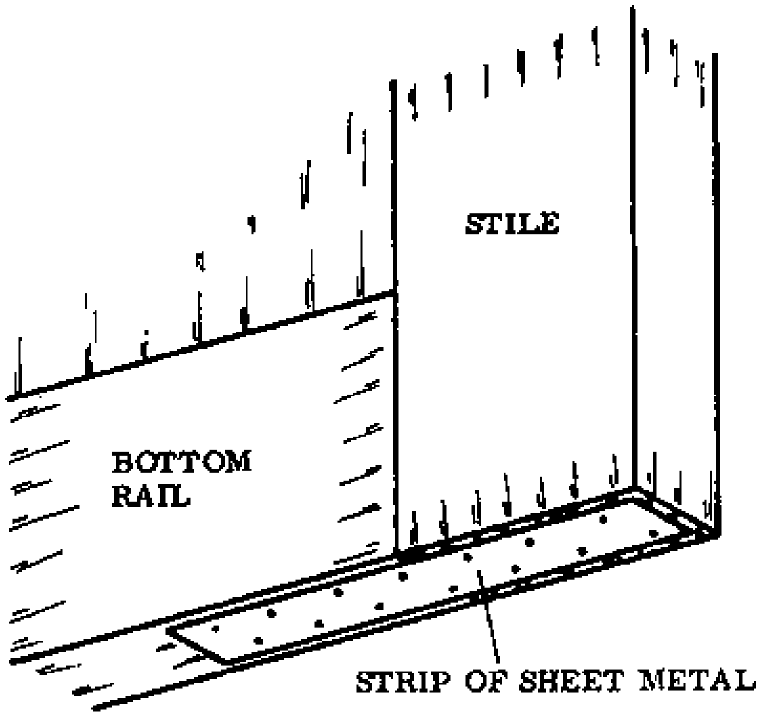


Fig. 2

NOTES:

Flush doors

The flush door with a framed core (Fig. 1) is a type of door that we frequently make in Rural Building. This door consists of a frame which has stiles (a), top and bottom rails (b & c), and narrow intermediate rails (d). It is covered on each side by a sheet of plywood (e). Sometimes flush doors for the outside of the building are covered on one or both sides by sheets of thin metal, usually aluminium or galvanized iron. Plywood−covered flush doors cannot be used where they will be exposed to rain and sun.

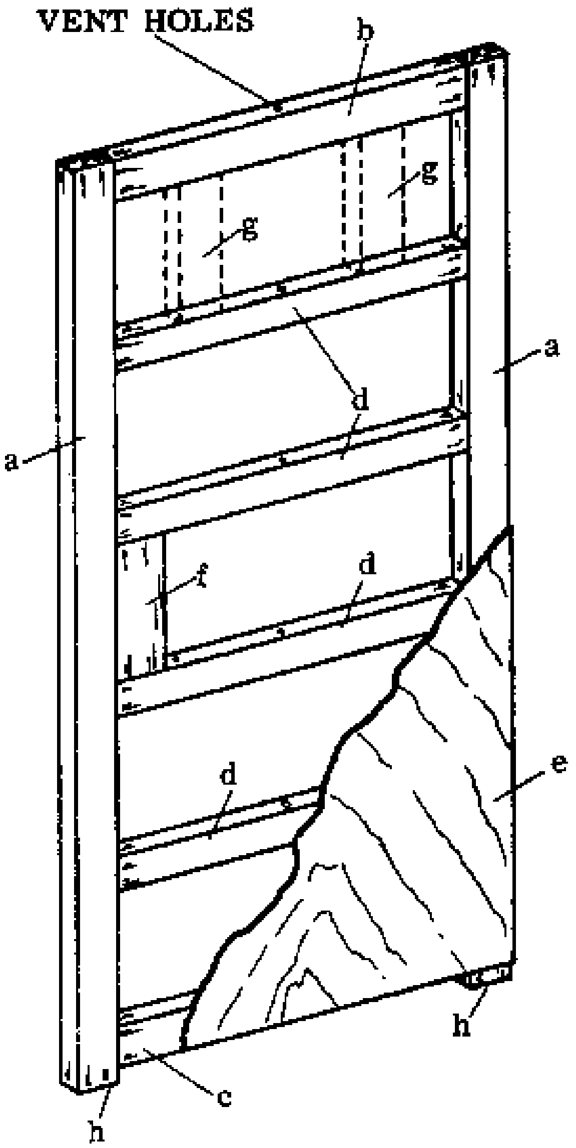


Fig. 1

Well seasoned Wawa is used for the frame. If the stiles are not wide enough to provide room for the mortice lock (Reference Book, page 223), then a lock block (f) is added. This block should be long enough so that does not restrict the lock position to only one spot. The location of the lock block should be indicated on the outside edge of the frame so it can be found later after the plywood or metal sheets are fixed.

When two additional members are placed between the rails (g), a pane of glass can be set in them to provide additional light for the room (Figs. 1 & 2).

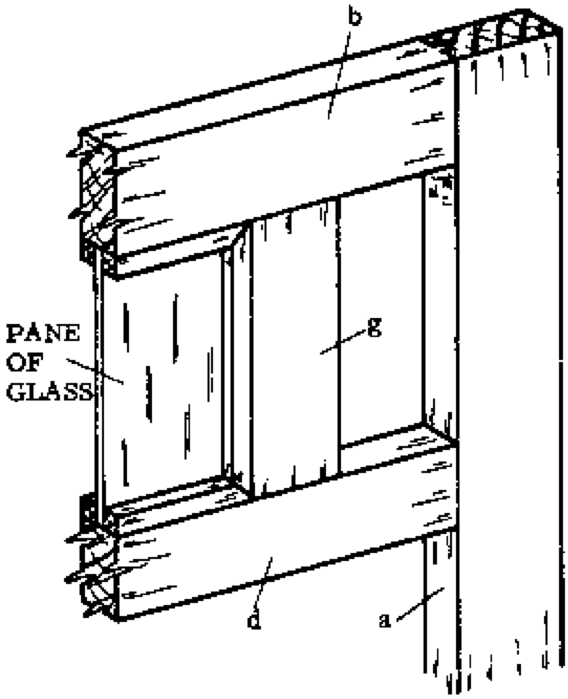


Fig. 2

To prevent damage to the top and bottom rails when the door is stored and moved around, the stiles can be left projecting past the rails (h), thus forming a rest for the door.

Ventholes can be drilled through each of the rails to ensure good air circulation within the frame. Take care that the ventholes in the top and bottom rails are not blocked by paint.

The joints for the flush door can be haunched stub tenons for the top and bottom rails (Fig. 3) and stub tenons for the intermediate rails.

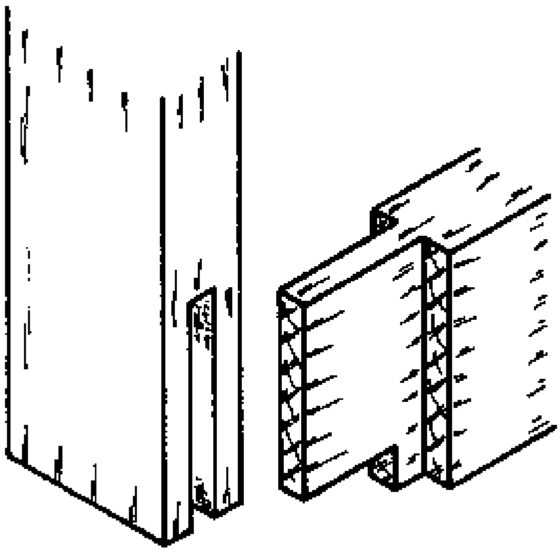


Fig. 3

– LIPPING: A strip of hard wood (Fig. 4) can be fixed to the striking stile to prevent damage to the plywood edges. Lipping is always done after the plywood has been fixed. A thoroughly painted lipping can be added to the top of the door if necessary to keep water out. The lipping joint should be a mitre joint.

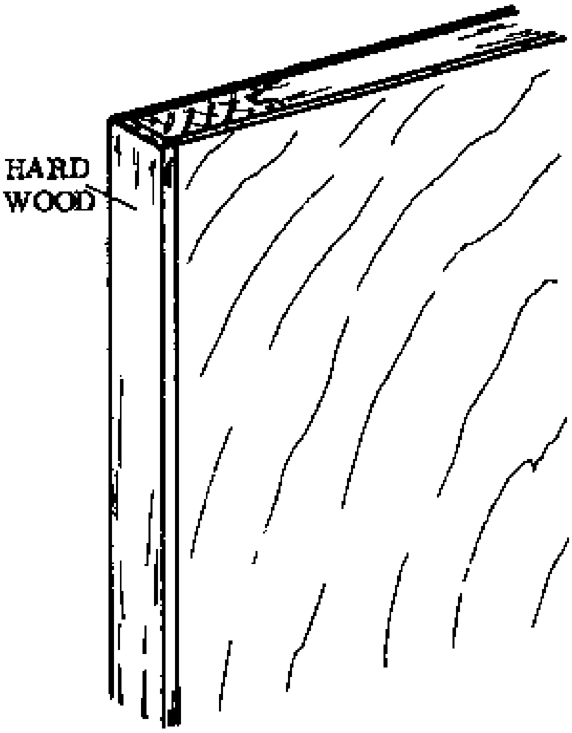


Fig. 4

NOTES:

– SEQUENCE OF OPERATIONS FOR MAKING A FLUSH DOOR: (also see Drawing Book, page 74)

a. Study the drawing.

b. Prepare a cutting list.

c. Select the wood.

d. Cut the wood to the right size. The plywood should be cut slightly larger than the door, so it can be planed to size later.

e. Plane the wood to size, and make the face marks.

f. Mark out the joints.

g. Prepare the joints.

h. Drill the ventholes.

i. Glue and clamp the frame together.

j. Fix the lock block. Indicate the position of the block on the outside edge of the door.

k. Plane the frame so the surfaces are flush.

l. Glue the plywood on both sides of the door and secure it with wire nails to the rails and stiles. If more than one door is being made, the doors can be set on top of one another and weighted down until the glue hardens.

m. Fix the lipping and finish off the door.

– TIMBER MEASUREMENTS FOR FLUSH DOORS:

Top and bottom rails	–	3 to 4 cm thick, 7 cm wide
Stiles	–	3 to 4 cm thick, 7 cm wide
Intermediate rails	–	3 to 4 cm thick, 5 cm wide
Plywood	–	6 mm thick
Distance between rails	–	30 cm

NOTES:

Large doors

Sometimes a large door is needed for a store or a similar building.

Large doors can be constructed like panelled doors. In addition to this framework, braces are used. The braces slope up from the bottom of the hinge side to the top of the opposite side.

The frame can be covered with plywood on the inside, and with either sheet metal (Fig. 1) or horizontally fixed overlapping boards (Fig. 2) on the outside. If corrugated sheet metal is used, the top edge has to be covered to prevent water from entering between the sheet metal and the door frame (Fig. 1, arrow).

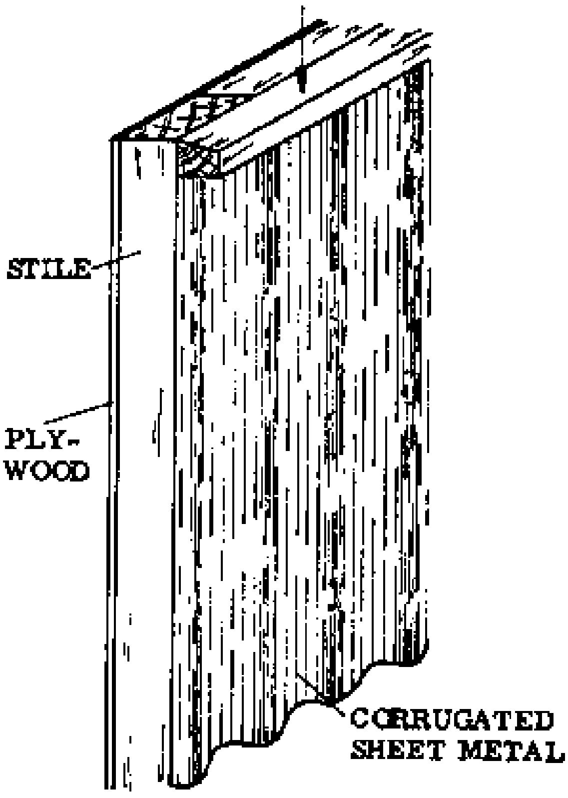


Fig. 1

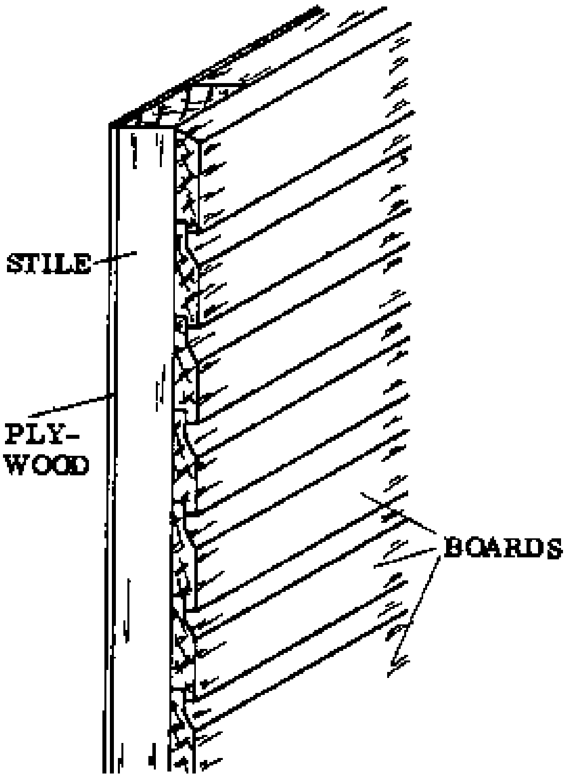


Fig. 2

The frame used for this kind of door should be heavier than the one used for an ordinary panelled door. The timber for the frame should be no less than 5 cm thick.

Each large door should have 3 band–and–hook hinges. If T–hinges are used, the strap has to be long enough to overlap a part of the rails. If the hinges are fixed to the stile only, the door will tend to sag.

In the Reference Book, page 229, there is a description of a simple locking device which can be made for this type of door.

WINDOWS

The function of a window is to let light and air into the building. When closed, the window should be draught–proof, weather–proof and burglar–proof. The size of the window should be appropriate for the room.

In Rural Building, windows consist of a window frame into which louvres or casements are fitted.

Casements are hinged to open to the outside. This makes them easier to waterproof than if they opened to the inside. The hinges should be fixed so that the casement opens flat to the wall. The frame of the window is set flush to the outside surface of the wall (see Installing Window Frames section, page 85).

Sometimes the hinges are fixed at the head of the window frame. This allows the casement to open upwards, thus providing shade for the opening and the wall. Refer to the Drawing Book, page 50, for ways to show the positions of hinges in the drawing.

Types of casements

In Rural Building, we deal with 5 different kinds of casements:

- Ledged and battened casements (Fig. 1)

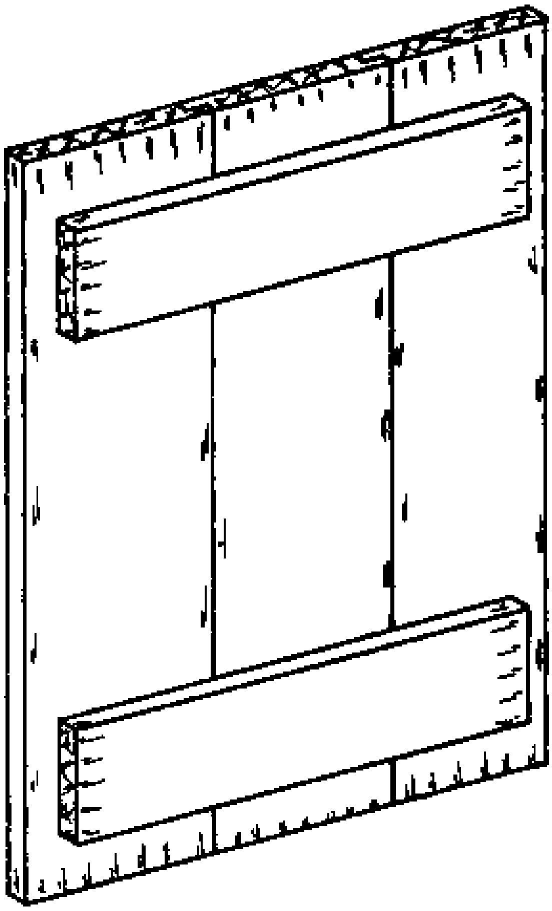


Fig. 1

– Ledged, braced and battened casements (Fig. 2)

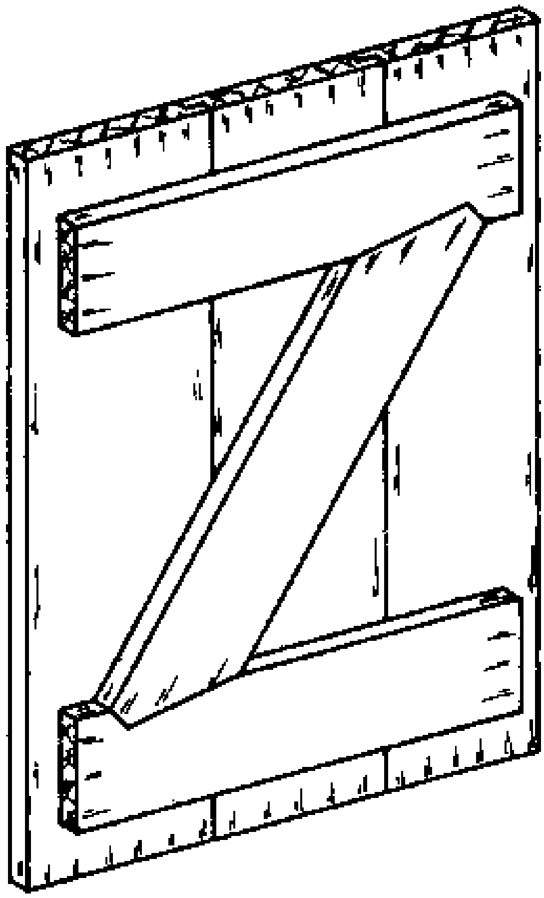


Fig. 2

– Panelled casements (Fig. 3)

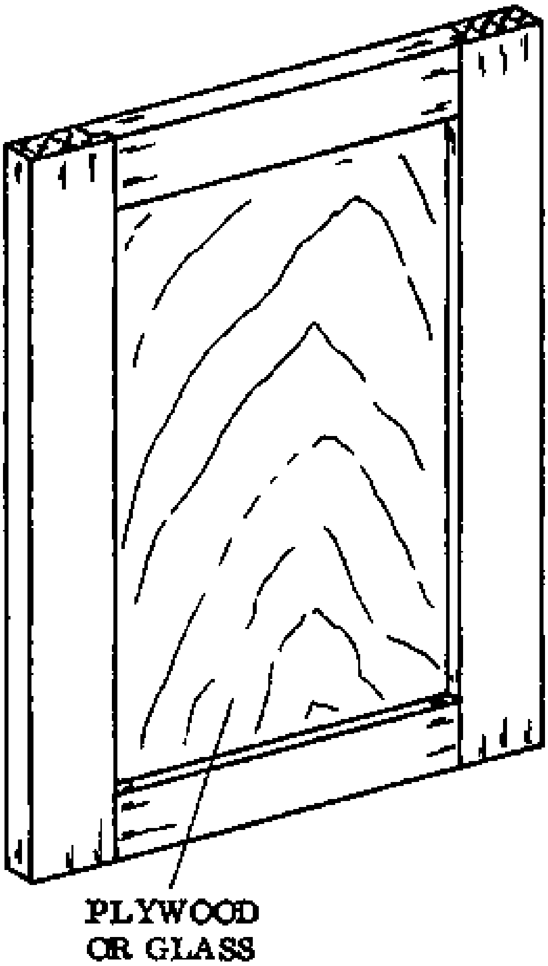


Fig. 3

– Glazed casements (Fig. 3)

– Flush casements (Fig. 4)

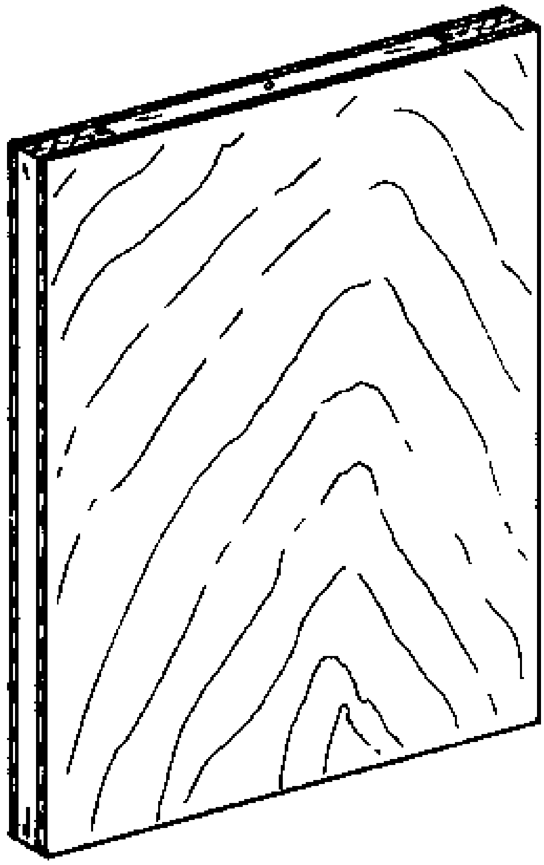


Fig. 4

It is necessary to leave at least 3 mm of play on all sides between the casement and frame (more if the casement is made during the dry season) so that the casement can open freely. This allows for expansion and shrinkage in the frame and casement.

Battened casements

Both types of battened casements are constructed in the same way as the corresponding type of door.

Matchboarding is also done in the same manner as for a door. Depending on the size of the casement, usually only two ledges are needed (Drawing Book, page 73).

Panelled casements

These can be made with grooved−in or rebated frameworks, in the same way as panelled doors (see Doors, page 101).

Usually the panels are made from plywood. Be sure to cut the bottom rail of the casement according to the slope of the cill.

The measurements of the members can be 5 to 7 cm wide and 3 to 4 cm thick.

The overall size of a panelled casement equals the inside measurement of the window frame, minus the allowance of at least 3 mm all around (Drawing Book, page 75).

Glazed casements

These are made with a rebated framework. The construction is the same as for a panelled door or casement (see Panelled Doors, page 101). Instead of a plywood panel, a pane of glass is installed in the framework (Fig. 1).

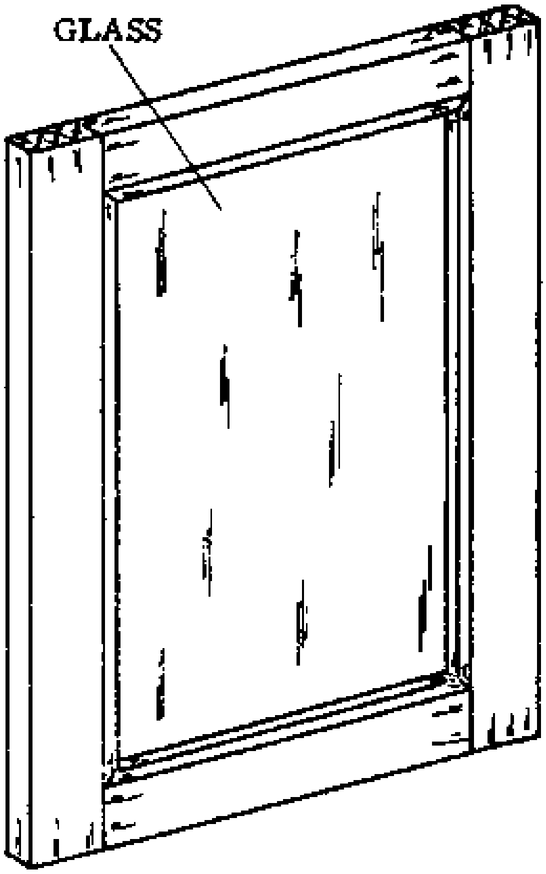


Fig. 1

Select the wood for this casement very carefully. It should be well seasoned and straight grained, so that the frame will not twist and cause the glass to break.

The joints are usually haunched stub tenons. Paint the joints and rebates before assembling the frame. The glass pane is always fitted after the frame has been assembled. The rebated framework is used because it permits the replacement of broken glass.

There are different ways of securing the glass in the rebated framework:

– By using beads, where the casement does not have to be waterproof (Fig. 1a)

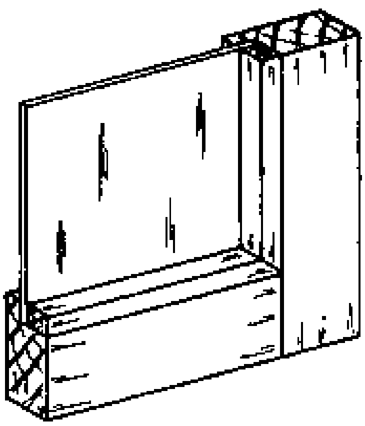


Fig. 1a BEADS

– By using putty, to make a waterproof seal (Fig. 1b)

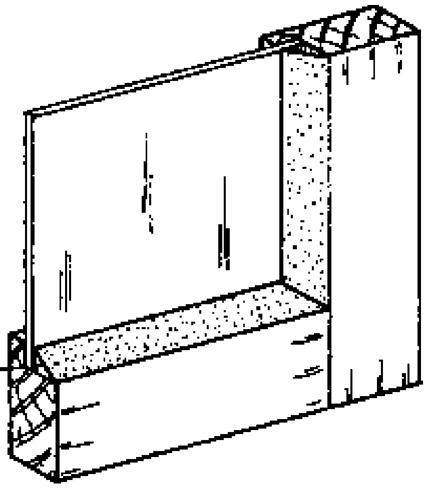


Fig. 1b

– By a combination of a thin layer of putty and beads.

The glass should always be cut 2 mm shorter in the length and the width, to make it easier to fit in the frame.

The sections of the frame members will be: 5 to 7 cm wide and 3 to 4 cm thick.

Flush casements

These are constructed in the same way as flush doors. Flush casements can be covered on one or two sides with plywood or sheet metal (aluminium or galvanized iron).

Flush casements should only be used where they will be protected from the rain and sun, for instance on a verandah.

Plywood should be glued and nailed to both sides of the casement, not one side only, to keep the casement rigid, straight and strong. For outside work, use waterproof glue.

– TIMBER MEASUREMENTS:

Top and bottom rails	–	3 to 4 cm thick, 5 to 6 cm wide
Stiles	–	3 to 4 cm thick, 5 to 6 cm wide
Intermediate rails	–	3 to 4 cm thick, 4 to 5 cm wide
Plywood	–	6 mm thick

The lower part of the bottom rail must be planed to fit the slope of the cill. The distance between the rails is approximately 30 cm (Drawing Book, page 74).

Joints

Note that in the construction of window frames and casements, different methods of framing are used.

For window frames, the horizontal members (heads and cills) have mortices, and the vertical members (posts and mullions) have tenons (Fig. 2, a; previous page).

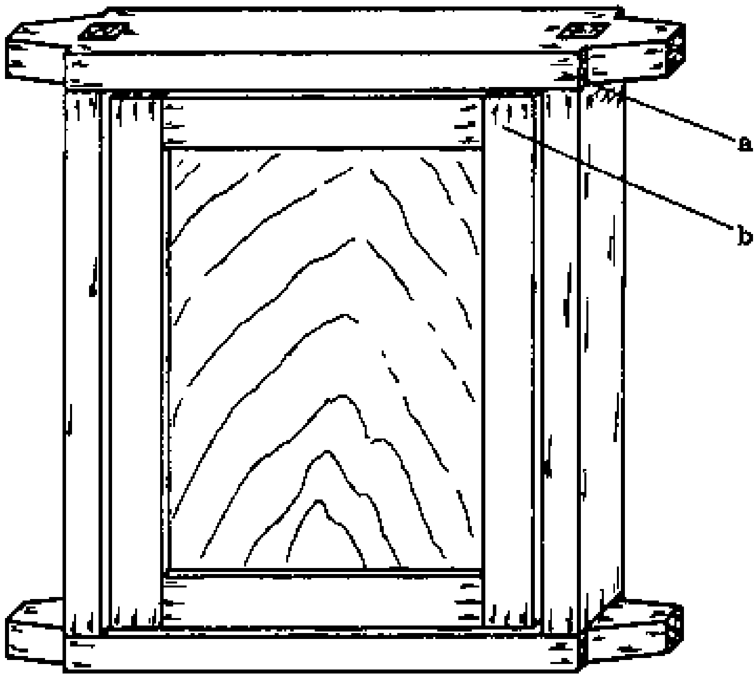


Fig. 2

For the casements, the vertical members (stiles) have mortices and the horizontal members (rails) have tenons (Fig. 2, b; previous page).

The same system applies for door frames and doors.

NOTES:

Louvre windows

– SEQUENCE OF OPERATIONS FOR INSTALLING LOUVRE WINDOWS: (see Reference Book, page 217)

a. If there will be mosquito wire on the window, you will have to be careful to set the louvre channels so that the louvres will be able to open without touching the wire.

b. Mark the position of the channel on the wooden frame, at the side where the operative channel (the one with the handle) will be fixed.

c. Grease the moving parts on the inside of the channel (use grease, not oil).

d. Fix the operative channel with one screw near the top.

e. Plumb this side. Secure the channel firmly with screws (the screw size will be 3 x 30, round head screws).

f. Install the non–operative channel, parallel to the first channel.

g. Secure this side loosely near the top, leaving the bottom free so it can be adjusted later.

h. Put in the louvre glasses, starting from the top and working down. Close the clip ends to secure the glasses in place.

i. When all the glasses are installed, close the louvres.

j. Move the bottom of the non–operative channel until the louvres fit tightly together and are parallel.

k. Now secure this side firmly with screws.

l. Check the installation (screws, clip ends, etc.) and operate the handle several times to make sure that the louvres move freely.

m. Fix the waterbar (either a wooden bead or a ready−made aluminium bar) at the head (outside the glass) and the cill (inside the glass), so that it is just touching the glass when the louvres are locked.

NOTES:

− SEQUENCE OF OPERATIONS FOR INSTALLING A SELF−MULLIONING LOUVRE WINDOW: If two or more louvres are to be set across the window frame, the metal channels can be fixed together with screws, to form a metal mullion. The metal mullion is installed before the other channels.

a. Mark the centres of the head and cill. The width of the window frame has to correspond to twice the length of a louvre glass, plus 3,8 cm for each set of channels, making 7,6 cm for both sets.

b. Mark out the position of the metal mullion on the head and cill. Keep in mind the position of the mosquito wire (Fig. 1).

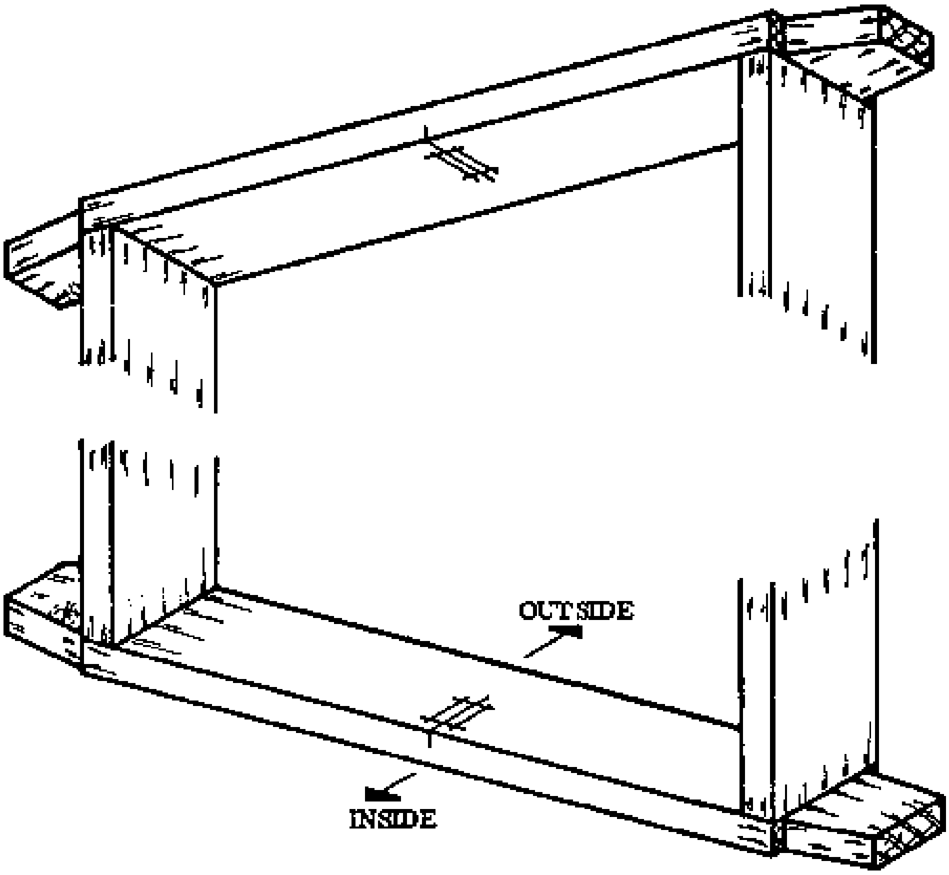


Fig. 1

c. Fix the bottom spacer on the cill (Fig. 2) at right angles to the face of the frame. The frame must be painted before the spacers are fitted.

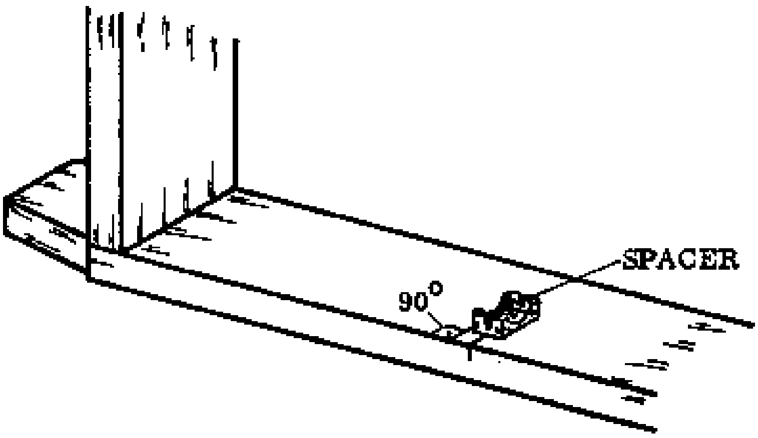


Fig. 2

d. If the cill is sloping, bend the lugs of the spacer so that they are upright. The bottom end of the louvre channel should be cut to fit the slope of the cill, so that it fits tightly (Fig. 3).

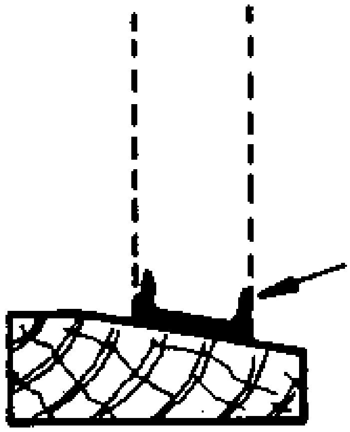


Fig. 3

e. To position the top spacer, place a louvre channel against the bottom spacer and plumb it with a spirit level. When it is straight, fix the top spacer exactly above the bottom spacer.

f. Take the non−operative channel and fit spacers into it at the places indicated by holes; these serve to stiffen the mullion.

g. Attach the non−operative channel to the spacers at the head and cill of the frame (Fig. 4).

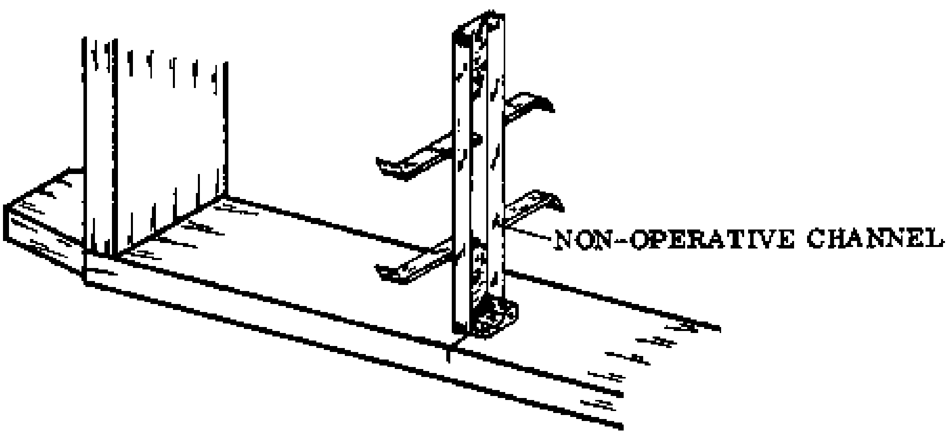


Fig. 4

h. Attach the operative channel to the non−operative channel with the special bolts and nuts.

i. Check the installation and operate the handle several times.

j. Install the other louvre channels to the window frame as in the previous page on installing louvre windows.

k. Make sure that all the channels are the same distance from the inside face of the window.

NOTES:

WORKING SCAFFOLDS

These are scaffolds which the workers stand upon to reach the higher parts of the construction. The tools and a supply of materials are also on the platform with the worker.

Jack scaffold

Although it can be no more than 2 m high, the jack scaffold is a satisfactory working scaffold for most jobs in Rural Building (Fig. 1). The block and trestle scaffolds which may be used for low level work are described in Basic Knowledge, page 158.

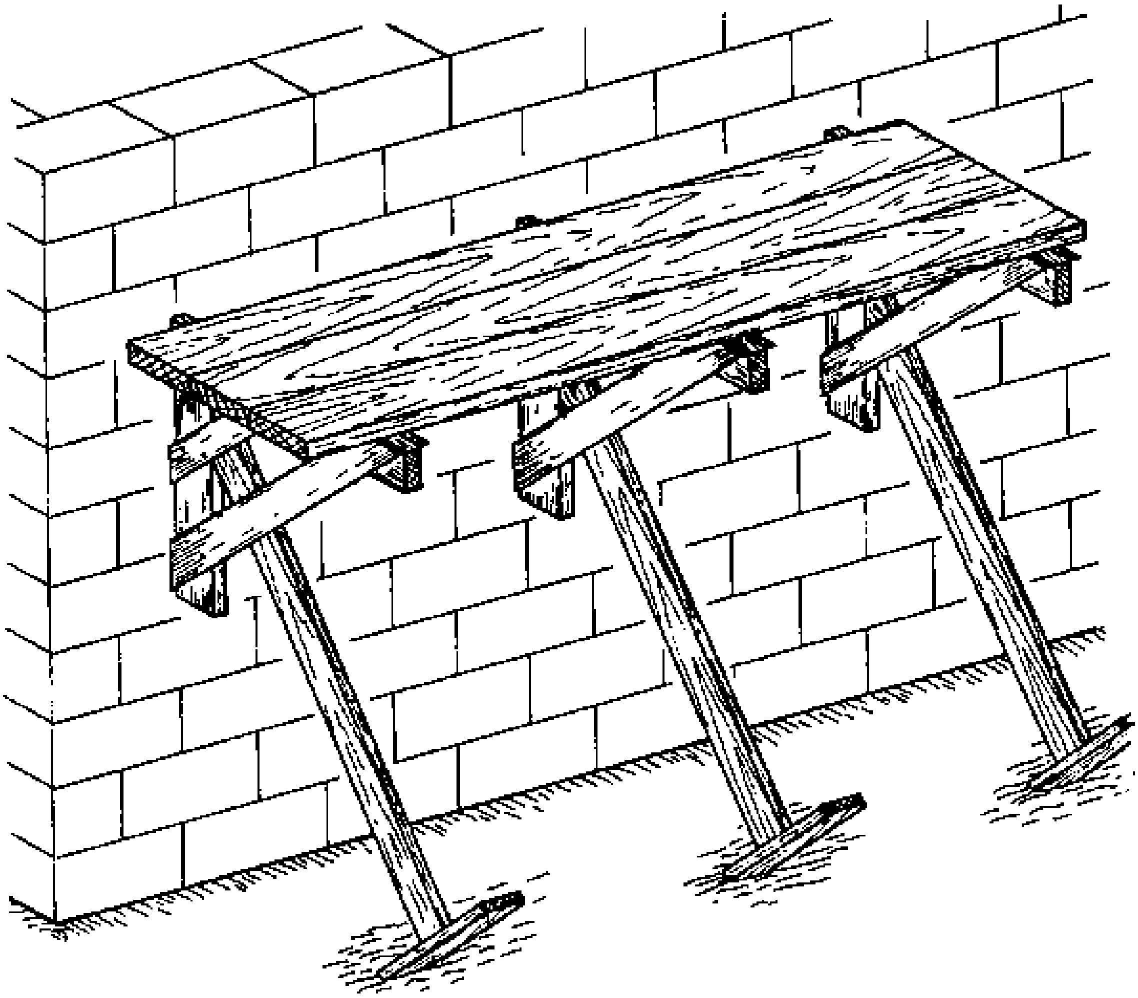


Fig. 1

The jack scaffold is a dependent scaffold, which means it is propped against the wall for support instead of standing independently like other scaffolds. The feet of the props have to be properly set in place so that they will not move and settle when the scaffold is in use. Never try to put any support under the wall leg of the jack, as this would actually make the scaffold unstable.

Each jack scaffold consists of three jacks, three props and three (approximately 4,5 m long) planks. If the scaffold is to be only 2 m long or less, two jacks are enough.

– CONSTRUCTING THE SCAFFOLD PIECES: The jacks consist of a wall leg and a ledge which is nailed edgewise to the top of the wall leg. Both boards must be at least 5 cm thick by 10 cm wide, and about 100 cm long. The right angle is braced with two ties on each side, in a way similar to the construction of a large square (Fig. 2, also see Reference Book, page 13).

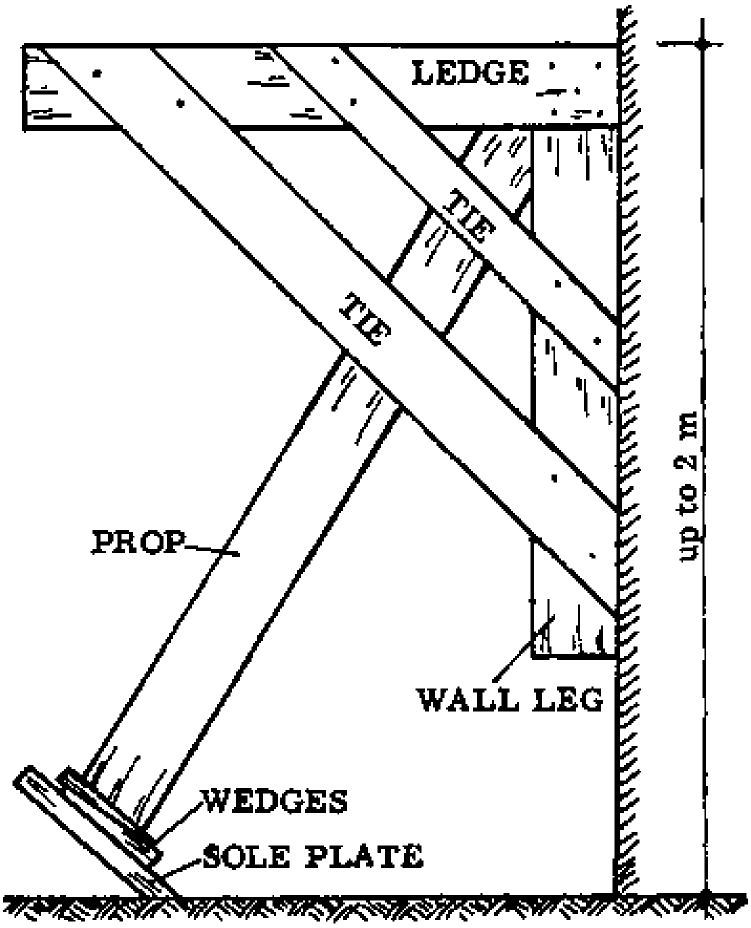


Fig. 2

The shorter tie should be set so that it doss not cover the corner of the jack, where the prop meets the angle. An opening is left, through which the position of the prop can be checked. The prop has to fit securely into the corner of the jack, without any "play" in the connection. The ties should be at least 2,5 cm thick, and the prop will be 5 by 10 cm by whatever length is required (remember that this scaffold should not be more than 2 m in height).

– ERECTING THE SCAFFOLD: Hold the jack with its wall leg against the wall, and fit the prop into the corner of the jack. Set the foot of the prop securely in the ground. The other jacks are set up in the same way. Check that all three are at the same height and the distance between them is not more than 2 m. The angle between the prop and the wall should be no less than 30 degrees and no more than 45 degrees (Fig. 3). In soft soil, sole plates must be set under the feet of the props.

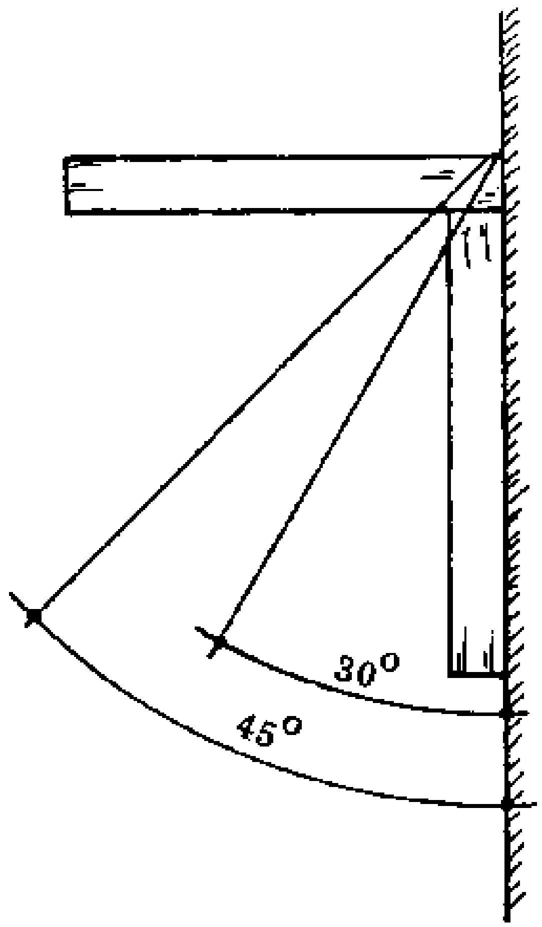


Fig. 3

– SAFETY PRECAUTIONS:

– Check that all the members of the scaffold are sound and without cracks.

– Check whether the upper ends of the props fit well and without play into the corners of the jacks

– Make sure that the feet of the props will not slip. In soft soil, they should be supported by sole plates set in the ground, at right angles to the props (Fig. 1).

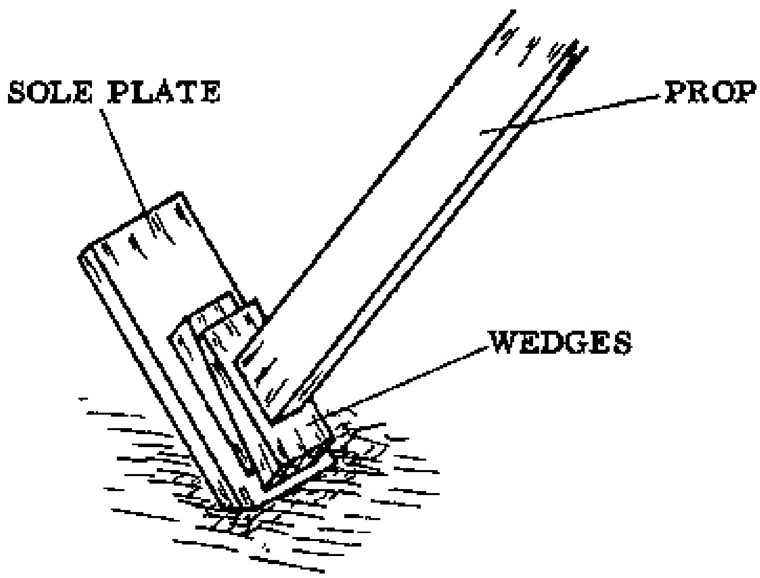


Fig. 1

– Pay attention when you lay the platform boards, so you don't create a scaffold trap. This is a place which looks safe but is not (Figs. 2 & 3). The free ends of the platform must not project by more than 25 cm past the ledge, and they should be blocked off by a foot–stop (Fig. 4).

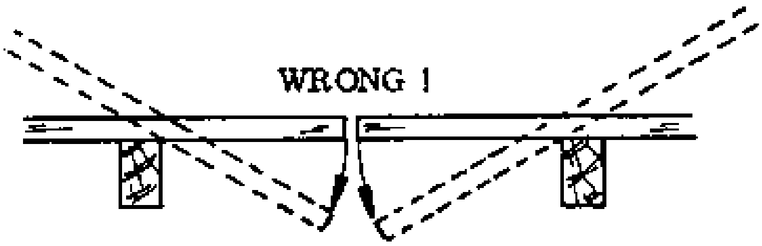


Fig. 2

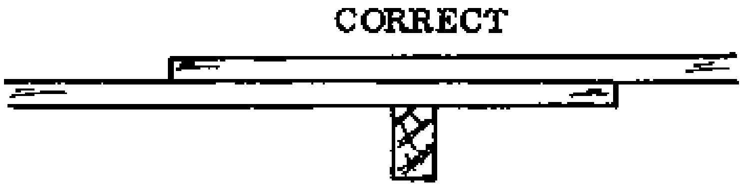


Fig. 3

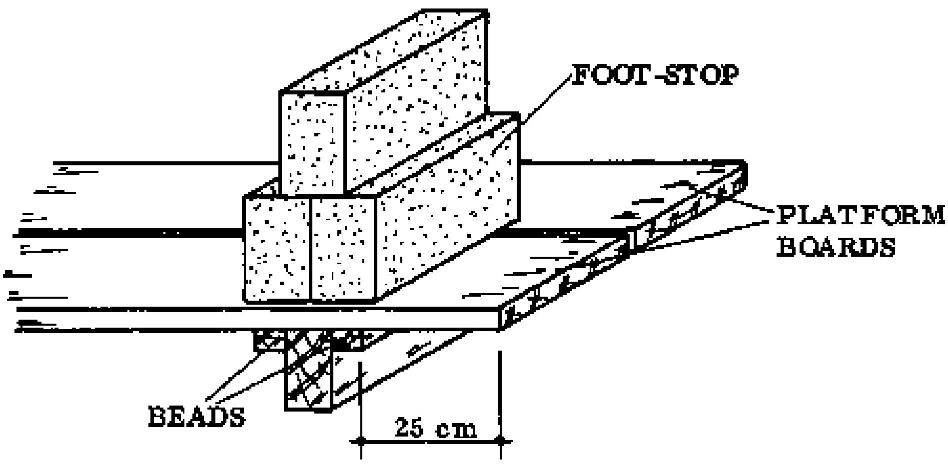


Fig. 4

– Wedges are used between the foot of the prop and the sole plate. By adjusting these, the prop can be tightened against the angle.

– Beads can be attached to the bottom of the platform boards to prevent them from shifting along the ledges (Fig. 4), or the platform boards can be nailed directly to the ledges.

– NOTE: Always pay attention to the safety of the scaffold. A carelessly erected scaffold is a danger to the lives of workers and passers–by.

NOTES:

Blocklayers scaffold

Like the jack scaffold, this scaffold is dependent on the wall for support. The construction is fixed with “putlogs” into the wall, and secured on both sides of the wall with cleats which are nailed to the putlog (Fig. 1).

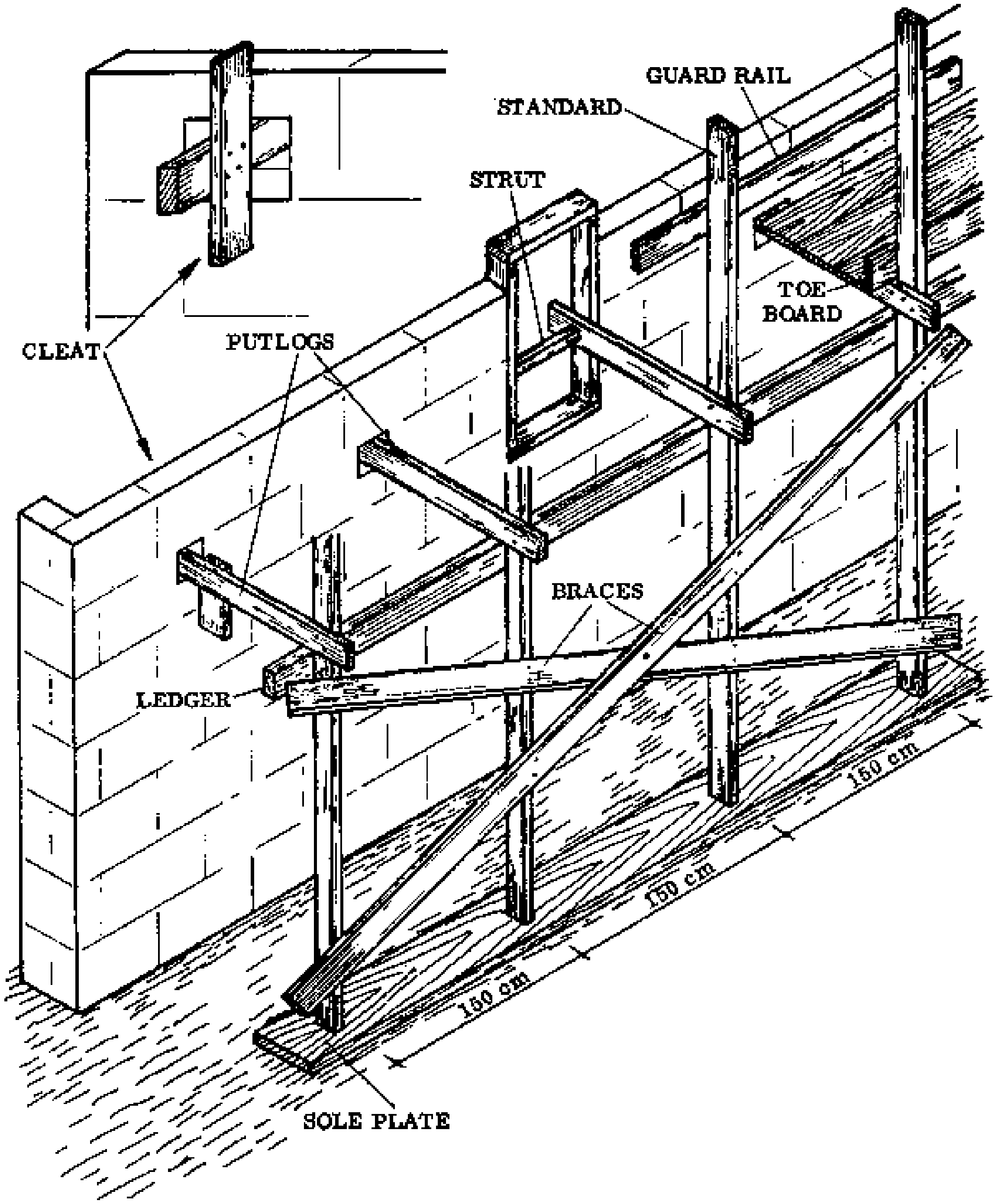


Fig. 1

Erect the standards on top of the soleplate (Fig. 2) and nail the ledger at the required height. Each putlog will have one end in a wall opening which was left during the blocklaying; and the other end is supported by the ledger and nailed to the standard. Secure the putlogs into the wall with two cleats, one on either side of the wall. Make sure that the cleat on the outside of the wall does not project above the putlog, where it will interfere with the platform boards.

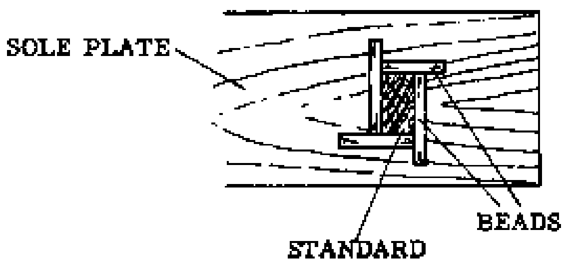


Fig. 2

Once all the putlogs have been secured, nail braces across all the standards to make the whole construction rigid.

Check the construction, then lay the platform boards. Fix the toe board, and nail the guard rail at a height of 90 cm above the platform.

If a putlog is secured inside of a window frame, add an additional strut inside the frame (Fig. 1).

The advantage of this type of scaffold is that it requires less wood to make the frame. The holes left in the wall are easily filled with small blocks before the plastering is done.

– MEMBERS OF THE SCAFFOLD: (see Fig. 1)

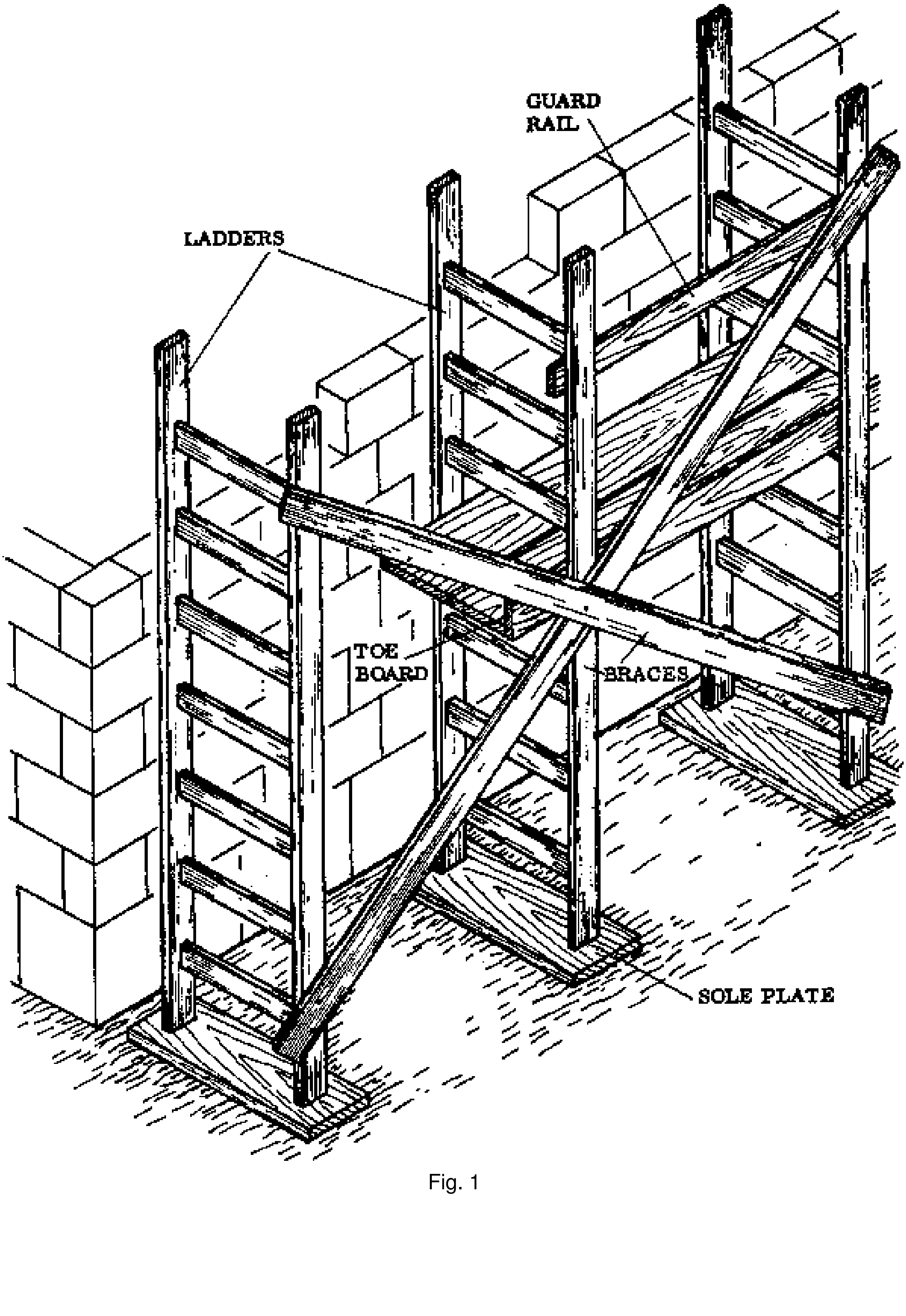


Fig. 1

– Sole plate
– Standards
– Putlogs
– Cleats
– Ledger
– Braces
– Platform boards
– Toe board
– Guard rail
– Struts (if needed)
– Pieces to secure the standards to the sole plate (Beads)

NOTES:

Ladder scaffold

This is an independent working scaffold, that is, it is not supported on the building but stands free. A ladder scaffold can be used where the height of the building is no more than 3,5 m.

Three or four ladders are usually used. Erect the ladders on top of the sole plates so that they do not sink into the ground under use. Keep the ladders plumb and straight, and nail two braces diagonally across the side.

If necessary use some wedges under the ladders to keep the structure steady.

Lay the platform boards and fix the toe board and the guard rail. The guard rail is fixed 90 cm above the platform.

Before any workers use the newly erected scaffold, make sure that all the parts are well secured and fixed according to the safest manner. Be aware that the scaffold has to carry not only the workmen but also a load of building materials.

NOTES:

Independent scaffold

This is similar to a ladder scaffold with the difference that no ladders are used. Timbers are used instead; these should be 5 x 10 cm by approximately 4,5 m long.

Sort out the timber, keeping the straight pieces for standards and the bent pieces for shorter members like putlogs.

Mark the height of the working platform on the standards, and nail the putlogs to the standards. Erect the standards on top of the sole plates, and nail the necessary braces to the outside of the structure.

Nail two additional boards (ledgers) under the putlogs. These give support to the putlogs.

Lay the platform boards and secure them with nails or battens. Fix the toe board. Nail the guard rail 90 cm above the platform.

If necessary, place some wedges under the standards to make sure that the whole structure is steady. Extra braces can be added to the outside of the structure; secure them to the ground with pegs (Fig. 1, broken lines).

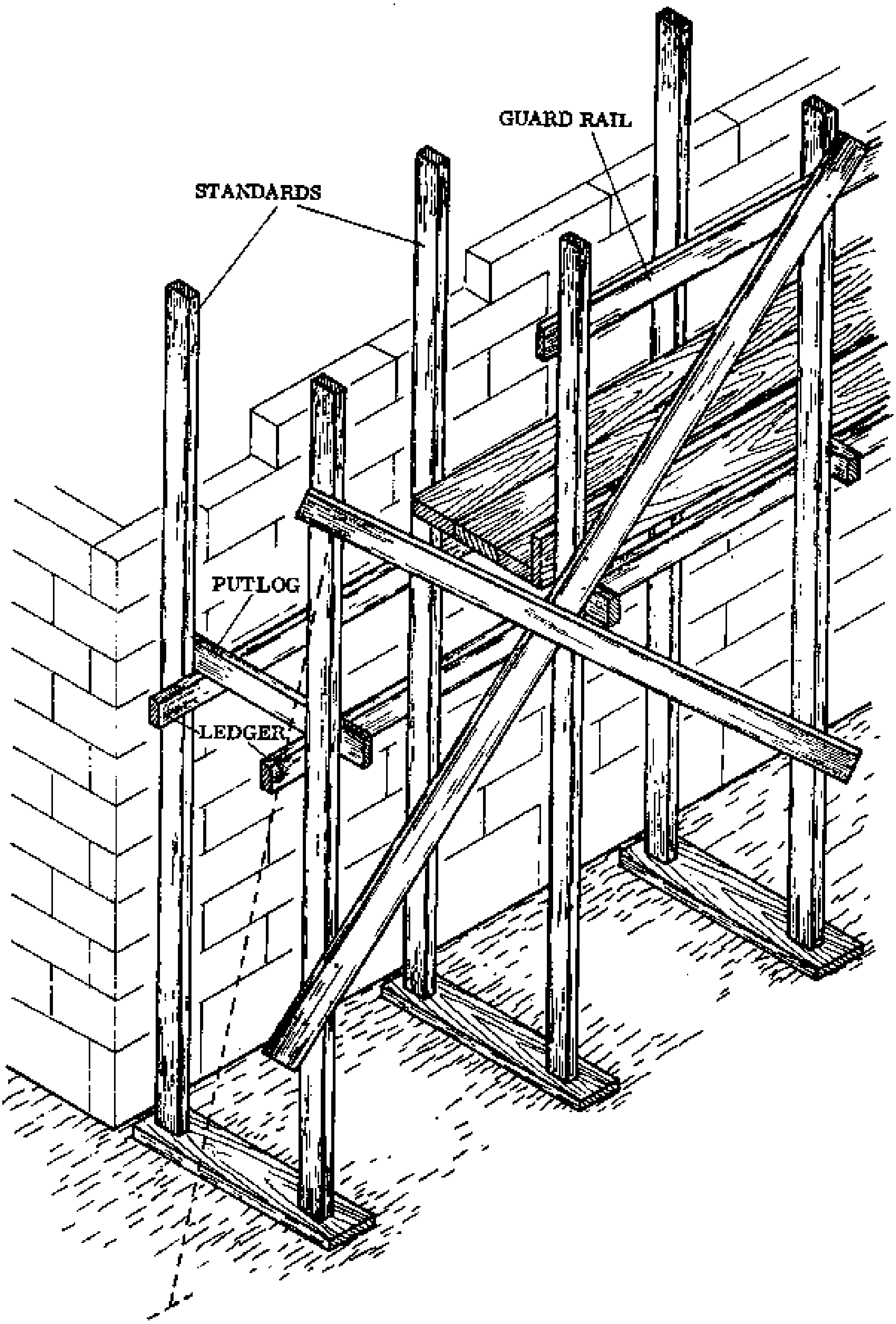


Fig. 1

Fig. 2 shows an alternative way to support the putlogs, with a wedge−shaped piece of wood nailed to the standard underneath the putlog.

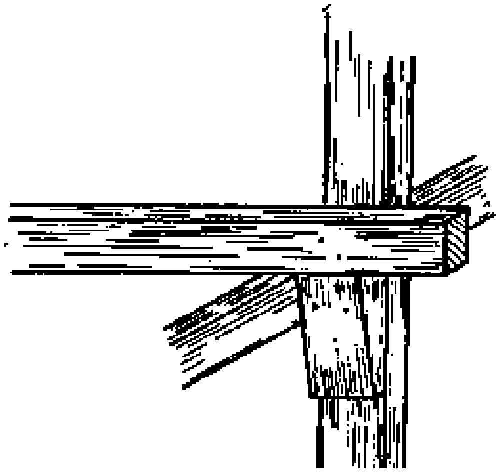


Fig. 2

SUPPORTING SCAFFOLD

As the term indicates, a supporting scaffold is used to support members of the structure until the mortar or concrete has hardened or cured; or until the parts are assembled, when the member will be able to support itself and the scaffold can be taken away.

The supporting scaffold is seldom used in Rural Building because in most cases a lighter and simpler strutting will serve for the purpose of supporting the usual reinforced concrete members as they are cast−in−situ. See page 167 of the Basic Knowledge book for an illustration of a typical strutting for a reinforced concrete lintel.

The heavier supporting scaffold is used only in cases where the member to be supported is very large and heavy. The supporting scaffold arrangement is shown in the illustration on the next page.

When you construct a supporting scaffold, pay particular attention to the stability of the structure, since it usually has to support very large and heavy members. The distance between the standards (also called struts) must be no more than 1 m (Figs. 1 & 2). All the shorter braces, which reinforce the connections between the putlogs and the standards and between the standards themselves, are fixed at 45 degree angles. The long braces, which go from the top of the structure down to pegs in the ground, are fixed at an angle of no less than 30 degrees. These help to keep the scaffold from tilting or overturning.

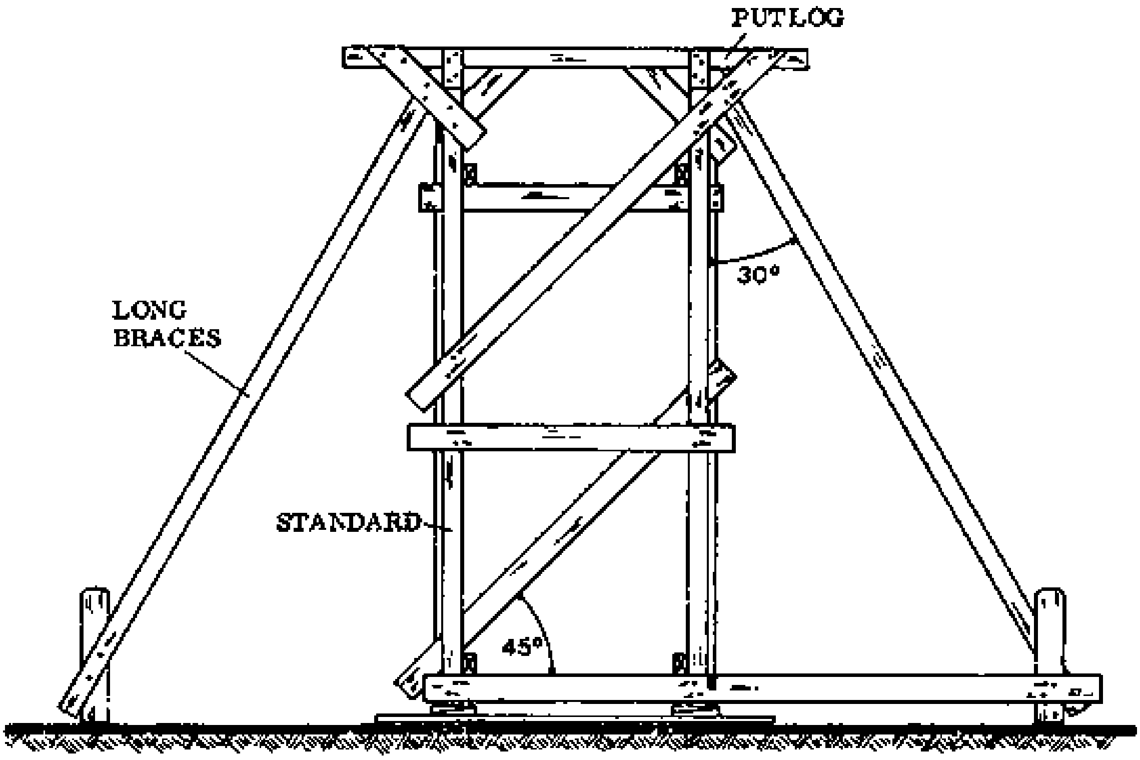


Fig. 1 SIDE VIEW

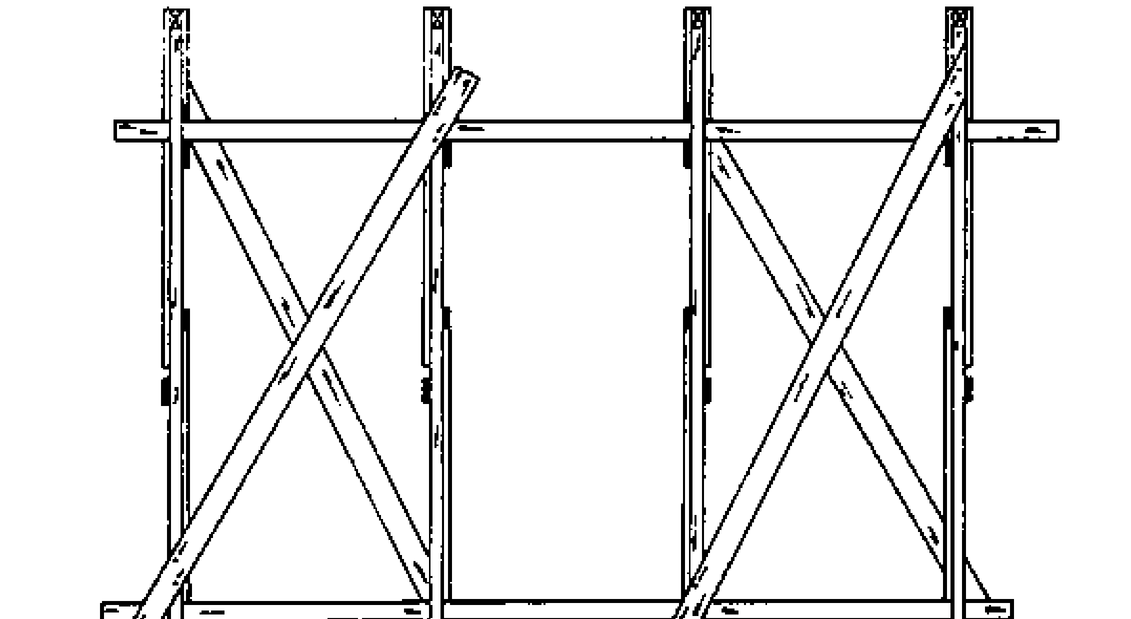


Fig. 2 FRONT VIEW

PROTECTIVE SCAFFOLDING

On most Rural Building construction sites, protective scaffolding is not necessary. This is because the structures are relatively low in height. However, when a higher structure such as a water tower is constructed, protective scaffolding becomes necessary to protect the people underneath from falling objects. On jobs where walls are being broken down, or where large and heavy objects are handled, it is advisable to erect a protective scaffold of some sort.

A second platform is made below the working platform, and a side projection is fixed at an angle to this (Fig. 3).

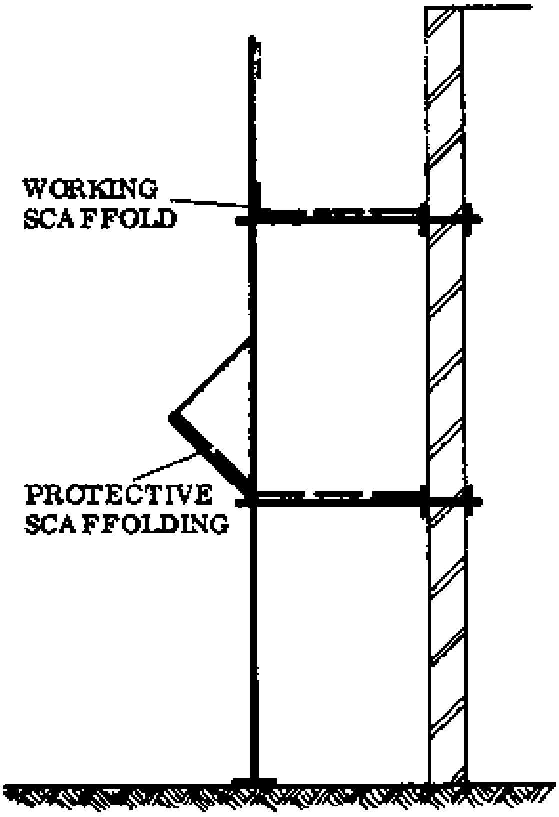


Fig. 3

The projecting piece is attached to the standards by wooden braces.

Any tools or materials which fall from the working platform will hit the projecting piece and roll onto the second platform, instead of falling to the ground.

NOTES:

ARCHES

Openings in walls such as doors and windows have to be closed at the top in such a way that the structure above them is supported. Before the use of reinforced concrete became common, smaller openings were bridged with wooden lintels, solid stone lintels and arches (see Basic Knowledge book, pages 162 to 164).

Wider openings were generally spanned by arches, or by a series of arches carried on piers or columns: the so−called arcade. In this book we discuss only one type of arch, the "segmental arch" where the arch is formed like a segment of a circle. Many other forms are possible with arches, but they are not important for Rural Building.

Before we continue with this chapter, it is essential to understand the technical terms that are used in connection with arches. The terms below are indicated in Fig. 1.

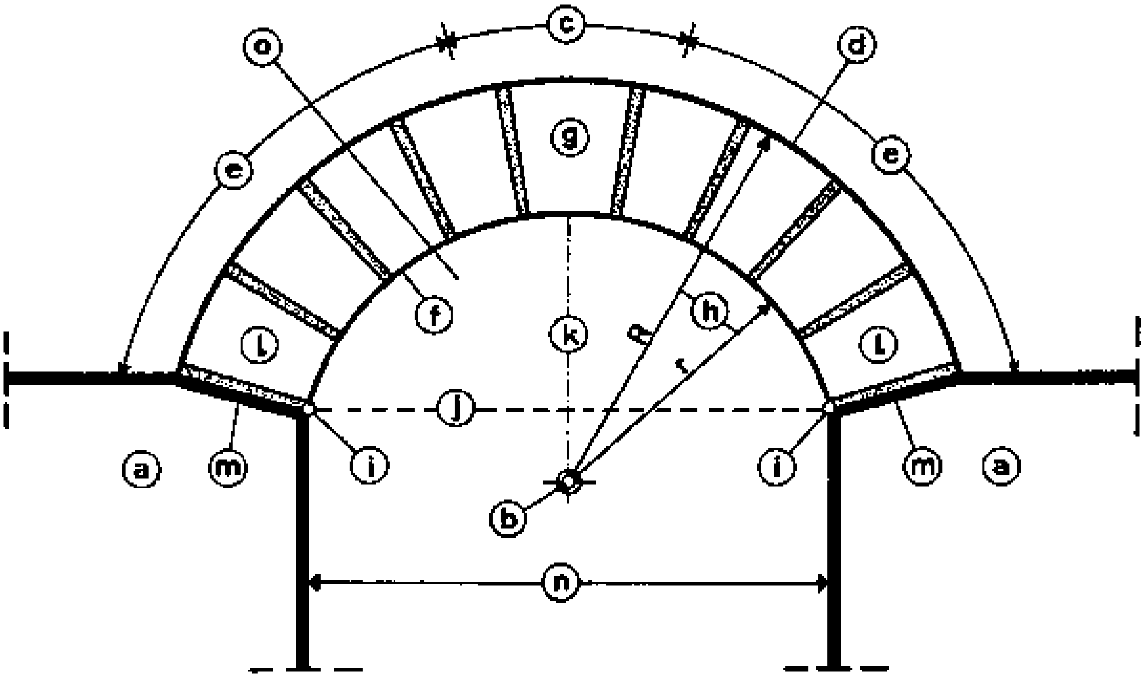


Fig. 1

Technical terms

– ABUTMENT: The word “abut” means to meet at one end or to border on something. An abutment (Fig. 1, a) is that portion of solid masonry that carries the weight of the structure of an arch. In Rural Building, the minimum width of an abutment at the end of a wall should be 3/4 of the span of the arch. This means that the distance from the arch to the end of the wall should be at least 3/4 of the span of the arch.

– CENTRE: This is the midpoint of the circle which describes the curve of the arch (b).

– CROWN: This is the portion of the arch which forms the top of the curve (c).

– EXTRADOS: The outer curved line of an arch, or the upper surface of the archstones (d).

– HAUNCH: The flanks of an arch, the sides of the curve (e).

– INTRADOS: The under surface or soffit of an arch (f).

– KEYSTONE: The central wedge–shaped archstone at the crown of an arch (g), which is the last stone to be put in place.

– RADIUS: The straight line (h) from the centre of an arch to any point on its intrados (the shorter radius, r); or to any point on its extrados (the longer radius, R).

– SPRINGING POINT: The point of intersection (i) between the intrados and the faces of the wall or pier blocks below. From there the arch “springs”.

– SPRINGING LINE: The line across the arch which would connect the springing points (j).

– RISE: The height of an arch measured perpendicularly from the springing line to the highest point of the intrados (k).

– SPRINGER: The first stone laid in an arch on either side (1).

– SKEWBACK: That portion of the abutment which directly supports the springers (m). It is so called because the surface slopes towards the opening.

– SPAN: The horizontal distance between the springing points (n); the length of the springing line.

– CAMBER: This is the space between the springing line and the intrados (o).

– ARCHSTONES: These are any of the stones or blocks which form the arch itself.

NOTES:

Stability of arches

All arches, regardless of their shape or dimensions, function as wedges. An arch distributes the load imposed on it to the abutments on both sides; these have to be strong enough to withstand the pressures (Fig. 1, a). This is the reason why the abutment which is at the corner or end of a wall must be at least as wide as 3/4 of the span of the arch (Fig. 1, b). Between two arches, thinner supports such as columns or piers can be used (Fig. 1, c).

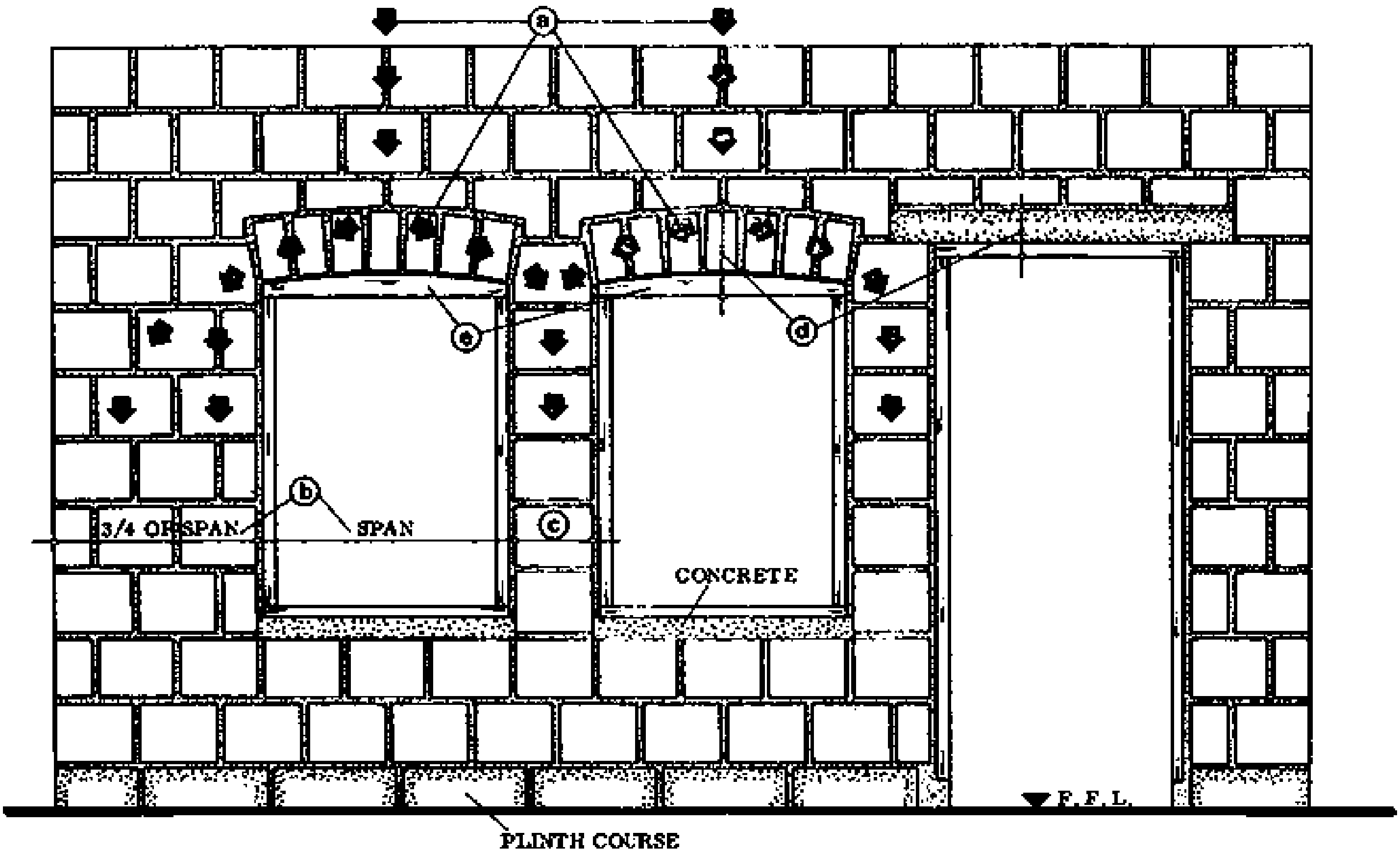


Fig. 1

It is always better to build two or three courses of blocks above an arch because this weight will improve its stability. The preferred material for constructing an arch is sandcrete blocks, because they can be cast to any shape required and can withstand high pressures. Of course landcrete or mud blocks can also be used, but these must be well protected against moisture penetration.

– DISADVANTAGES OF ARCHES:

– All arches, especially those which have unusual shapes, require more space than a lintel (Fig. 1, d).

– Frames must be shaped on their top according to the curve of the intrados (Fig. 1, e); or if a square frame is to be fitted, the remaining space above it must be closed with plywood etc.

– A temporary wooden support, the centring or turning piece, is needed during the construction; this piece has to be exactly the correct shape.

– Masonry arches cannot be prefabricated.

– Specially made archstones are often required.

– ADVANTAGES:

– Arches are more economical because scarce and expensive building materials like reinforcement iron are not needed.

– Locally available building materials such as mud blocks can be used to build arches.

– In contrast to cast–in–situ lintels, the walling above an arch can continue immediately after it is completed, because the arch does not have to set.

– Traditional building styles can be maintained and developed in a simple and cheap way.

– Arches, if well constructed, give the building a more attractive appearance and demonstrate the skill of the builder.

The segmental arch

The segmental arch is the most important one in Rural Building. This is mainly because:

– The construction depth measured from the springing line to the crown is comparatively small; with the result that the building costs are low.

– The construction is not too difficult and specially made tapered blocks are not necessarily required.

– The time spent on the construction of this kind of arch can be shorter than the time spent for constructing a reinforced concrete lintel.

Types of centring

“Centring” is the term generally applied for the curved wooden piece which temporarily supports arches or domes during their construction. It is comparable to the strutting (not the shuttering) for concrete members.

The actual shaping part of the centring is called the “turning piece”. There are three main types of centring:

– A solid wooden board, about 5 cm by 7,5 cm, placed edgewise. Its upper surface is carefully and evenly shaped according to the curve of the intrados (Fig. 1). Its use is restricted to short–span openings; not exceeding about 100 cm wide. The disadvantage of this type is that the archstones rest on only a small area, which might lead to the blocks tilting during the laying.

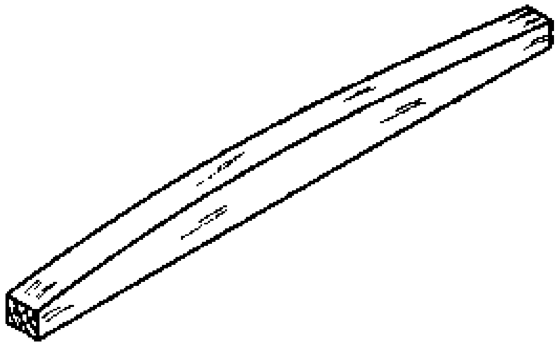


Fig. 1

– Two wooden planks or sheets of plywood are connected by spacers, so that the archstones are supported on their outer edges (Fig. 2). Both turning pieces must be precisely cut and planed to the same shape, and must match with the curve of the intrados.

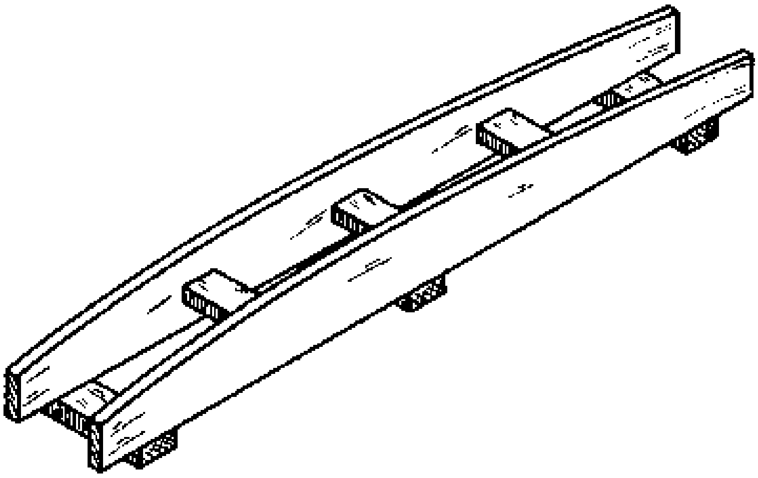


Fig. 2

– Arches spanning wider openings and those which have a rise of more than about 1/10th of the span need to be supported by a stronger centring, with either open or closed lagging (Fig. 3).

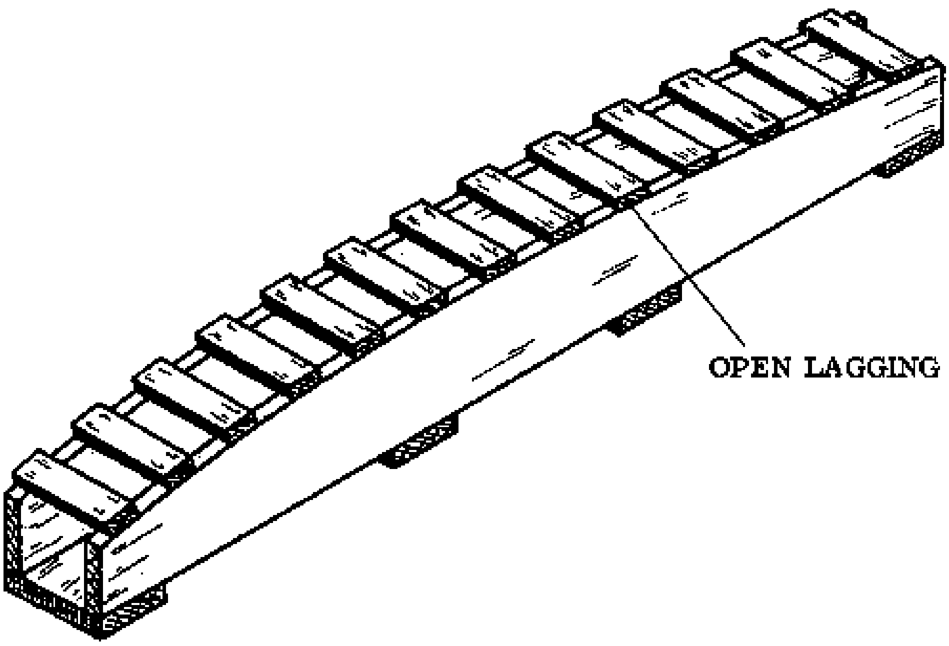


Fig. 3

The three types of centring may be combined with the frame or may form part of the frame; the head. In this case no strutting is needed, and the centring piece simultaneously acts as a permanent seal of the space between the springing line and the intrados (Fig. 4). The lagging must then be fixed in between the turning pieces so it is flush with the upper curved edge and is not seen (Fig. 4).

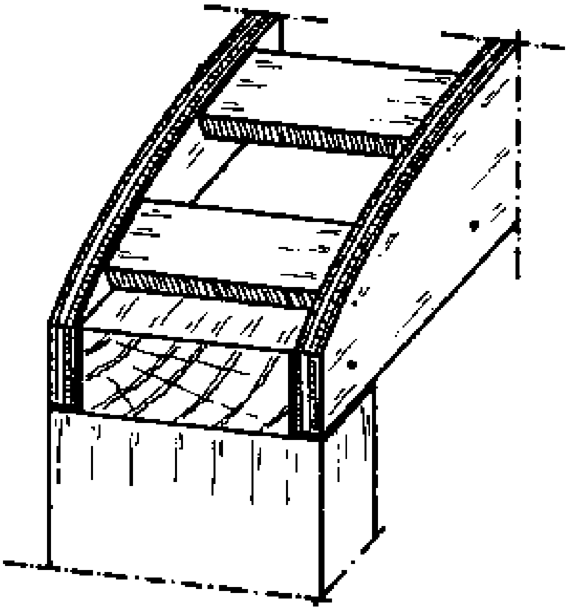


Fig. 4

Setting out the turning piece

To set out the turning piece means to mark the curve of the intrados on a suitable piece of board or plywood, so that after it is cut and planed it can serve as a temporary support and guide for the arch construction. The positions of the archstones are also marked on the turning piece so that no mistakes can be made during laying.

As far as Rural Building is concerned, the radius of the circle which describes the curve of the intrados will always be three times the span of the opening. For example: if the span of the opening is 80 cm (the clear width), the radius must be 3 x 80 cm = 240 cm; if the span is 180 cm, the radius is 540 cm, etc.

The curve obtained from this rule will result in an arch which is flat enough so that not much space is wasted, but also curved enough to ensure stability.

– SEQUENCE OF OPERATIONS:

– You need a large, flat and level space for the setting out.

– Mark the span of the opening on a suitable board (Fig. 1, a).

– Determine the springing points (at least 2 cm from the edge of the board) and drive in short nails to mark these points. Leave the nails projecting, and make sure that they are both the same distance from the edge of the board (Fig. 1, A & B).

– Place the board on the ground and secure it with nails or pegs as shown, so that it cannot shift to any side.

– Fix your mason line on nail A, and measure off from there three times the span of the opening along the line. Use this length to describe a short section of a circle on the ground (Fig. 1, b).

– Repeat this procedure with the line fixed on nail B (Fig. 1, c). Both circle sections will intersect at point C, which is the centre of the arch. Secure the centre point with a nail or peg.

– Fasten the mason line on peg C and tie a pencil at the distance of three times the span of the opening.

– Keep the line taut and describe a circle section, while marking the section on the board. This curved line should intersect with the springing points, A and B, and the curve resembles the curve of the intrados.

– To check the accuracy of the setting out, measure the rise of the arch perpendicularly from the springing line to the highest point of the curve. This distance must be 4,2% of the span (0,042 x span (in cm) equals the rise (in cm).

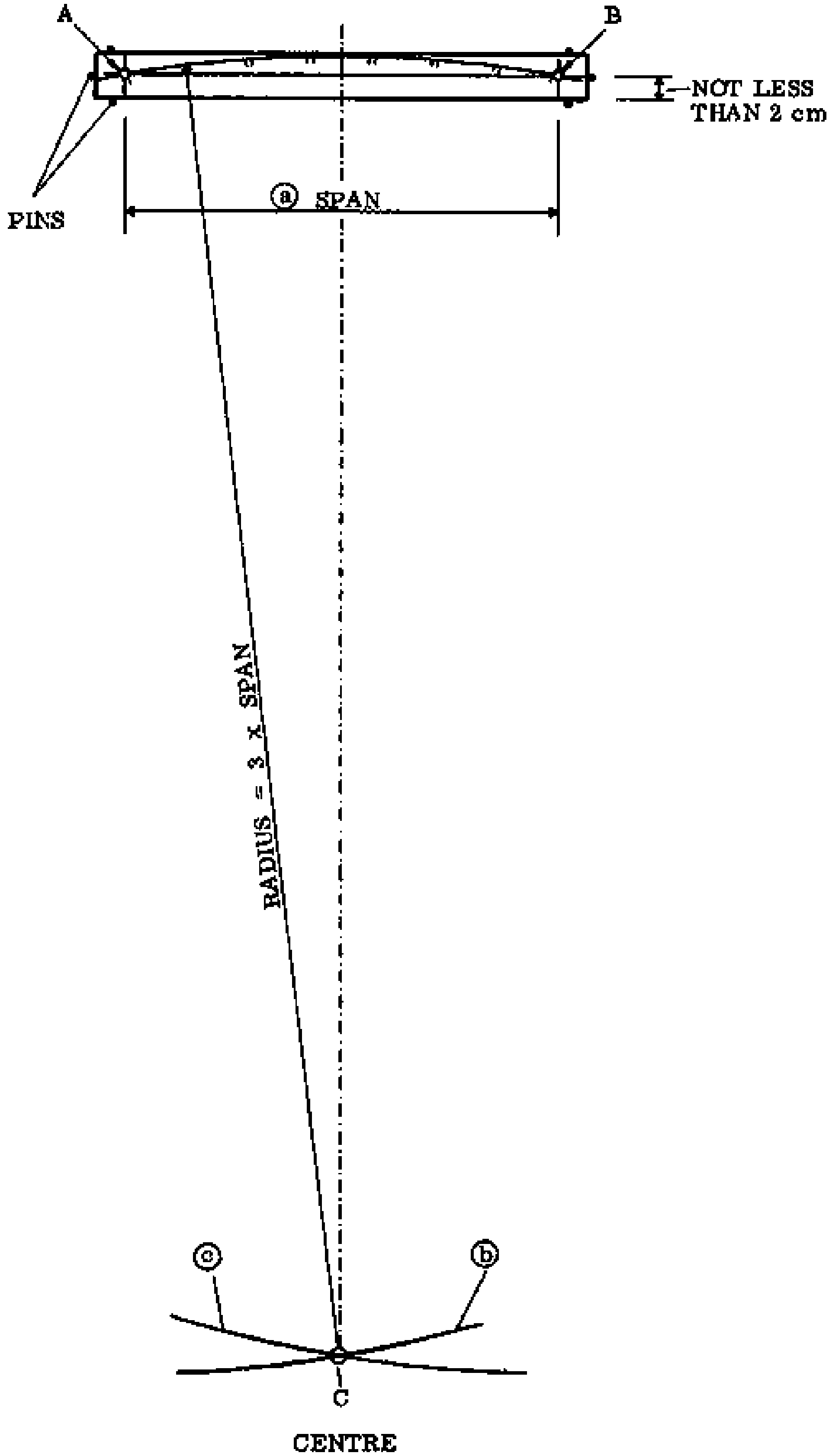


Fig. 1

Positions of the archstones

Regardless of which type of arch is constructed and what kind of archstones are used, the total number of blocks or bricks must add up to an odd number: the keystone in the middle is flanked by an even number of archstones (Fig. 1).

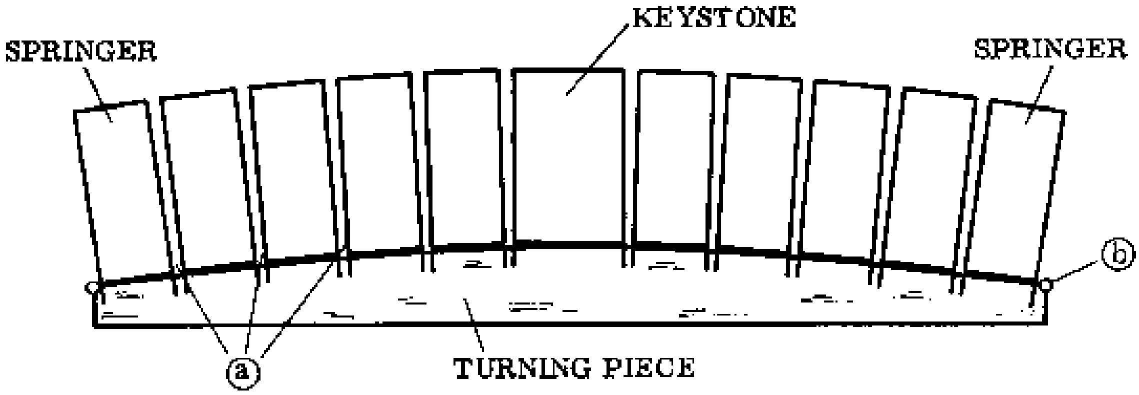


Fig. 1

Therefore the position of the keystone is usually marked first, followed by the archstones to the left and right. Cross joints are 1 cm wide at the intrados (Fig. 1, a), and wider at the extrados, because common blocks are used which results in wedge−shaped joints.

The marking continues until the springing points are either just reached or a little overlapped (Fig. 1, b). If it happens that there is a distance of more than 1 cm between the lower outside corner of the springers and the springing points, then one more block must be added to each side (Fig. 2). These two blocks will then become the springers, although they overlap by far the springing points.

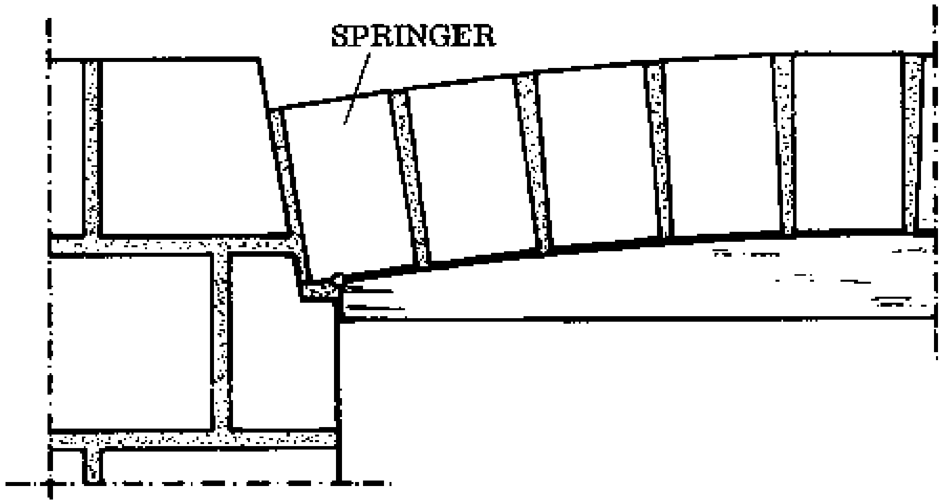


Fig. 2

There are two ways to avoid this:

– One can reverse the marking by starting from the springing points and marking by turns from the left and right up towards the crown. The remaining opening is then filled with either a specially made keystone, or with concrete (Fig. 3). This is preferred if the springers would overlap the springing points by too much.

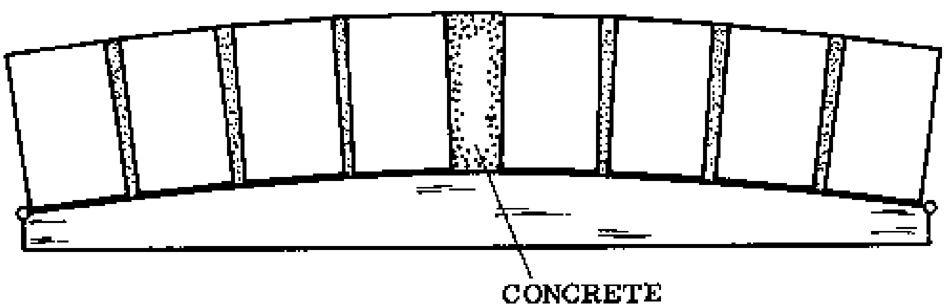


Fig. 3

– The most perfect solution would be to use specially made archstones which are wedge−shaped and fit exactly in the arch (Fig. 4). This requires some detailed and accurate planning, and more time and materials.

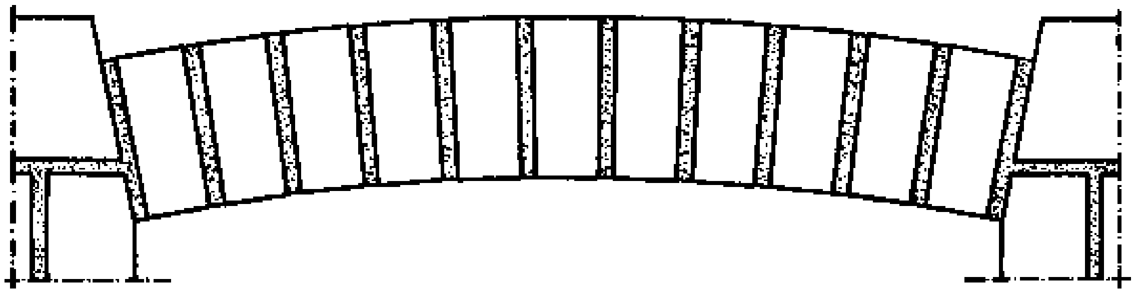


Fig. 4

NOTES:

Setting up the centring

The board on which we marked the curve of the intrados and the positions of the archstones is now prepared for assembly and erection.

The first step is to cut off both ends of the board squarely at the marks which indicate the span. These cuts must pass through the springing points. Then the intrados is roughly shaped with the saw and then exactly planed to the mark, to make a smooth and evenly curved edge.

If the centring will be a part of the frame, it is now fitted to the frame head as in Figs. 1 and 2, and set into its place together with the frame. In this case it is best to make two identical turning pieces to seal the camber on both sides of the wall. They are fixed outside and inside flush with the frame. The hollow part in between the pieces is filled with a mixture of sand and ash; both to keep insects out and – if there is no lagging – to give more support to the archstones which otherwise would have to rest on the turning pieces only.

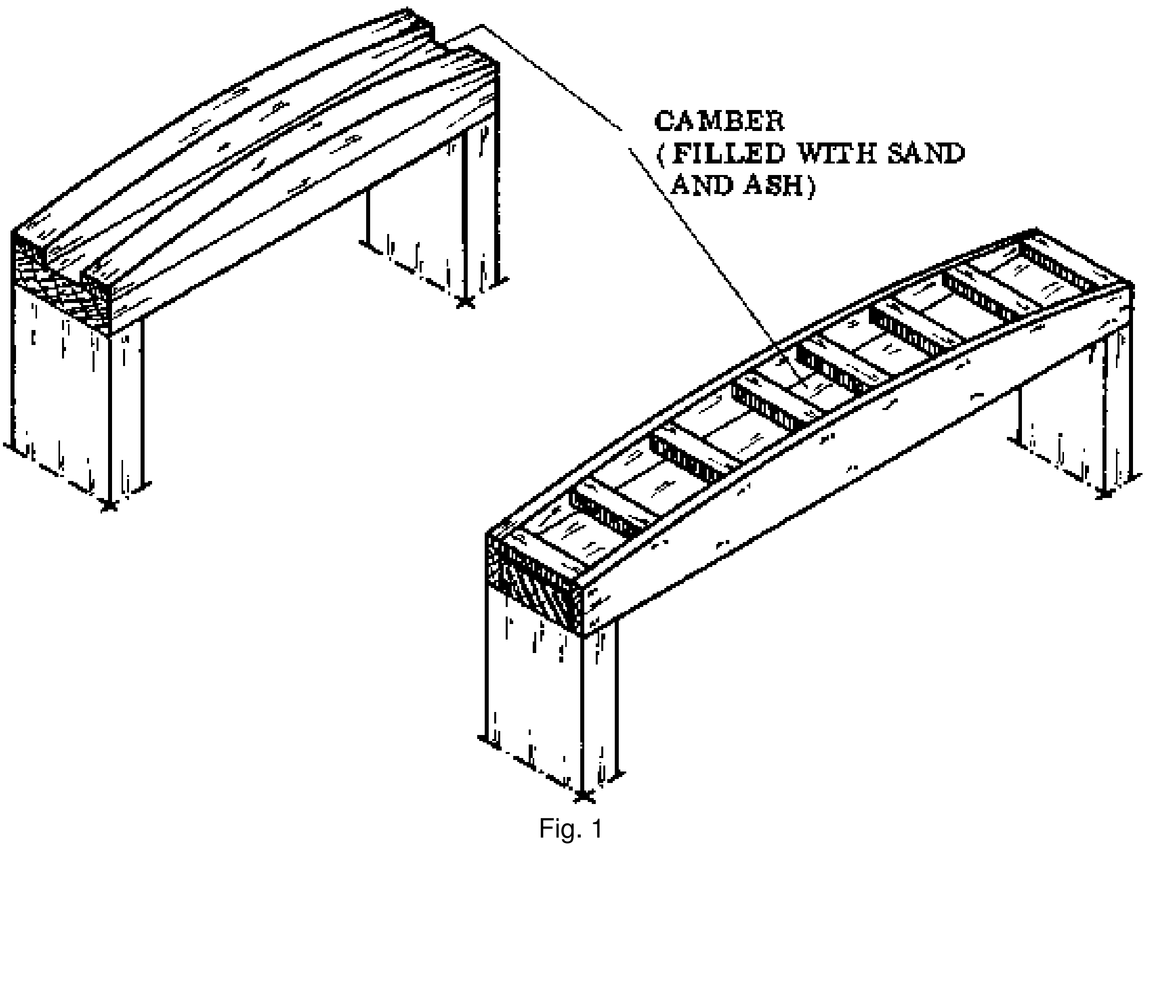


Fig. 1

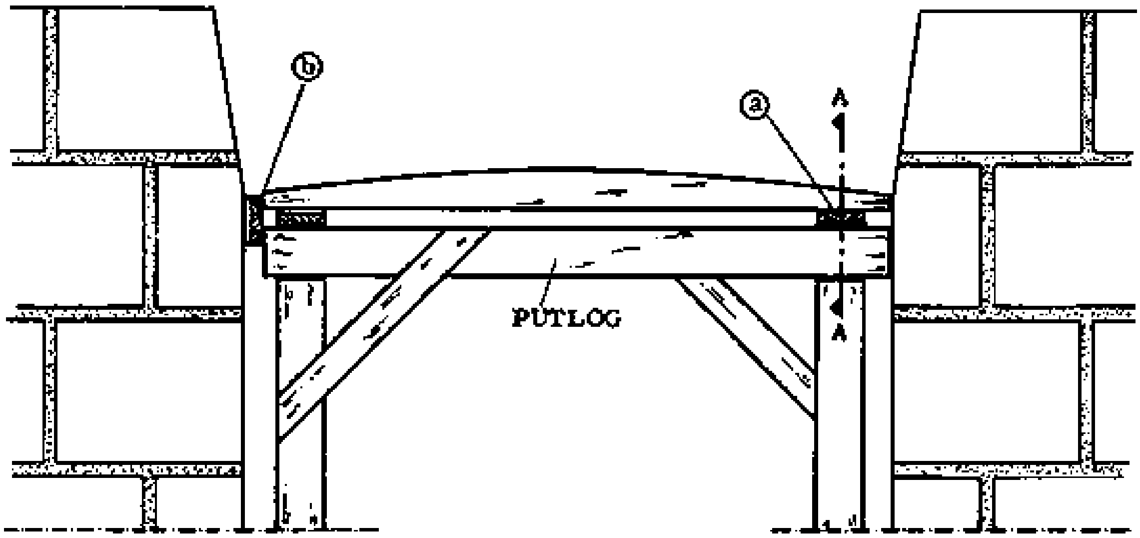


Fig. 2

Note that the marks of the springing points are cut off when the turning piece is combined with the frame. This is because it is cut flush with the outside of the frame. This means that the thickness of the joint between the frame and the wall has to be taken into account when marking the slope of the skewback.

If the centring piece is to be removed after the arch is finished, it must be set in a way so that it can easily be taken out. This is done by placing it on wedges as in Fig. 3, (a). It might be necessary to cut the turning pieces slightly shorter on one end so that the centring fits easily into the opening. In that case the end which has not been cut rests against the wall while the gap on the other side is closed tight with wedges to prevent shifting (Fig. 3, b).

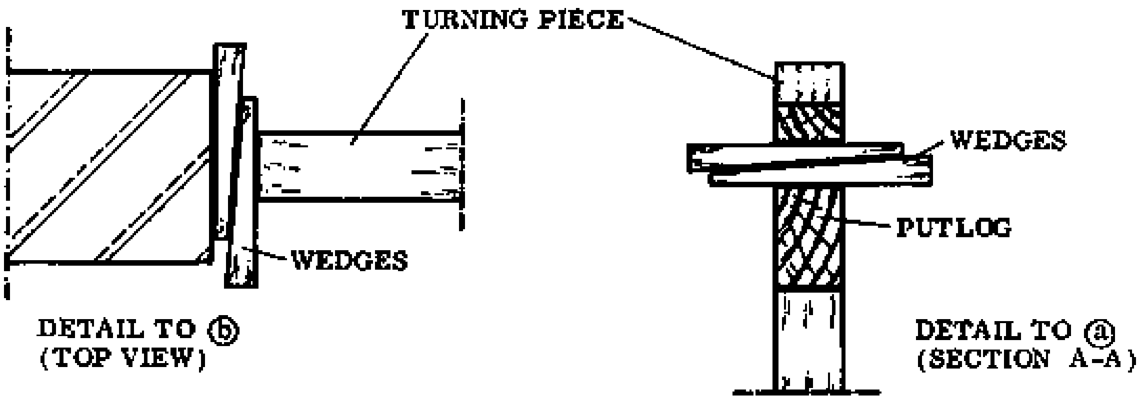


Fig. 3

Try to avoid making the springing points in line with a bed joint. The sideways force from the arch can possibly cause cracks along the bed joint. The best solution will be to distribute the pressure over two courses (Fig. 3).

When you set the centring piece in position, do not forget to level the soffit, which must be exactly horizontal and parallel to the springing line.

NOTES:

Skewback template

Before you can start laying the archstones, the abutments with their skewbacks must be prepared so that the springers can be laid at the correct angle. To be sure that the angle of the skewback is correct, the Rural Builder can use the template described below (Fig. 1).

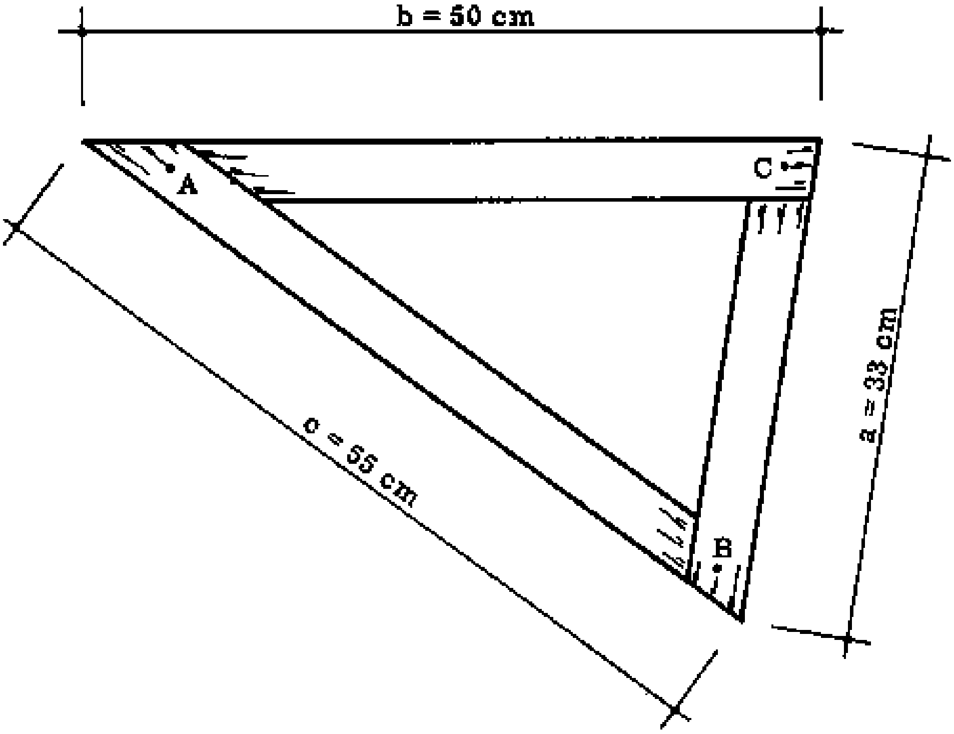


Fig. 1

This skewback template can only be used for a segmental arch where the radius of the arch is 3 times the span of the opening. Provided the rule of “r = 3 x span” is observed strictly, the same template can be used for any segmental arch, regardless of the length of the span. In other words the width of the opening and the size of the arch make no difference in the angle of the skewback for arches made according to this rule; the angle will always be the same.

– MAKING THE TEMPLATE: The template is made from wooden battens. It is simply a triangle with the outside dimensions as follows: side “a” = 33 cm, side “b” = 50 cm, and side “c” = 55 cm (Fig. 1). The angle at C is the angle we need to mark the skewback.

Use three battens that are a few centimetres longer than the measurements required. This allowance can be cut off when the template is assembled. Plane one edge of each until it is exactly straight and mark the length on this edge. Nail the battens together as in Fig. 1; or make accurate halving joints and join the pieces together with wing nuts instead of nails, so that they can be taken apart and put back together when they are needed in the future. The corners should be marked on both sides with the letters A, B and C, so that the ends are not accidentally mixed up when it is reassembled.

– USE OF THE TEMPLATE: The outside edge measuring 50 cm (side b) is held along the springing line, while the tip of the corner C is at the springing point (Fig. 2). The direction of the shortest side (side a) extended upwards with a straight edge gives the slope of the skewback. To mark the skewback on the other side, the template is simply turned around and the procedure is repeated.

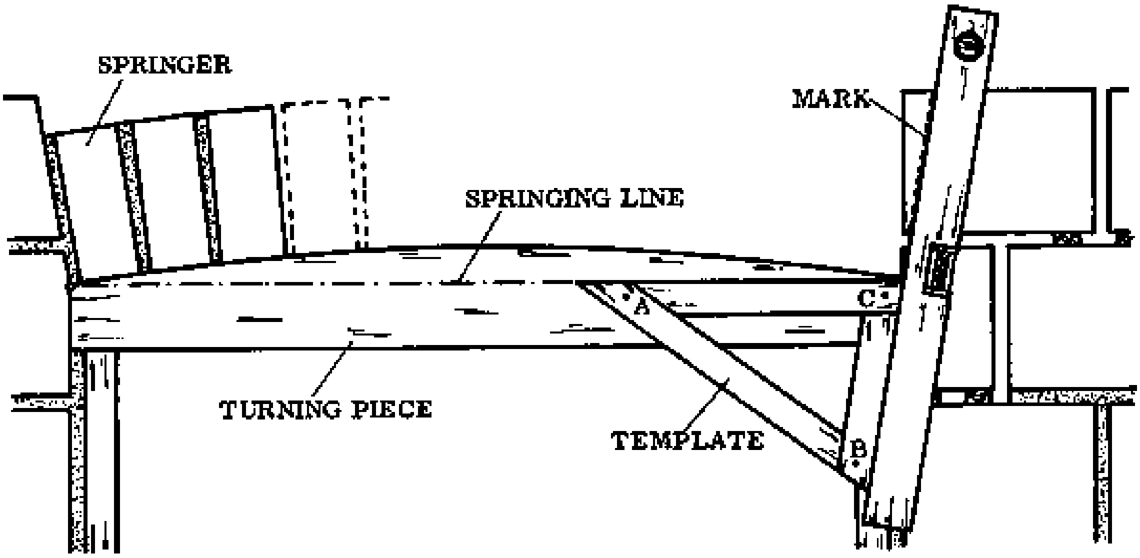


Fig. 2

– Note that corner B must always point downwards during the marking.

NOTES:

Laying the archblocks

The four blocks which have the skewbacks are marked and cut before they are laid in mortar. They are set temporarily in place on wooden battens which have the same thickness as the bed joint (Figs. 1 & 2, right sides). Mark the slope of the skewback with the template, and remove the blocks to cut them to shape. Then they can be laid in mortar and the arch can be continued.

Fig. 1 shows a segmental arch built with landcrete blocks. For this purpose, 1/2 blocks have to be cut, or preferably made specially in the Tek block press. This is easily done by putting a 1 cm thick board (for the 1 cm joint) edgewise in the middle of the mould box. The arch is built up by laying the blocks by turns on alternate sides, as indicated in Fig. 1 by the numbers.

The axis of each block should point towards the centre of the arch, with the result that ideally only the middle part of each block should rest on the turning piece, and the lower corners of the blocks do not contact the turning piece; there should be small wedge−shaped gaps. This is because the block faces are straight but the top edge of the turning piece is rounded.

The wedge−shaped joints between the archblocks need special attention. They must be properly filled with a rather wet mortar. If there is a gap left in the centre of the arch it is closed with concrete, which functions as a keystone (Fig. 1).

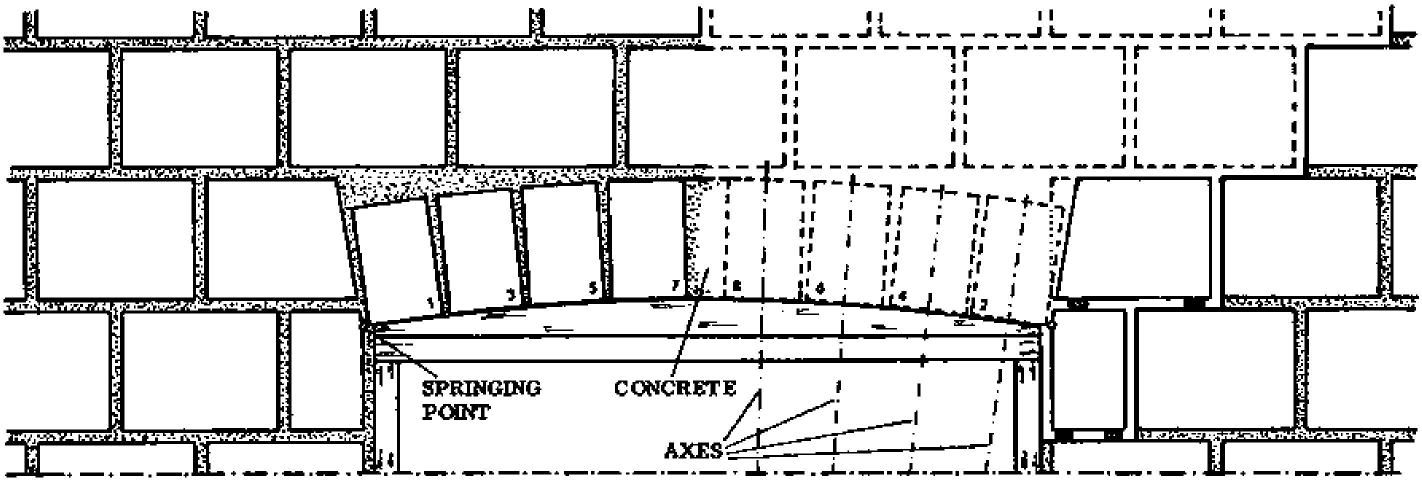


Fig. 1

Segmental arches over a span exceeding approximately 120 cm should be constructed with sandcrete blocks. The skewback blocks which abut the springers should also be sandcrete, so as to better distribute the pressure (Fig. 2).

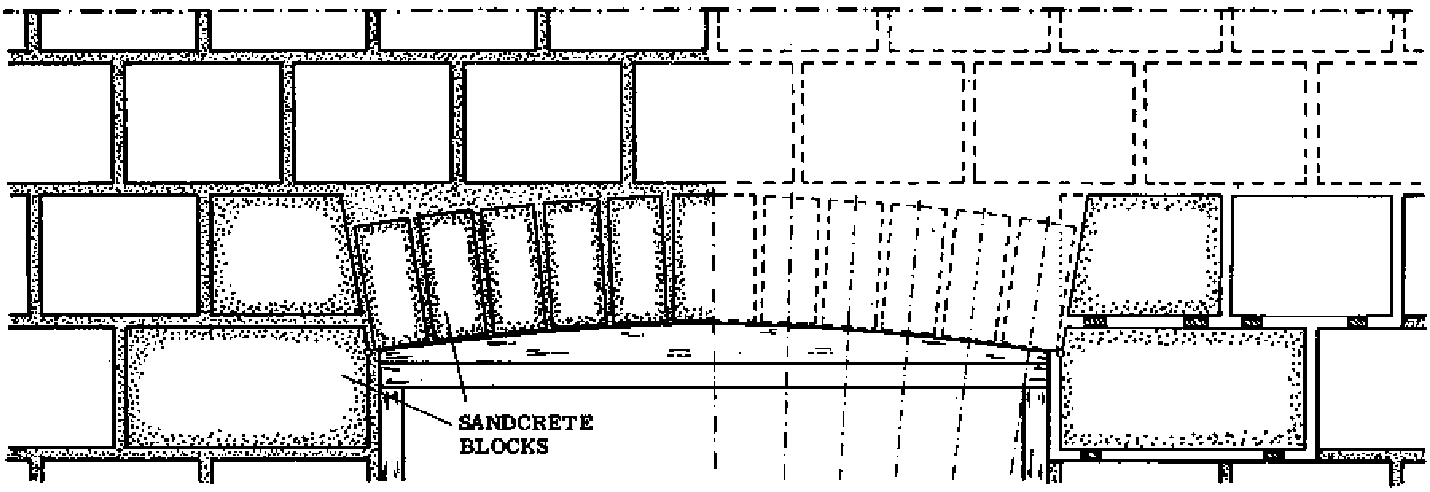


Fig. 2

To meet this requirement specially made blocks are needed. The skewback blocks must be 1 cm smaller in height than normal sandcrete blocks, so that they fit in with the landcrete courses. This is achieved by inserting a 1 cm thick piece of wood into the sandcrete block machine.

The archstones consist of 1/4 blocks which can also be made in the machine by inserting three 2 cm thick boards at a distance of 10 cm apart. The keystone is formed with a normal block of 15 cm thickness, cut to match the thickness of the wall.

If the centring is not combined with the frame, it is slightly lowered on completion of the arch, and removed after four days.

– NOTE: Try to set the centring so that the crown of the arch will be level with the top of the upper abutment course (Figs. 1 & 2) and not somewhere in the middle. The distance between the springing line and crown can be calculated as follows: 0,042 x span, plus height of archblocks.

REINFORCED CONCRETE LINTELS

Formwork

The formwork for cast−in−situ lintels consists of two main parts: the shuttering and the strutting. Precast lintels need only shuttering because they are cast on the ground.

− CONSTRUCTION: The construction of the formwork is shown in Fig. 1, page 167 of the Basic Knowledge book. This illustrates a situation where the frame will be set later or where there is an opening without a frame.

Since in most cases the frames are set already, the formwork does not require special strutting (Fig. 1). The head of the frame then acts as part of the soffit of the shuttering. The side boards must be fixed so that the vertical sides of the concrete lintel will be flush to the surface of the blockwork (Fig. 2).

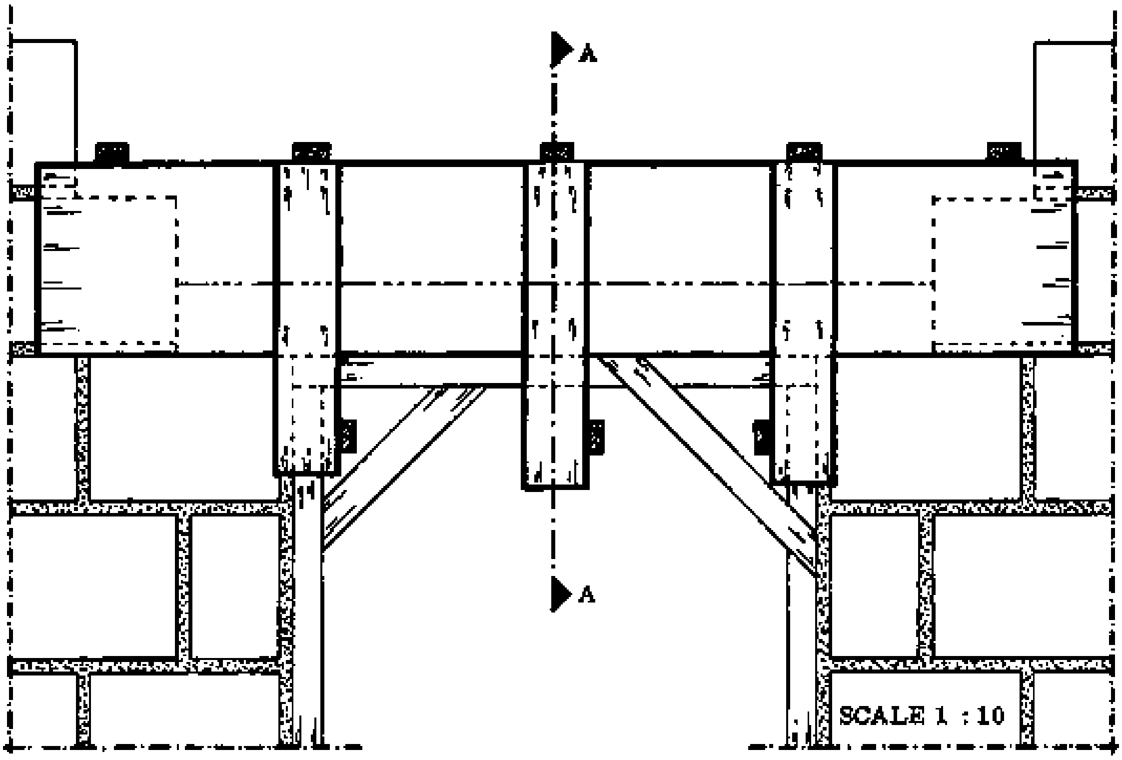


Fig. 1

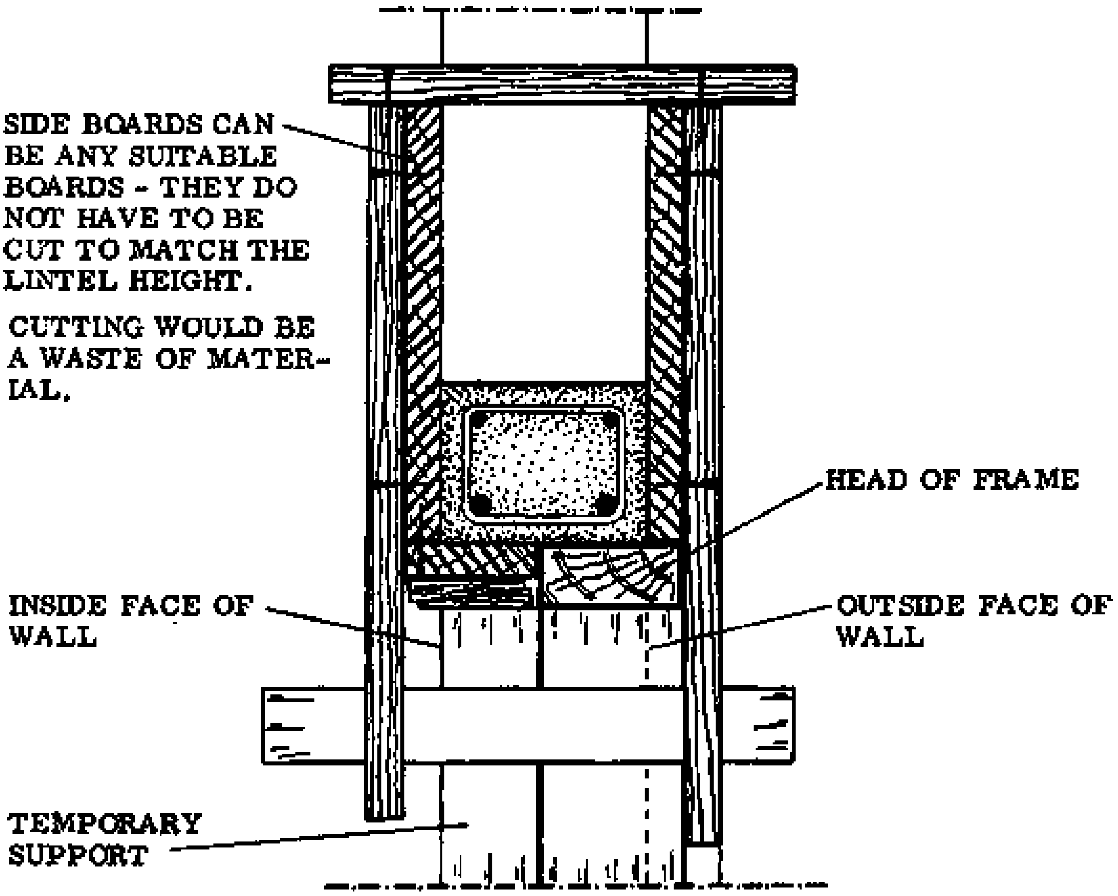


Fig. 2 CROSS SECTION A–A SCALE 1:5

– PREPARATION: If the lintel will not be plastered over later, the inside of the shuttering boards which are in contact with the concrete should be planed until they are smooth. This makes the stripping easier and also gives the concrete surface a nicer appearance. The inside of the shuttering may be treated with a special formwork lubricant, if this is available. Old engine oil can serve the same purpose; it should be applied lightly.

In case the lintel will be plastered later, it is better to leave the contact faces of the shuttering rough–sawn. Instead of oiling, wet the shuttering boards thoroughly with water, so that they don't absorb too much moisture from the freshly cast concrete.

Before casting the concrete make sure that the inside of the shuttering is clean; all joints, slits and gaps closed; and that the clear cover (the thickness of the concrete covering the reinforcement iron) is the correct thickness everywhere.

NOTES:

Reinforcement

The reinforcement for a lintel consists of a combination of different iron rods assembled to form a so–called “reinforcement cage” (see Basic Knowledge book, page 166).

In Rural Building the most commonly used reinforcement iron is round and has a smooth surface. It is available in rods with diameters ranging from 6 mm to 28 mm; but the most common sizes the Rural Builder uses are 6 mm (1/4”) rods and 12 mm (1/2”) rods.

If ribbed bars or tentor bars are available, these are preferred because the concrete grips better to a rough surface. Figs. 1a, b, c, and d show how the surfaces of some reinforcement bars look. Also see page 171 of the Reference Book.

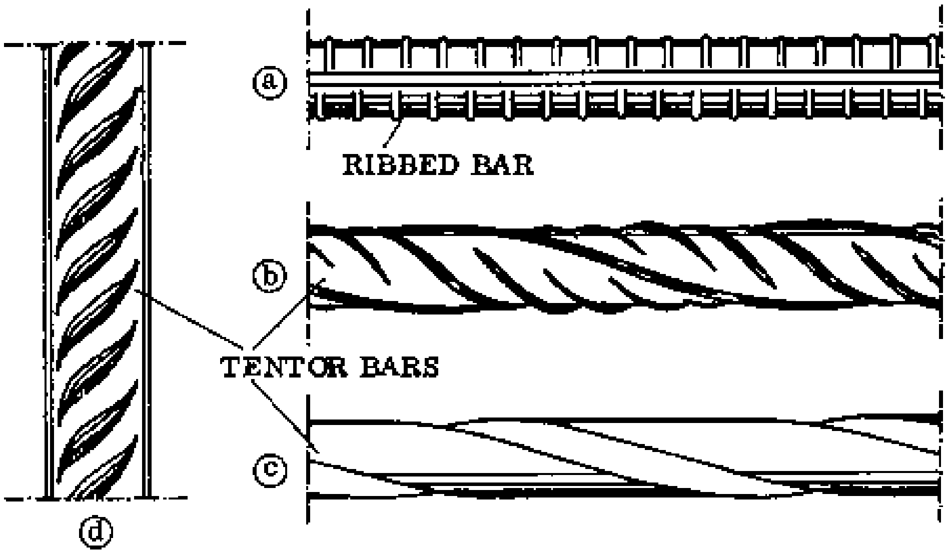


Fig. 1

– BENDING REINFORCEMENT BARS: According to how they will be used, sometimes iron rods must be bent or shaped to a hook form at the ends so that they can be well anchored. This must be done according to the following rules:

– All circular bars with smooth surfaces must have U–shaped end hooks (see Figs. 2a & 3a). For ribbed bars and tentor bars L–shaped hooks are sufficient (Figs. 2b & 3b).

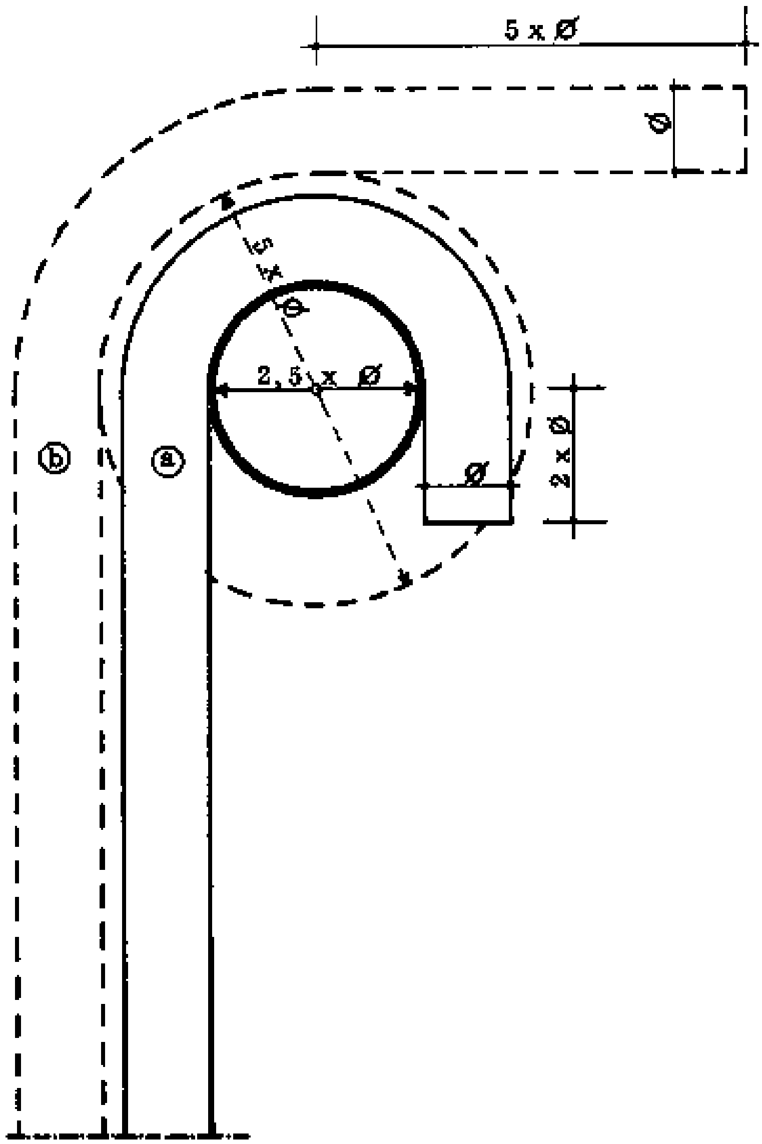


Fig. 2

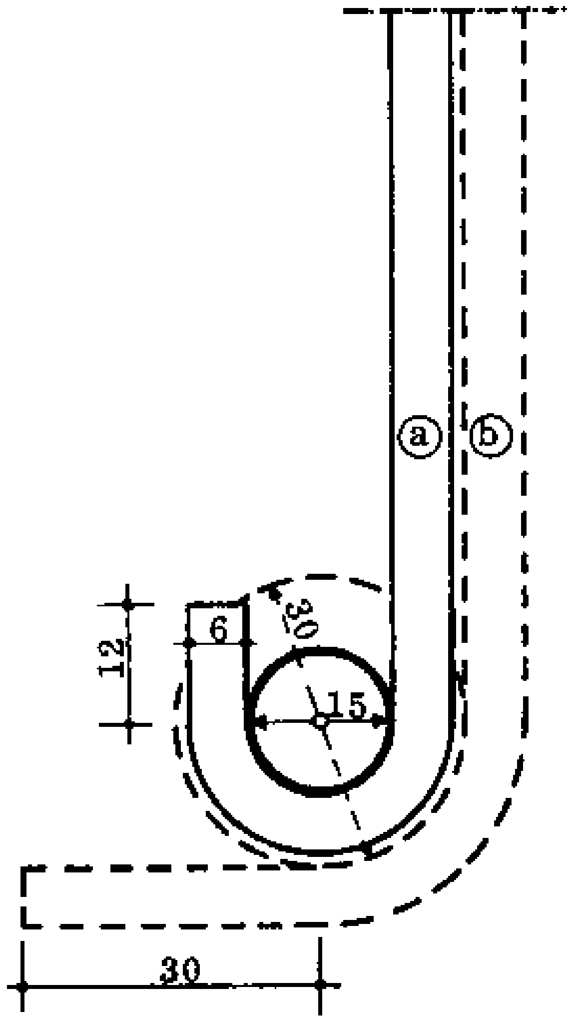


Fig. 3

– The minimum length for the straight end part of the hooks is: 2 times the rod diameter for circular bars; and 5 times the rod diameter for ribbed bars and tentor bars (Figs. 2 & 3).

– The smallest permissible bending diameter can be calculated according to the figures in the table below.

DIAMETER OF ROD	CIRCULAR BARS	RIBBED BARS & TENTOR BARS
6 mm up to 20 mm	2,5 x rod diameter	5 x rod diameter
22 mm up to 28 mm	5 x rod diameter	7 x rod diameter
more than 28 mm	––––––––––––	10 x rod diameter

The smallest permissible bending diameter for the 6 mm circular bar in Fig. 3a will be 15 mm; or 2,5 x 6 mm. For the 6 mm ribbed bar in Fig. 3b, the bending diameter will be at least 30 mm, or 5 x 6 mm.

– NOTE: As a rule, main bars should never be extended. If this is necessary, the shortest overlap for bars under tension is 75 cm, and the ends of the bars must have U–shaped hooks (Fig. 4).

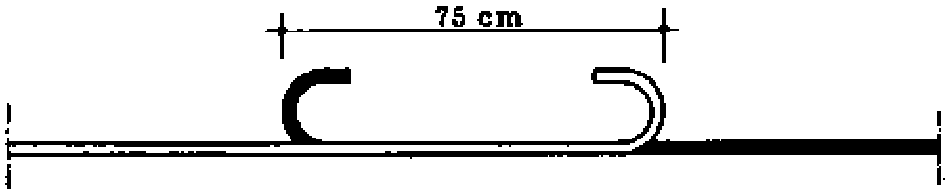


Fig. 4

Reinforcement systems

The construction of large reinforced concrete members usually requires complicated calculations to determine the diameters, number, shape and arrangement of the rods. This job should be left to a qualified design engineer.

However small and simple members of the structure such as lintels, columns, short span beams, etc. can be constructed by the Rural Builder according to the sketches, particulars and hints given here.

To place the reinforcement rods correctly, it is essential to understand and be able to predict in which part of the concrete member tensile stress (tension) is likely to occur. This is where the member has to be reinforced by the main bars. Fig. 1a shows the bold outline of a lintel; the dotted line shows how it would tend to bend under pressure. The arrows show how the whole upper part is under pressure, while the lower surface is under tension.

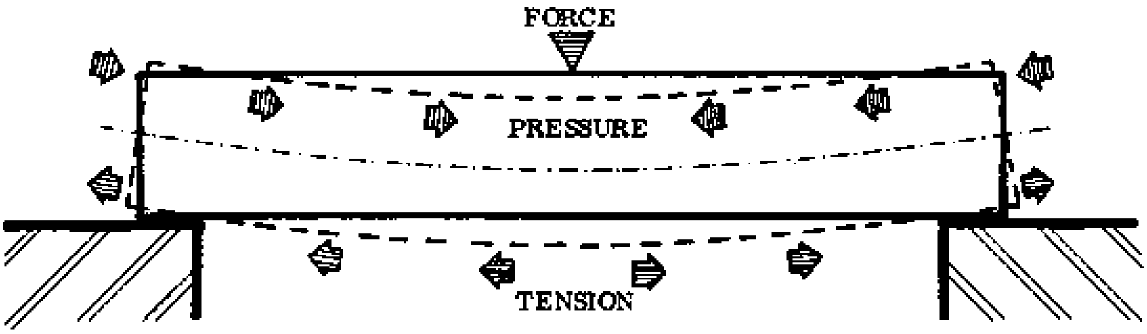


Fig. 1a

Fig. 1b illustrates how the lintel can be reinforced against this tension. Note that the main bars are on the bottom, in the zone which is under tension; and that the ends of the main bars are anchored on top, within the zone that is under pressure.

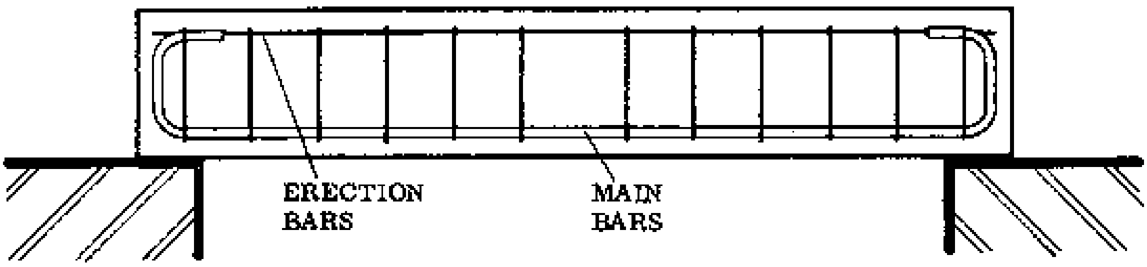


Fig. 1b

Fig. 2 shows another situation, where a beam is supported from one side only. This is called a cantilever beam. The unsupported end will tend to bend as shown. Here the main bars are on top to counteract the tension in the top surface (Fig. 2b).

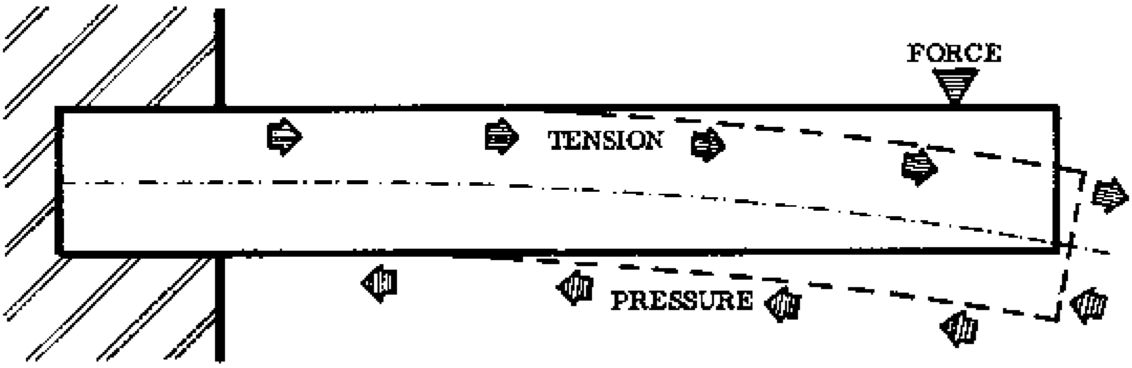
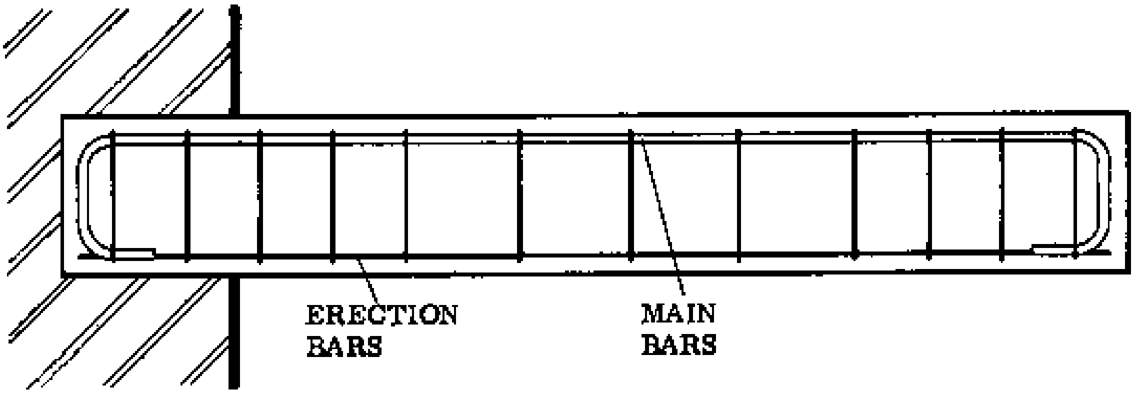


Fig. 2a



Fig, 2b

NOTES:

The longer reinforced beam or lintel shown here in Figs. 1a and 1b is reinforced with main bars on the top and bottom.

The cross section in Fig. 2 shows how the clear cover is measured from the outside of the stirrups to the outside face of the concrete. In other words, the clear cover or concrete cover is the distance between the concrete surface and the nearest reinforcement bar, regardless of the function of the bar.

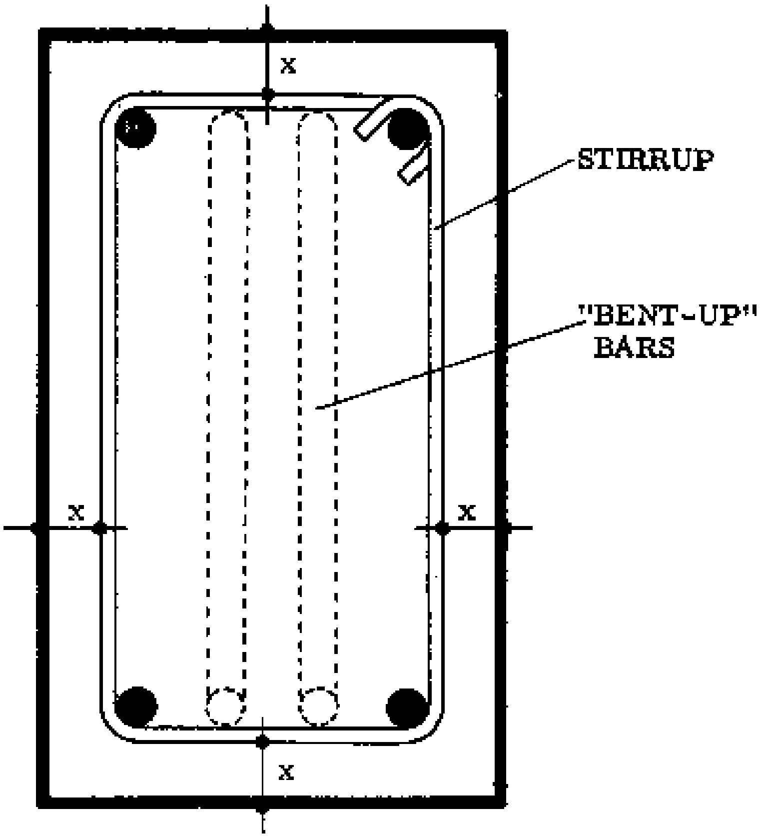


Fig. 2 CROSS SECTION A–A

x = CLEAR COVER

The distance between the stirrups is never more than 20 cm. For safety, the Rural Builder is advised to put the stirrups no more than 15 cm apart. The stirrups closer to the supporting walls (50 cm away and closer) should be no more than 10 cm apart (see the illustrations here and on the next page).

So–called "bent up" bars are sometimes used as part of the reinforcement system (Figs. 1 & 2) but these are not used in Rural Building because of the difficult calculations required to place them correctly; also they are not necessary for the small structural members which are required in Rural Building.

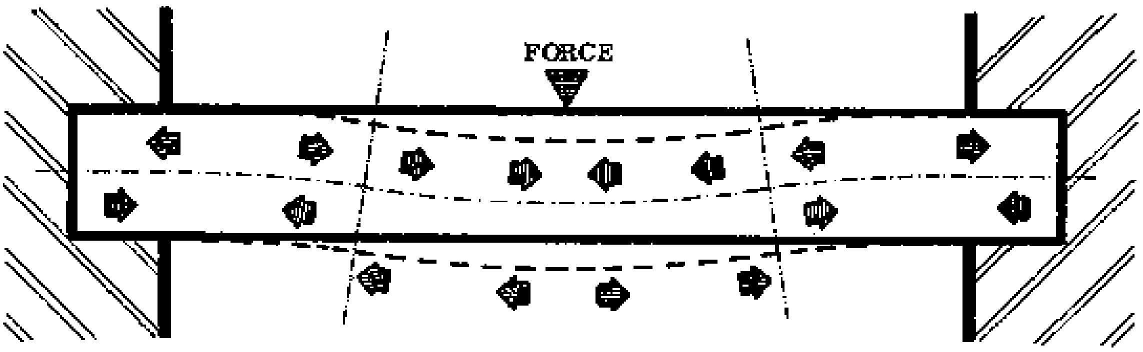


Fig. 1a

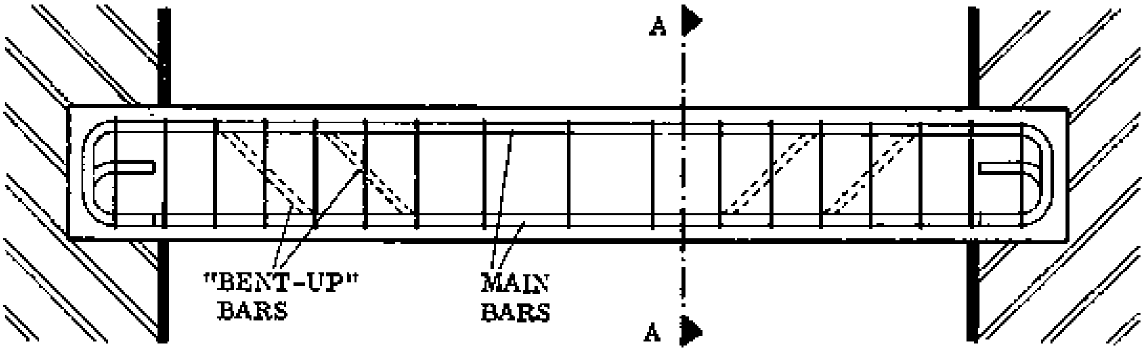


Fig. 1b

NOTES:

On the left is a drawing of a reinforcement system for a continuous beam; this might occur for example in an eave beam supported by a reinforced pillar (Fig. 1).

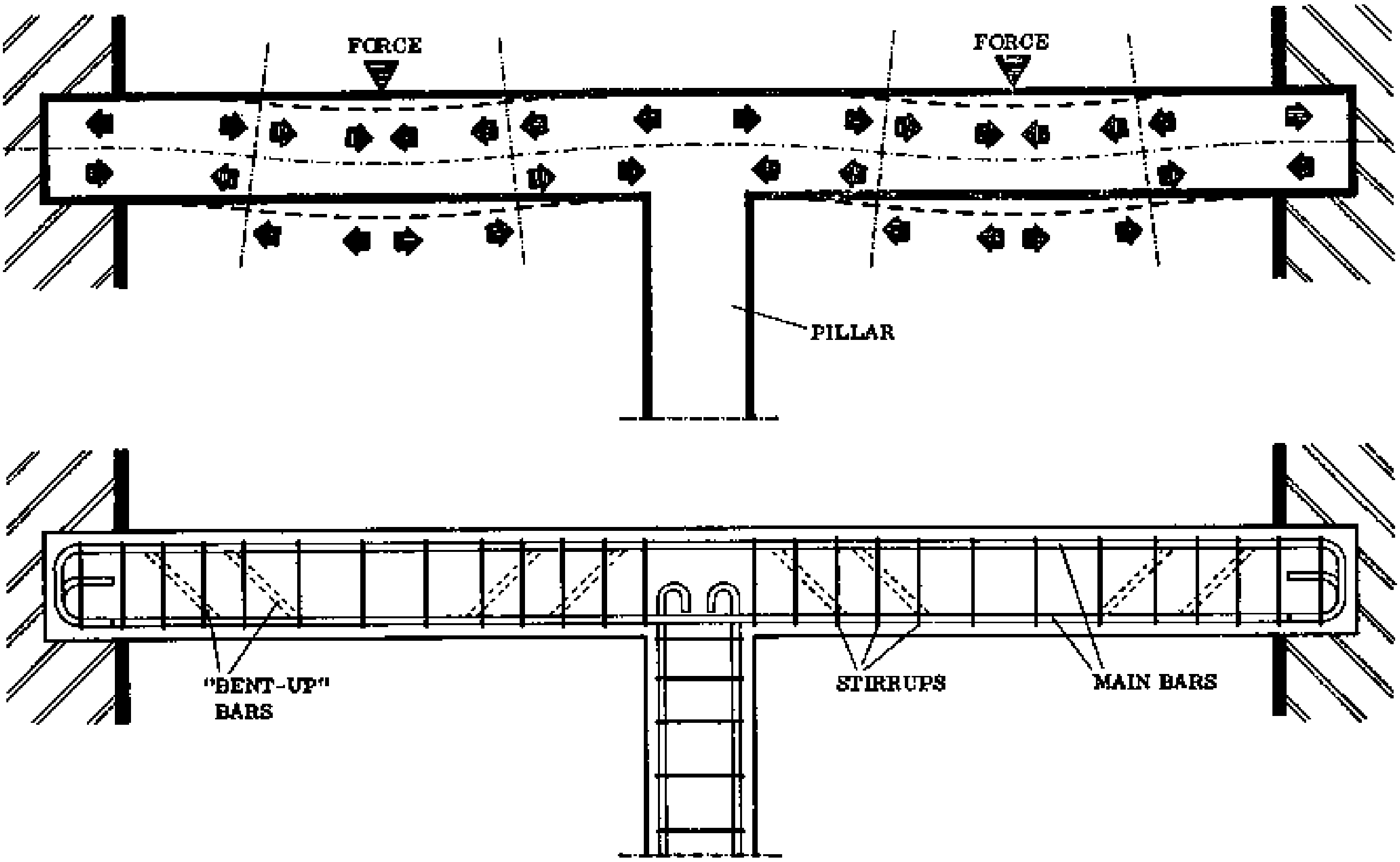


Fig. 1

Corrosion in reinforced concrete

It may seem strange, but the weakest part of a reinforced concrete structure is the hard iron, because it is easily broken down if it is not protected well. The structure remains stable only as long as the iron is protected against corrosion.

The main problem with reinforced concrete is the development of very small cracks in the concrete, which means that the iron is exposed to air and becomes rusty. On the concrete surface below the cracks, reddish brown rust stains appear. Once these are visible it is usually too late to save the member.

Unless immediate protective measures are taken, the rust develops more and pressure builds up between the iron and concrete, causing the concrete cover to break open; this speeds up the rusting process and eventually the reinforcement bars become too weak to carry loads or to withstand other forces. The system then collapses.

– PREVENTION OF CORROSION: Here we must include a strong warning against over–reliance on concrete strength. Not only laymen, but also many construction experts believe “the more cement, the harder and the better the concrete”, and they tend to improve the mix proportions by using greater amounts of cement. This is wrong, because very hard concrete is not only expensive but it is also not necessarily the best protection against rust. Therefore, the Rural Builder is advised to follow the correct mix proportions.

If possible use high quality steer for the reinforcement as this does not rust as easily as common circular bars.

The surface of the concrete should be protected against the weather by the application of a waterproof cement paint (see Reference Book, page 201). However, such a paint coat is wasted if rust stains are already present. The paint does not seal the cracks and only makes the stains disappear for a short time, if at all.

– NOTE: Never apply paint on concrete surfaces that have not set hard yet. Possible shrinkage of the concrete during the hardening process would cause tiny cracks in the paint coat, making the paint useless as protection against the penetration of water and air.

WALLING ABOVE FRAMES

The last part of the walls above the frames should consist of at least three courses of blocks, so that the roof construction can be well anchored. Experience has shown that anchoring the trusses in the ring beam alone is not sufficient for them to withstand strong wind forces. Therefore, the anchorage irons are placed in the first bed joint just above the frames (see Anchorage, page 197).

If the exact positions of the trusses are not known yet, the irons can be set later, in the finished wall. This is done by passing the iron through a hole chiselled in the bed joint (Fig. 2 a). It is generally better and easier though to plan ahead and place the irons during the wall construction. The irons are set in grooves so that they will be flush to the wall surface and will be covered and protected later by the plaster or render.

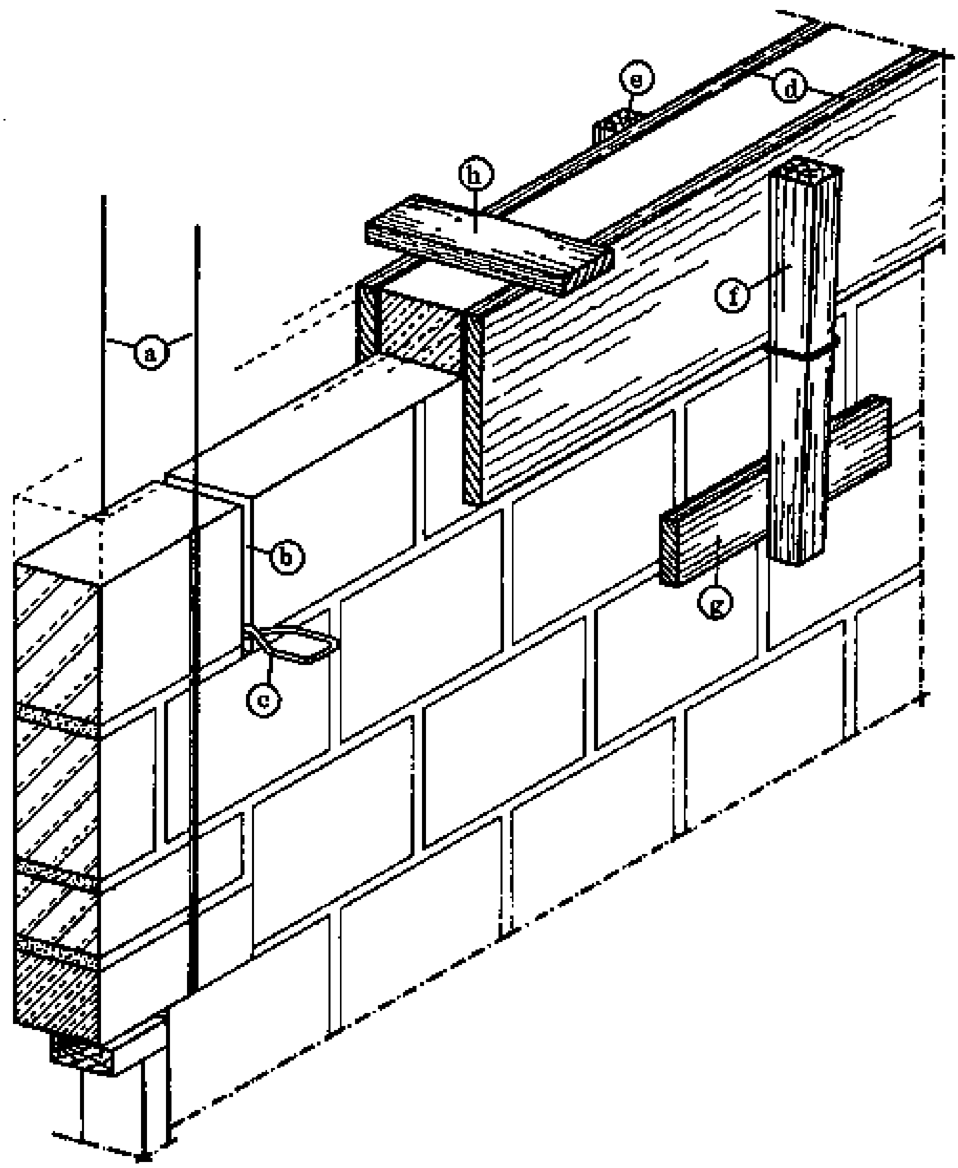


Fig. 2

FORMWORK SYSTEM FOR RING BEAM

If a reinforced concrete ring beam will be made, every third cross joint in the last course is left open (Fig. 2, b) so that formwork clasps can be inserted.

These special clasps have been developed and manufactured at NPVC in order to save strutting materials and to ease the construction of the formwork for a ring beam. Formerly long standards and braces in great number were needed to construct the formwork. With the clasp however, only a few short boards are necessary for the bracing. The formwork clasps are easy to handle and have passed all tests at NPVC. They are made from a piece of iron rod bent as shown in Fig. 1, and welded to hold the loop ends closed.

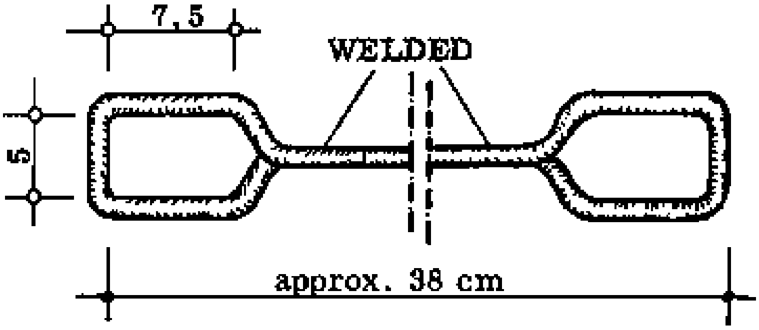


Fig. 1

Fig. 2 shows the formwork system, and Fig. 3 shows the cross section. When the clasp is inserted in the open cross joint (Fig. 2, c) the remaining open space must be closed with paper (empty cement bags) to make it possible to remove the clasp later. The side boards (d) rest on the clasps and are pressed against the wall by straight boards (e) on one side, and wedge–shaped boards (f) on the other side. Short pieces of board below the side boards (g) act as distance pieces to keep the shuttering boards plumb. Cleats or spreaders (h) may also be used to maintain the correct width of the beam. There are no nails used, except for fixing the cleats, which reduces the damage to the boards.

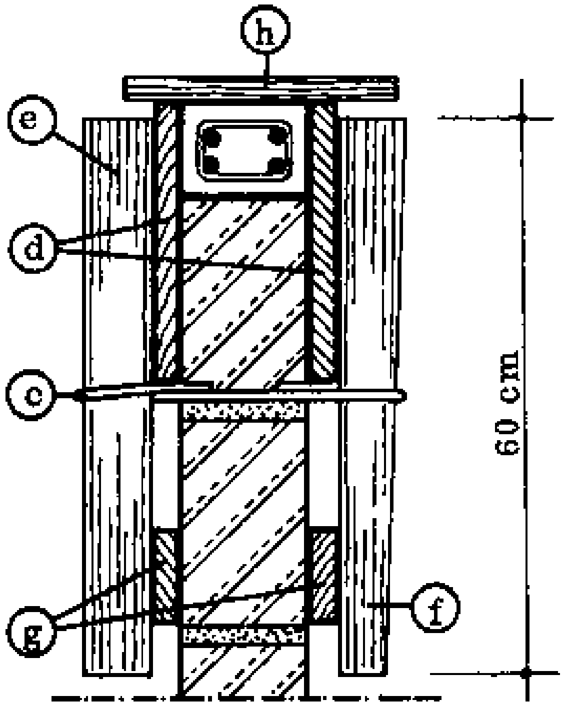


Fig. 3

The Rural Builder is advised to supply himself with at least four clasps and to carry them along with his set of tools.

ROOFS IN GENERAL

The roof is a very important part of the building structure. It performs several essential functions:

- It gives shelter to people.
- It provides shade.
- It isolates the building from cold and heat.
- It keeps out dust and dirt.
- It protects the interior of the building.
- It sheds rainwater.

Roof types

There are many different types of roofs. In Rural Building we deal only with the following four types:

- The lean–to roof (Fig. 1)

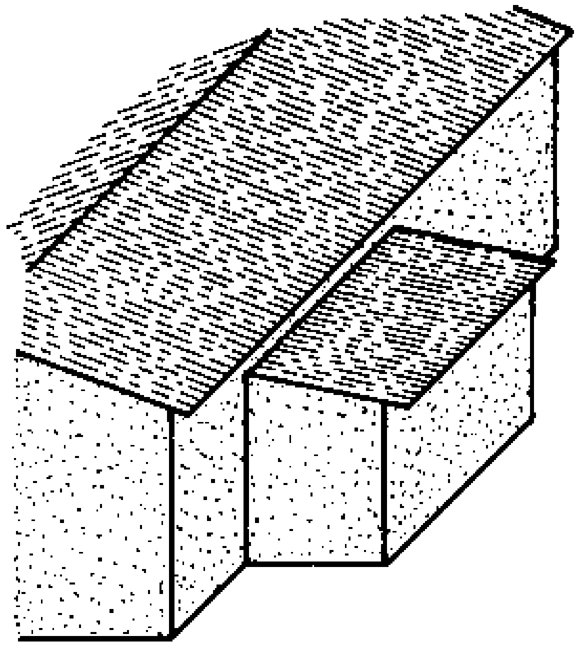


Fig. 1

- The pent roof (Fig. 2)

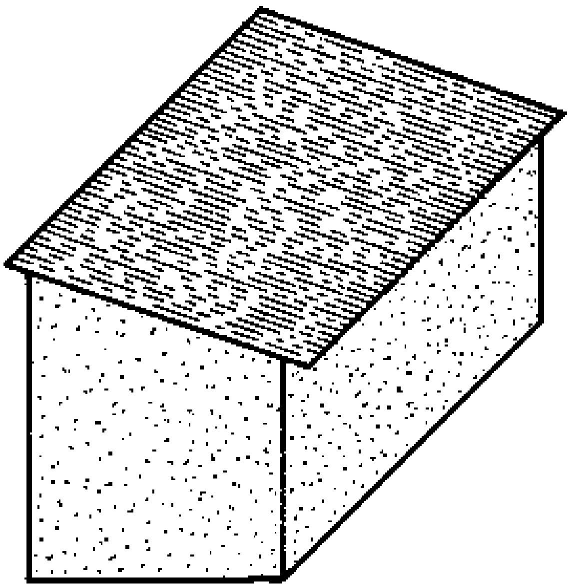


Fig. 2

- The gable roof (Fig. 3)

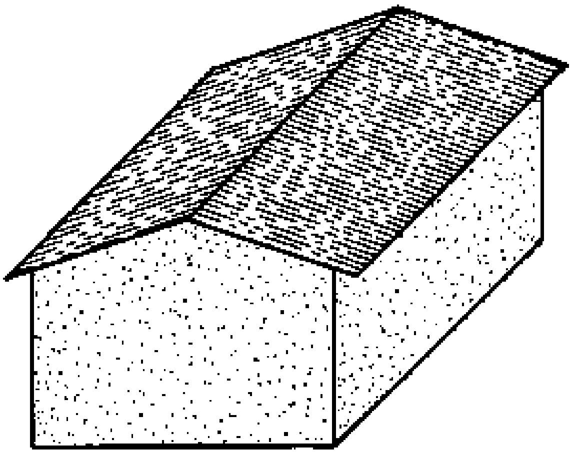


Fig. 3

– The hipped roof (Fig. 4).

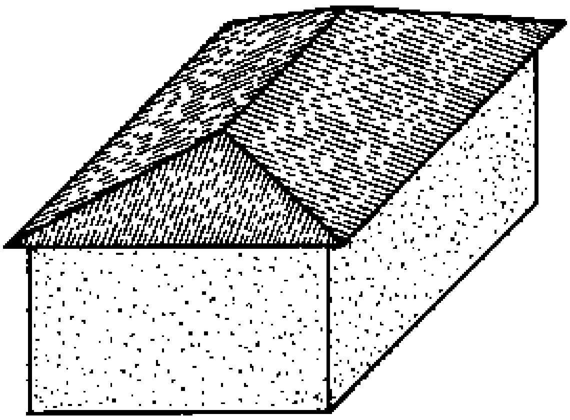


Fig. 4

These roofs will be described in detail in the following sections of the book. In the next few sections we will describe some factors which are important in the construction of all roofs. These must be understood well before we can go on to describe the construction details of the particular roof types.

NOTES:

Size of the roof

The cost of roofing sheets will be a significant part of the cost of the whole building. Therefore it is the size of the roofing sheets which will determine the size, and especially the width, of the whole building.

For this reason, we make an outline design of the roof before we determine the other measurements of the building. We cannot design the building first and later fit a roof on it. The outline design tells us the width that our building should have so that we can fit a roof on it without unnecessary and wasteful cutting and trimming of the sheets (Reference Book, pages 239 & 240).

To make the outline design of the roof, we need to know:

– the pitch of the roof
– the effective length of the sheets
– the distance the roof will project past the outside walls of the building.

Roof pitch

The angle of the slope of the roof is called the pitch. Most roof types have a standard pitch. If corrugated sheet materials (Reference Book, pages 230 and 231) are used, the pitch angle should be between 15 and 20 degrees (Fig. 1).

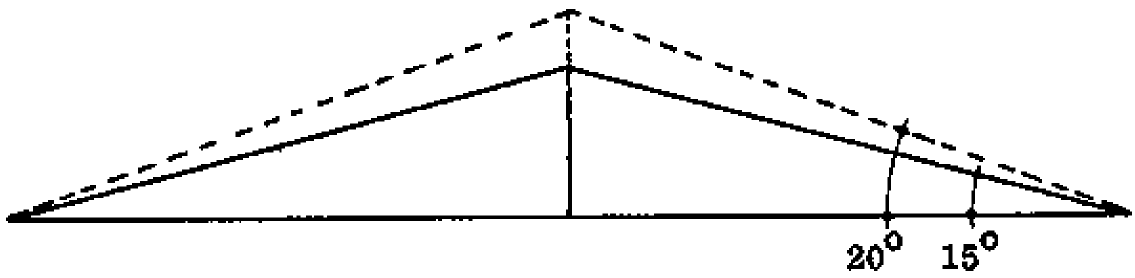


Fig. 1

NOTES:

Effective length of the sheets

The effective length of roofing sheets is the length of the sheet (x) minus the overlap (y) between the sheets (Fig. 2).

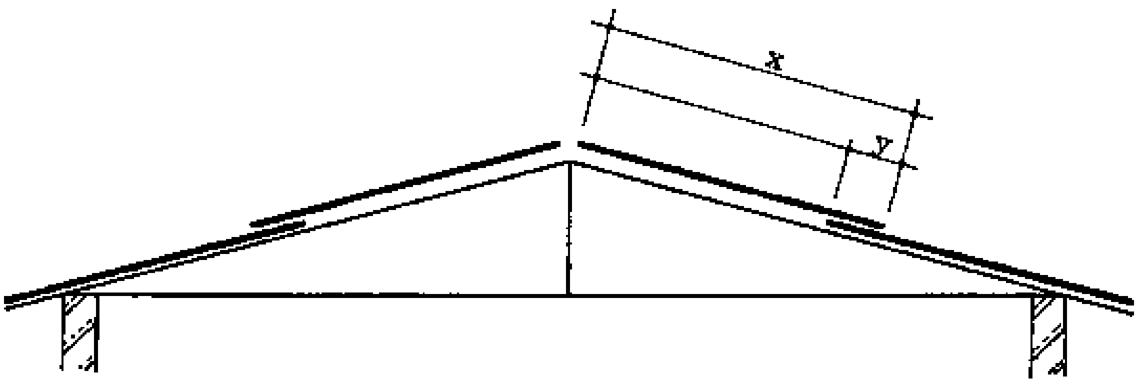


Fig. 2

The minimum overlap in the length for corrugated sheeting materials is 15 cm. The most common length for roofing sheets in Ghana is 244 cm.

In order to use the sheet materials as economically as possible, we use either 1, 1 ½, 2, 2 ½ or 3 (and so on) sheets to cover the distance from the highest point of the roof to the lower edge. Thus the effective length will be:

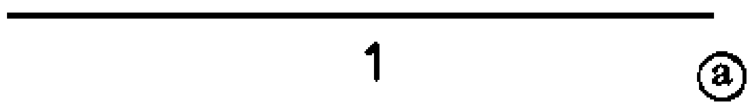
– for 1 sheet	– 244 cm
– for 1 ½ sheets	– 244 cm + 122 cm – 15 cm = 351 cm
– for 2 sheets	– 244 cm + 244 cm – 15 cm = 473 cm
– for 3 sheets	– (244 cm x 3) – (15 cm x 2) = 702 cm
– and so on.	–

NOTES:

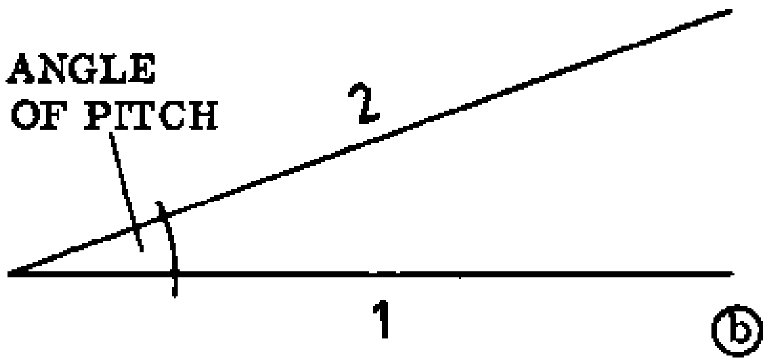
Outline design

The outline design should be made in as large a scale as possible, since it is used to find some measurements for the future building design.

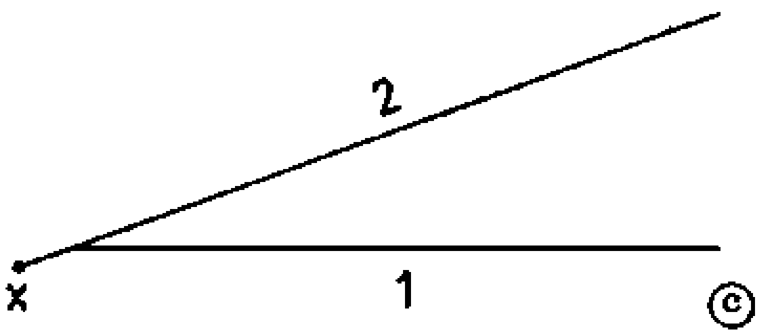
a. Draw a horizontal line (line 1).



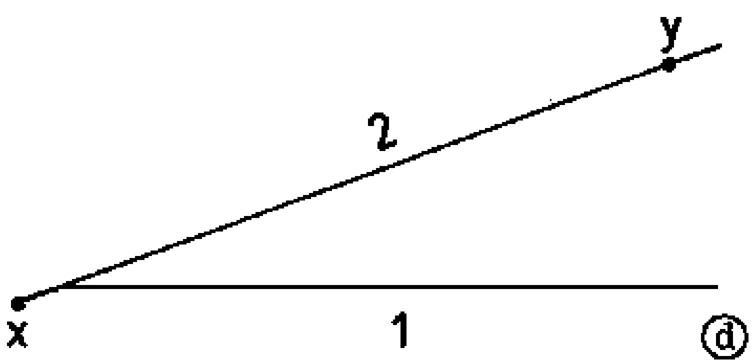
b. Draw line 2. The angle between line 1 and line 2 should be the angle of the pitch of the roof.



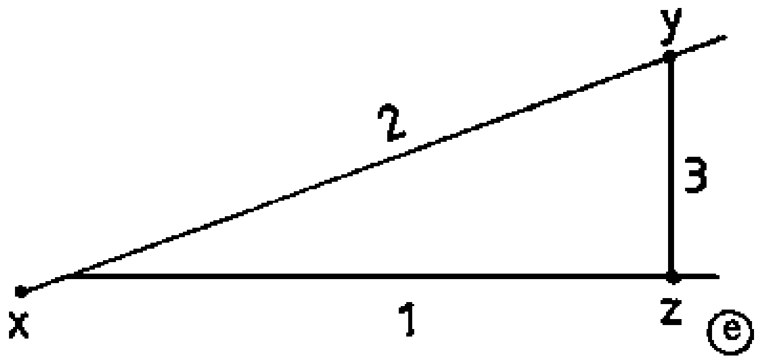
c. Extend line 2 to show the projection of the roof beyond the wall of the building. Mark point x at the end of line 2.



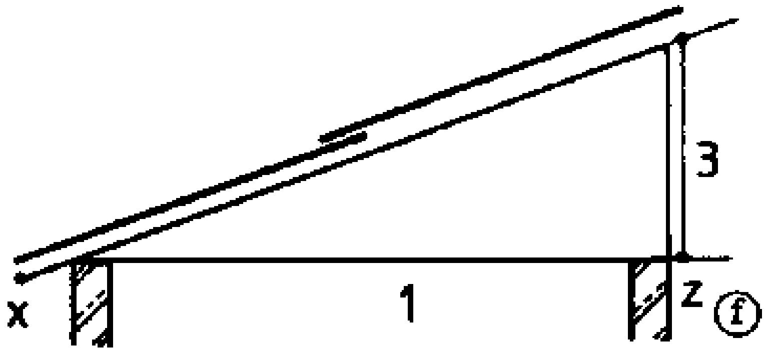
d. Measure the effective length of the sheets from point x, remembering to sub tract the overlap. Mark point y on line 2.



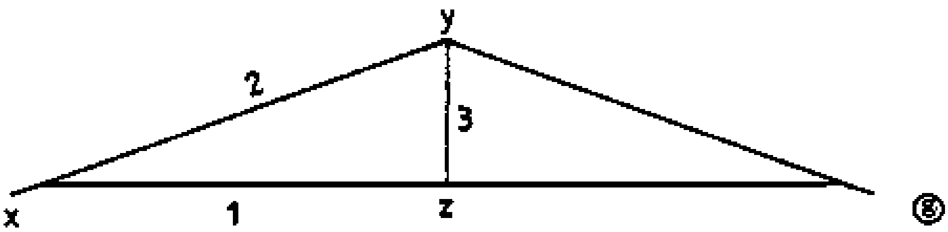
e. Make a line perpendicular to line 1 and passing through point y. This is line 3. Mark point z on line 1.



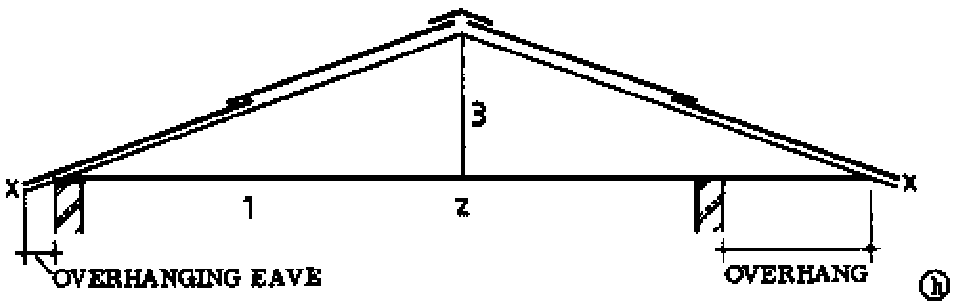
f. If a lean−to or pent roof is planned, the length of line 1 up to point z gives the width of the building. Now indicate the supporting walls and the sheets with the overlap. In a lean−to roof, remember that the end of the sheet at the top is en closed in the wall; and for the pent roof, the sheets project past the wall on the top side.



g. If a gable roof is planned, draw the other half of the roof in the same manner. The extended line 1 will give the width of the building.



h. Indicate the supporting walls, sheets and the overlap.



– TERMS: The point where the sloping lines meet, point y, is called the “ridge”. Line 3 is the “rise” of the roof.

If the horizontal line (line 1) projects beyond the supporting walls, the projecting part is called an “overhang”.

If the sloping part projects beyond the wall, the projecting part is called an “overhanging eave”.

The lowest part of a sloping roof is called the “eave” (point x).

NOTES:

Loads

In order to build a good strong roof, it is necessary to take into account certain forces that will affect it. We call these forces "loads".

Some of the loads come from the weight of the roof itself and the ceiling. These are called "dead loads". They consist of: (see Fig. 1)

- the weight of the roof covering
- the weight of the roof construction
- the weight of the ceiling
- the weight of anything attached to the ceiling such as ceiling fans or light fixtures.

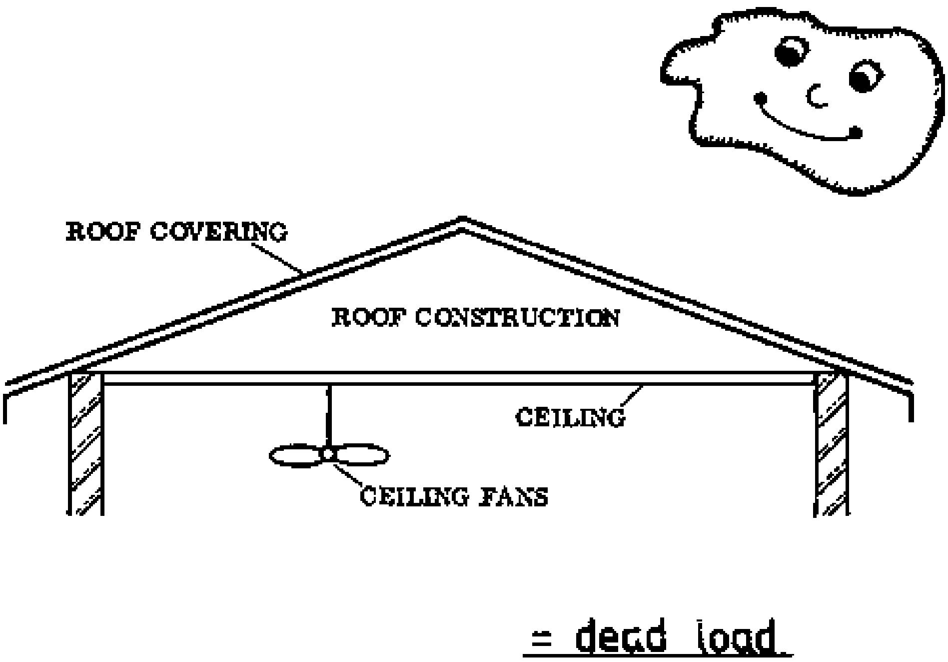


Fig. 1

Other loads are caused by external (outside) forces such as rain or wind. These are called "external loads". External loads are: (see Fig. 2)

- windloads
- rainloads

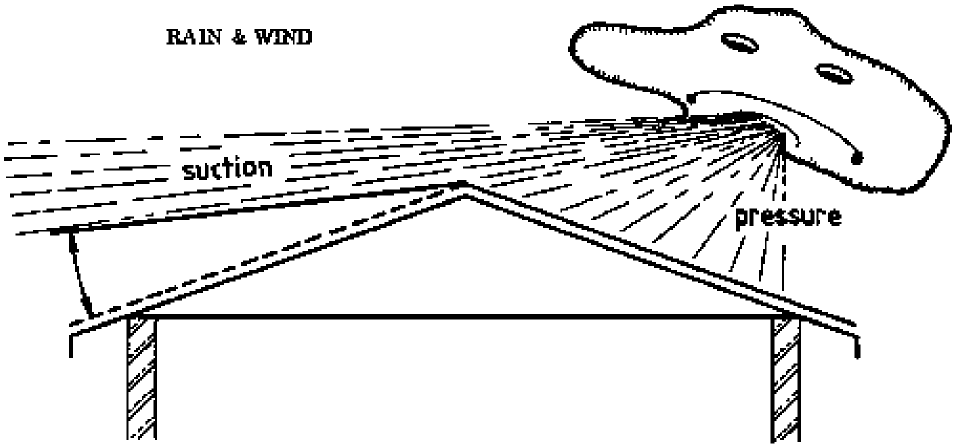


Fig. 2

All loads, external and dead loads, must be taken into account in the planning and construction of a roof.

The most dangerous load in Ghana is the windload. Strong winds or storms can cause a lot of damage to a roof if it is not well made and securely fixed to the building.

One particular danger is the suction on one side of the roof caused by the wind, which creates pressure on one side and suction on the other side of the roof (Fig. 2). This suction on roofs can be demonstrated by an experiment. Fold a sheet of paper in half and blow over the top edge. The other half of the paper will be lifted up by suction.

– SHAPE OF THE ROOF WITH RESPECT TO WINDLOAD: Roof constructions can be severely damaged by storms. Apart from the precaution of anchoring the roof well, which will be discussed later, there are some ways to shape a roof so that it is less vulnerable to the force of the wind:

– Consider carefully the pitch of the roof. Roofs with a pitch of less than 10 degrees are much more prone to high suction forces.

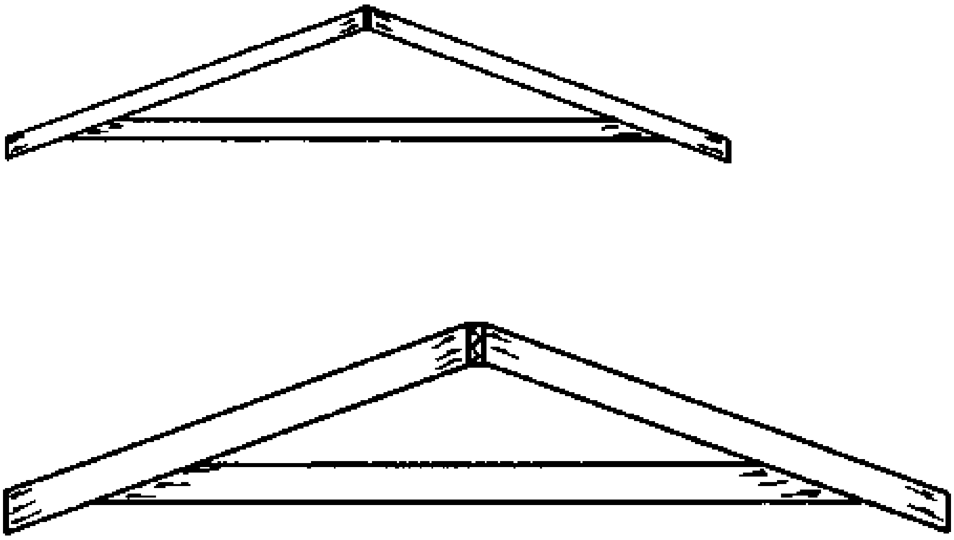
– 15 to 20 degrees is a better roof pitch, because it causes less suction.

– Consider making a hip roof instead of a gable roof. This will decrease the suction even more.

– See the Drawing. Book, pages 105 and 106, for more suggestions.

LIGHT–WEIGHT STRUCTURES

As the span (width) of the building increases, the strength of the roof construction must also be increased. Formerly this was done by using thicker and wider timbers (Fig. 1).



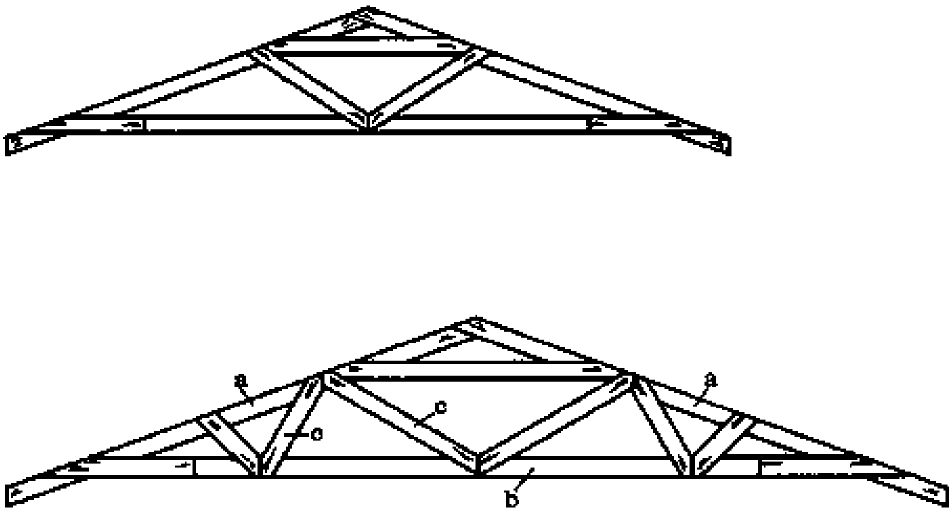
FOR INCREASED SPAN LARGER TIMBERS ARE USED

Fig. 1 TRADITIONAL ROOF CONSTRUCTION

This method resulted in very heavy and expensive roof constructions. Large timbers are normally much more expensive than smaller timbers (compare the cost of 5 x 7,5 cm Odum and 5 x 15 cm Odum).

This kind of roof construction is now uneconomical, as well as difficult because of the complicated joints needed for large timbers.

In modern light−weight structures, the strength of the roof is increased for larger spans by building up brace structures in the shape of triangles (Fig. 2), instead of using larger timbers. This construction uses small timbers, which are cheaper and lighter in weight; therefore we get a light−weight structure.



FOR INCREASED SPAN MORE BRACES ARE USED

Fig. 2 MODERN LIGHT−WEIGHT STRUCTURES

Light−weight structures are less costly, and result in a smaller dead load on the roof. Another advantage is that we can use simple joints instead of complicated roofing joints.

Since the construction is built up from small members, it is sometimes called a “built−up structure”. This is the only type of roof construction we will learn in Rural Building.

− TERMS: The sloping members are called “rafters” (Fig. 2, a).

The horizontal member is called the “tie beam” (b).

The members strengthening the construction are called “braces” (c).

NOTES:

Basic shape of the roof construction

It is essential that the roof construction remains rigid. To ensure this, we need to find a shape for it which cannot be distorted.

– NOTE: The only construction shape that cannot be distorted is a triangle.

The strength and efficiency of the triangular construction can be proven by experiment:

For example, a square shaped construction (Fig. 1) can easily be distorted. The only resistance to the distortion is in the corner joints. This construction is called a "non–perfect" or imperfect structure.

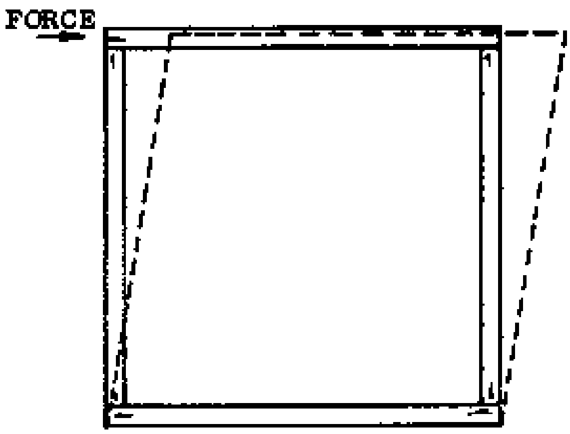


Fig. 1

A triangle shaped structure cannot be distorted (Fig. 2). When force is applied to any part of it, the frame remains rigid. This construction is called a "perfect" structure.

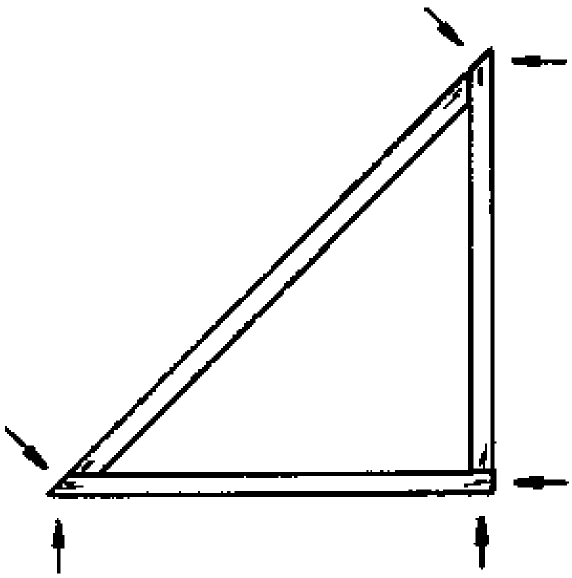


Fig. 2

As soon as a diagonal brace is introduced to a square shaped frame (Fig. 3), it becomes rigid. The brace changes the square shape into two triangles, making it a perfect structure.

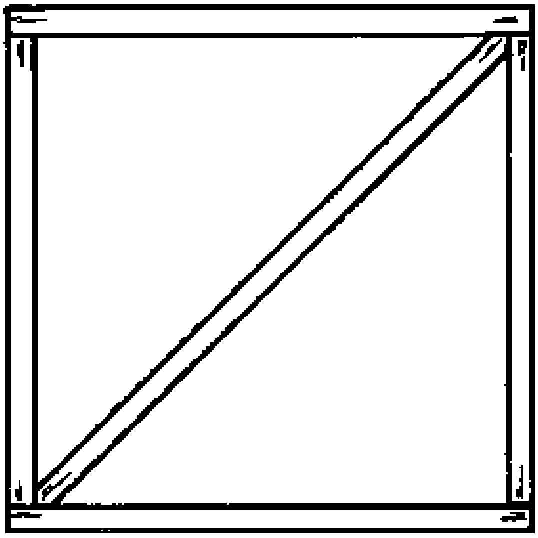


Fig. 3

If the brace were to be installed vertically or horizontally instead of across the diagonal, the structure could still be distorted because it would still be non−triangular, and thus an imperfect structure.

There are many examples of triangular constructions in our surroundings. Look at a bicycle frame, scaffold braces or braces for a door frame, for example.

In Fig. 4 are shown some perfect structures.

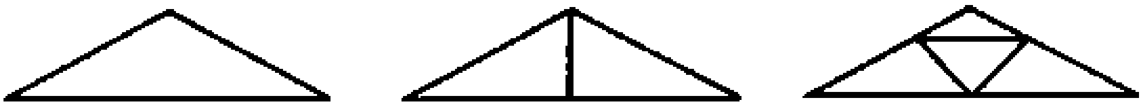


Fig. 4 PERFECT STRUCTURES

In Fig. 5 are shown some imperfect structures.

Fig. 5 IMPERFECT STRUCTURES

In roof construction, it is essential to make only perfect structures.

Technical terms

− TIE BEAM: This is the horizontal member of the roof structure which ties together the feet of the rafters (Fig. 1, next page).

− RAFTERS: These are the sloping members which give support to the purlins (Fig. 1, next page).

− BRACES: These are the members which strengthen the construction.

− ROOF TRUSS: This is the structure made up of the rafters, tie beam and braces, which forms the main load carrying unit in some kinds of roofs.

− PURLINS: These members lie across the rafters and support the roofing sheets.

− RIDGE: This is the highest point of a roof construction.

– RISE OF THE TRUSS: This is the vertical height of the truss (Fig. 1, a), measured between the highest point of the truss and the soffit of the tie beam.

– SPAN OF THE TRUSS: This is the clear horizontal distance between the internal faces of the rafters (b) at the point where they meet the soffit of the tie beam.

– SPAN OF THE BUILDING: The building span is the clear horizontal distance between the inside faces of the walls which support the roof (c).

– OVERHANG: When the tie beam projects beyond the supporting wall, the projecting part is called the overhang (d). The overhang is measured square to the wall.

– OVERHANGING EAVE: When the rafters project beyond the supporting wall, the projecting part is called an overhanging eave (e). The width of the overhanging eave is measured square to the wall.

– EAVE: This is the lowest part of the overhang or overhanging eave (point x).

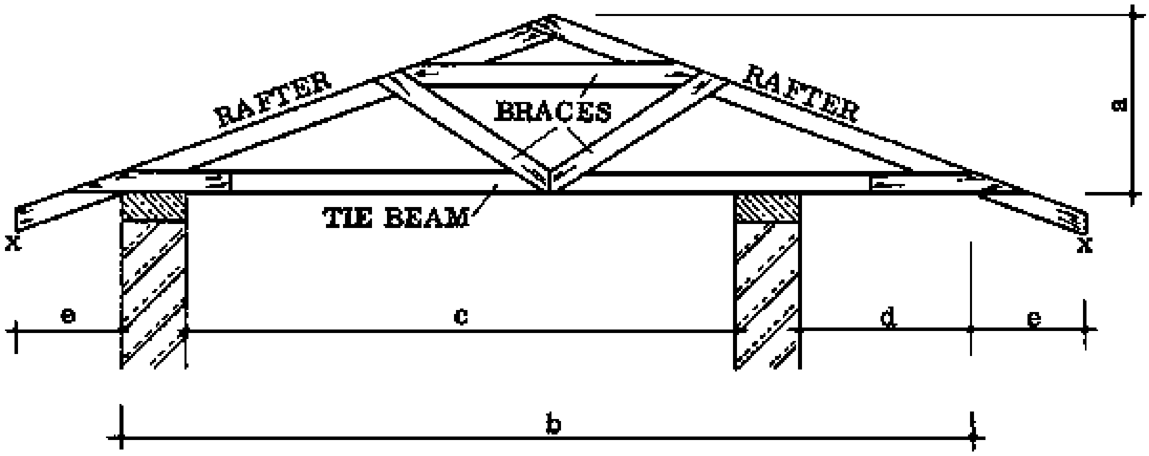


Fig. 1

NOTES:

LENGTHENING JOINTS FOR LIGHT–WEIGHT STRUCTURES

Always select the timbers before starting work on the roof construction. Keep the long straight pieces for the rafters, tie beams, and purlins; and the short pieces for braces.

Sometimes pieces of the right length may not be available. Then it may be necessary to join the members in order to make them longer.

All joints used for lengthening the members of the roof construction will be fish joints with one or two fish plates. These will be discussed in detail in the next section.

Keep in mind that each lengthening joint in the roof construction will weaken the roof. Therefore, try to select the timbers so that you don't need to use many lengthening joints.

Where to place a lengthening joint

It is often difficult to judge where to place a lengthening joint. In general, one can say that it should be as close as possible to a support such as a wall or pillar, but we must also keep in mind that the joint is weak, so it cannot be in a place where it is under strain.

For example: A 6 m long tie beam is needed. The only long piece of wood you have is 5,70 m long. If you join that to a 30 cm piece to make 6 m, then the joint will indeed be near a load–carrying wall – but in relation to the entire structure the joint will be in the wrong place, because most of the weight of the truss is concentrated in that area, where we now have a weak joint.

In this case, a better solution is to join two shorter pieces to get the required length.

Lengthening joints should also not be placed where the braces meet the member.

NOTES:

Fish joints

We have said that a fish joint will be sufficiently strong for most parts of the roof construction. However, when we assemble a fish joint, we have to follow certain guidelines to end up with a strong joint.

A fish joint will usually be assembled with nails. The strength of the nailed fish joint depends first on the number of nails used; and second on whether one or two fish plates are used. The length of the fish plates should be at least 5 times the width of the joined members.

ONE NAILED FISH PLATE

– SHEAR STRESS IN A JOINT WITH ONE FISH PLATE: If one nailed fish plate (Fig. 1) is used, the nails tend to shear off (break) at the joint line between the members and the fish plate because of the force exerted as the members try to move apart (Fig. 3). The joint is said to be in single shear (Fig. 2).

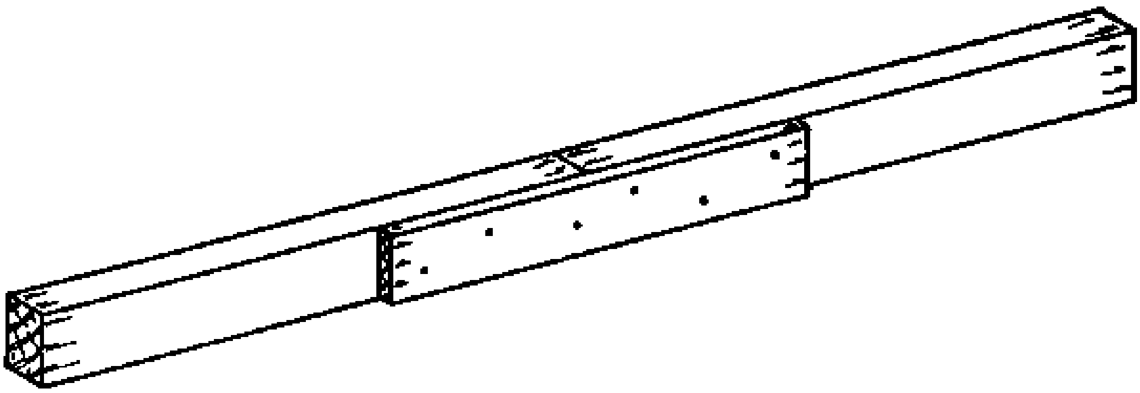


Fig. 1

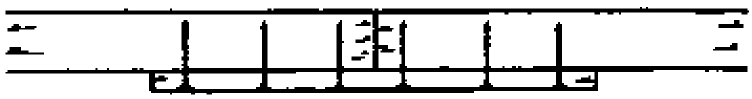


Fig. 2

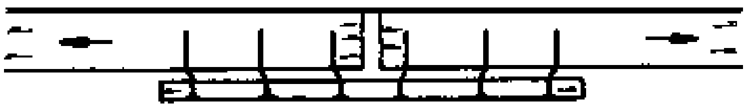


Fig. 3

In order to prevent the members from moving apart and shearing the nails, it is necessary to clinch the nails, so that they are anchored firmly (Fig. 4).

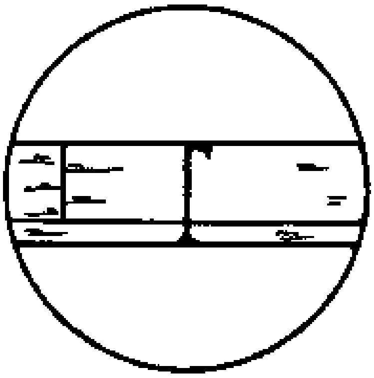


Fig. 4

TWO NAILED FISH PLATES

– SHEAR STRESS IN A JOINT WITH TWO FISH PLATES: When two nailed fish plates are used (Fig. 5) to join the members together, the nails tend to shear at two points. The joint is said to be in double shear (Fig. 6).

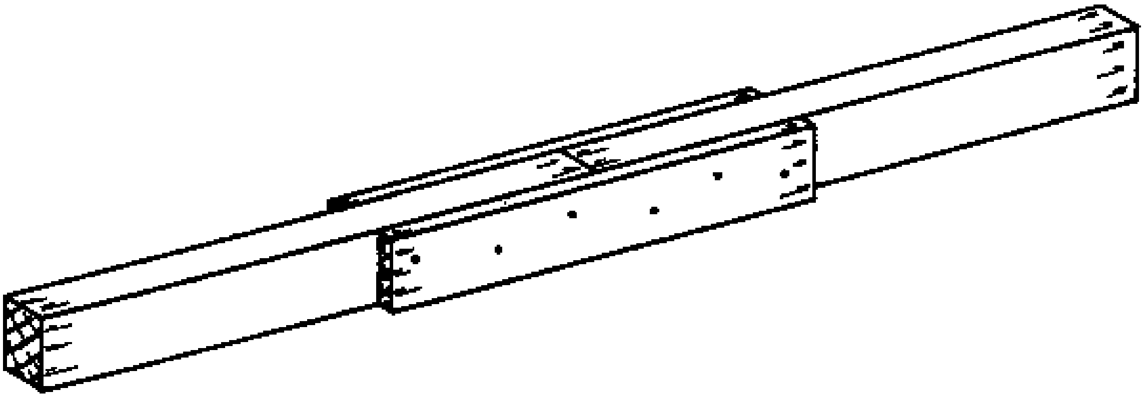


Fig. 5

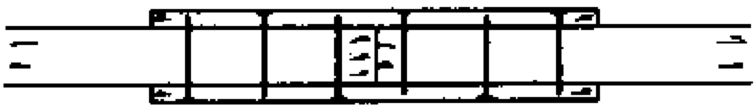


Fig. 6

In this joint there is less tendency for the members to pull apart, since there are two fish plates (Fig. 7). The nails must go through both fish plates.

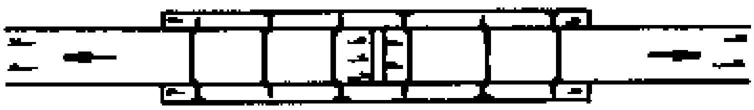


Fig. 7

– NOTE: The strength of a joint in double shear (with two fish plates) is approximately twice that of a similar joint in single shear (with one fish plate).

– NAILING THE FISH JOINT: We have seen that the strength of a nailed fish joint depends on the number of nails used in it and on the number of fish plates. It is important that the nails are fixed correctly, or the joint will be weakened.

- The nails should be evenly distributed over the entire fish plate.
- Nails should always be staggered.
- Nails should always be blunted.

– If thick nails are used, they have a tendency to split the wood. Often staggering and blunting cannot prevent this splitting. In this case it is necessary to drill holes for the nails. The holes should have a slightly smaller diameter than the nails.

There are certain rules for spacing the nails on the fish plate. These are:

– In the direction of the grain, the distance between the nails should be 10 times the thickness of the nail (Fig. 1, next page).

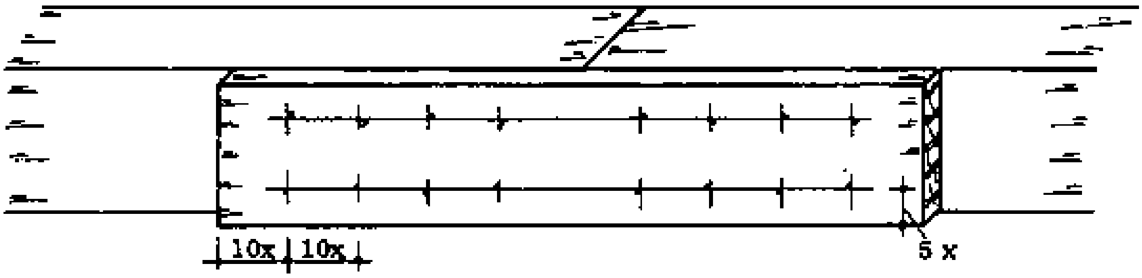


Fig. 1

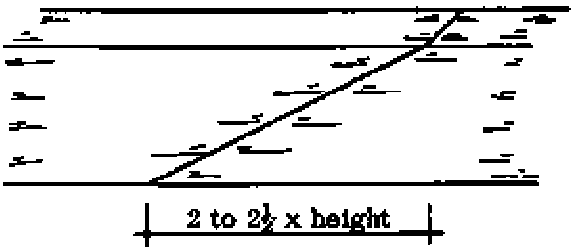
– The distance to the margin of the fish plate should be: in the direction of the grain, 10 times the thickness of the nail; and across the grain it should be 5 times the thickness of the nail (Fig. 1).

– See the Reference Book, page 207, and Basic Knowledge, pages 92 to 94, for more details about nails and nailing.

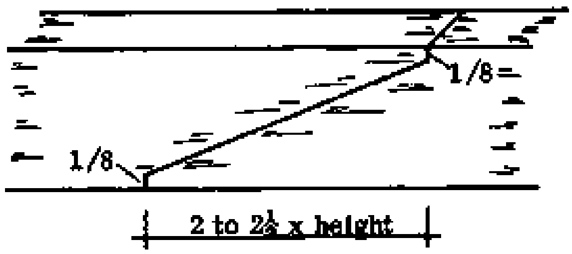
Other lengthening joints

Other joints besides the butt joint with fish plates are sometimes used to lengthen the members of a roof construction. These joints require more work to make and they are not necessarily better than the ordinary fish joint. They are used only if extra strength is required.

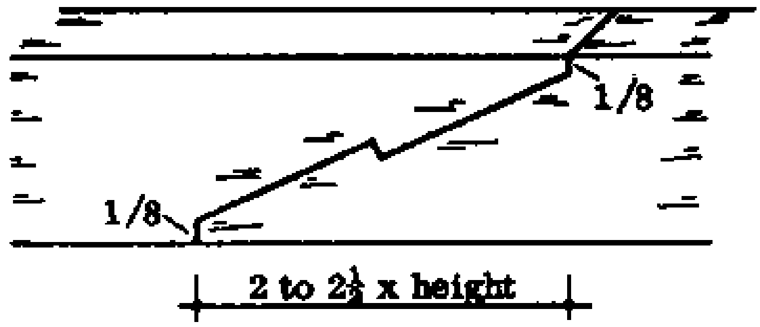
These joints are:



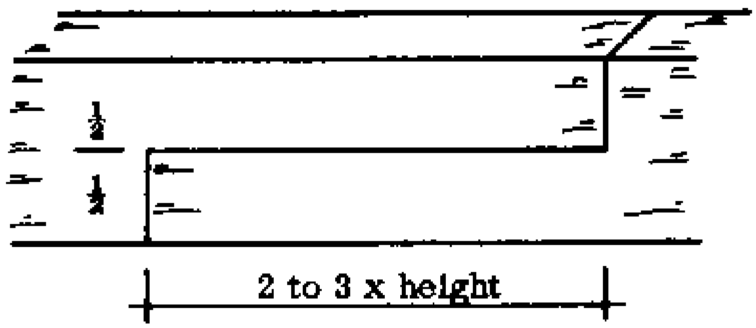
1. COMMON SCARF



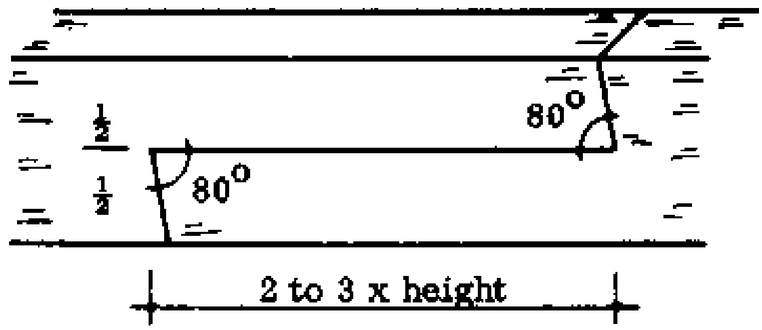
2. STOPPED SCARF



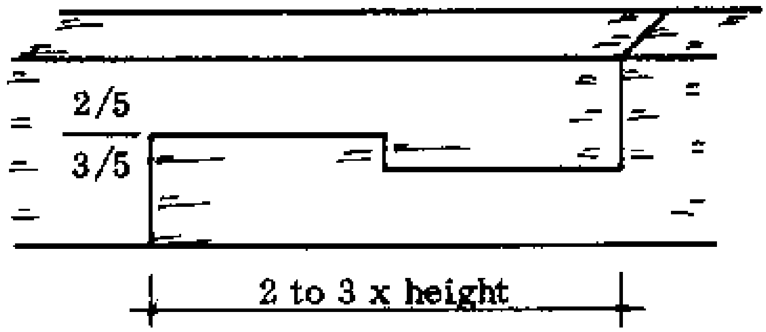
3. STOPPED HOCK SCARF



4. HALVING JOINT (if fish plates are used it is a “splice”)

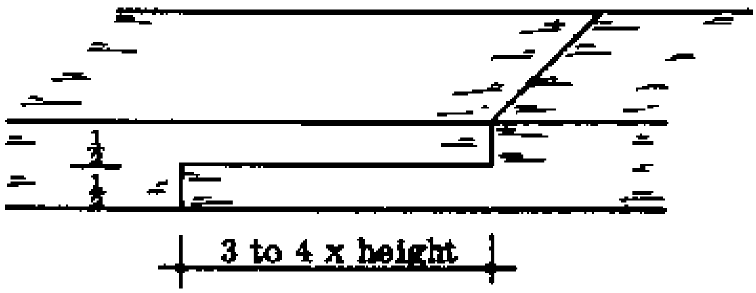


5. HALVING JOINT

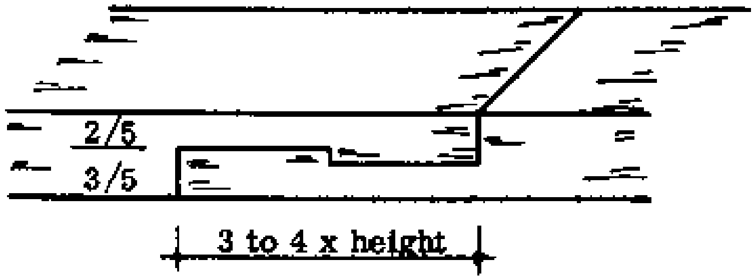


6. HOOK HALVING JOINT

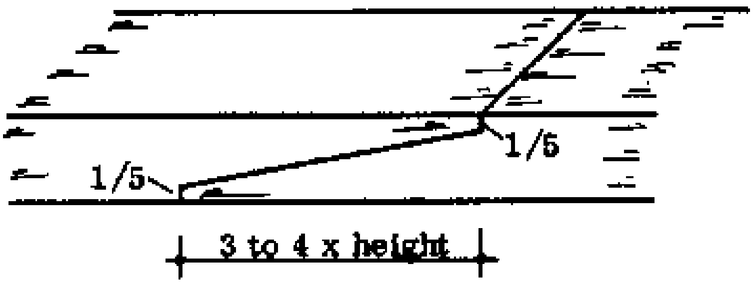
Joints 1−6 are normally used for joining rafters, tie beams or purlins in the length. They can be used with one or two fish plates.



7. HALVING JOINT



8. HOOK HALVING JOINT



9. STOPPED SCARF

Joints 7−9 are used mostly for Joining wall plates in the length. The corner joint for a wall plate can also be a halving joint.

CONSTRUCTION DETAILS

Lean−to roof

A lean−to roof is a sloping roof attached to the wall of another building. It is “leaning” against the building. It is usually used for a small store or similar building which is attached to an existing building. The main members are: (Fig. 1)

− the wall plate (a)	5 x 10 to 15 cm
− the rafters (b)	5 x 7,5 to 10 cm
− the purlins (c)	5 x 7,5 cm
− the fascia board (d)	2,5 x 20 to 30 cm
− the sheet material (e)	

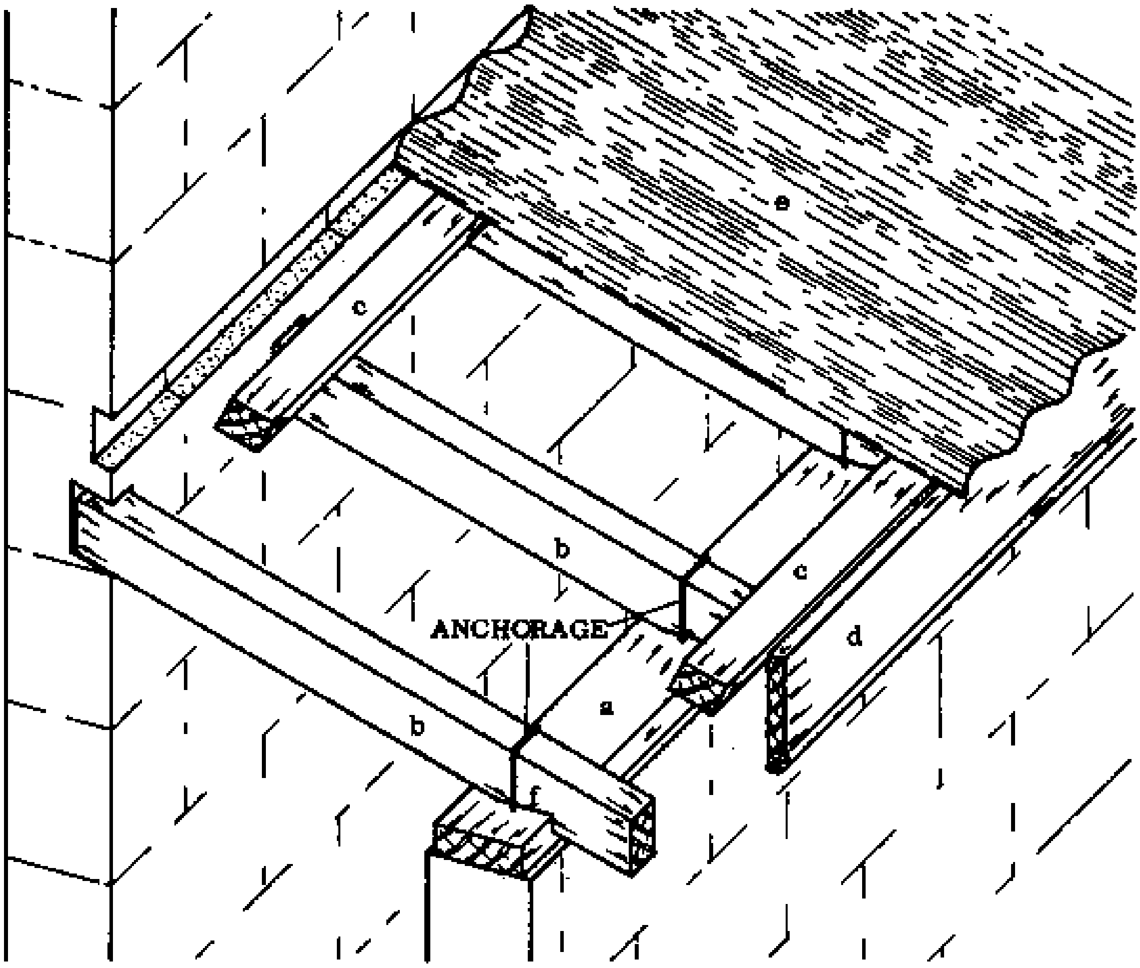


Fig. 1

The above measurements can be used as a guide in selecting timbers for this kind of roof.

Below are some rules for the construction.

– A good method for fixing rafters onto the main wall is to chisel holes in the wall into which the rafters can be fitted. The holes should be deep enough to ensure a safe rest for the rafters (Fig. 1).

– The lower part of the rafter should rest on a wall plate (a) or a concrete belt. The rafter and wall plate should be firmly anchored through at least 3 courses of blocks.

– The rafters should each be fitted with a “bird's mouth” near the end (f). The depth of the bird's mouth should be 1/5th of the width of the rafter. This is so that the rafters rest securely on the horizontal support.

– The purlins (c) should be well secured to the rafters.

– To prevent water from entering between the wall and the sheeting material, the part of the sheet which attaches to the main wall should fit into a recess in this wall, so that the ends of the sheets can be plastered over later (Fig. 1).

– In an open fronted structure, the roof is supported by pillars on the open side, instead of by a wall. The plate which rests on the pillars and supports the rafters is called the “eave plate” (Fig. 2, g). The size of the eave plate should be about 5 x 7,5 to 10 cm.

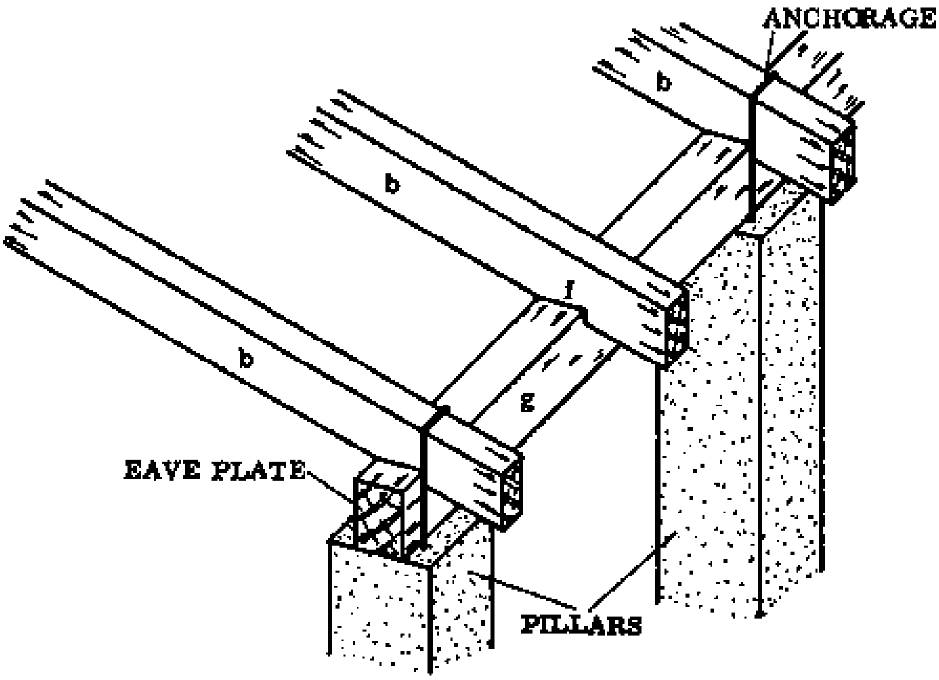


Fig. 2

– Remember that in an open construction the pillars must not only support the dead load of the roof construction, but also must be strongly anchored in the ground so they cannot be pulled out by a strong wind catching the roof from underneath.

– Note that in an open–fronted construction side walls are to be avoided. If they are required, there must be openings in them to permit wind to escape. A building with an open front should never face in the direction of the prevailing wind (the direction from which the wind usually comes).

NOTES:

Pent roof

A pent roof is a roof which slopes to one side. It differs from a lean–to roof in that it is not attached to the wall of another building, but is supported by its own walls.

In Rural Building, we deal with two types of pent roof: the ordinary pent roof and the enclosed or parapetted pent roof.

– ORDINARY PENT ROOF: In this roof, the rafters and purlins project beyond the outside walls and a fascia board is fixed all around the building. The pitch of this roof will usually be about 15 degrees. The main members are: (Fig. 1)

– the wall plate (a)	5 x 10 to 15 cm
– the rafters (b)	5 x 15 cm
– the purlins (c)	5 x 7,5 cm
– the fascia (d)	2,5 x 20 to 30 cm
– the sheet materials (e)	

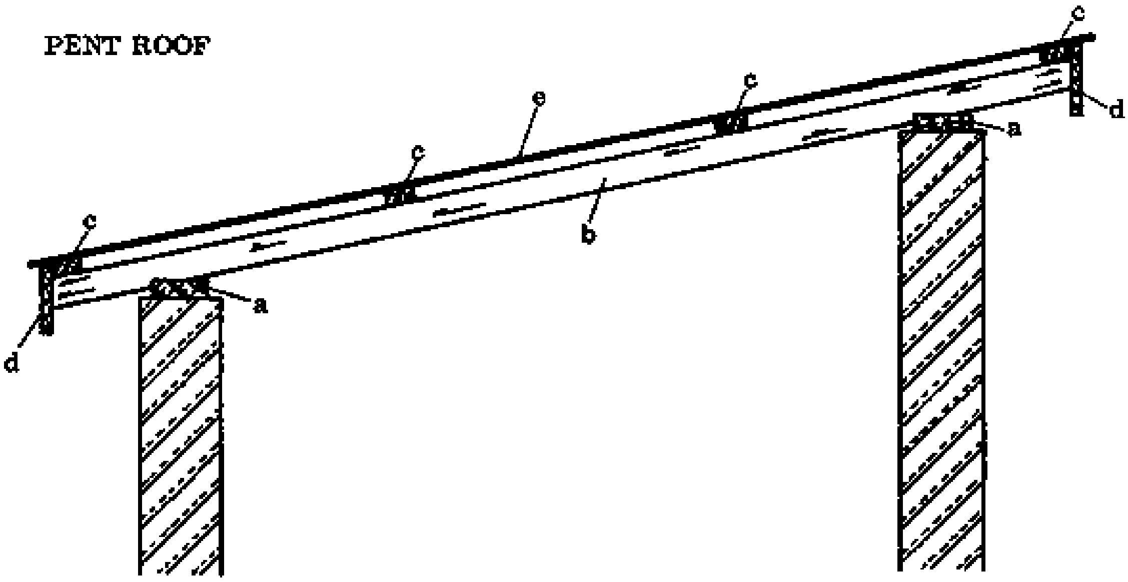


Fig. 1

The above timber measurements can be used as a guide in selecting the timbers for an ordinary pent roof; that is, a pent roof with a span of less than 3,5 m. The distance between rafters should be 1 to 2 m, and the distance between the purlins depends on the size of the sheet material.

There are certain rules for constructing this type of roof:

– The rafters should always be fitted with a bird's mouth so that they rest securely on the wall plate (Fig. 2).

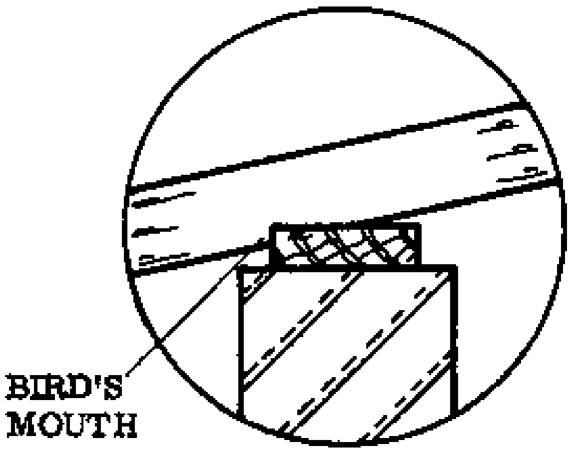


Fig. 2

– Wall plates, rafters, and purlins should be well anchored (see the section on anchorage which comes later in this book).

The pent roof is often used because it is cheaper to construct than other roofs, since only rafters and purlins are used, and no tie beam, braces, etc. are needed.

NOTES:

– ENCLOSED OR PARAPETTED PENT ROOF: In this roof, the higher wall and the two sloping walls enclose and protect three sides of the roof. The parts of the walls which project above roof level are called parapets. Parapets help to reduce suction on the roof and to keep the sheets in place. The pitch of this roof will be about 15 degrees (Fig. 1). The parts of the roof are:

– the wall plate or concrete belt (a)

– the rafters (b)	5 x 7,5 cm
– the tie beam (c)	5 x 7,5 cm
– the braces (d)	2,5 x 7,5 cm
– the purlins (e)	5 x 7,5 cm
– the fascia (f)	2,5 x 20 to 30 cm
– the sheet material (g)	
– the parapet (h)	

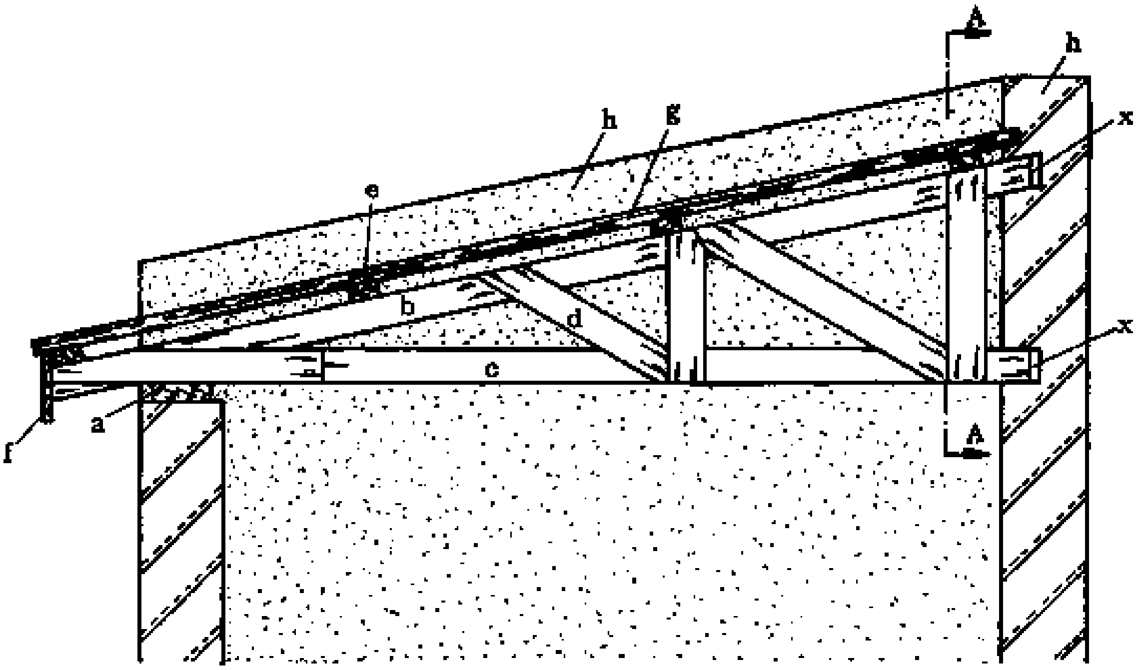


Fig. 1

The measurements above can be used as a guide for constructing this kind of roof. The distance between the rafters should be 1 to 2 m, and the distance between the purlins will depend on the size of the sheet material.

Keep in mind the following construction pointers:

– A built–up structure is used for this roof (a half truss). We will learn about how to make the truss in a later lesson.

– Before the half truss is erected, all the walls should be built to the level of the tie beam. The truss is then erected and the walling continued.

– There should be an expansion gap at the end of each rafter and tie beam (Fig. 1, x) where they fit into the wall; and at the ends of the purlins (Fig. 2, x). The gap prevents the wall from being cracked when the wooden member expands.

– The sheet material should be fixed so that about 1/3rd of a corrugation on each side of the roof is enclosed in the wall (Fig. 2). To keep water out, this edge should be pointing upwards (Fig. 2a).

– Leave about 10 cm space between the last truss and the wall so that there is enough space for plastering (Fig. 2, y).

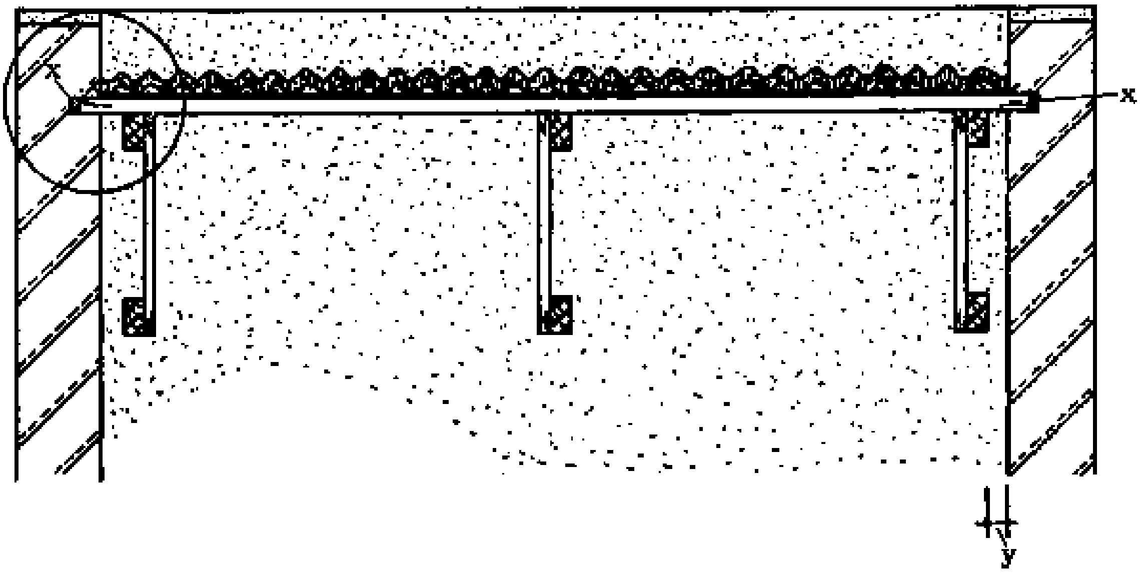


Fig. 2 CROSS SECTION A–A

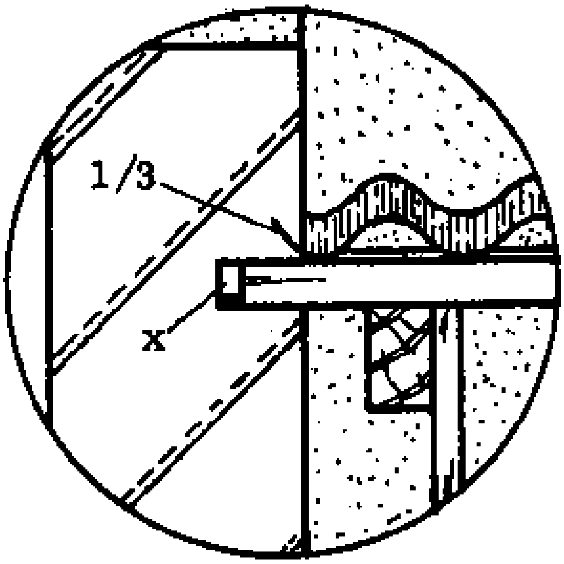


Fig. 2a ENLARGED DETAIL

NOTES:

Gable roof

This is a roof which slopes down on the two sides of the ridge and has a gable on one or two end walls. The gable is the triangular shaped part of the end wall where it comes up to the sloping edges of the roof.

The advantage of the gable roof over the pent roof is that it can be constructed to permit cross ventilation. It can be used for large or small spans.

In Rural Building, the kind of gable roof we make is constructed with built–up trusses. The main parts and members of the gable roof are (Fig. 1):

– the wall plate or concrete belt (a)

– the rafters (b) 5 x 7,5 cm

– the tie beam (c) 5 x 7,5 cm

– the braces (d) 2,5 x 7,5 cm

– the purlins (e) 5 x 7,5 cm

– the fascia (f) 2,5 x 20 to 30 cm

– the sheet materials (g)

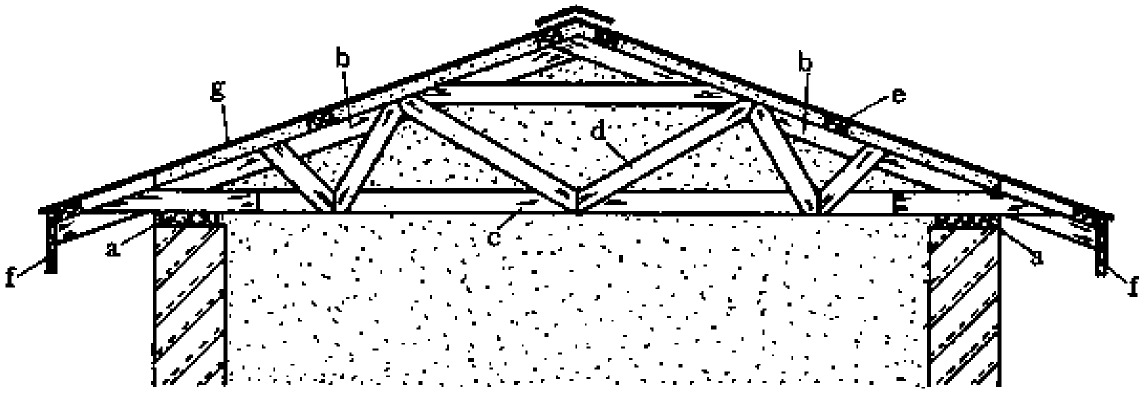


Fig. 1

The above measurements should be used as a guide when you make this type of roof. The distance between the trusses will be about 200 cm. The last truss should be close to the wall, except if parapets are used. In that case leave about 10 cm space for mortaring.

The gable ends can be constructed so that the purlins project beyond the gable and the fascia boards are nailed onto them. The end sheets should be nailed so that the last corrugation folds down over the top of the fascia.

Another way of constructing the gable is to put a parapet on top of the gable in the same way as for a parapetted pent roof. Again, the sheets should be enclosed in the parapet wall by about 1/3rd of a corrugation, with the edge pointed up.

The parapet can be on top of the gable wall only (Fig. 2), or the wall can project with the parapet beyond the ends of the sheets (Fig. 3).

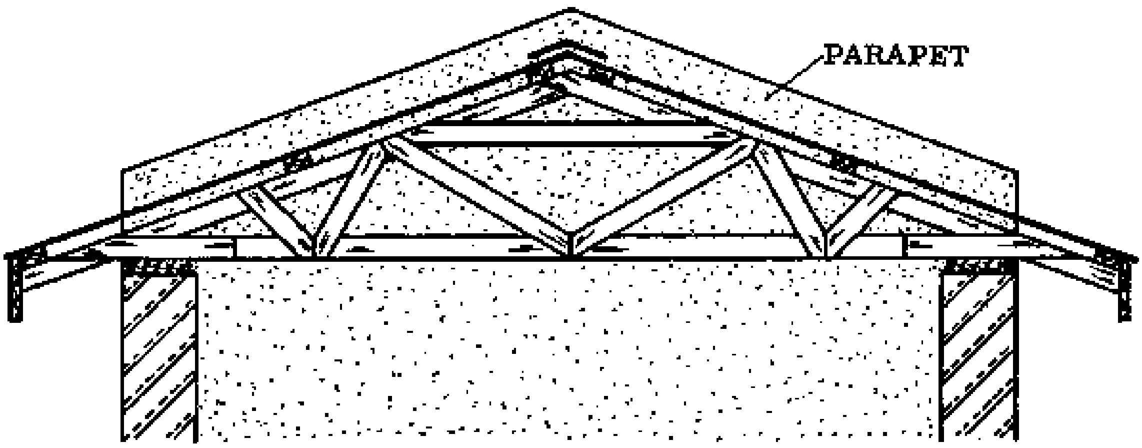


Fig. 2

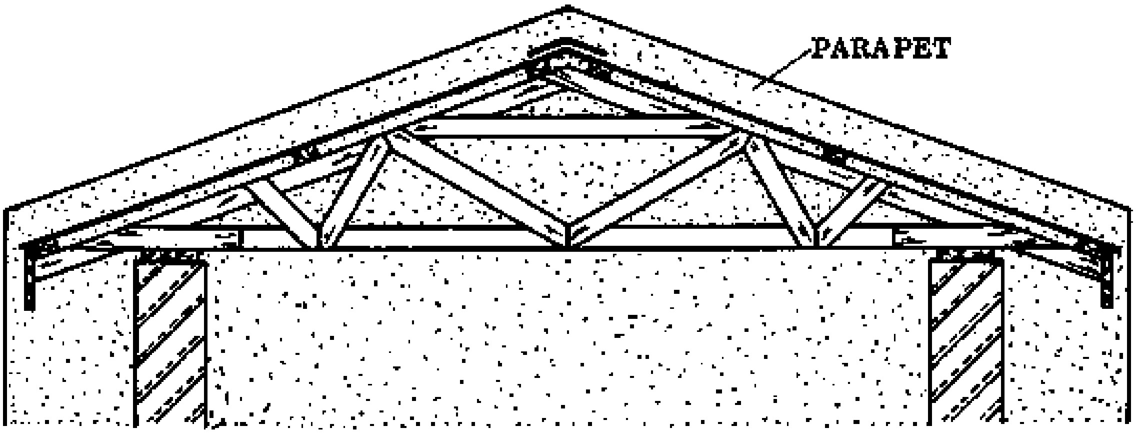


Fig. 3

NOTES:

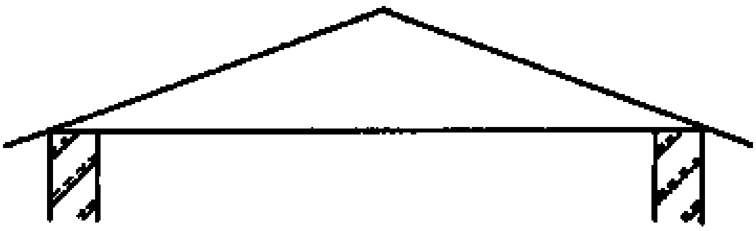
Designing built−up trusses

Built−up trusses are used in gable roofs to support the purlins and the roof covering.

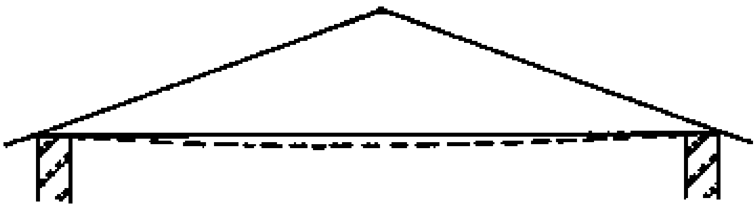
In constructing these trusses, we must remember the principle of “perfect structures” (see Light−Weight Structures), otherwise the roof construction may get distorted.

The following points will show why roof trusses are built up in the way they are.

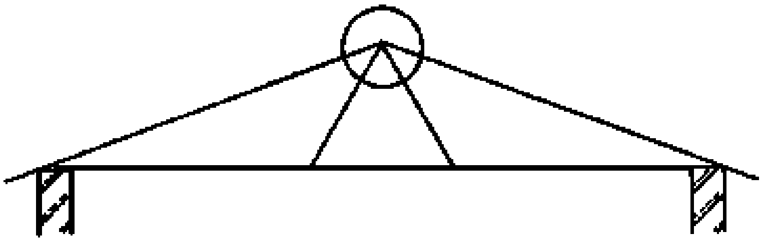
1. Figure 1 shows that a roof construction of only rafters tends to spread the walls. This is because the roof doesn't have a triangular shape, so it is not a perfect structure. This construction could cause damage to the walls, the roof, and the whole building.



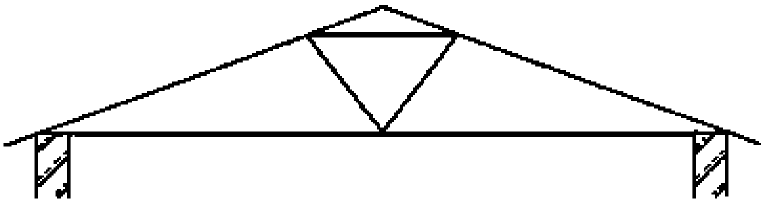
2. As we see in Fig. 2, as soon as a tie beam is introduced we get a triangular shaped, perfect roof structure.



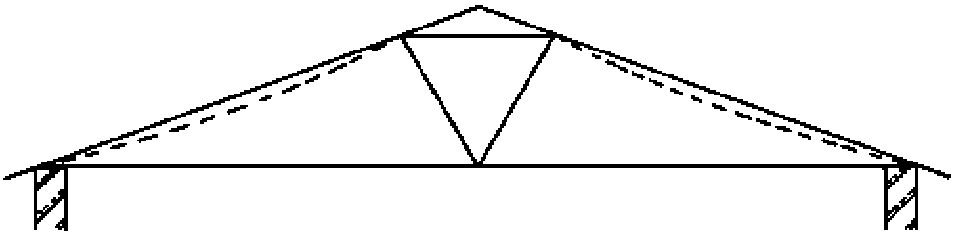
3. As the span of the roof increases the tie beam tends to sag.



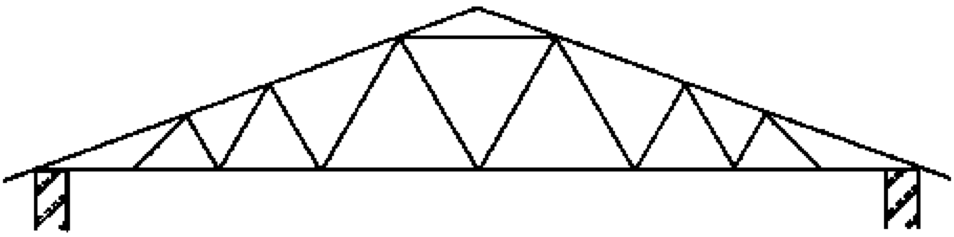
4. To prevent the sagging of the tie beam, braces are introduced. Because there are 4 members (2 rafters and 2 braces) that meet at the ridge, there is a danger of over−nailing the joint, which would weaken the truss. Therefore we need to find another way of fixing the braces while keeping a perfect structure.



5. This is a possible solution to prevent overnailing.



6. As the span increases still further the rafters will also be longer and they will tend to bend.



7. To prevent the rafters from bending, more braces are introduced.

Joints for the truss

At the ridge, two rafters must be joined together. This is done with a halving joint (Fig. 1).

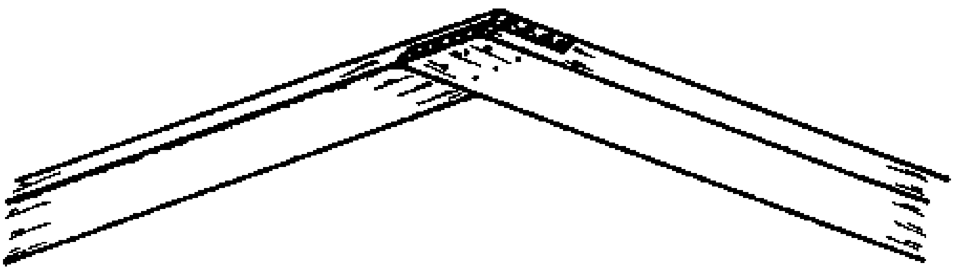


Fig. 1

The halving joint is assembled with a few long nails. They should be long enough that they can be clenched on the opposite side. Take care not to overnail the joint.

The rafter – tie beam joint can be a fish joint with two nailed fish plates (Fig. 2). After the fish plates are fixed, they must be cut so that they don't project past the edge of the rafter.

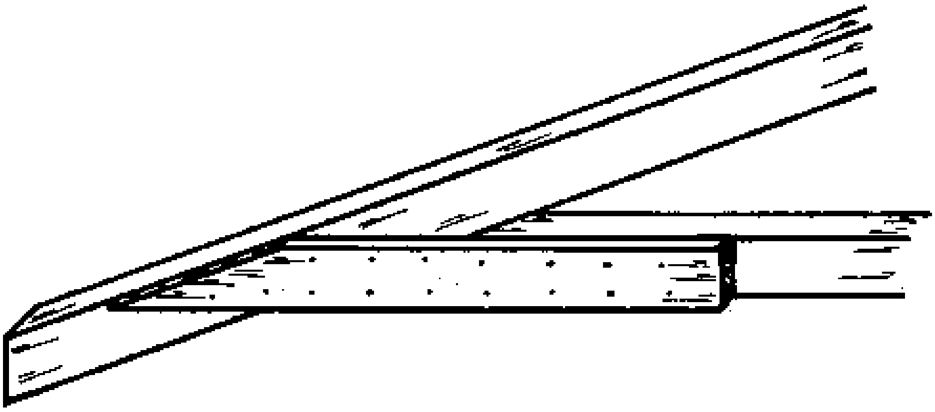


Fig. 2

If large trusses are made, short braces can be used to strengthen the joint instead of fish plates (Fig. 3).

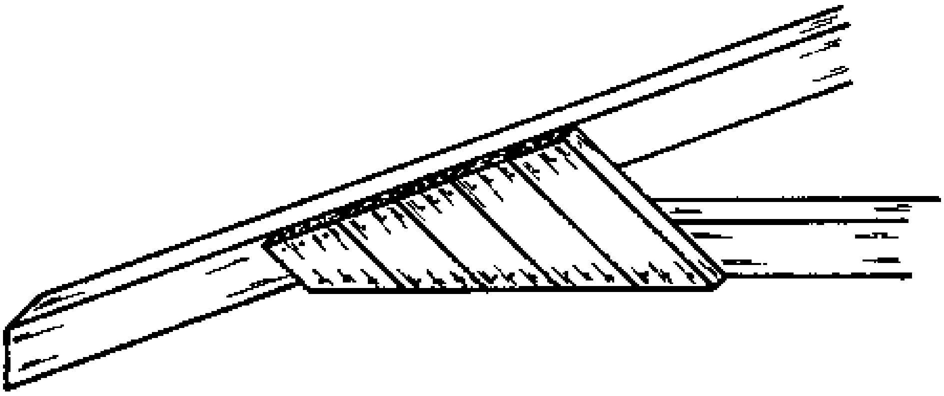


Fig. 3

The braces are added according to the required pattern of the truss. At the place where the two braces meet, they should be cut so that the areas where they are nailed to the truss (areas a and b) are as large as possible and of equal size on both braces (Fig. 4).

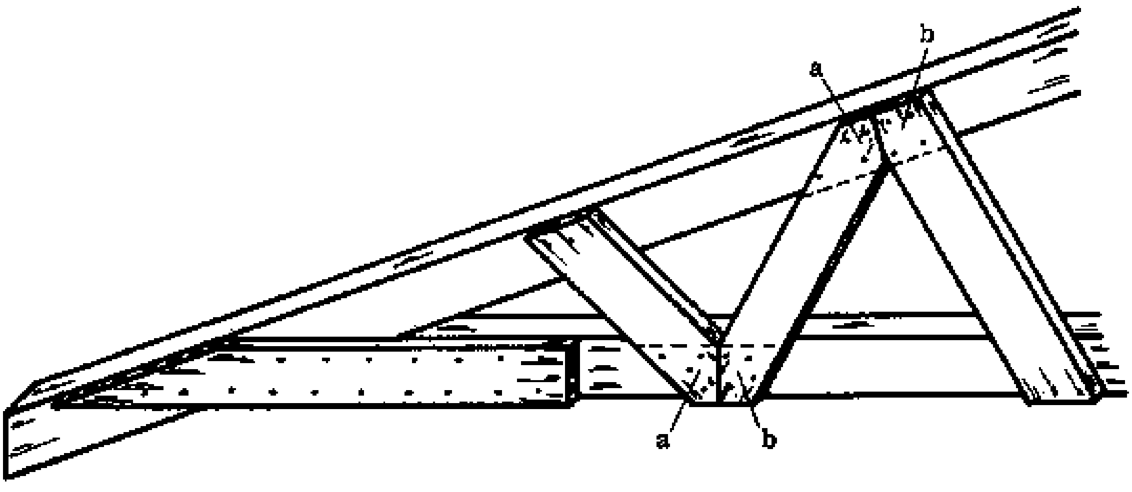


Fig. 4

This is done by placing them on top of each other, marking and cutting during the assembly of the truss.

All of these reinforcements can be added on either one or both sides of the truss, depending on the strength that is needed for the construction.

NOTES:

Marking out built−up trusses

Before you start to mark out the trusses, measure the span of the building at several points and find out the span of the truss. Make sure that the truss is long enough to cross even the widest span of the building.

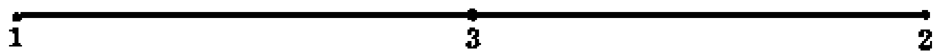
Do not forget the difference between the span of the building and the span of the truss. You must take into account any verandahs or overhangs in the span of the truss. The outline design will help you to find out the different spans for the building and the truss.

The marking out is done in a cleared, flat area of the building site. After the area is cleared, the shape of the trusses is laid out with iron pins knocked in the ground and with the mason line.

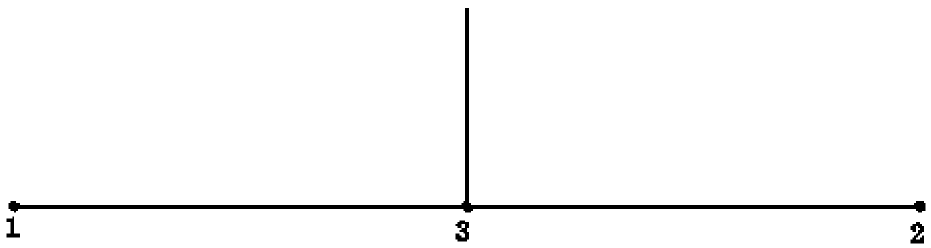
− SEQUENCE OF OPERATIONS:

a. Place pegs 1 and 2 at a distance equal to the span of the truss, and stretch a line between them.

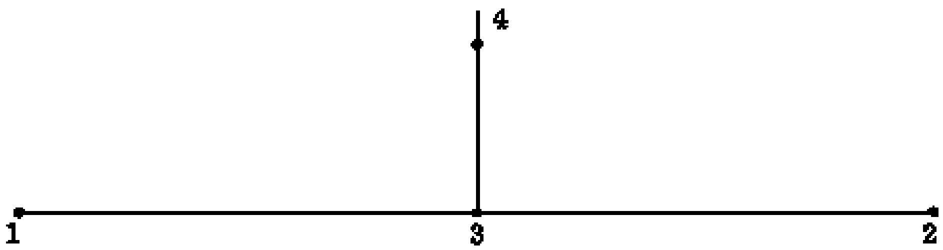
b. Divide the distance from point 1 to point 2 in half, and mark point 3.



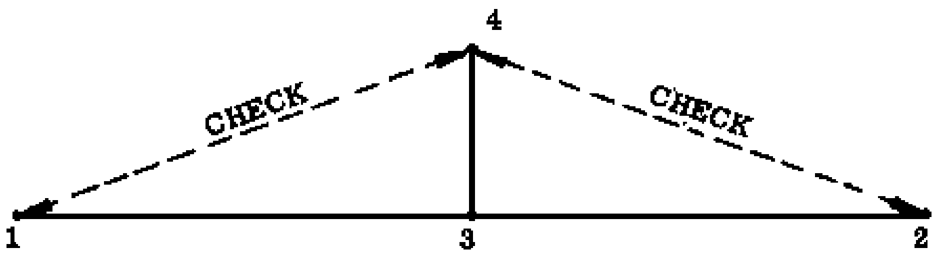
c. From point 3, erect a line perpendicular to line 1−2 (use a large square or the 3−4−5 method).



d. Place peg 4 along the line from point 3, at the distance of the required rise of the truss.



e. Check that the distances 1−4 and 2−4 are equal.



f. Check that the roofing sheets will fit as planned, including a sufficient over lap. Check this by measuring from peg 1 to peg 4, then add the overhang and the projection of the fascia board.

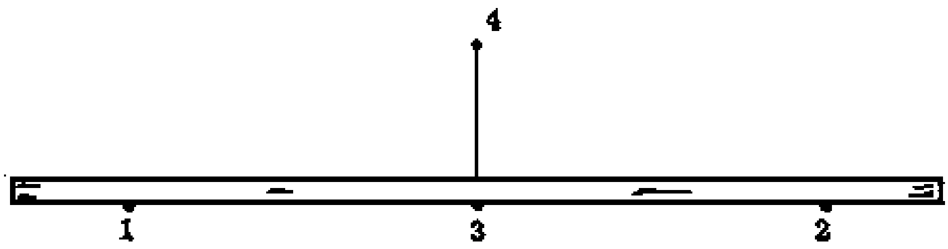
NOTES:

Assembly of built-up trusses

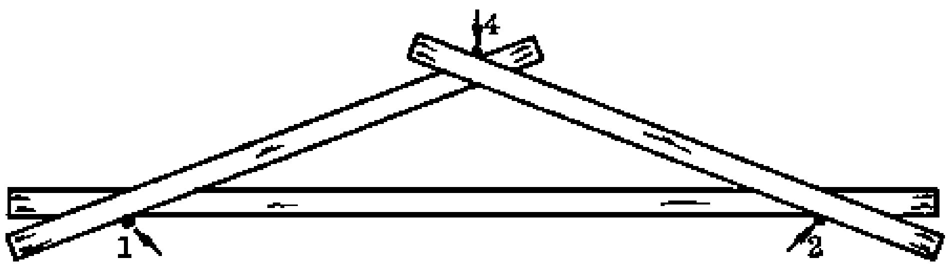
Before you assemble the truss select the timbers, measure them against the setting out, and if necessary join pieces to get members with the required lengths (see Lengthening Joints, pages 169 to 173).

– SEQUENCE OF OPERATIONS:

a. Lay the tie beam along the line from peg 1 to peg 2.

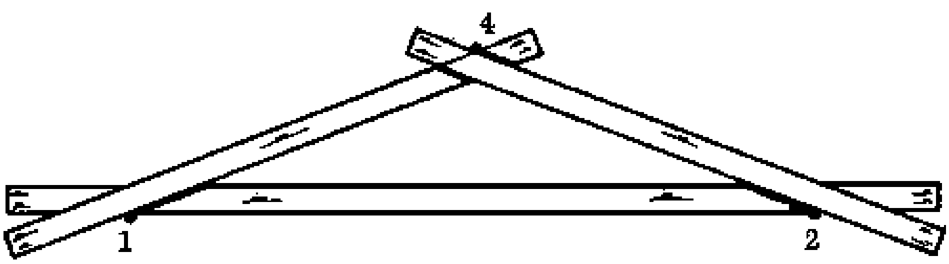


b. Place the two rafters between pegs 1 and 4; and between pegs 2 and 4. Note the positions of pegs 1, 2 and 4 with respect to the boards. This is very important. Rafters should be slightly longer than needed. This allowance is cut off after the trusses are erected.

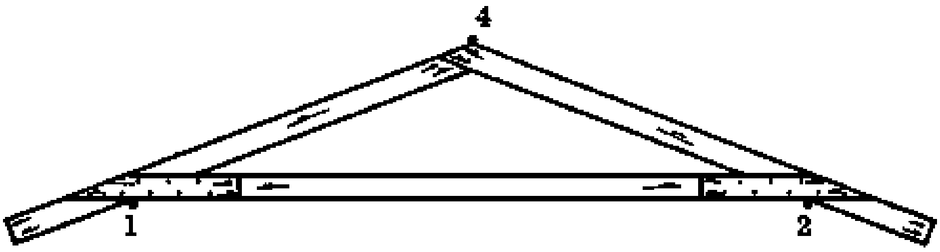


c. Mark the halving joint on the rafters at the ridge and cut it.

d. Mark the cutting lines on the tie beam and cut the ends.

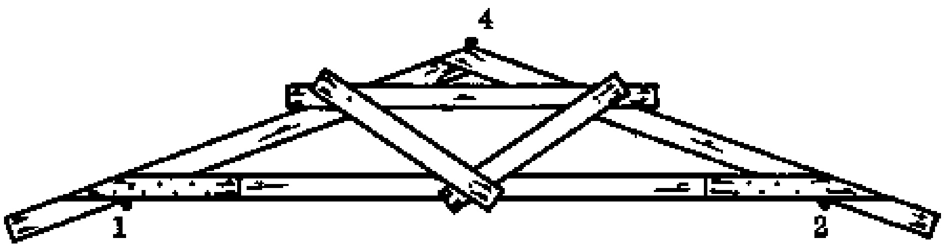


e. Assemble the ridge joint with a few nails; and the rafter to tie beam joint with fish plates.



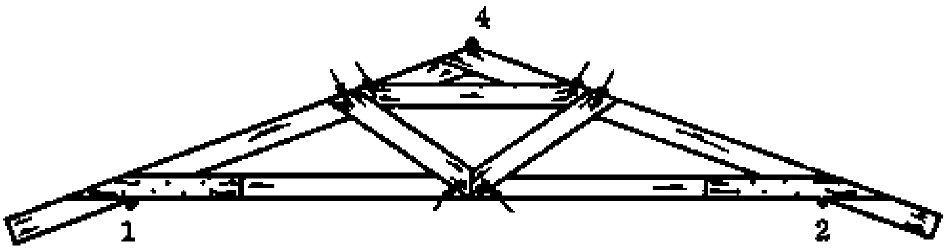
f. Mark the positions of the braces according to the plan, on the rafters and tie beam.

g. Lay the braces one over another on top of the tie beam and rafters. Use a single nail to fix them temporarily.



h. Cut the braces to the correct shape, keeping in mind that the size of the area where each is nailed to the truss must be the same for all of them (arrows).

i. Fix the braces with nails.



j. After the braces are fixed, if necessary a second fish plate can be fixed on the other side of the rafter–tie beam joint. Turn the truss over and fix this plate. Sometimes it is also necessary to fix braces on both sides.

k. Mark the positions of the purlins on the rafters. This will make work easier later on.

l. The other trusses can be assembled on top of the finished first truss.

– NOTE: Always use dovetail nailing, throughout the truss.

NOTES:

Erecting a roof structure for a gable roof

As soon as the trusses are finished, the roof can be erected. If wood preservatives are used they should be applied before the truss is erected. Creosote is often used as a preservative for trusses. If the roof will not be erected immediately, keep the trusses dry and in a shady place.

– SEQUENCE OF OPERATIONS:

a. Hang a truss upside−down across the span of the building, at each gable end (Fig. 1).

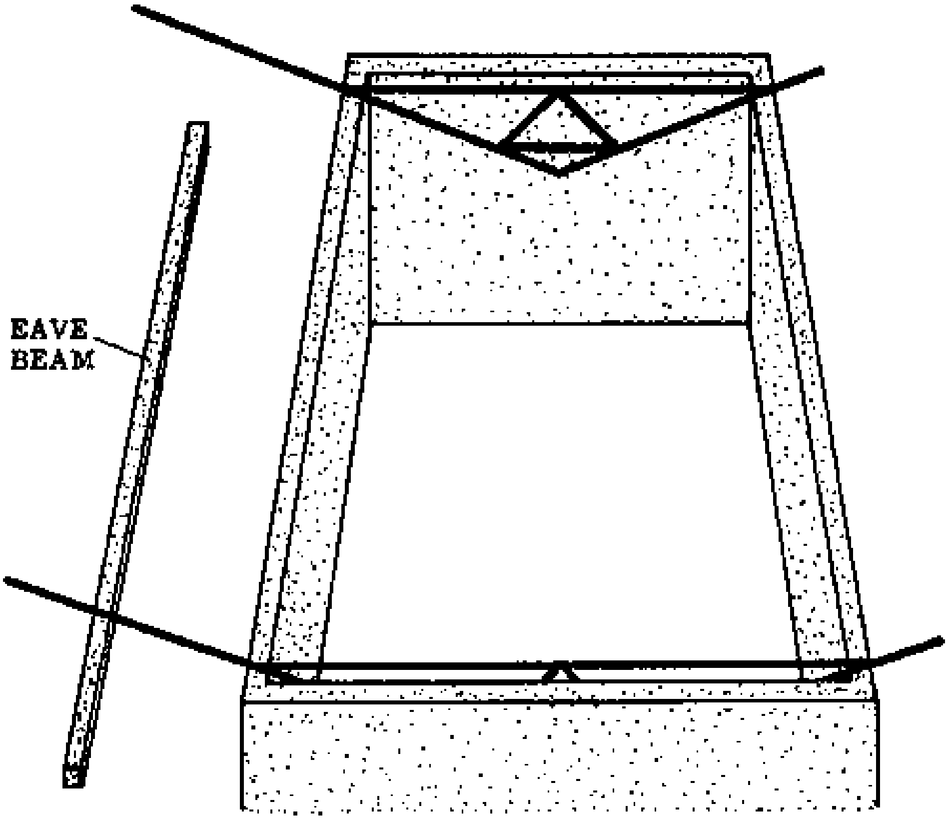


Fig. 1

b. Turn the trusses over and plumb them (Fig. 2).

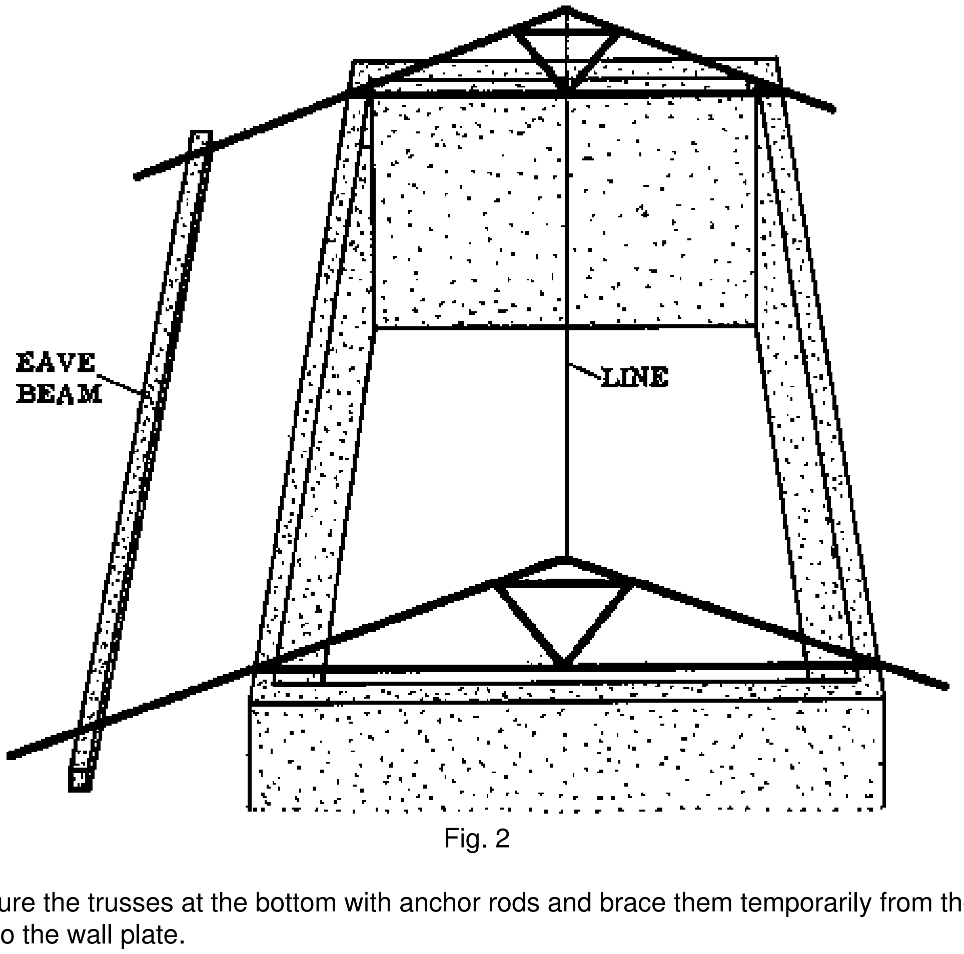


Fig. 2

c. Secure the trusses at the bottom with anchor rods and brace them temporarily from the rafter to the wall plate.

d. Fix a line from one ridge to the other (Fig. 2).

e. Hang the other trusses, one after the other, upside−down between the walls. Turn each one over and plumb it according to the line before hanging the next one. Brace them temporarily.

f. Nail the purlins according to the measurements of the roof covering (the sheets) and secure them (a section on Anchorage is included later in this book). If the rafters overhang to cover a verandah, make sure that the eave plate is also well secured.

g. Fix a line at the bottom end of the rafters, on the gable ends of the roof, at the level of the required overhang. Cut off the ends of the rafters according to the line.

h. Cut off the purlins to the correct length.

i. Build up the gables.

j. Nail the fascia boards on the purlins and rafter ends.

Once the roof structure is erected, cover it as soon as possible to keep out the sun and rain; otherwise the wood may start to twist and the joints will loosen. If the trusses rest on a concrete belt, put roofing felt between the concrete belt and the tie beam to help prevent dampness.

NOTES:

Purlins

The function of the purlins is to support the roofing sheets and to stiffen the whole roof structure. They are supported by the trusses and sometimes the gable ends. The lengthening joints for purlins can be fish joints.

The size of the purlins should be 5 by 7,5 cm.

The lowest purlin of the construction is called the eave purlin (Fig. 1). The highest one is called the ridge purlin.

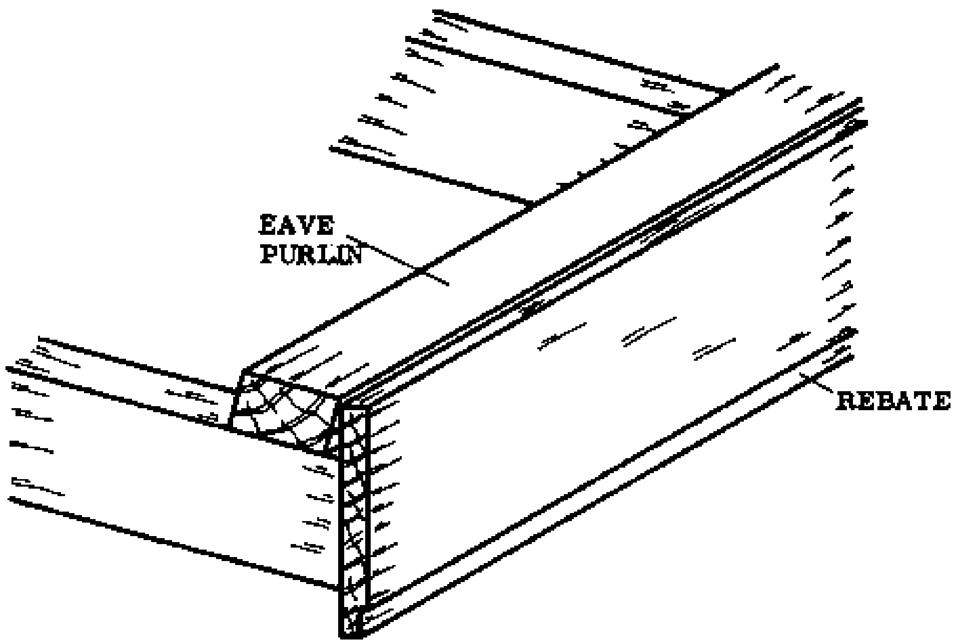


Fig. 1

To make a wider area for nailing the sheets, lay the purlins flat on the rafters. If larger distances must be bridged, lay the purlins on edge. This reduces the nailing area, but it prevents the purlins from sagging.

The distance between the purlins depends on the size and type of sheets which are used for the roof covering. If thick sheets with the normal 244 cm length are used, then one purlin at each end of the sheet plus one in the middle will be sufficient. For very thin sheets one extra purlin should be added for each sheet.

If the building will require more than 2 sheets to cover the length of the rafter, be careful that the purlins are set at the correct distance apart.

It makes work much easier if you mark the positions of the purlins on the rafters as you assemble the trusses.

Fascia boards

Fascia boards are often added to the roof construction. They are wide boards which are fixed on the rafter ends and the purlin ends at the gables of the roof construction.

Fascia boards are about 20 to 30 cm wide and 2,5 cm thick. A small rebate can be made into the lower edge of the board to give it a better appearance (Fig. 1).

If the rafter projects below the fascia it can be cut off as shown in Fig. 2.

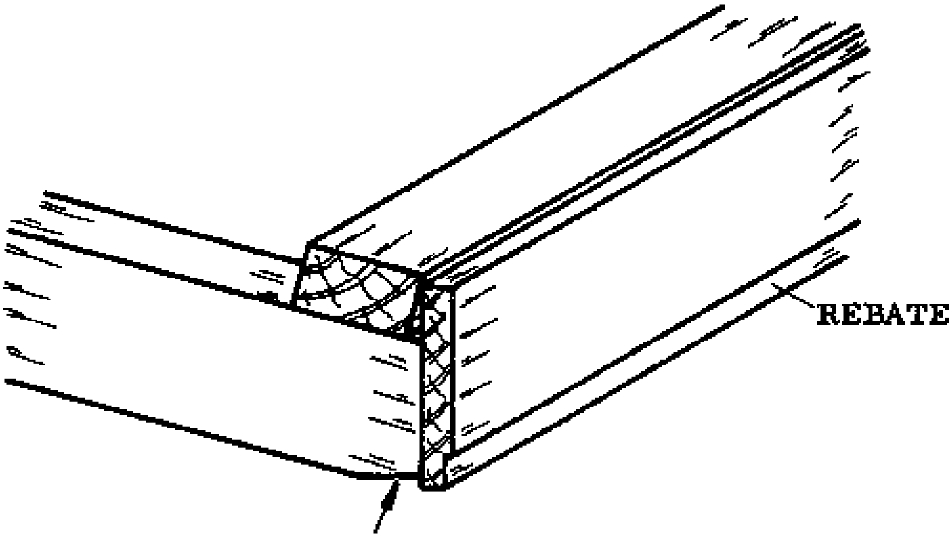


Fig. 2

The eave purlin should be at the correct height so that it does not interfere with the fascia. The fascia boards are fixed before the sheets are laid.

A butt joint is sufficiently strong to use for lengthening the fascia boards, if a fish plate is nailed behind it for strength (Fig. 3). The corner joints should all be mitre joints so that the end grain of the boards is not exposed (Fig. 4).

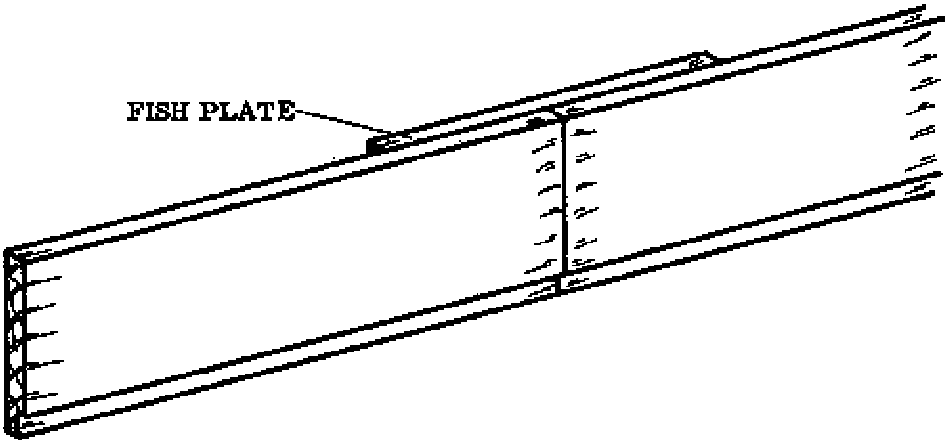


Fig. 3

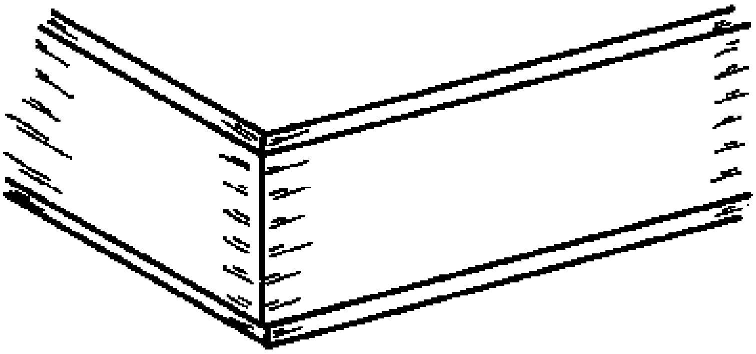


Fig. 4

Before the boards are fixed they should be painted, since it will be difficult to reach some parts later, especially the top edge. Pay special attention to the places where they are joined together. The end grain should be soaked with paint to prevent water from entering there.

Verandahs

When a building with a gable or pent roof has a verandah, there are two possible methods for constructing a roof to cover it:

– By extending the tie beams to cover the verandah (Fig. 1)

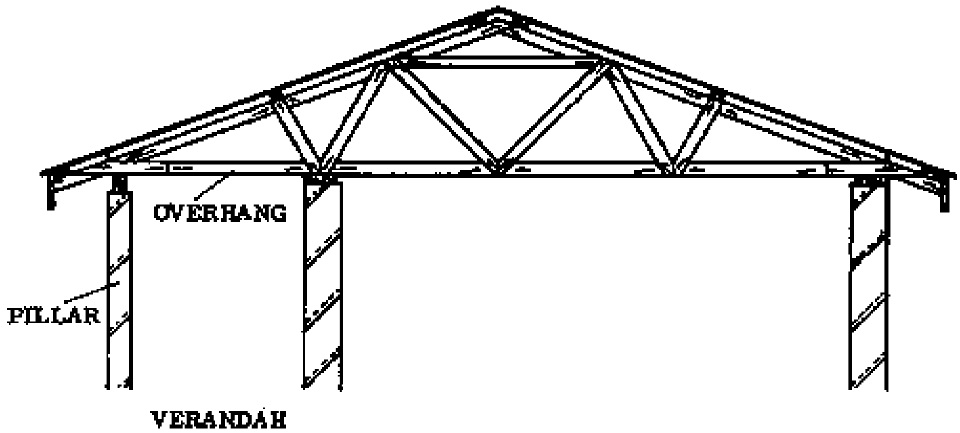


Fig. 1 EXTENDING THE TIE BEAMS

– By extending the rafters to cover the verandah (Fig. 2).

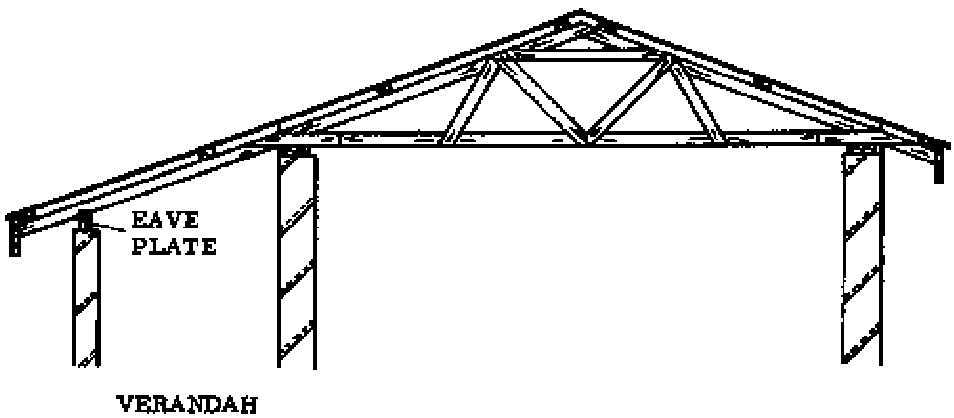


Fig. 2 EXTENDING THE RAFTERS

– REMEMBER: Open verandahs should not face the direction of the strongest winds.

– EXTENDING THE TIE BEAMS: The part of the tie beam that covers the verandah is called the overhang (Fig. 1). For a small overhang, supporting pillars are not necessary, but it should be braced very well. If the overhang is wide, then pillars are needed to support it (Fig. 1).

If the building has a gable roof, an ordinary truss construction can be used, with the span of the truss including the width of the verandah.

Since the parapetted pent roof has a half truss construction with a tie beam, this construction may also be used with it.

– EXTENDING THE RAFTERS: The overhanging rafters cover the verandah. Note that the building must be high enough so that the lower edge of the verandah is not inconveniently low (Fig. 2). This construction can be used with either an ordinary pent roof or a parapetted pent roof as well as with a gable roof.

The feet of the rafters are supported by an eave plate or a concrete eave beam which rests on pillars. The joint between the rafters and the eave plate should be a bird's mouth to ensure proper support for the rafters. The depth of the bird's mouth should be about 1/5th of the width of the rafter.

The eave plate is normally set edgewise on the pillars. In most cases 5 x 10 Odum is large enough for the eave plate. Take care that it is well anchored on the pillars.

There are certain lengthening joints which are often used for joining eave plates. These are described in the chapter on “Lengthening Joints”.

The pillars themselves have to be well anchored in the ground, since they not only have to carry the weight of the structure but also have to hold the roof down in heavy storms (see Lean–to Roofs).

At times the builder may choose to construct the verandah roof using a combination of projecting rafters and projecting tie beams.

Anchorage

Whatever the form of the roof construction, it must be tied securely to its supporting walls or pillars. If this is neglected, the roof can easily be damaged or even torn off in strong winds.

The following are some points which are important in anchoring a roof.

– ANCHORAGE RODS: The roof is secured to the walls by these iron rods. They can be fixed in the wall during the wall construction if the positions of the trusses have been decided, or else they can be fixed in the finished wall.

– In the first method, the rod is inserted in the bed joint as the third course be low the top of the wall is laid. The rod is bent at a right angle so it can fit into the cross joint (Fig. 1); and it is positioned just inside the face of the wall.

When the next course is laid, the block above is chiselled out to make a shallow groove (approximately 1 cm deep) for the rod (Fig. 1).

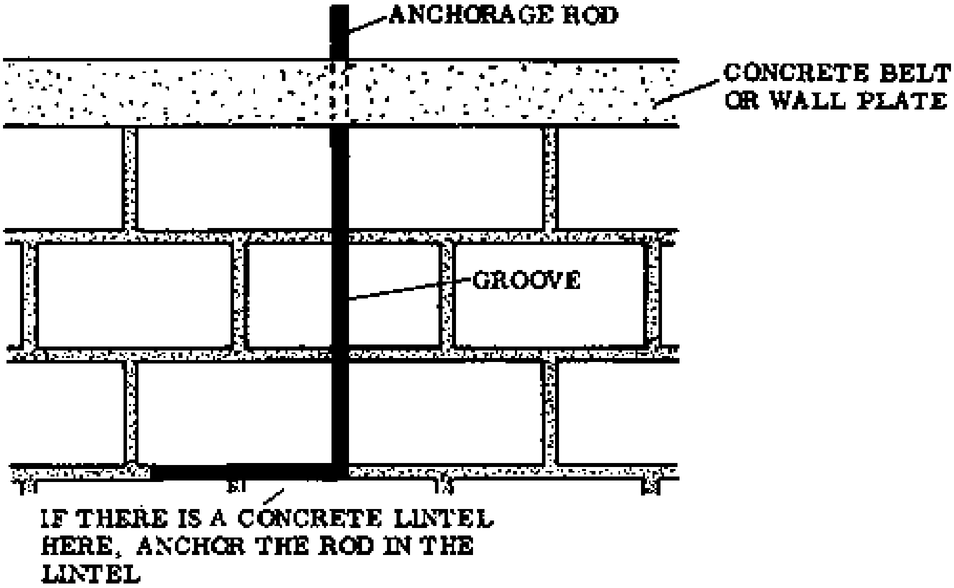


Fig. 1

The rod fits into the next cross joint and is bent gradually inwards toward the top centre of the wall, coming out where it can pass later through the wallplate or concrete belt (Figs. 1 & 2).

When the truss is erected, the rod is bent around the rafter and tie beam both, and secured with nails (Fig. 2).

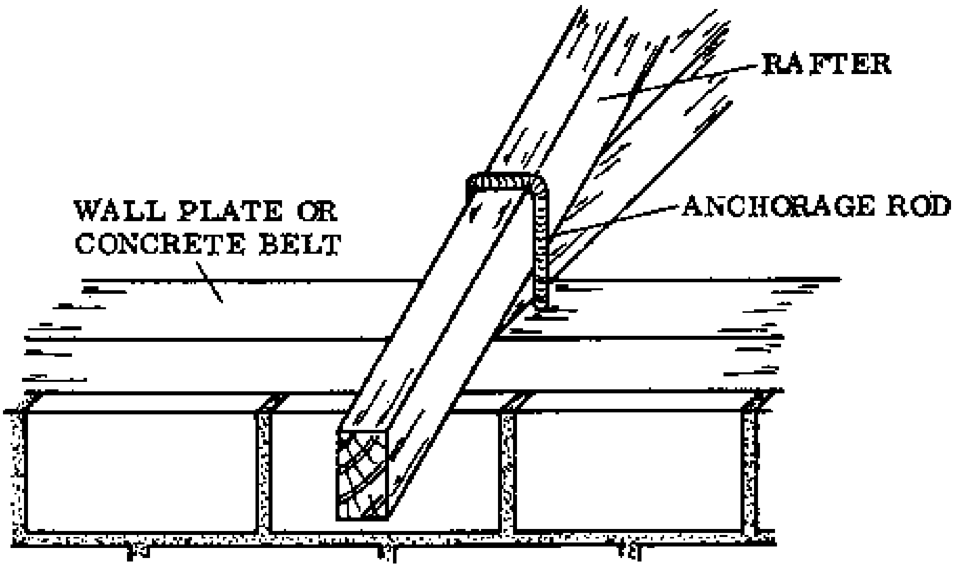


Fig. 2

– With the second method, the rod is inserted through a hole chiselled in the bed joint of the third course from the top, after the wall is complete. The ends of the rod are bent up and over the tie beam and rafter, overlap each other, and are secured on both sides with nails (Fig. 3).

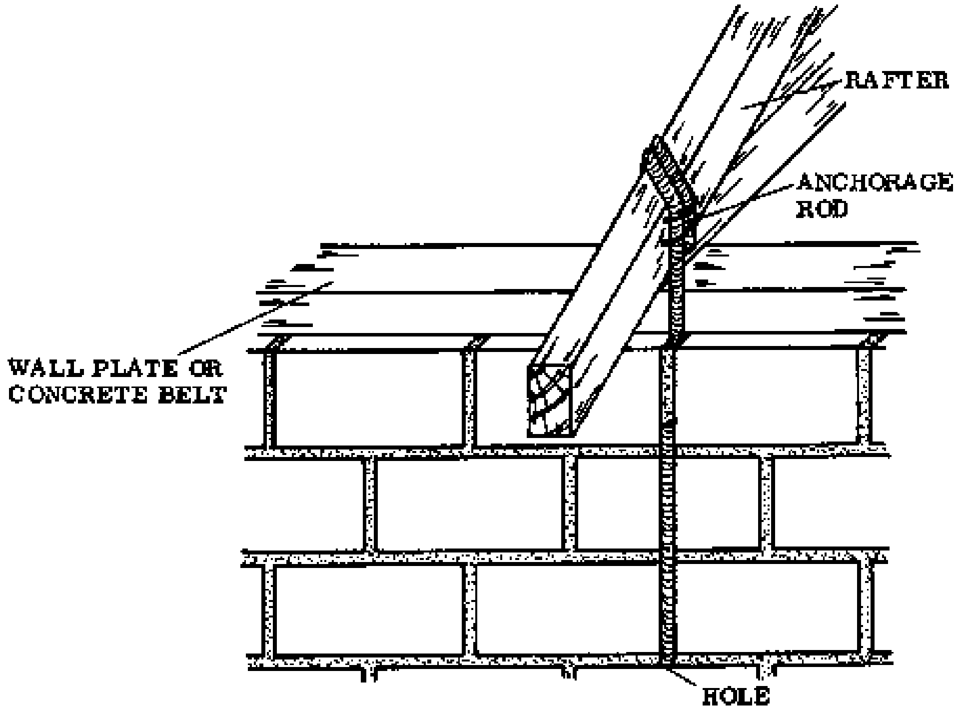


Fig. 3

The second method is chiefly used when the roof of an existing building has to be secured. If you are constructing a whole new building, it is best to plan ahead a bit and use the first method, which is both easier and stronger.

– ANCHOR BEAM: Once the wall is completed, the top of the wall may be covered with a strip of reinforced concrete all around the outside walls of the building. This is the anchor beam, also known as the ring beam or concrete belt. The roof anchorage passes through this belt. The anchor beam performs three functions:

– It keeps the outside walls of the house together, thus strengthening them.

– It provides a firm base for the trusses and distributes their weight over the softer landcrete blocks below.

– It anchors the trusses and adds weight to help keep the roof construction from being lifted up in heavy winds.

– WALL PLATE: For smaller spans the Rural Builder can install a wooden wall plate instead of an anchor beam. The roof anchorage passes through the wall plate and through at least three courses of blocks.

There are several joints that may be used to connect pieces lengthwise to make the wall plate (see Lengthening Joints, page 173). The wall plate should be about 5 cm thick by 15 cm wide.

– TRUSSES: The trusses should be evenly spaced across the roof, with one at each gable end and the rest about 2 m apart from each other. Every truss should be anchored to both the walls that it rests upon. The anchorage rod is bent around both the tie beam and the rafter, and secured with nails (Fig. 2, previous page).

– PURLINS: Tie all the purlins to every rafter, preferably with iron rods. These are shaped as shown in Fig. 1, by hammering the rod flat on both ends and drilling holes in the ends, then bending the rod to a U–shape.

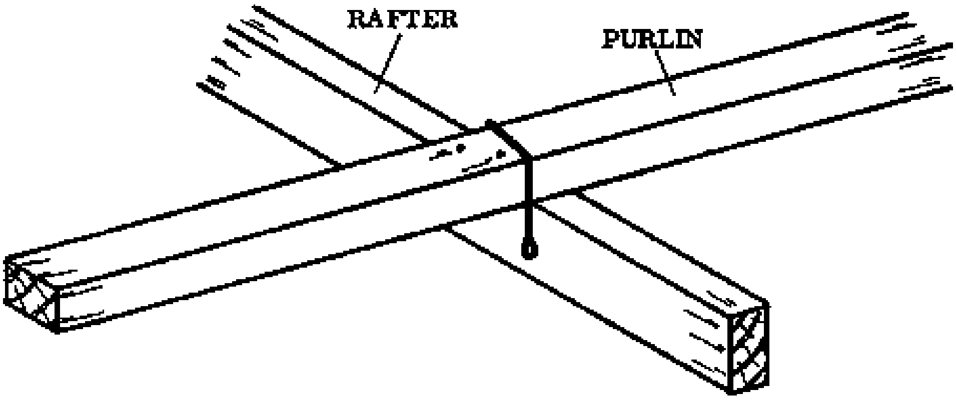


Fig. 1

If these fixings can't be made, it is possible to make wooden fixings (Fig. 2). Two wooden pieces are used, one on either side of the purlin.

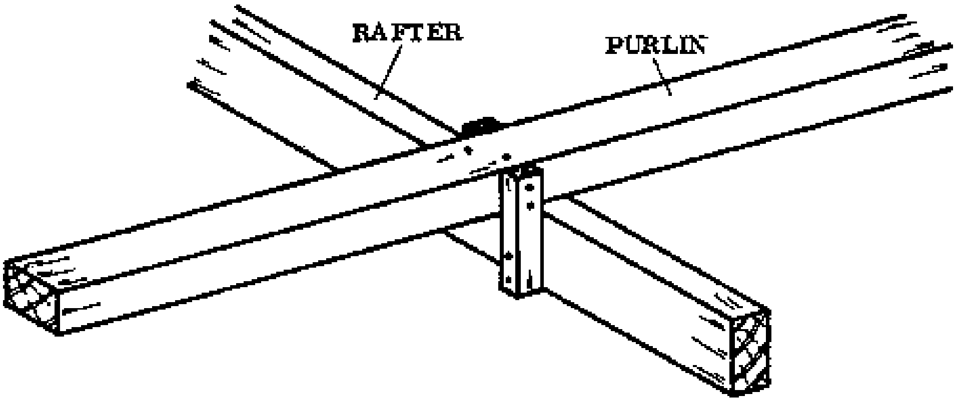


Fig. 2

Barbed wire can also be used as an alternative to the iron rods. Wrap it firmly around and nail it securely.

Whatever fixing you use, take care to fix the nails so they are not pulled out by the force of the wind on the roof. Fig. 3 shows two badly nailed fixings.

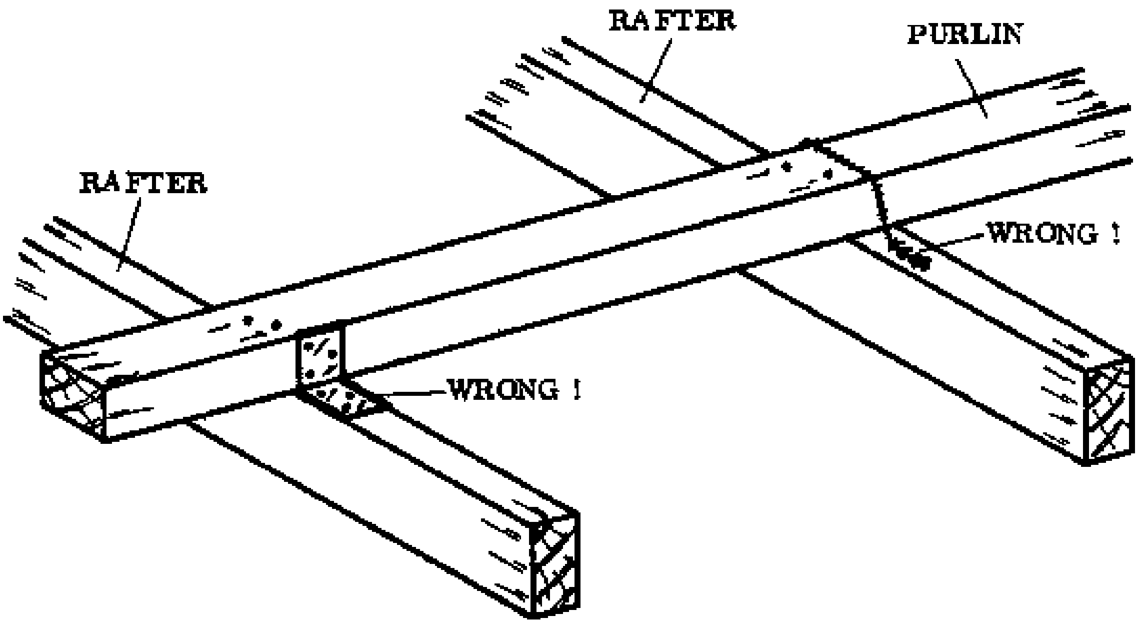


Fig. 3

NOTES:

ROOF COVERING

See the Reference Book, pages 207, 230 and 231 for descriptions of the sheet materials and roofing accessories; also see pages 239 and 240, Tables of Figures.

Alignment of the sheets

If possible, always start laying the sheets from one end of the roof so that the free ends of the sheets face away from the direction of the wind. This reduces the danger of the sheets being blown away as they are being installed.

Start laying from one end of the building to the other. As each new sheet is laid, lift the edge of the previous one so that it overlaps the new sheet by 2 corrugations. Each sheet is thus held in position by the one previously fixed, so they are more easily aligned in the correct position.

Exact sidelaps (2 corrugations) and endlaps (15 cm) are essential to make the roof waterproof.

– NAILING: When you nail corrugated roofing sheets to purlins, always nail through the top of the corrugation. This is so that rain will tend to run away from the nail (Fig. 1).

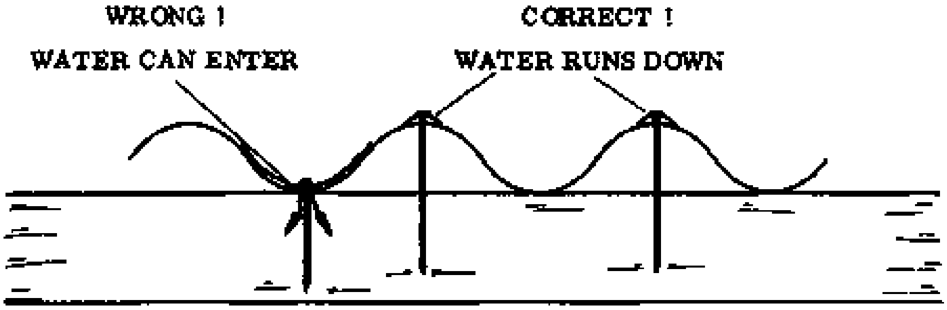


Fig. 1

Each nail should be driven in until the roofing felt just touches the sheet. If it is driven further, the nail will flatten the corrugation and distort the sheet. This can cause the roof to leak.

The sheets should be nailed to all the purlins. Nail every second corrugation in the sheets along the eave purlin and along the ridge purlin; and also on the end sheets at the gables. Over the rest of the roof, nail at every third corrugation over the purlins (Fig. 2).

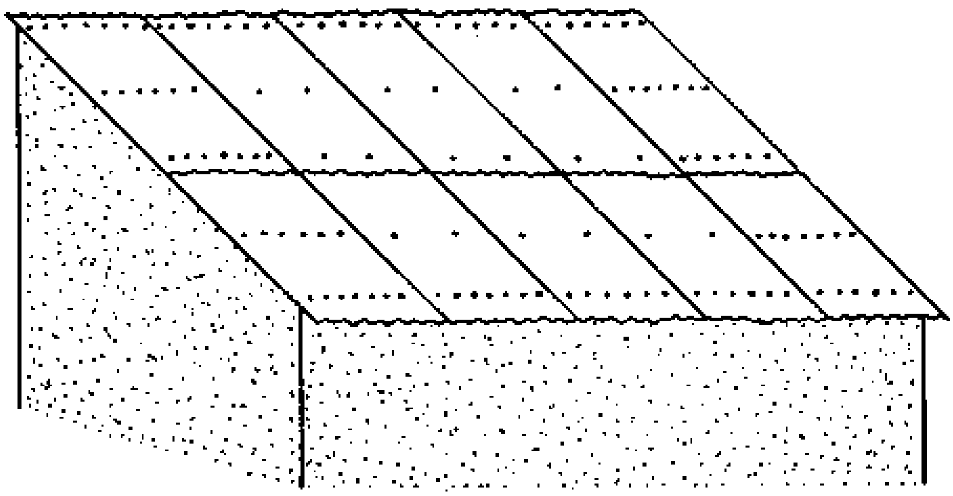


Fig. 2

– HOW TO LAY THE SHEETS: Before the sheets can be laid, the gables must be built up to the correct height. Make sure that all the nail heads of the wooden construction are punched well below the surface.

Fix a line on the eave to indicate the desired projection of the sheets. Note that the sheets should project about 2 cm over the fascia board in order to provide a drip overhang.

It helps to station a helper at eave level to observe if the general line of the sheets is straight and that they project uniformly. Another helper can check that the sheets are straight along the corrugations from the eave to the ridge.

The helpers can also check from both sides of the roof to see if the corrugations match at the ridge line (Fig. 1).

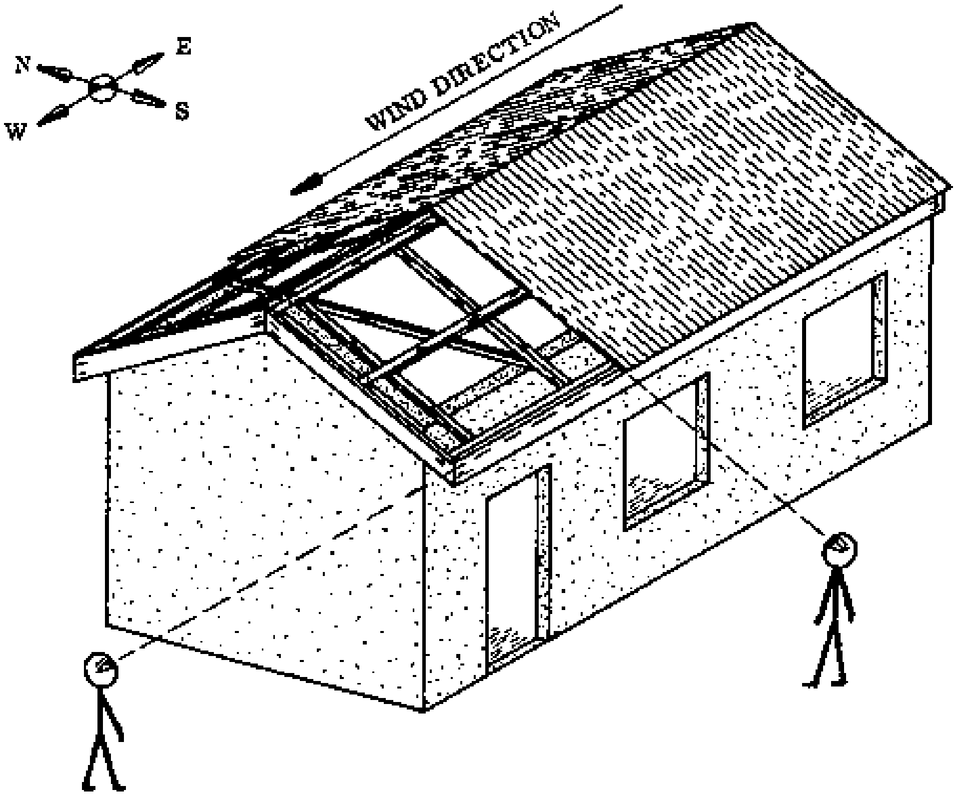


Fig. 1

For nailing the sheets it is best to have one man at each purlin.

– SEQUENCE OF OPERATIONS: In order to join the overlaps correctly, follow this sequence, starting from the end of the roof which is in the direction where the strongest winds are coming from (here it is the east) (Fig. 1).

a. Place sheets 1 and 2 loosely along the gable end, with sheet 2 overlapping sheet 1 by 15 cm in the length (Fig. 2).

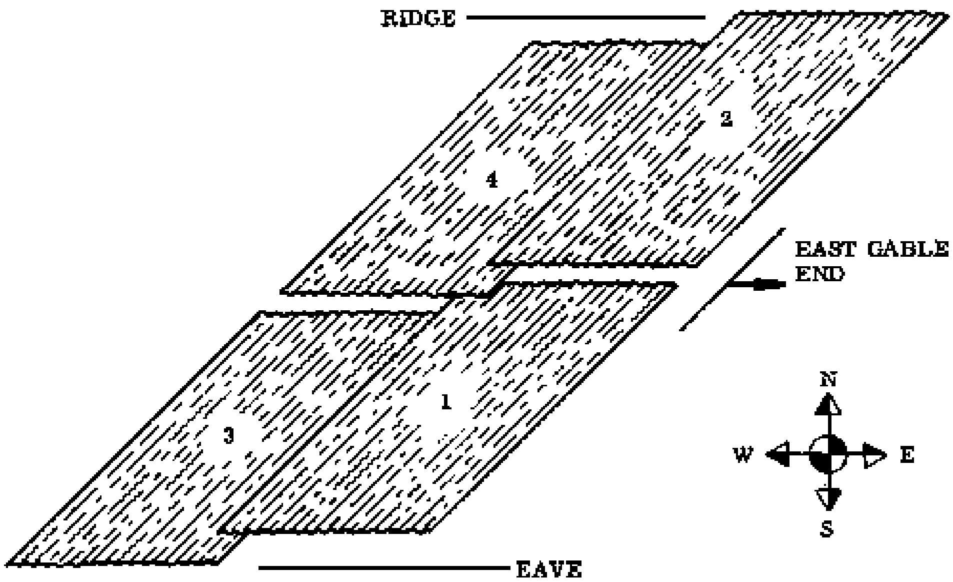


Fig. 2

b. Align them with the help of the two observers on the ground.

c. Secure the sheets with one nail in the middle. One man should do the securing, or the sheets might shift because of the shocks of the hammer blows.

d. Have the observers check that the sheets are still straight in both directions.

e. Nail the sheets home with all of the required nails except the nails at the edges where the next sheet will be fixed under.

f. Place sheet 3, lifting up the edge of sheet 1 until it overlaps sheet 3 by two corrugations (Fig. 2).

g. Place sheet 4, lifting sheet 2 until it overlaps sheet 4 by two corrugations. Sheet 4 should overlap sheet 3 in the length by 15 cm (Fig. 2).

h. Align sheets 3 and 4 with the help of the two observers on the ground.

i. Secure the sheets with one nail each at the centre.

j. Recheck the straightness in two directions.

k. Nail the sheets home with all the required nails except the ones at the edge where the next sheet fits.

l. Continue with this sequence until the whole roof is covered.

m. Proceed to build the parapets if they are required.

If no parapets are made, the last corrugation at the gable ends can be lapped over the fascia board, turned down and nailed onto the face of the fascia. Place the nails at intervals of about 10 cm.

– NOTE: In northern Ghana, the strongest winds are from the east, so you should start laying the sheets from the east end of the building. In areas where the wind comes from another direction lay the sheets accordingly.

Sidelaps

Since corrugations often get distorted or flattened, it can sometimes be difficult to get an exact and watertight sidelap between the sheets.

To straighten the sheet and get a good sidelap, fix all the required nails in the middle corrugation after first securing the sheet with one nail and checking the straightness. Then press the sheet to the correct position and nail the rest of the sheet (Fig. 1).

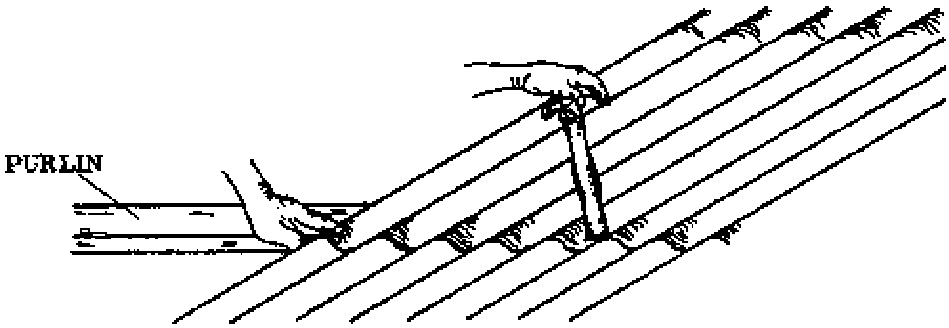


Fig. 1

Do not try to get a sheet in the correct position by nailing the corners where the 4 sheets meet. This will distort the sheet even more.

Ridge caps

If no ready–made ridge caps are available, they can be made on the site with aluminium or galvanized iron sheets. With the help of two straight–edged boards, the sheets are bent to the required angle on the work bench (Fig. 2).

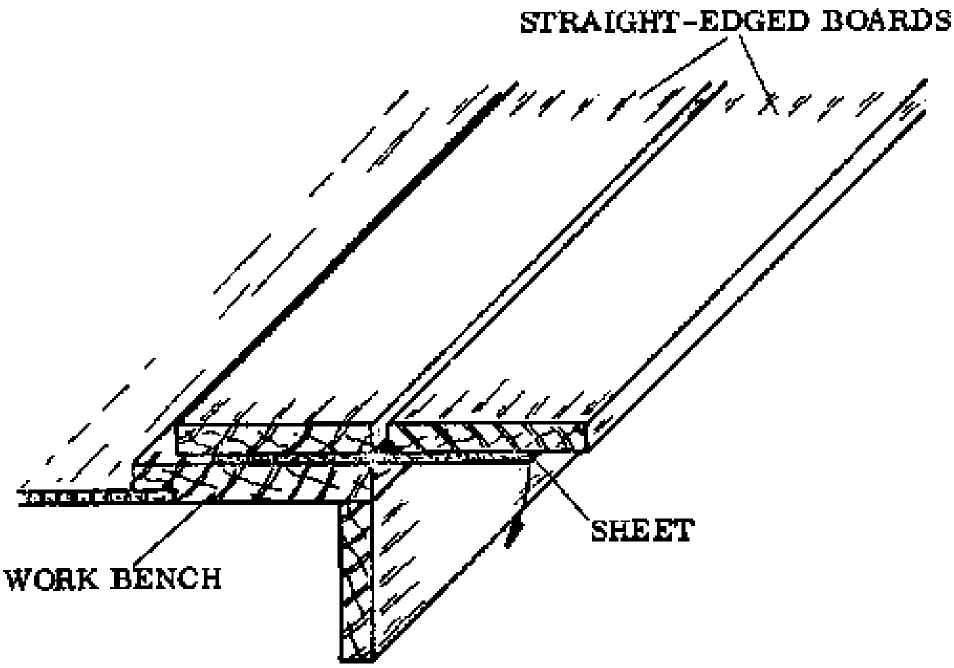


Fig. 2

It is better to make the ridge cap so that the bend goes across the corrugations, rather than along them. This ensures a tighter fit, but the corrugations on both sides of the roof have to match exactly (see Reference Book, pages 231 & 239).

Helpful hints for roof covering

– Put all nails into the washers with the roofing felt before you start laying sheets, to prevent delays.

– The roofing felt can be cut with an iron pipe that has been filed to a cutting edge at one end (Fig. 3).

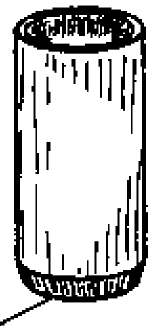


Fig. 3

– Use soap to make driving nails easier in hard wood.

– There should be people on the ground ready to hand up the sheets.

– Before you put a sheet in place, make a mark on the previous sheet to show where the purlin is for nailing.

– Always use a line at the eave, with supports if necessary to keep it straight.

– Have a long, slim and pointed punch ready. It can be made locally from an iron rod. This punch is used to pierce holes through in places where the nail must pass through 4 sheets. Without piercing the hole for the nail first, there is a danger of flattening the corrugation and distorting the overlap while nailing it.

– If a nail begins to bend and should be pulled out, use a round piece of timber or metal as shown in Fig. 4.

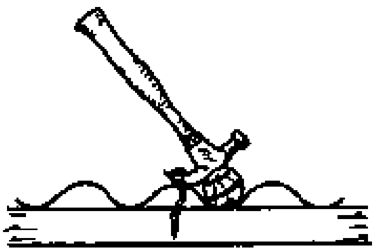


Fig. 4

– Be careful in handling the sheets. They have sharp edges which can cut you deep–

– If a corrugation has been badly damaged through pulling out a nail, try to restore the area around the nail hole to as near as possible the original shape. A round piece of metal can be put under the corrugation to help in this.

– If the sheets have to be cut, do not leave the cut–off pieces lying around. They can still be used for other work.

– Do not leave sheets lying where people might step on them and flatten the corrugations.

– Be sure, especially in seasons where there is a danger of storms, that no sheets are left loosely nailed to the roof, or left on the ground without being weighted down or otherwise secured. A sheet blown around by the wind can easily kill someone.

NOTES:

HEAT PENETRATION – INSULATION

One of the main goals of building in the tropics is to reduce heat penetration into the building. There are a number of building constructions which help to make the building cooler.

– Build in an east–west orientation, so the sun hits directly on only the end walls of the building.

– Construct a verandah to shade the wall.

– Construct overhanging eaves or overhangs to shade the walls.

– Use an open roof construction (no ceilings) on the verandahs, overhangs and overhanging eaves; to permit cross ventilation between the roof and ceilings in the rooms.

– Make ceilings in the rooms so that the sun cannot heat the room directly through the roofing sheets and so that there is cross ventilation between the sheets and the ceiling.

– When possible, use a combination of any or all of the above constructions.

LIGHTENING

To prevent lightening from striking a building, you can install a lightening conductor. This is a pointed copper rod, which is fixed above the highest point of the roof and connected to a copper rod driven into the ground. Long buildings need more than one lightening rod. Follow the manufacturer's instructions to install the conductor.

NOTES:

HIP ROOFS

A hip roof is often chosen as an alternative to a gable roof. It has a nicer appearance, and it is less vulnerable to suction from heavy winds. However it takes more work to construct it, and requires more timber than a gable roof. Also there is a certain amount of waste involved in cutting the sheets at the corners. The hip roof is more apt to leak unless it is constructed exactly right.

The main part of the construction is the same as for the gable roof. In addition, a half truss and two hip trusses are needed for each hip (Fig. 2).

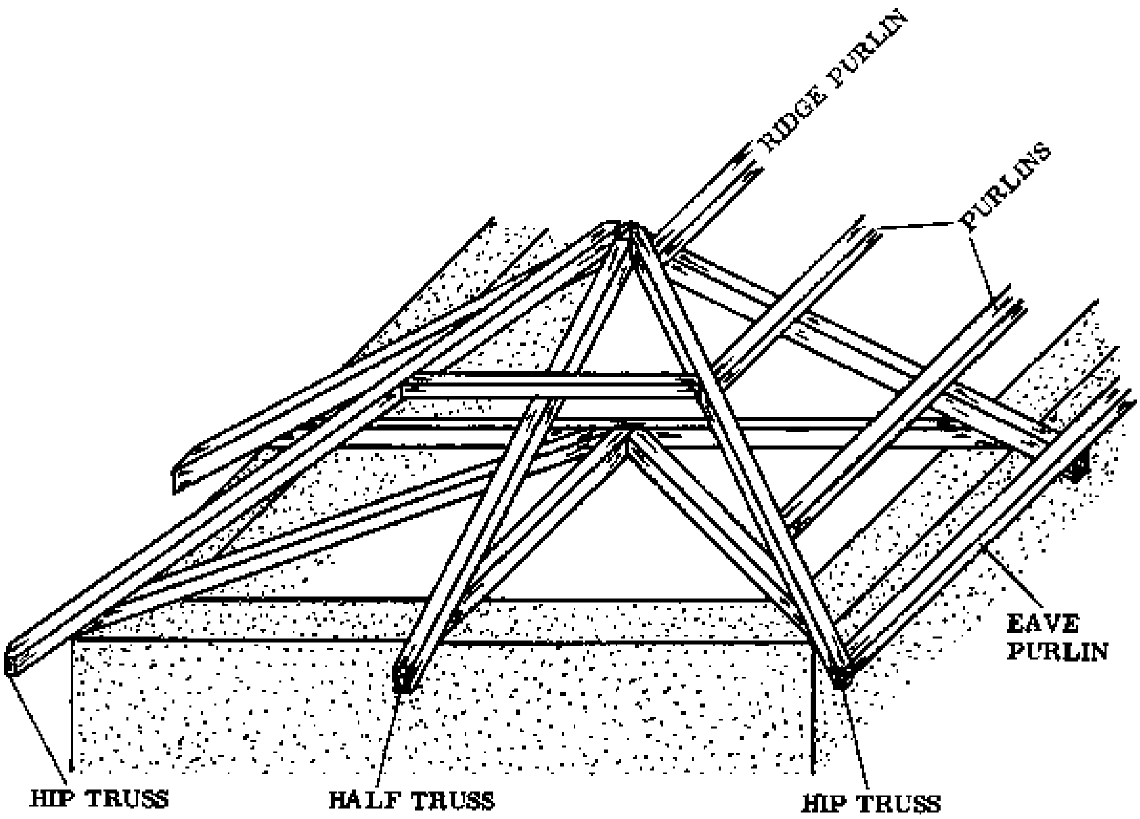


Fig. 2

– NOTE: TO MAKE THE ABOVE DRAWING SIMPLER, BRACES ARE NOT SHOWN.

The two hip trusses run diagonally from the ridge of the last full truss to the corners of the building. The hip rafter has to sit higher than the other rafters, so that the purlins butt into it at the side instead of lying on top of it. This is so that the sheets will be able to fit smoothly around the hip (Fig. 1).

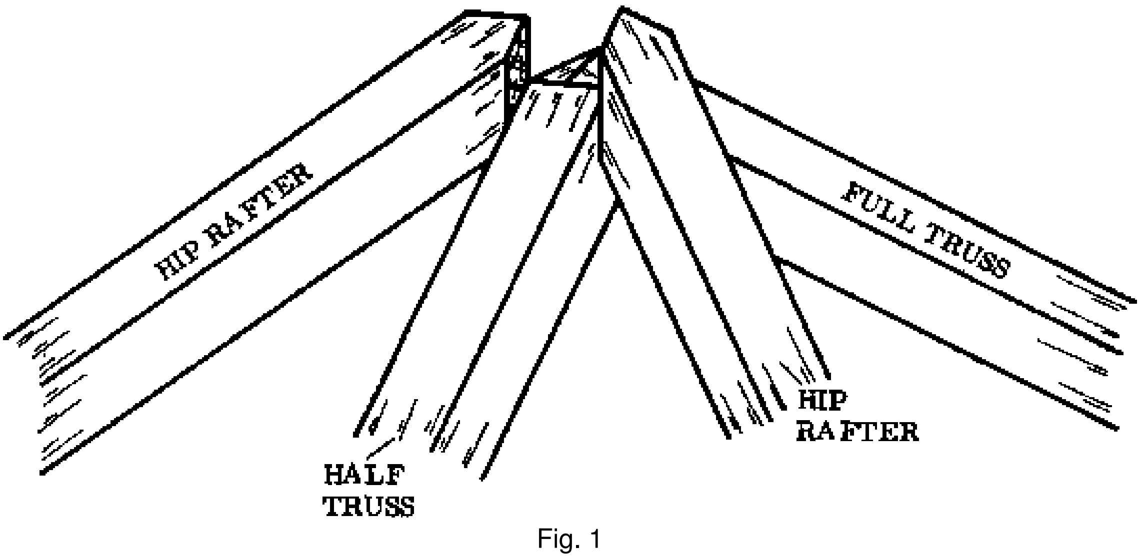


Fig. 1

The half truss is set out in the same way as the full truss, with only half the span. If the tie beams of the other trusses will project beyond the walls, the half truss tie beam has to project by the same amount (Fig. 3).

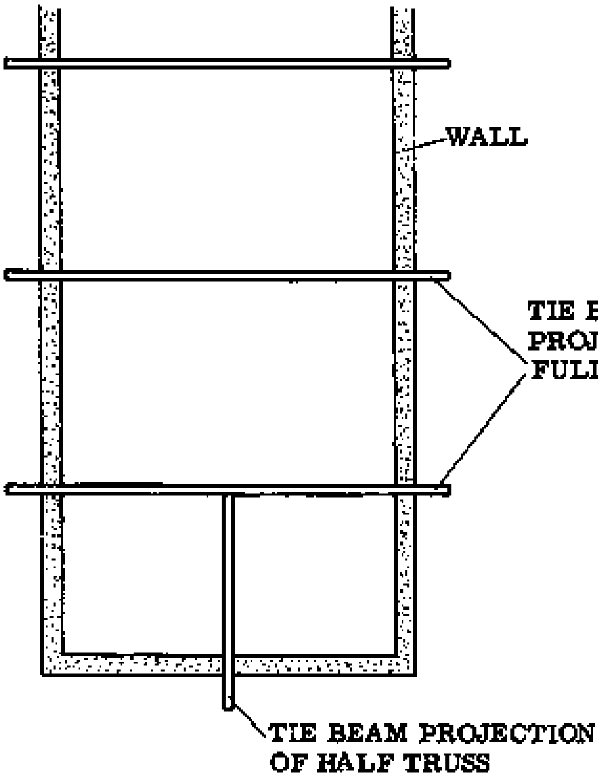


Fig. 3

Setting out and constructing the half truss

Before the half truss is fixed, all the other trusses have to be in place.

To assemble the half truss, use the same setting out which was made for the full trusses. Simply construct half of a full truss. The last brace near the ridge should be set back about 10 cm from the end, to leave space for fixing the trusses together (Fig. 1, arrow).

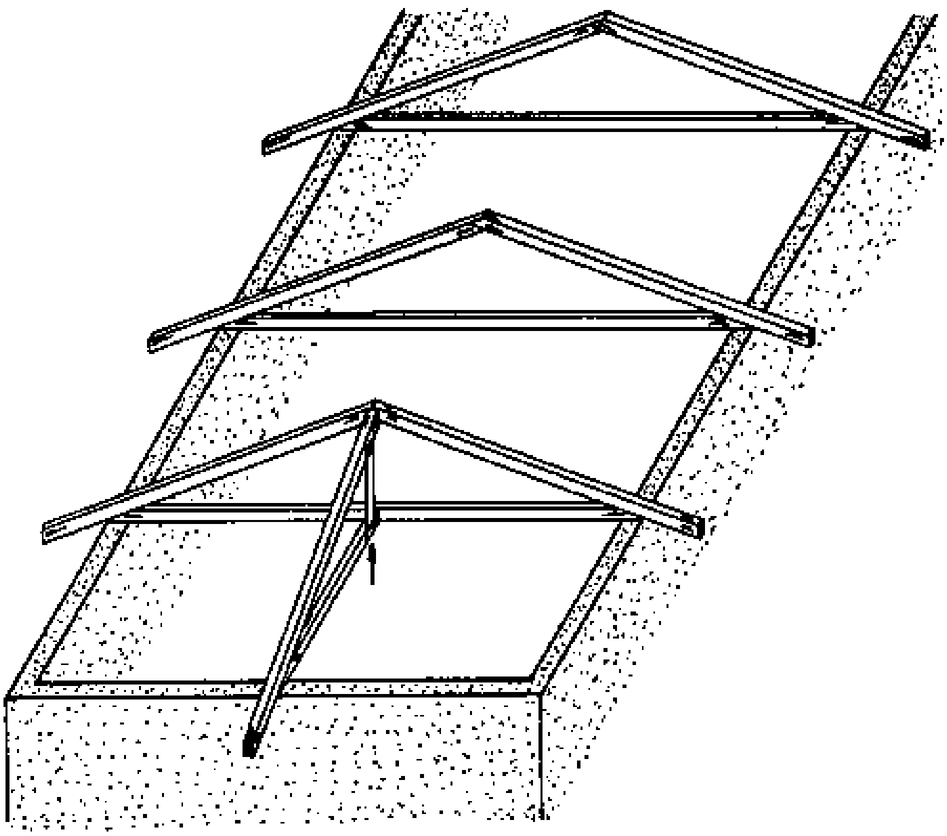


Fig. 1

– NOTE: TO MAKE THE DRAWINGS SIMPLER, BRACES ARE NOT SHOWN.

When the half truss is ready, fix it temporarily into place against the full truss. Remember that if the other tie beams project past the walls, the half truss tie beam must also project, by the same distance.

Position and measurements of the hip truss

Follow the sequence below to find the measurements for the hip truss, as well as its correct position.

a. Lay two purlins flatwise near the eave and ridge, across the last 3 full trusses of the roof. Make sure that they are aligned parallel to the wall, and nail them temporarily (Fig. 2).

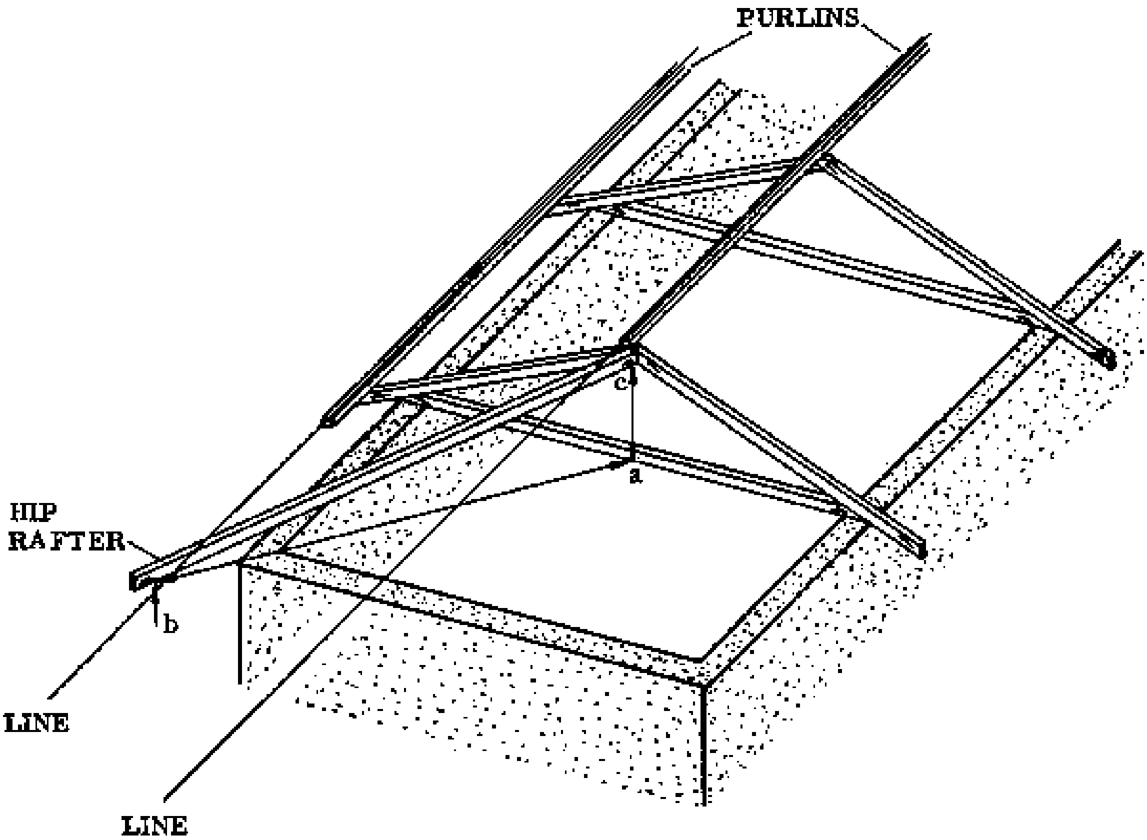


Fig. 2

b. Fix a line along the top surface of each purlin. The lines should extend past the ends of the purlins to the end wall of the building, where they can be held taut by a temporarily fixed pole. The lines must be taut and parallel to the side wall. Each line should touch the whole length of the top surface of the purlin (Fig. 2)

c. Have two men put the hip rafter in position, holding it so that one end is at the ridge and the other end is above the corner of the building. The top surface of the hip rafter should just touch both lines. Thus, the top of the hip rafter is on the same level as the top of the purlins.

d. Now another man can measure the length of the hip truss tie beam, which will be the horizontal distance from the centre of the full truss tie beam (Fig. 2, point a) to the soffit of the hip rafter outside the wall (point b). This distance is the span of the tie beam for the hip truss (see Fig. 3).

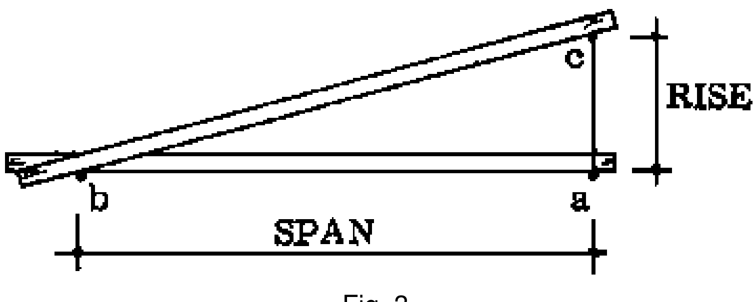


Fig. 3

e. To obtain the rise of the hip truss, measure the distance from the soffit of the full truss tie beam to the soffit of the hip truss rafter (Figs. 2 & 3, point a to point c).

Now that you have the measurements for the hip truss, you can go ahead to construct it. Measure the other hip truss for the opposite side of the roof in the same manner.

Constructing the hip truss

Look at the hip roof design in the Drawing Book, page 108.

– SETTING OUT:

a. Drive pegs 1 and 2 in the ground at a distance equal to the span of the hip truss (the span is measured as described on the previous page). Fix a line between the pegs (Fig. 1).

Fig. 1

b. Fix a line perpendicular to line 1−2, starting from peg 1 (Fig. 1).

c. Drive peg 3 at a distance equal to the rise of the hip truss (Fig. 1).

– ASSEMBLING THE HIP TRUSS:

d. Lay the hip tie beam against pegs 1 and 2 (Fig. 2)

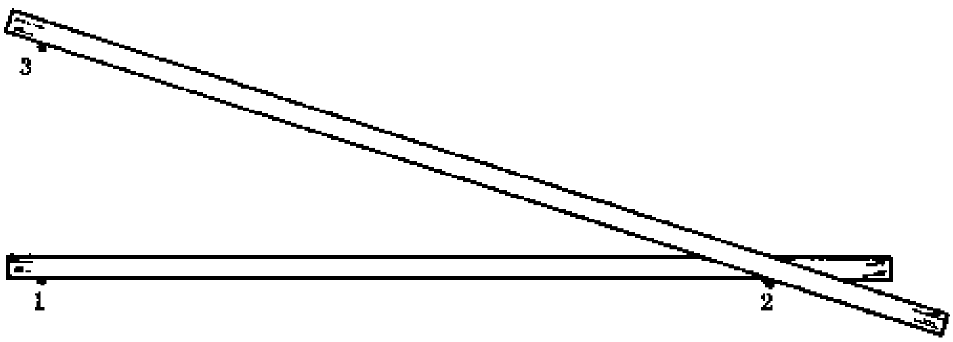


Fig. 2

e. Lay the hip rafter against pegs 2 and 3 (Fig. 2). Make sure that the tie beam and rafter are correctly positioned with respect to the pegs.

f. Cut the rafter−to−tie beam joint. Mark the inside end of the tie beam (a) and the inside end of the rafter (b). Make sure that the rafter has a long project ion on the eave end (Fig. 3). This projection is trimmed only just before the fascia board is fixed (c).

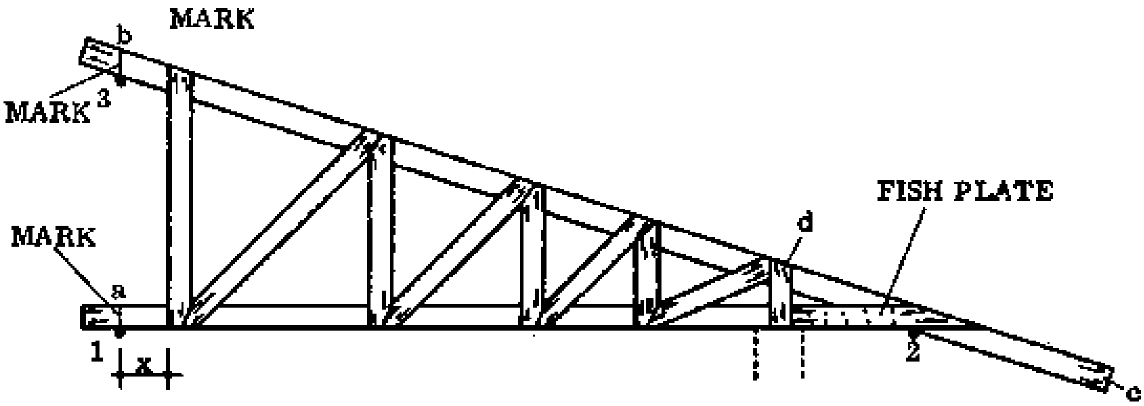


Fig. 3

g. Nail the braces and the fish plates. The last vertical brace on the ridge end is set back (Fig. 3, x) so that there is space to fit the trusses together later. Nail a short vertical brace (Fig. 3, d) where the tie beam meets the supporting wall.

h. Cut the ends of the rafter and tie beam (ends a and b) at a 45 degree angle, as shown in Fig. 4.

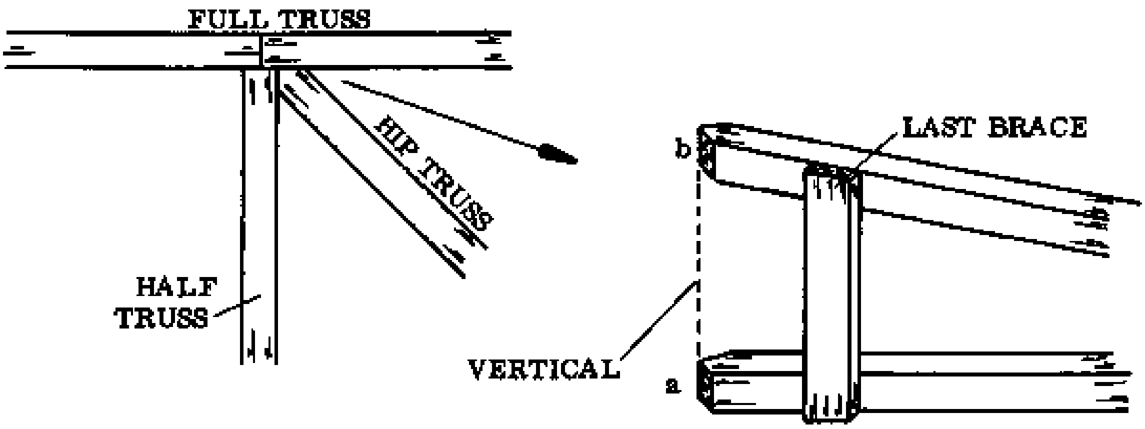


Fig. 4

i. Assemble the second hip truss on top of the first one.

NOTES:

Erecting the hip of the roof

When the half truss and hip trusses are ready, the hip structure of the roof can be erected. The connection between the tie beams of the half truss, hip trusses, and full truss can be made as shown in Fig. 1. The rafter connection is made as shown in Fig. 1 on page 208.

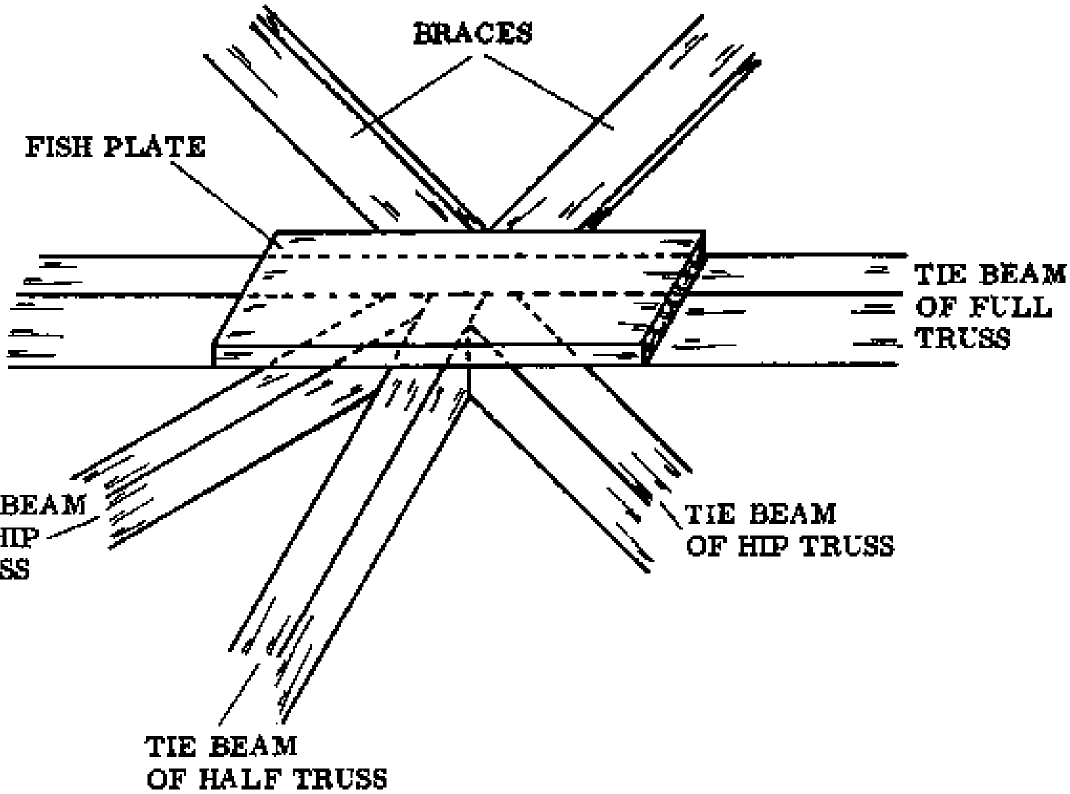


Fig. 1

– FIXING THE PURLINS: The purlins which butt against the hip rafter must be cut at exactly the correct angle so that they will fit snugly against the rafter.

– Mark the positions of the purlins on top of the hip rafters, and insert a nail at the mark to support the purlin during marking (Fig. 2).

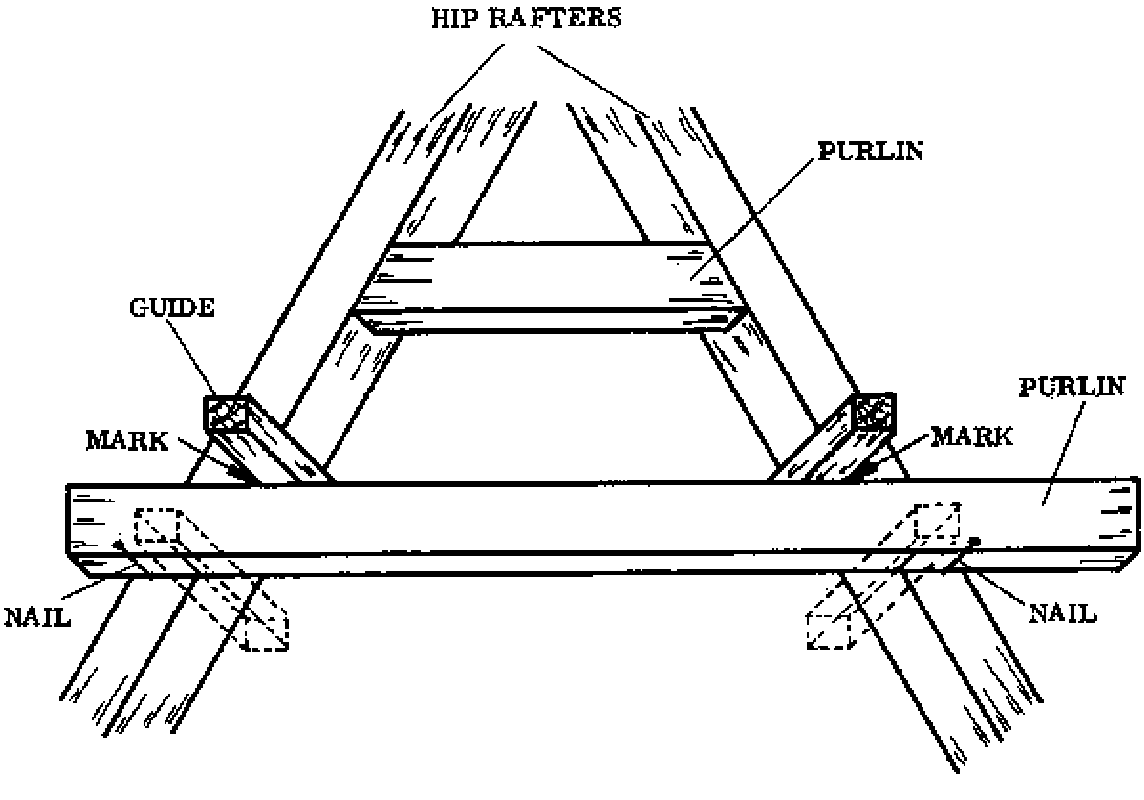


Fig. 2

– Place the purlin against the nails and mark the cutting lines. Use a short piece of wood as a guide (Fig. 2). Make the marks on both sides of the purlin at once, then mark both sides at the other end.

– Cut the butt joints and fix the purlin.

Fix the rest of the purlins in the same manner. The layout for the purlins on a roof with a single sheet length on each side is shown below (Fig. 3).

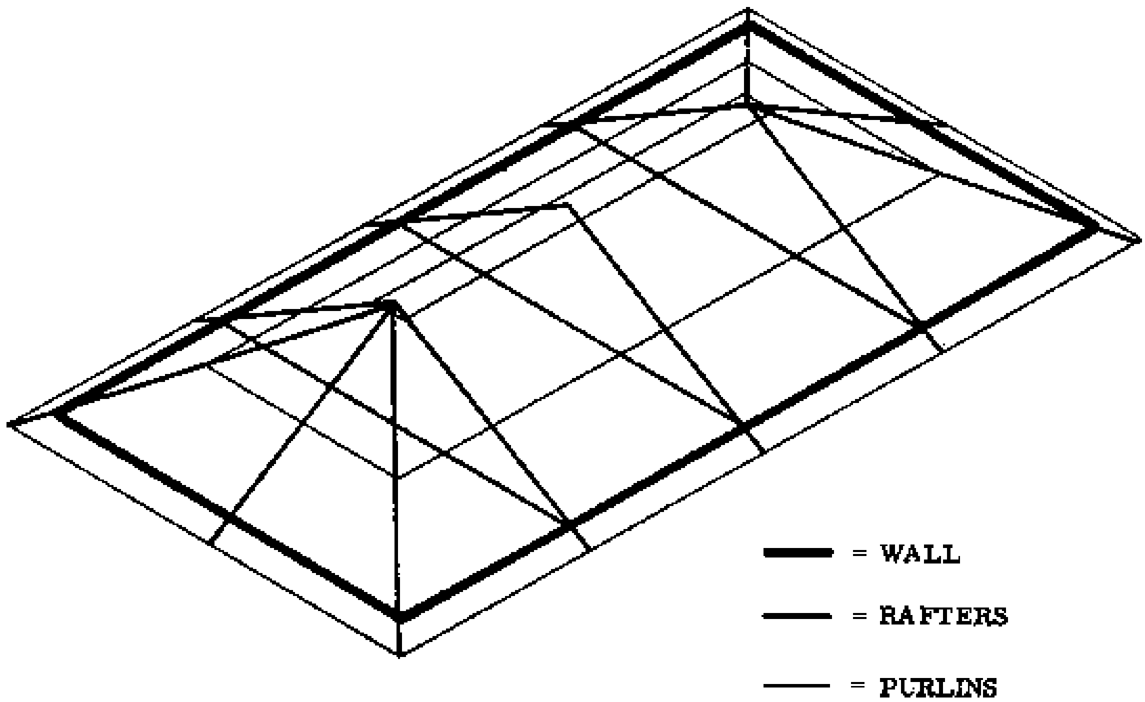


Fig. 3

Covering a hip roof

Nail two purlins parallel to the hip rafters, as shown in Figs. 1 and 2. The extra purlins provide more area for nailing the hip ridge cap.

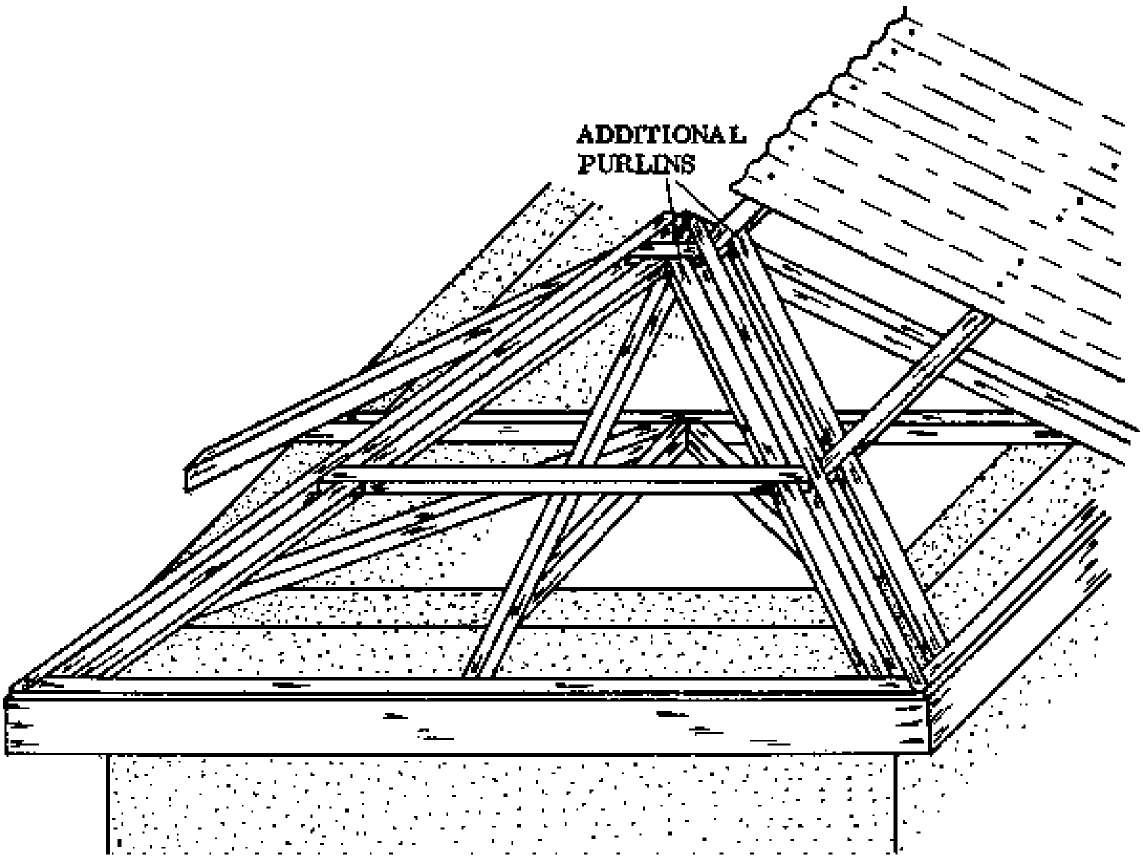


Fig. 1

– NOTE: TO MAKE THE DRAWING SIMPLER, BRACES ARE NOT SHOWN.

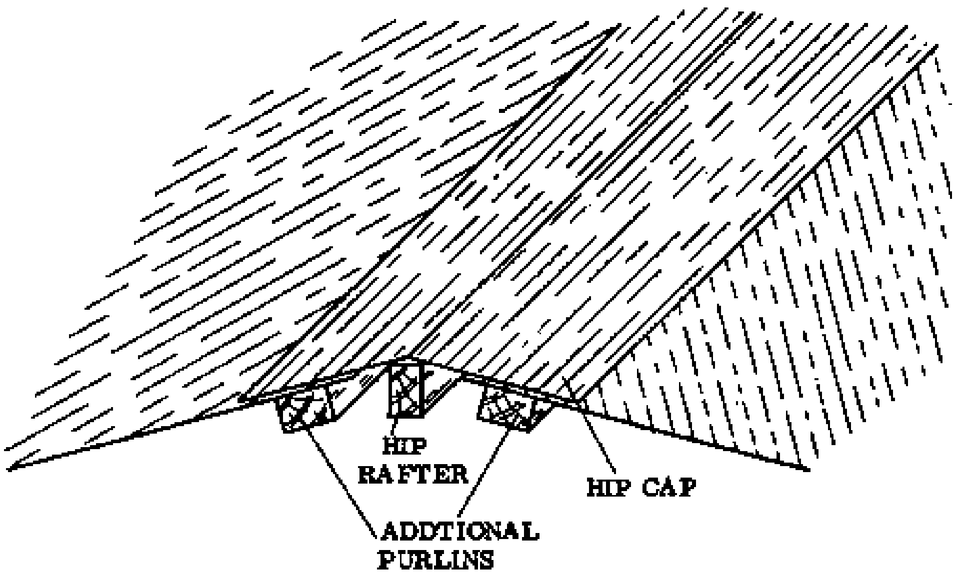


Fig. 2

Lay the first sheet at the hip rafter in position and mark with a straight edge where it should be cut. Cut the sheet and nail it in position before you mark and cut the next sheet. Continue in this way until the hip is covered.

A hip cap, similar to the ridge cap, must be used to cover the hip line, where the sheets meet. If no ready−made caps are available, one can be made as explained on page 205.

NOTES:

HIP AND VALLEY ROOF

When a roof is constructed for an L− or U−shaped building, a hip and valley roof is normally used.

The main problem of this construction is to make a truss which provides sufficient nailing area for the valley and also for the hip. This is solved by assembling two trusses, with spacers in between to connect them (Fig. 1). The spacers provide the required distance between the trusses. This distance is important, because the valley should be wide and deep enough so that rain can run down it easily and so it does not get blocked by leaves (Fig. 1).

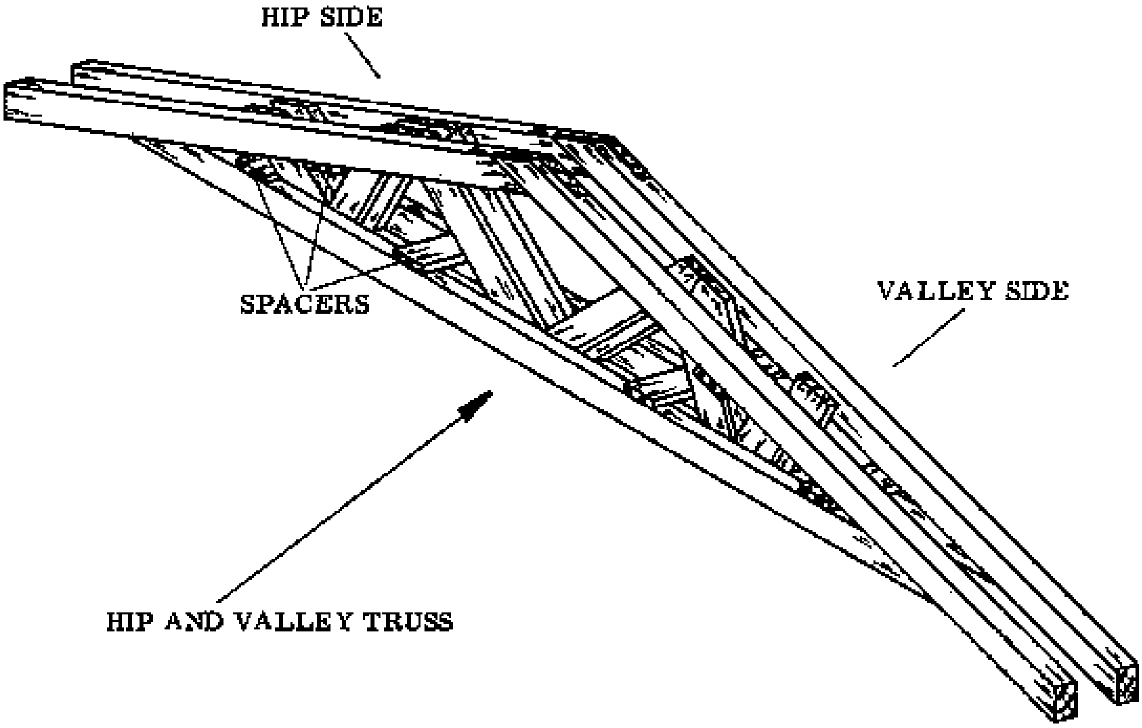


Fig. 1

As in the hip roof, the hip rafters and the valley rafters must be set higher so that the purlins meet them at the sides, and don't lie on top as they do with the other trusses.

If a large span must be covered with a hip and valley truss, it may be necessary to add some half trusses onto the hip and valley truss to provide enough support for the purlins (Fig. 2).

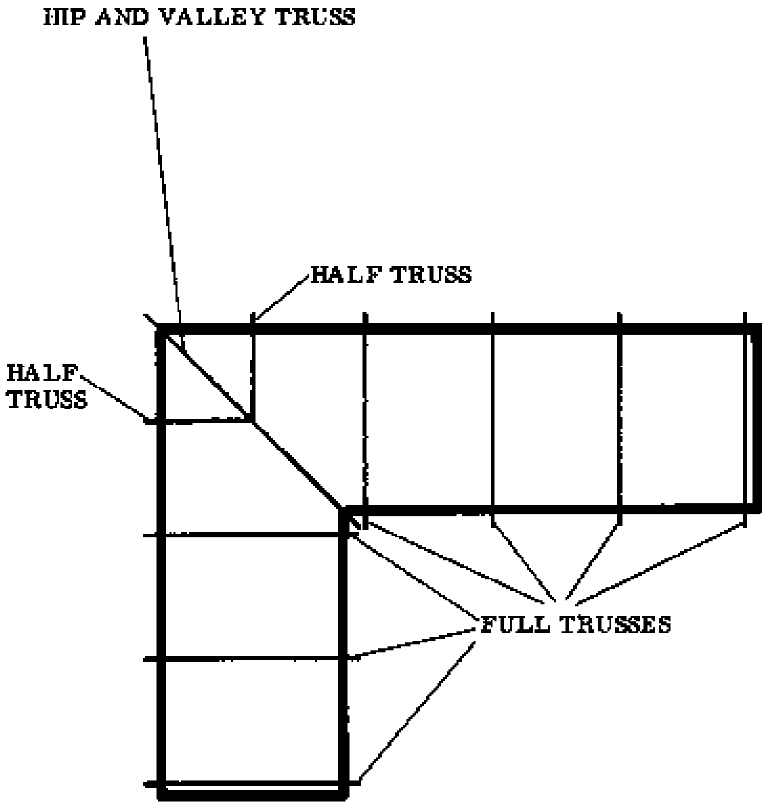


Fig. 2

NOTES:

Position and measurements of the hip and valley roof

– Start by erecting poles in the positions shown in Fig. 1, and fix lines at the ridge.

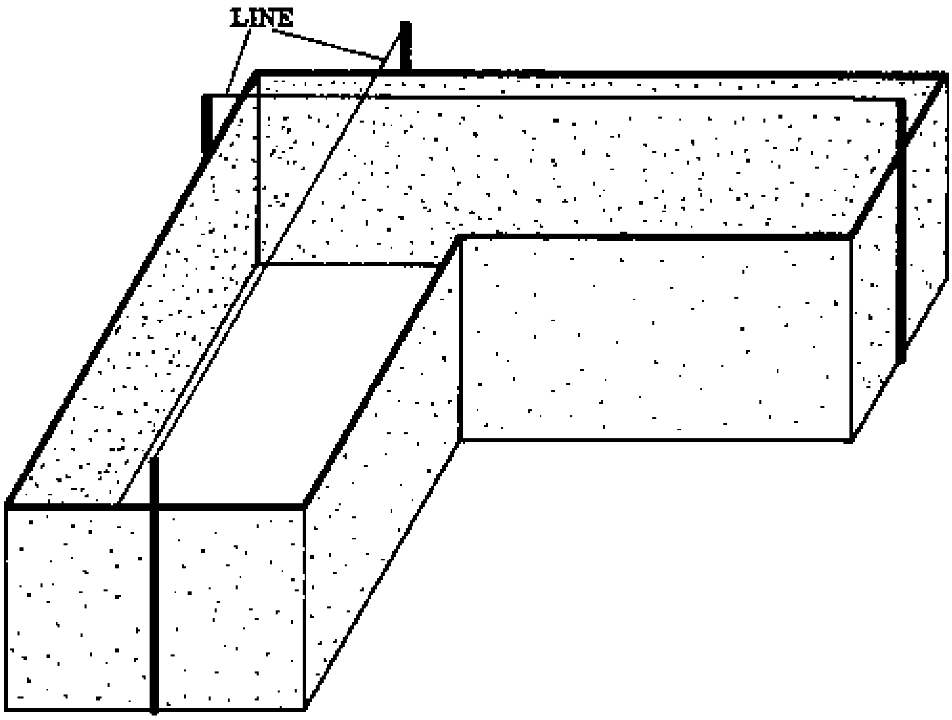


Fig. 1

– Erect the ordinary trusses according to the lines in their correct places (Fig. 2). Refer to the section on erecting a gable roof, page 191.

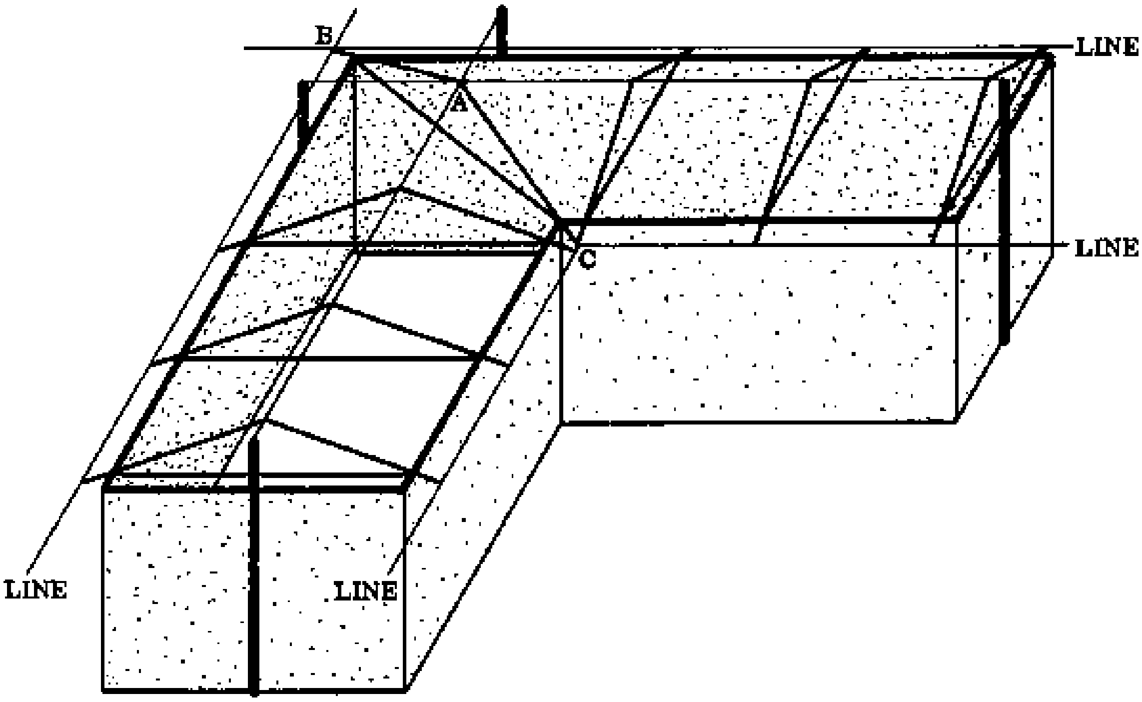


Fig. 2

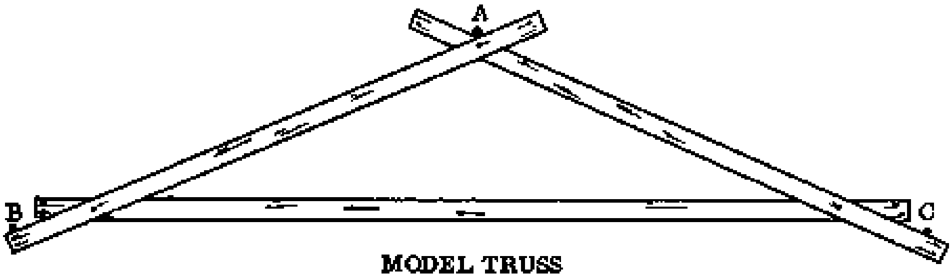
– Lay purlins temporarily on top of the rafters, as was done with the hip roof (page 211).

– Fix lines parallel to the walls along the tops of these purlins, at eave height on both sides of the roof (Fig. 2).

– Set the ridge lines higher, by the amount of the purlin thickness (Fig. 2).

– Now you will have–three points where the lines cross. These are: point A at the ridge; point B at eave height, and point C on the other side at eave height (Fig. 2). These points mark the outer surfaces of the hip and valley truss.

– Next construct a lightweight, temporary model truss. Hold it in position on top of the roof (Fig. 3). Adjust it until points A, B, and C touch the outer surface of the truss.



MODEL TRUSS
Fig. 3

– Now the model truss will have the correct dimensions and can be used as a model for constructing the two trusses of the hip and valley truss.

NOTES:

Construction of a hip and valley truss

Take the model truss down and set it on the ground in a cleared and level spot.

– Place an iron peg at each side of the model where the rafters meet the tie beam (Fig. 1, pegs 1 and 2) and one peg at the ridge (peg 3). Remove the model truss.

– Now lay the actual tie beam on the ground against the pegs.

– Lay the two rafters on the ground in the correct positions. Be sure that the members are in the correct positions with respect to the pegs, as in Fig. 1.

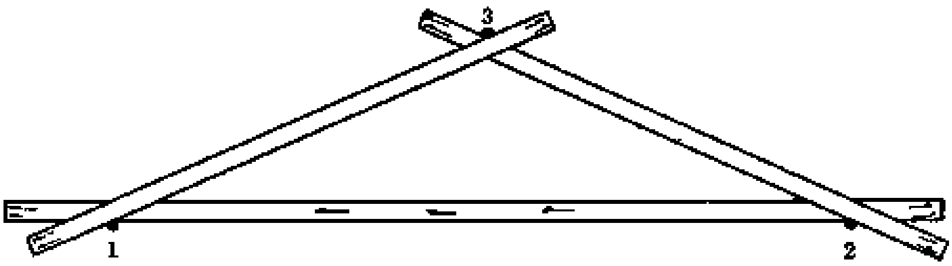


Fig. 1

– Cut the rafter–to–tie beam joint, and the ridge joint (Fig. 2).

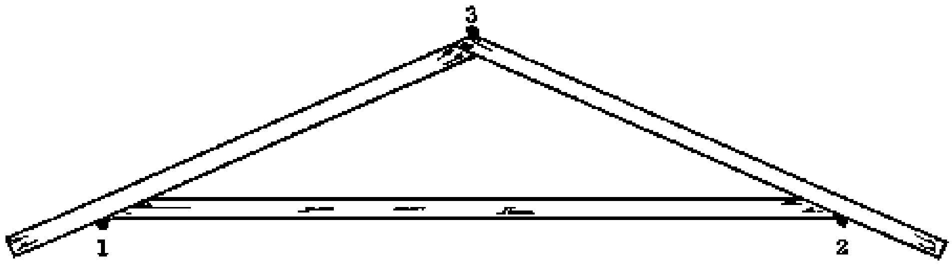


Fig. 2

– Nail the braces. Take care that the braces are set back from the top of the rafters on the valley side, so there is room to construct the valley later (Fig. 3).

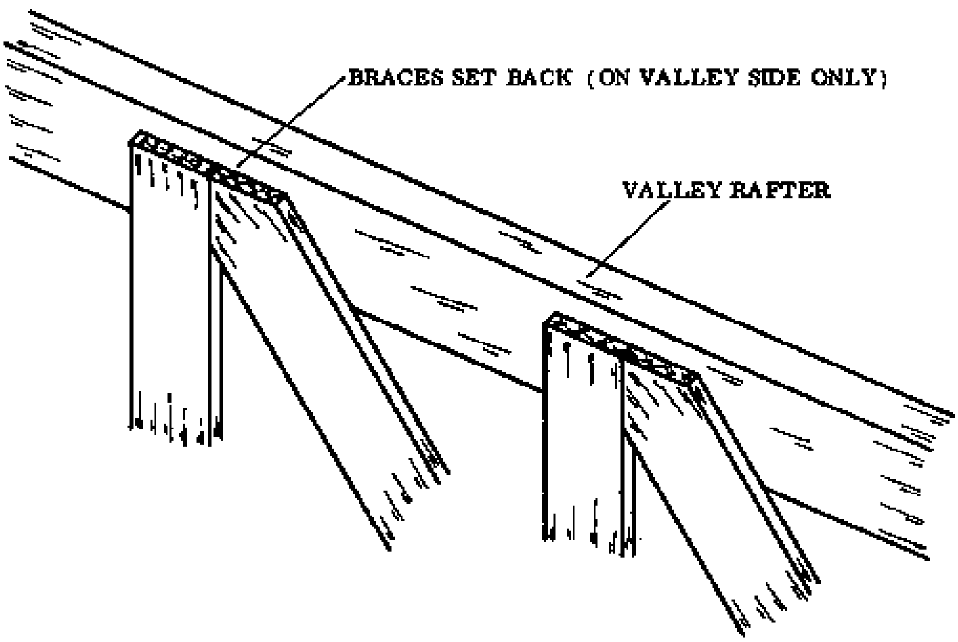


Fig. 3

– Assemble the second truss on top of the first one. Be careful to nail the braces so that later when the two trusses are combined, the braces will all be on the inside (Fig. 4).

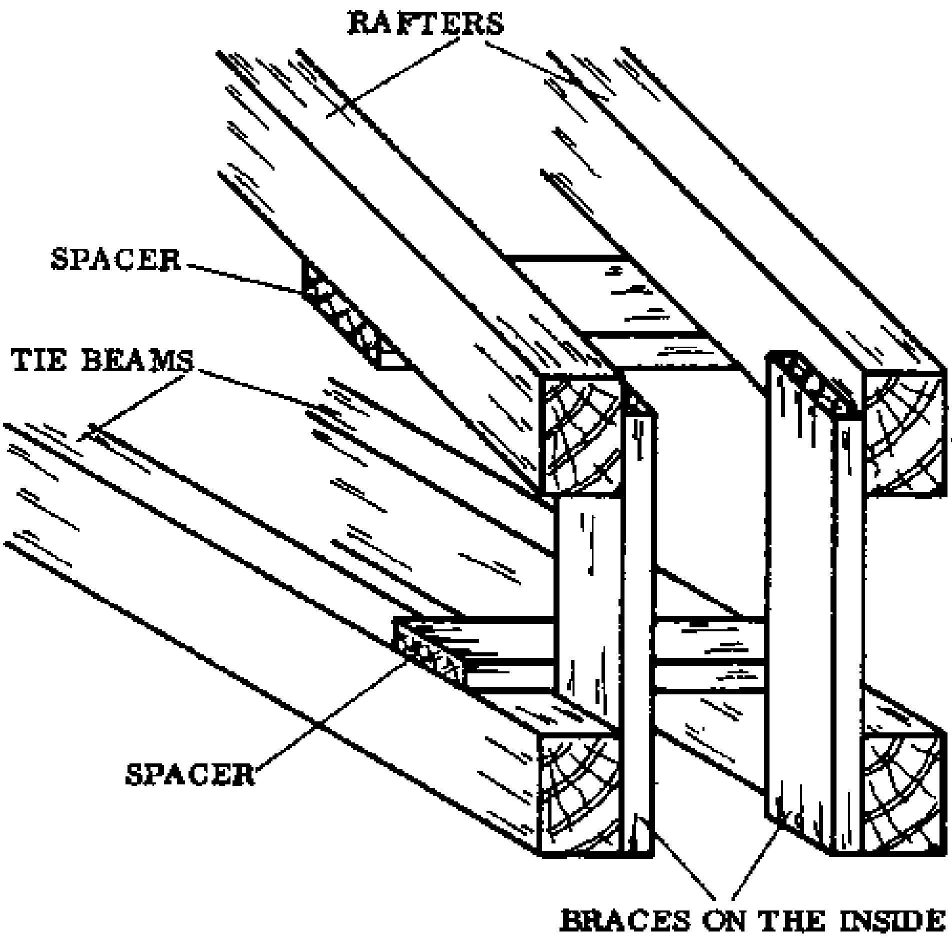


Fig. 4

– When both trusses are ready, they can be set in place on top of the wall. Then the spacers can be nailed to keep the trusses at the correct distance apart. Re member that the distance between the trusses should be wide enough (approximately 15 cm) to provide a wide valley.

Covering a hip and valley roof

First fix the fascia boards and the purlins. Fix a line at eave level and cut the rafters according to this line. Then nail the eave purlin and the fascia boards.

At the place where the fascia boards meet at the valley, cuts have to be made in the fascia boards according to the shape of the gutter (Fig. 1).

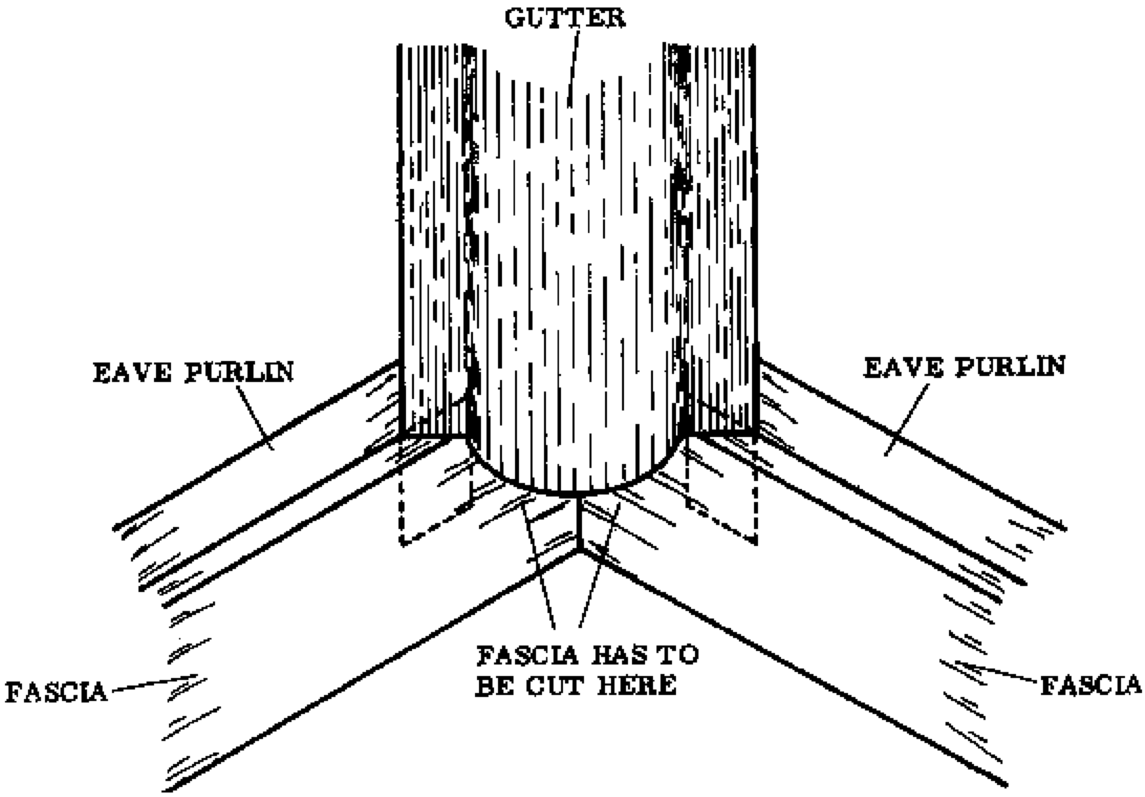


Fig. 1

Now fix the gutter in the valley. Lay a strip of sheeting metal lengthwise in the valley in the form of the required gutter. Fix it there temporarily with nails. The final fixing will be done as the other sheets are laid, since they have to be laid on top of the gutter. The overlap for the gutter sheets should be about 30 cm in the length.

Now lay the first sheet into position at the valley, mark and cut it. Nail this sheet and place the next sheet in position. Continue in this way until the hip and valley are covered.

Install the hip cap as explained for the hip roof.

The ridge cap on the main ridge is always covered last, since it has to overlap all the rest.

PLASTER AND RENDER

Plaster or render is a mortar coating over the blockwork. We call the coating on the inside walls “plaster” and the coating on the outside walls “render”. The main difference between the two is that render is generally richer in cement than plaster, because it has to be weather resistant. In the following pages we will refer to the application of either plaster or render as “plastering”.

The function of the plaster inside is to make the walls smooth so that they are easier to clean, free of insect hiding places, and have a better appearance. Also, if the house is constructed out of wood or bamboo closed up with mud or clay, the plaster acts as a protection against fire.

The render on the outside surface of the walls is essential to protect them from the influence of the weather, especially if landcrete blocks or mud blocks are used. When these blocks are exposed to moisture for long periods, they gradually become soft, expand, and finally crumble away. The render must therefore be water resistant.

– All external walls should be covered with render. The sides of the building that face the heaviest weather (in north−western Ghana, this comes from the north−east) should be covered with a somewhat richer mix (Fig. 1, a, next page).

– All so−called wet rooms such as bathrooms, toilets, kitchens, and washing areas should be plastered and painted. (Fig. 1, next page: K = kitchen; S = shower; and W = washing area.)

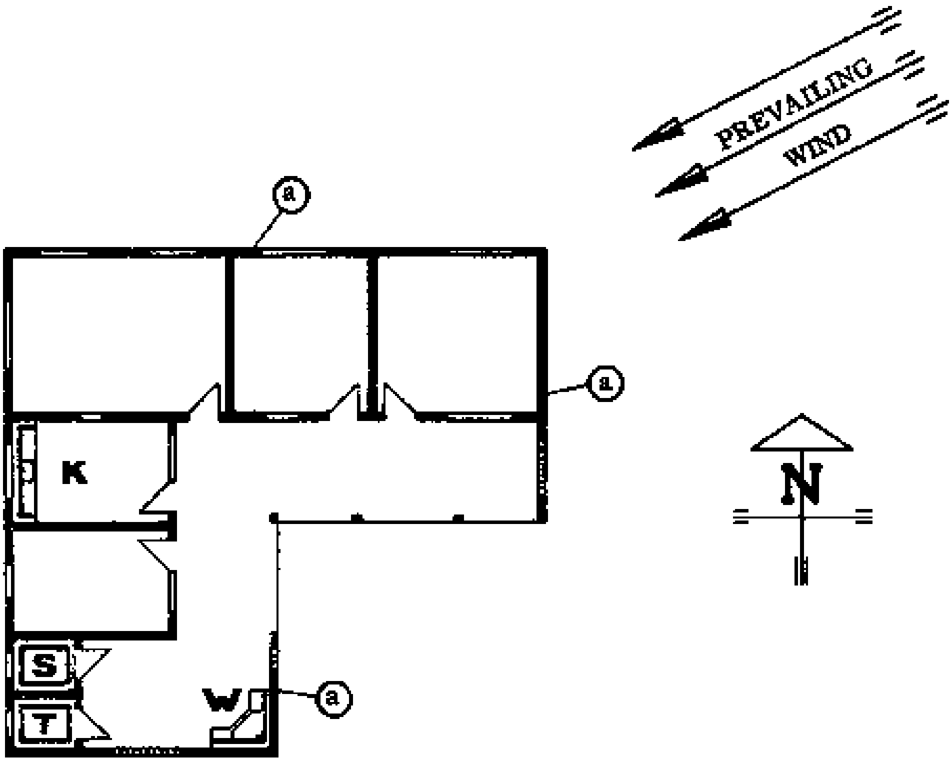


Fig. 1

Composition of plaster or render

In Rural Building, plaster or render consists of cement, sand, and water. Lime can be added to the mix, but this is not always available.

Sharp and relatively coarse sands are preferred for render, although they produce a mortar which is not easy to work with. The size of the grains should be no greater than 5 mm; the sand should be well graded (Reference Book, pages 148 and 149); and it should not contain more than 20% very fine particles (powdered sand).

The sand for plaster should be well graded, but less coarse than sand for render (see Reference Book, page 159).

– MIX PROPORTIONS: The mix proportion for plaster need not be better than 1:8, and may be as low as 1 : 12. The exception to this is the plaster for an area which is often wet, such as a bathroom or washing area. These should be plastered with a mix of about 1 : 6.

The mix proportion for render should never be better than 1 : 6; this is for the north and east sides of the building (or whatever direction the heaviest rain comes from). The other sides of the building can be covered with a mix which is at least 1 : 10 (see the Reference Book, Tables of Figures, page 234).

Exceptions are made for special structures which need waterproof plastering, such as water storage tanks, septic tanks, inspection chambers, manholes, etc. The mix proportion of the plaster used on these may vary from 1 : 3 up to 1 : 1, because the permanently moist surfaces keep cracks from developing.

– REMEMBER: The richer the mix, the more likely it is to develop cracks. Save materials and money by following the rules for correct mix proportions.

Preparing the wall for plastering

During the blockwork as the wall is built–up, the first measure is taken to prepare the wall for plastering: the joints are raked out to a depth of approximately 1,5 cm (Fig. 2). This is done immediately after each course is completed. Raking out the joints gives the plaster or render a better grip to the wall.

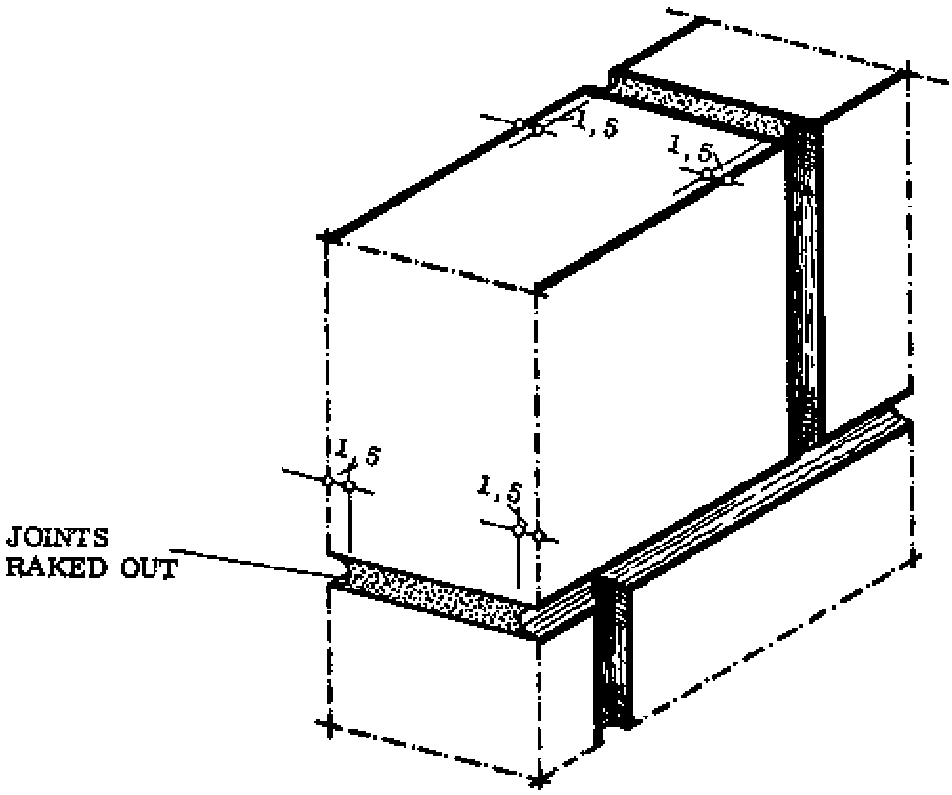


Fig. 2

Before any plaster or render is applied, the wall must be brushed to remove the dust and dirt which would weaken the grip of the mortar. The masonry must then be thoroughly watered, especially during the dry season. This reduces the absorption of water from the freshly applied mortar, so that the mortar hardens well.

– NOTE: Some experiments at NPVC have shown that the landcrete surface can be improved by leaving the walls exposed to one or two short rains before plastering. The rain washes out the finer particles, leaving a rough surface which bonds to the plaster or render better. This method is risky however, because it is impossible to tell in advance how long the rain will last and how heavy it will be.

Application techniques

– SPATTERDASH: In order to give a good grip on smooth surfaces such as sandcrete, or to reduce the amount of moisture absorbed from the freshly applied mortar, spatterdash may be applied before plastering. This is done with the spatterdash apparatus (see Basic Knowledge, page 178), using a very wet and rich mix (1 : 3, up to 1 : 1). The spatterdash layer is never more than 5 cm thick.

The plaster or render is generally applied in a single layer on top of the spatter–dash, or else directly on the blockwork surface. This layer will be 15 to 20 cm thick.

Sometimes a second coat or finish coat is applied on top of the first layer. This must be done before the first layer has hardened. The second coat is usually made where the plaster has to be very thick, for example where the wall is very uneven so that a thick coat of plaster has to be applied to get a smooth surface. The second coat should be about the same mix as the first coat, and about 5 cm thick.

Don't start plastering on a wall which is in direct sunlight. This would cause the render to dry out too quickly, resulting in a “burnt” render which is useless.

Instead, start plastering in the early morning on the west side of the building, going clockwise around the building to the north, east, and south sides so that the freshly plastered areas are always in the shade.

Areas which are too large to be completely plastered in one day are divided into smaller areas by introducing working joints (Fig. 1). The joints should always be vertical, so that water will flow away as quickly as possible from the joint.

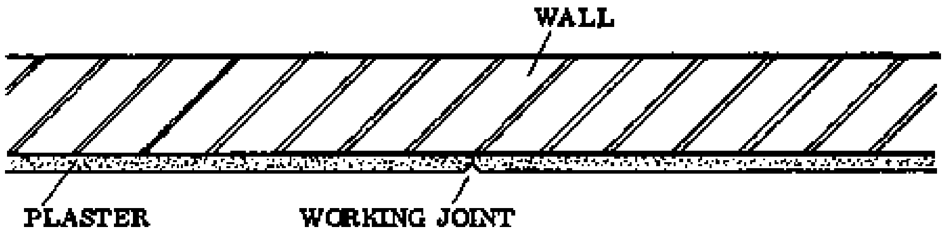


Fig. 1

In Rural Building, the inside of the building is generally plastered after the roofing is completed.

– PLASTERING THE FOOTINGS: Here we must add a note about the footings. These have to be plastered before the rising wall. This is done as shown on the left (Fig. 2; a, b, & c).

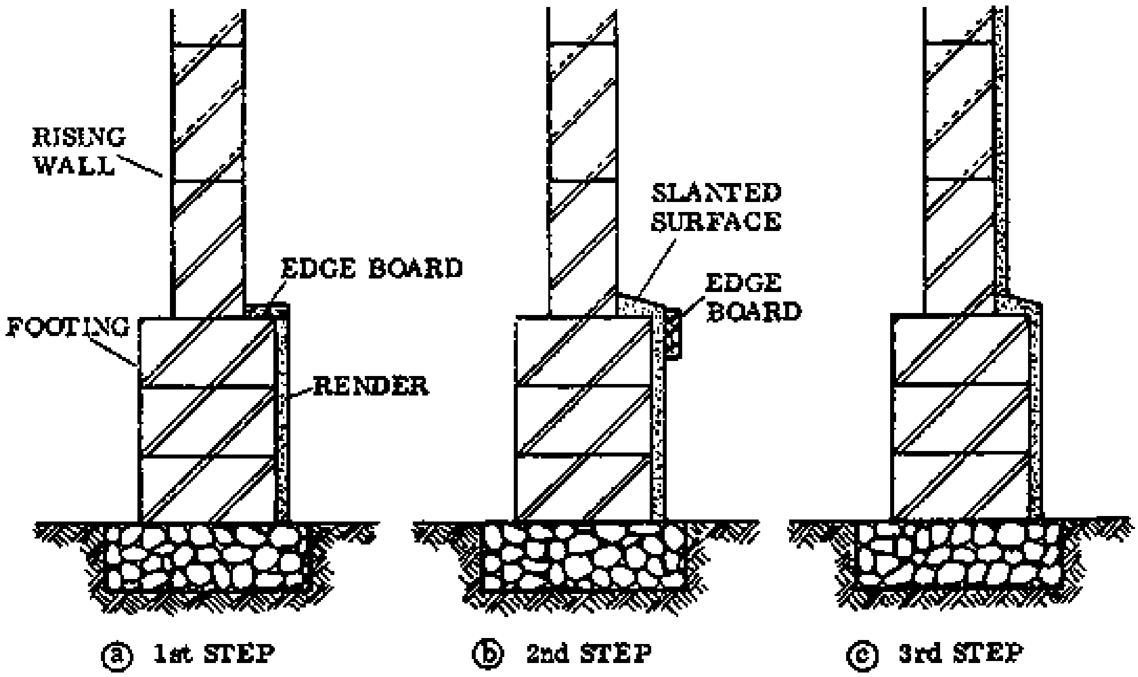


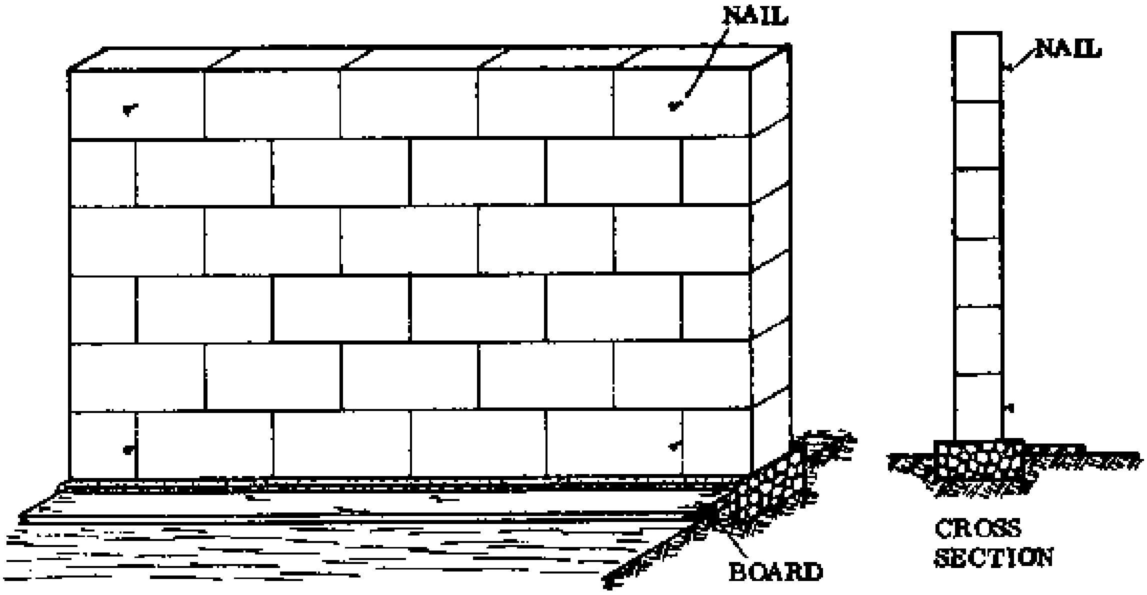
Fig. 2

An edge board is laid on the ledge of the top of the footings, and the vertical surface below is plastered according to the procedure explained on the following pages.

Next the ledge is plastered. The render must form a slanted surface so that water runs away from the wall. It is important that this slanted surface is made before the rising wall is plastered, because otherwise the joint between the two would allow water to enter (Fig. 2; b & c).

NOTES:

Sequence of operations for plastering a straight wall



a. Study the wall which is to be plastered; notice the holes and projecting parts.

b. Clean the wall with a hard brush and chisel off any projecting blocks.

c. Soak the wall thoroughly with water; try to wash off the loose particles. Clean the wall very well, especially the area near the footings and the footings them selves.

– NOTE: In the drawings here the footings have been left out, to make the drawing simpler. The plastering of the footing – rising wall connection is made as explained on the previous page.

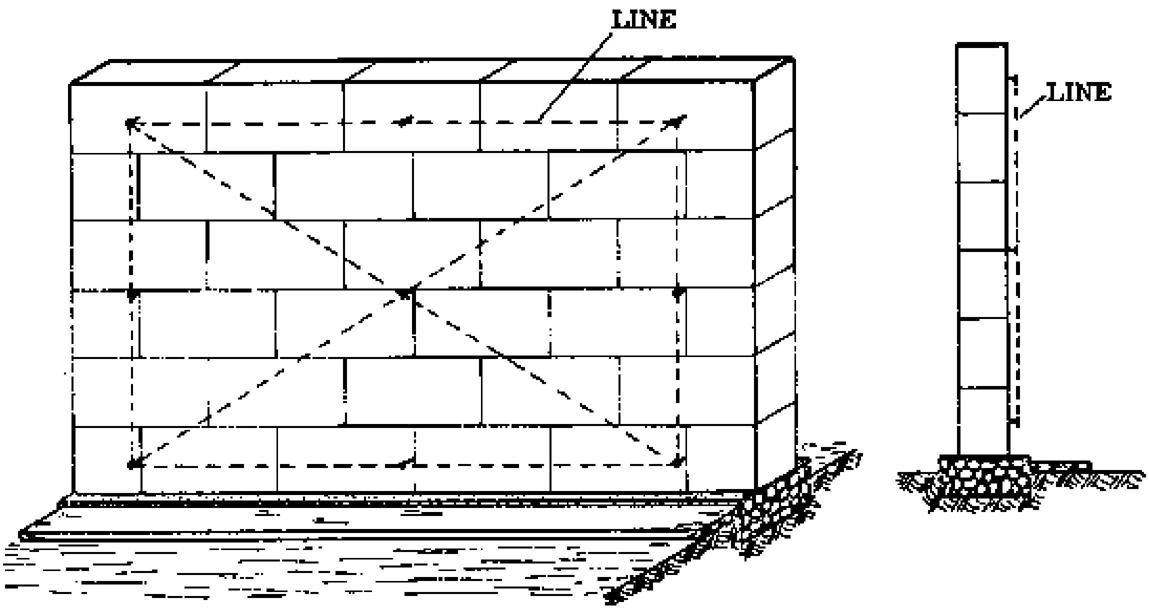
d. Place boards against the foot of the wall to catch the mortar which is dropped.

e. Prepare some mortar which is of the same strength as the wall, and use it to fill up the larger holes in the wall.

f. Make a scaffolding to work from, if this is needed.

g. Insert four nails, one at each corner of the wall.

NOTES:

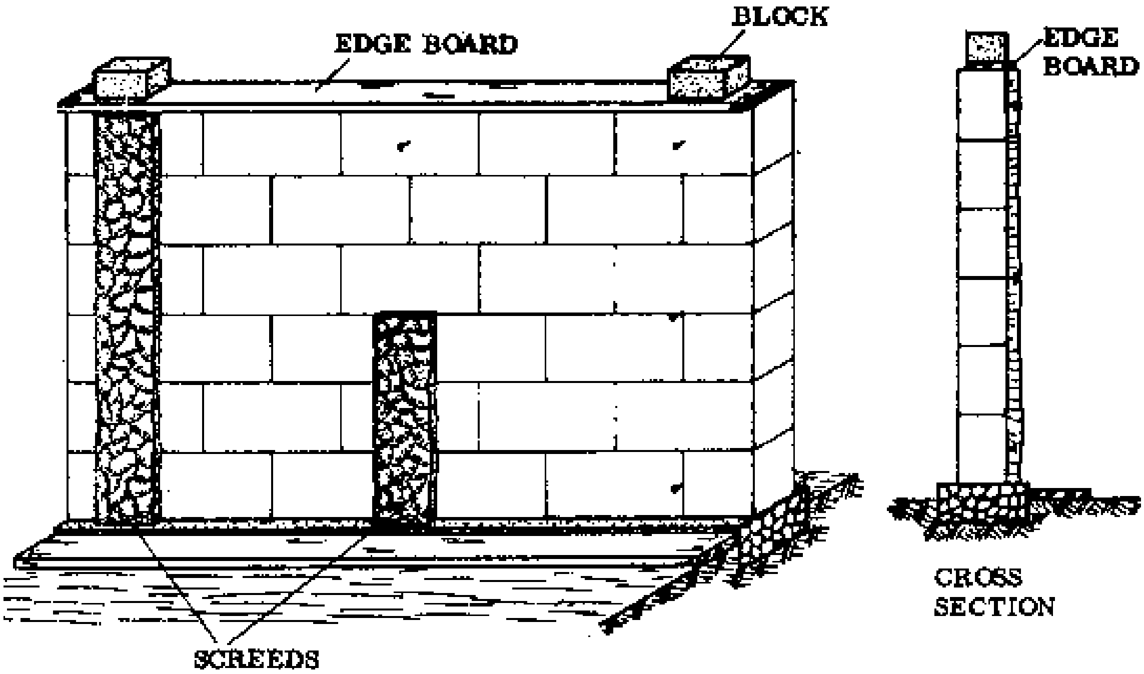


h. Fix lines around all four corners and across the diagonals.

i. The surface contained by the nail heads and the lines should be flat and plumb. Check this using the plumb bob and straight edge. Make corrections by knocking the nails in until they are ail in the same plane; this will be the surface of the future plaster layer.

j. When the four corners have been adjusted, insert more nails along the mason lines, as shown above. The heads of the nails should be at the same height as the lines. The distance between the nails should be no more than the strike board can bridge.

NOTES:



k. Fix the edge boards. The edge board at the top of the wall can be held in place with blocks on top of it. The edge boards should project by the same amount as the nails – the thickness of the future plaster layer.

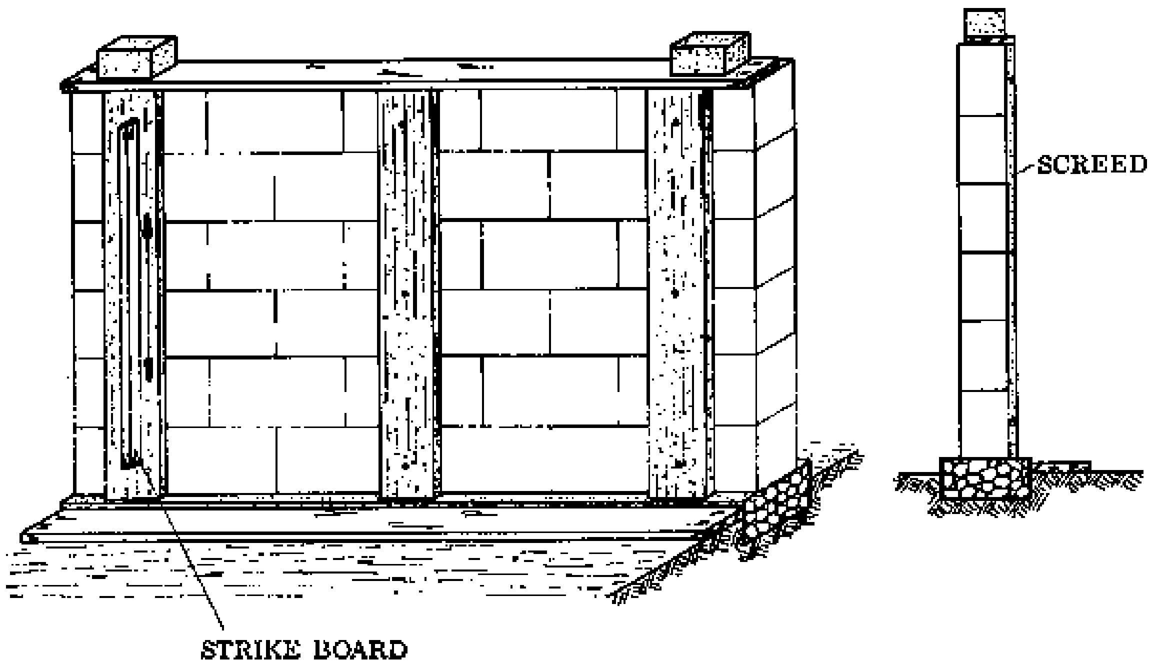
l. Now the plastering can start. Make sure that you have enough time to finish the whole area you want to plaster at once, otherwise wait until the next day.

m. Mix the mortar according to the required proportions. Take care that there are no stones in the plaster. Make up a dry mixture first and add water to this as it is needed. Do not mix too much at once, and keep the mortar covered with paper bags or other covering to keep out the sun and wind.

n. Sprinkle the wall with water again.

o. Build up screeds (guiding strips) by throwing mortar against the wall in vertical strips. The mortar should cover the nail heads completely.

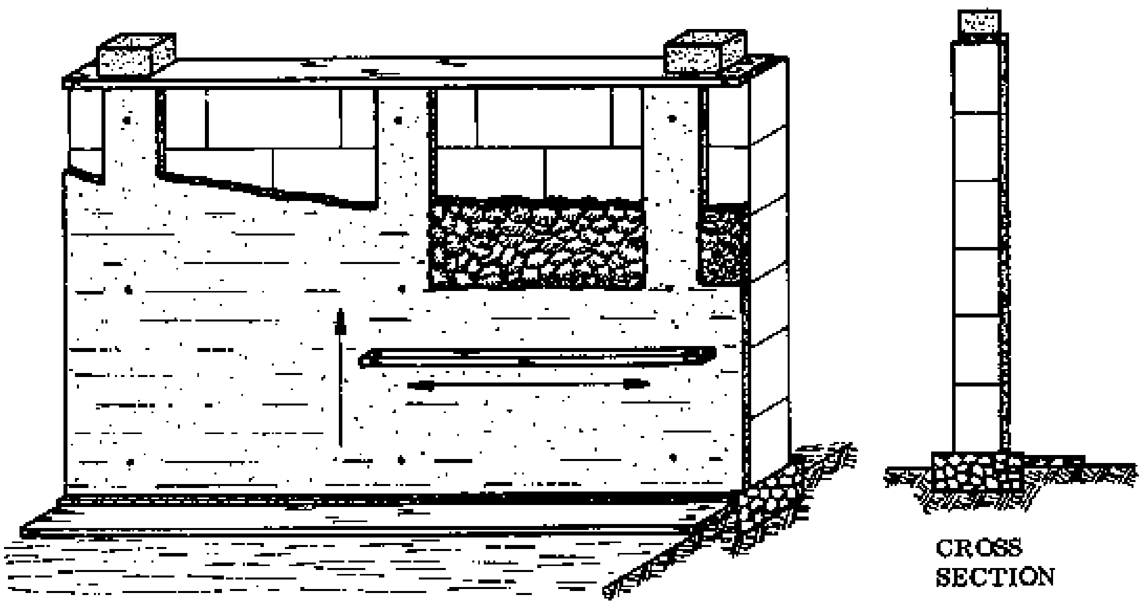
NOTES:



p. Use the strike board to smooth off the screed flush with the heads of the nails. Return any mortar which drops down to the headpan. Give the strike board an up and down movement as you move it across the screed, to obtain a good surface.

q. Let the screeds set for a while, until they are hard enough so that no mortar will be taken off by the strike board during the next steps.

NOTES:



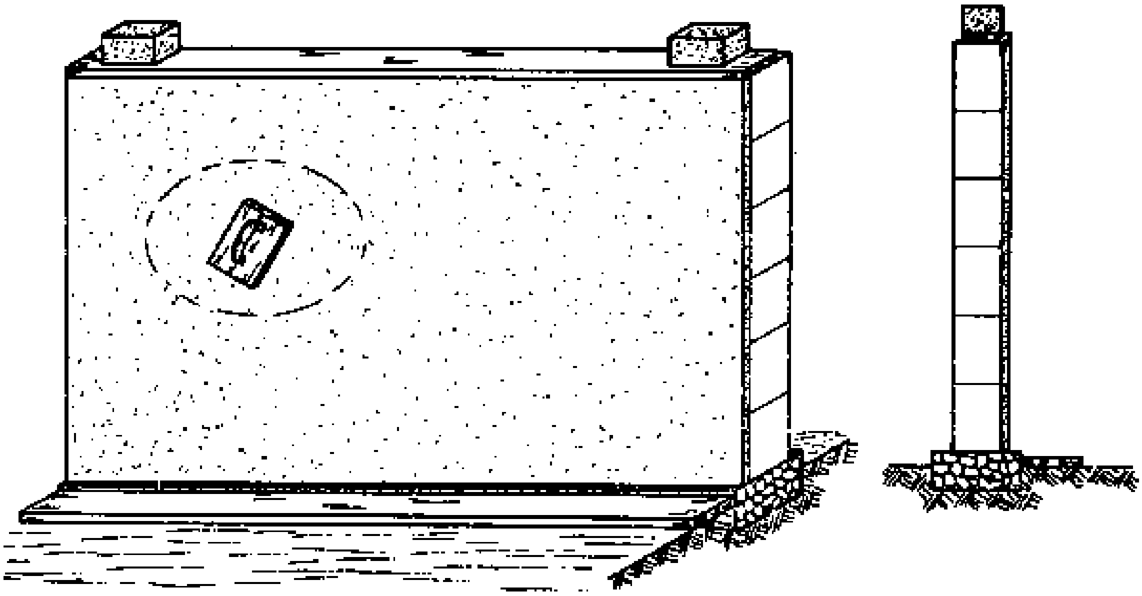
r. When the screeds are hard enough, sprinkle the wall with water again.

s. Fill in between the screeds with mortar. Throw the mortar against the wall, so that it grips well to the wall. The mortar should be a bit thicker than the screeds.

t. Press the strike board to the screed and move it up the wall, holding it horizontally. The board should remove the excess mortar so that the surface of the mortar is flush with the screeds. Make sure that the strike board does not remove any of the mortar from the screeds. Return all surplus mortar to the headpan.

It is not necessary to fill up the whole section between the screeds before you start to smooth the plaster. Fill in the plaster as high as you can comfortably reach, then smooth this and fill in the rest with the help of a scaffold so you can reach the top of the wall. Smooth up to the top of the wall. However, you should never leave a section halfway finished, because it will not join properly when you continue the next day.

u. When the whole wall has been levelled off the nails should be removed and the last finishing work can be done.



– FINISHING: If the wall should be finished with a textured surface, a wood float can do the job. Turn the float around systematically to obtain a regular texture.

If a wall should be smooth–surfaced, use a steel float and take care that the sharp edges do not remove mortar from the plastered surface.

Dip the wood float in water regularly, but don't over–wet the mortar because it could come down or “sag”.

Take care that the plaster or render comes to the footings (here, to the foundations) and cut it off properly. The edges around openings and outside corners should be rounded or chamfered.

Before stopping work, make sure that the work is finished off properly and is clean. Someone should return in the evening and sprinkle water on the freshly made plaster or render. Water the plaster or render regularly in the next few days so that it cures properly.

The edge boards can be removed the next day.

– CURING: Watering the plaster or render is very important, especially during the dry season when the harmattan is blowing. Don't watt until the whole work is finished before you put water on the parts which were done first; the fresh plaster can dry out in a few hours.

If you started on the west side of the building in the morning, be sure to water those sections in the afternoon when the sun is shining on them.

Positions of edge boards for plastering corners

Below are illustrations of the correct method for plastering around corners. In Fig, la, the first step is shown; in Fig. 1b the second step. The arrows indicate the areas which are plastered in each step. The boards project by the thickness of the plaster.

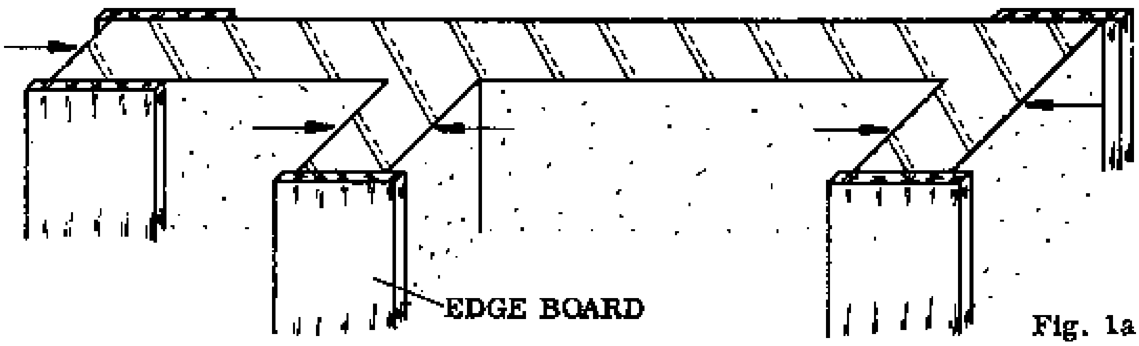


Fig. 1a

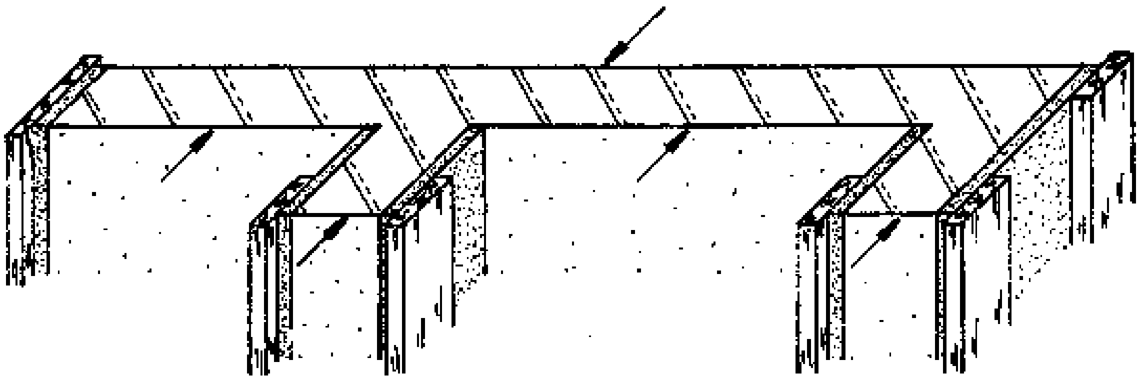


Fig. 1b

Positions of edge boards for plastering around frames

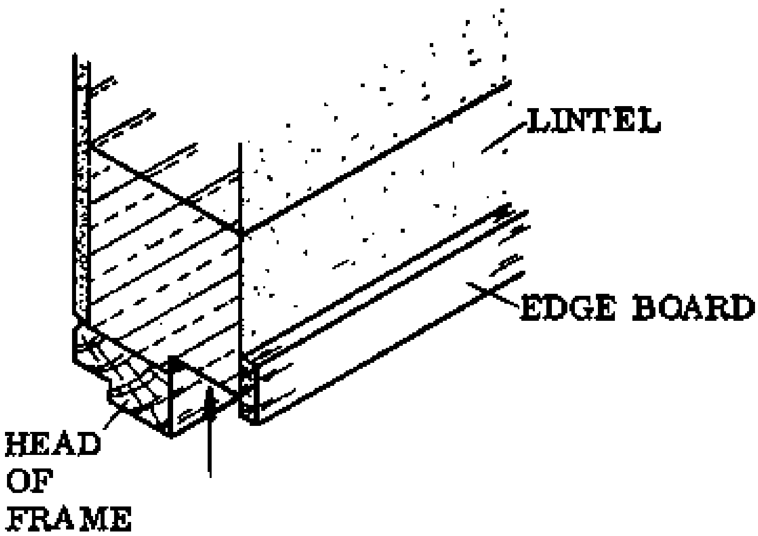


Fig. 2a 1st STEP

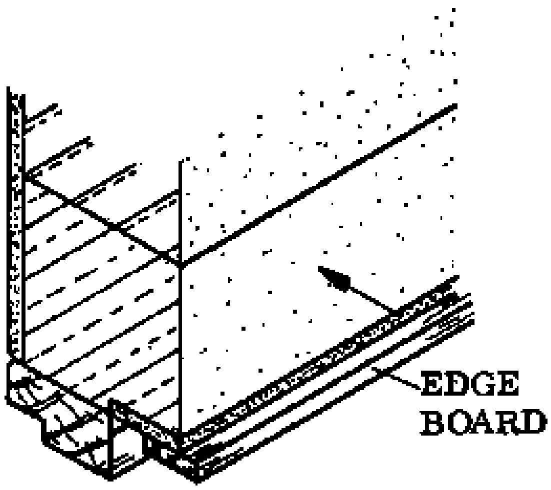


Fig. 2b 2nd STEP

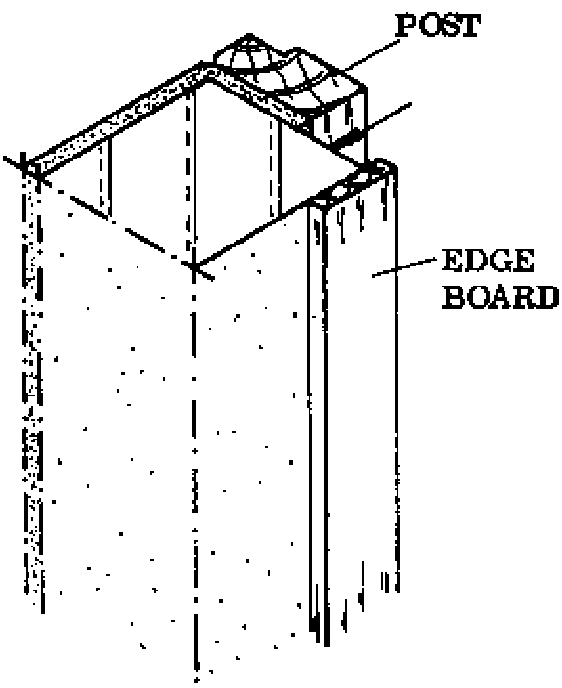


Fig. 3a 1st STEP

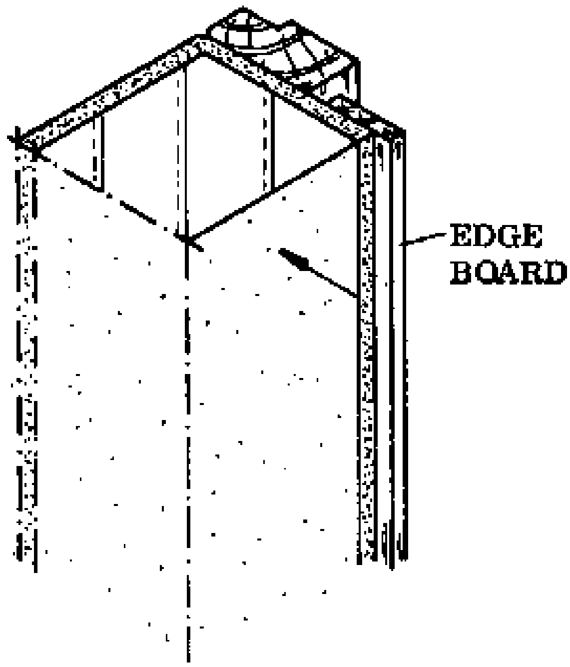


Fig. 3b 2nd STEP

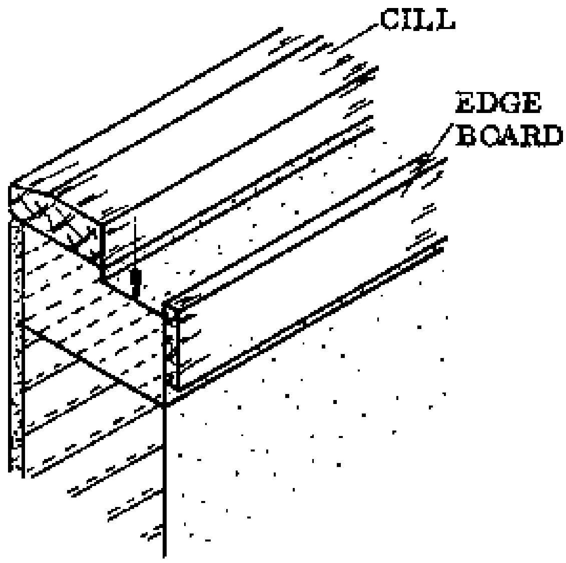


Fig. 4a 1st STEP

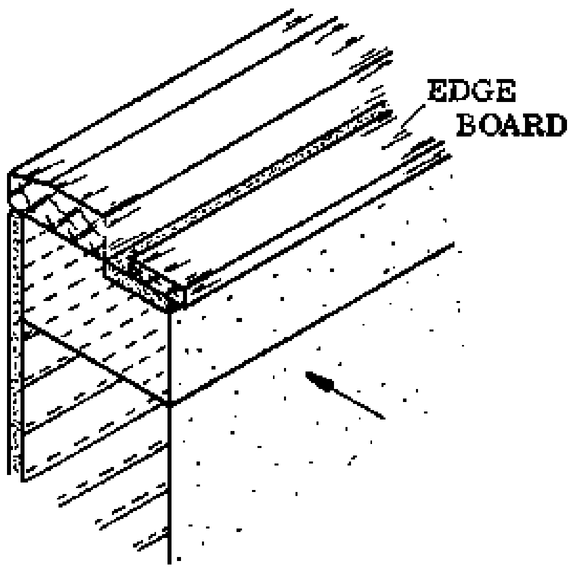


Fig. 4b 2nd STEP

Position of edge boards for plastering the tops of gables

Figs. 1a and 1b show the positions for the edge boards.

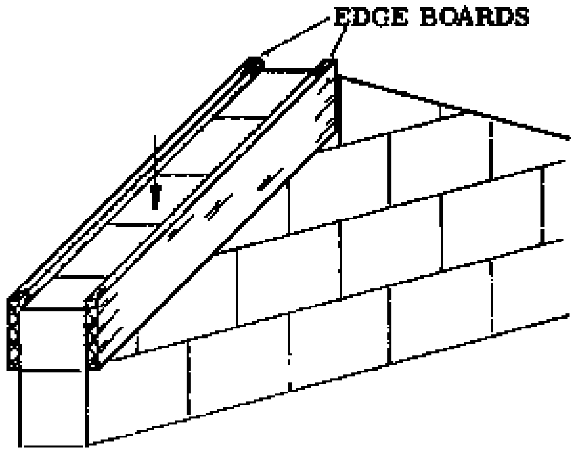


Fig. 1a 1st STEP

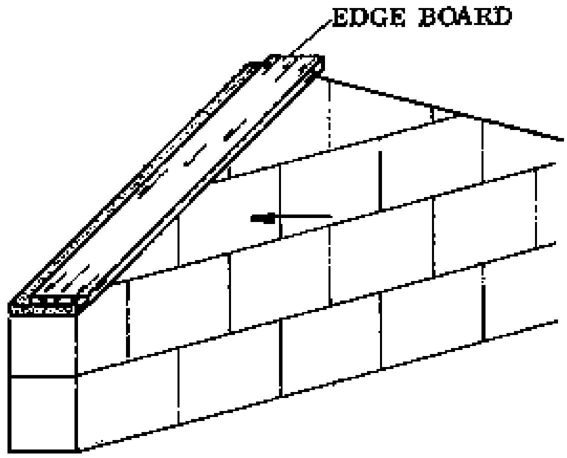


Fig. 1b 2nd STEP

NOTES:

Positions of edge boards for plastering the top of a parapetted pent roof

Figs. 2, 3, and 4 show the positions of the edge boards for plastering.

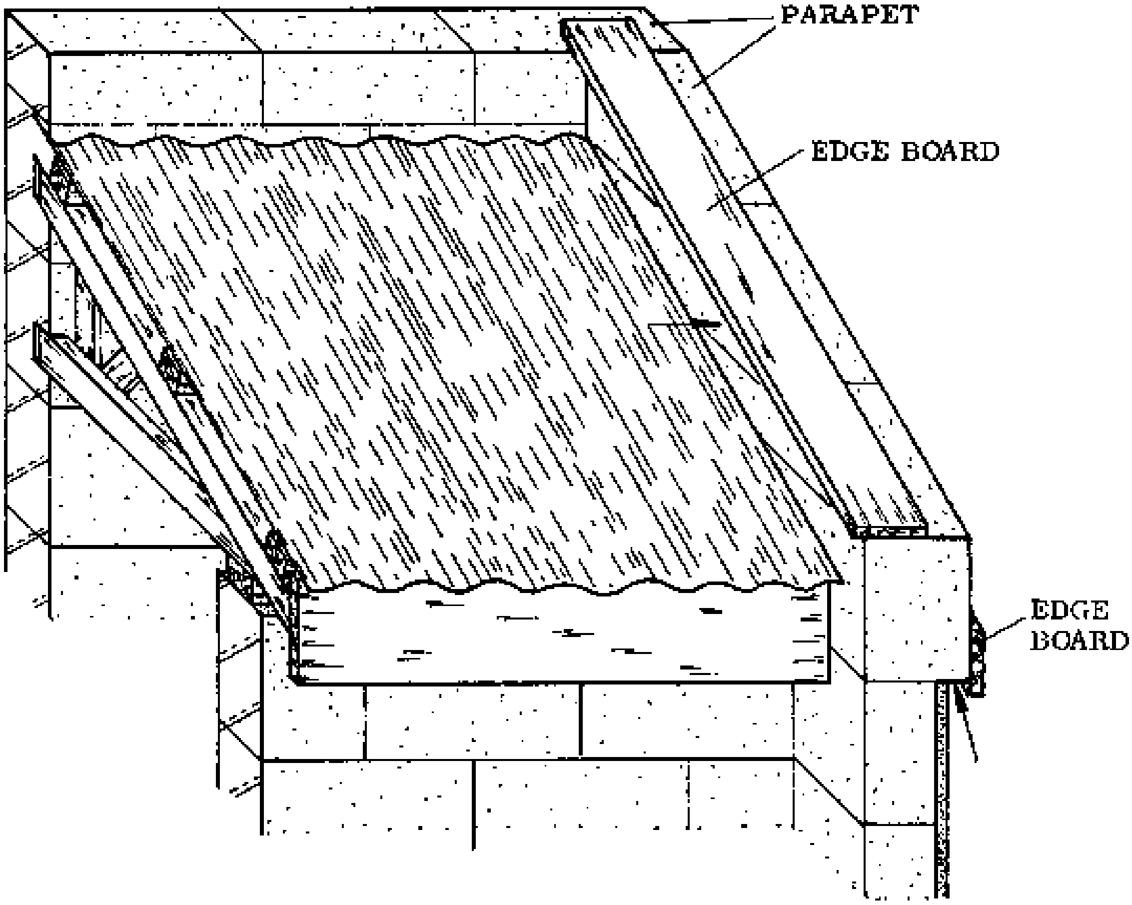


Fig. 2 1st STEP

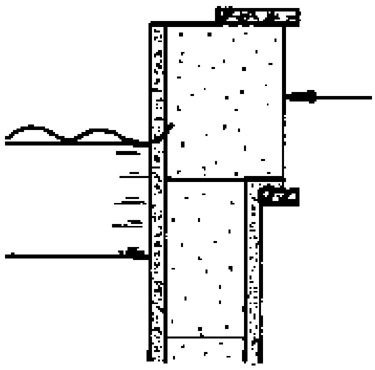


Fig. 3 2nd STEP

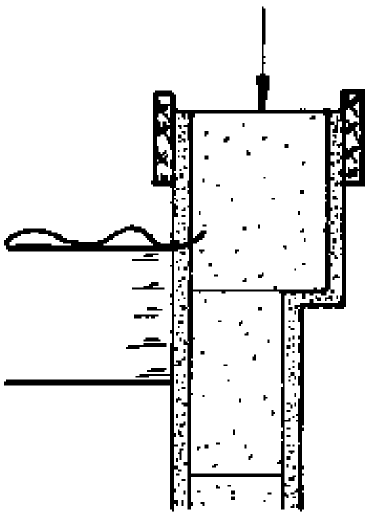


Fig. 4 3rd STEP

Positions of the edge boards for plastering openings

Plaster the inside surfaces of the opening first (Fig. 1), then the rest of the wall can be plastered as usual (Fig. 2).

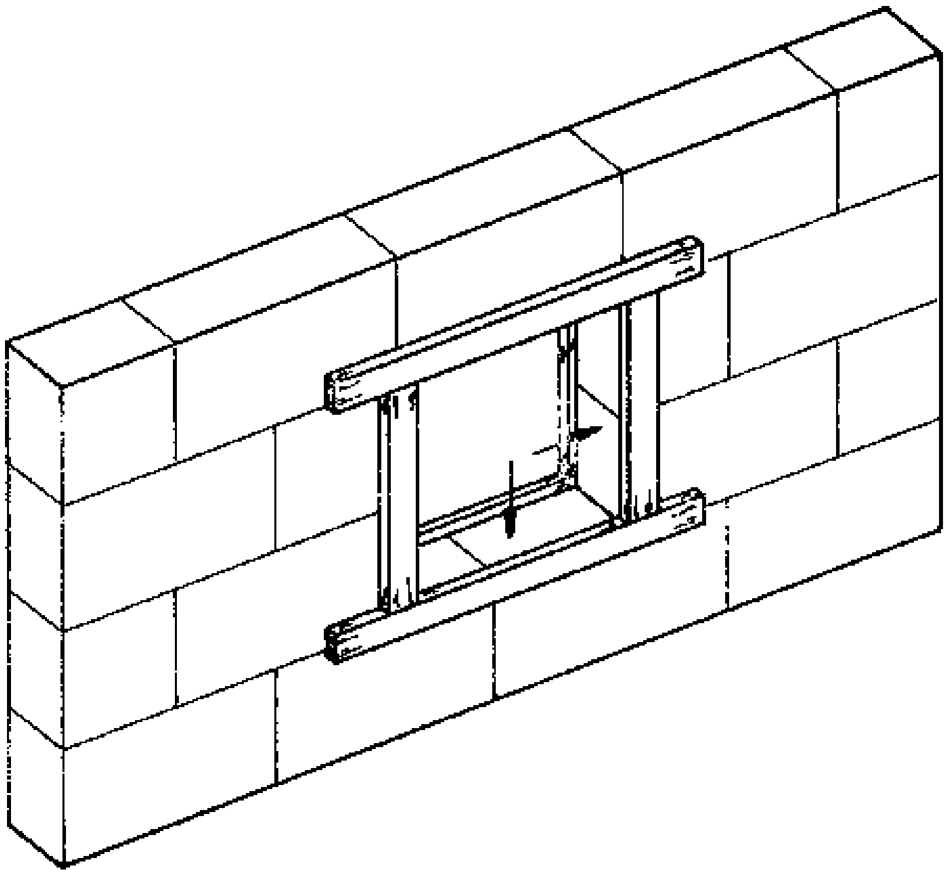


Fig. 1

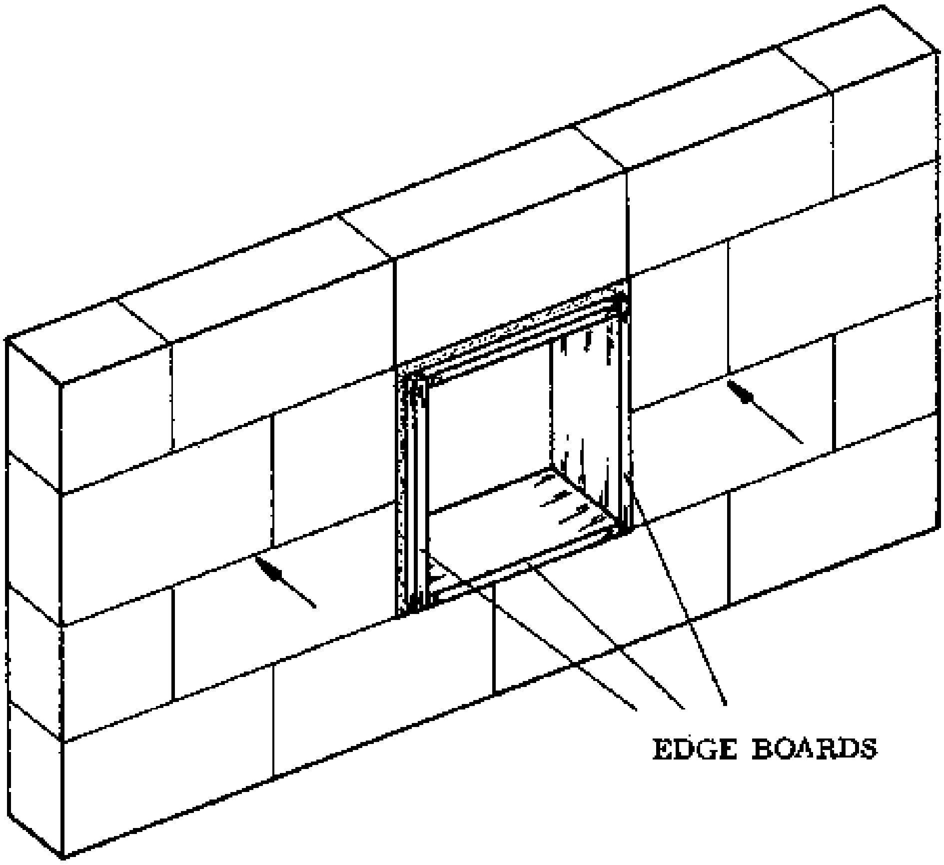


Fig. 2

FLOOR CONSTRUCTION

It is best to construct the floor after the roof covering has been completed. This makes it easier to cure the floor without problems caused by the concrete drying out too quickly and cracking.

Floors are constructed on top of the hardcore filling. There are two methods for floor construction used in Rural Building: one−course work and two−course work. One−course work means that the floor is made in a single layer; while in two−course work the floor is constructed in two layers, the base layer and the floor screed or finishing layer. For an explanation of the two methods and their respective advantages and disadvantages, see the Basic Knowledge book, page 179.

Any floor which is larger than 10 square metres should be divided into “bays” before it is cast (Basic Knowledge, page 180). The bays should be as nearly square−shaped as possible, so that the shrinkage on each side of the bay will be the same. The bays are separated from each other by edge boards during the casting. The smaller the bays, the fewer cracks will appear. In floors which are in the sun, the bays should be no more than 5 square metres in area, and expansion gaps should be made between them.

Expansion gaps and shrinkage gaps are explained in the Basic Knowledge book, page 183. Shrinkage gaps are made between the bays in either one−course or two−course work, to keep the floor from cracking as it hardens and shrinks a bit. Expansion gaps are larger gaps made in the base layer of two−course work when the floor is exposed to the sun or to large temperature changes, which can cause cracks when the floor expands with the heat and contracts as it cools.

The procedure for casting a floor is explained on the following pages.

NOTES:

Sequence of operations for one-course work

The hardcore filling is usually made well beforehand, to allow it to settle properly. It is constructed as explained on pages 59 and 60 in this book. The last 6 cm up to the top of the footings is filled with sand. The hardcore forms a firm support for the floor (Fig. 3).

a. Clean the whole area and level the sand surface (Fig. 1).

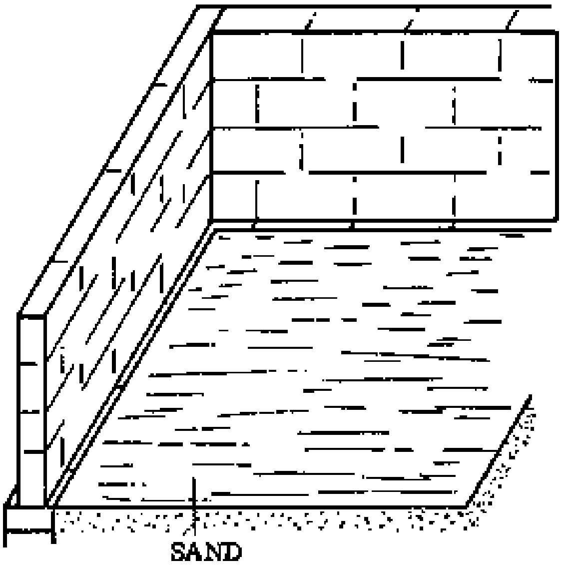


Fig. 1

b. Divide the area of the room into bays and mark the bays on the walls (Fig. 2).

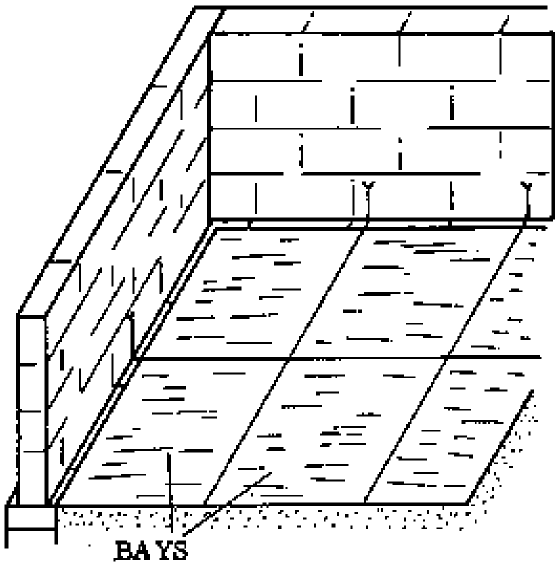


Fig. 2

c. Mark the positions of the edge boards on the sand between the marks on the walls (Fig. 2). Lines may also be fixed between the wall marks at the height of the finished floor level (Fig.. 3).

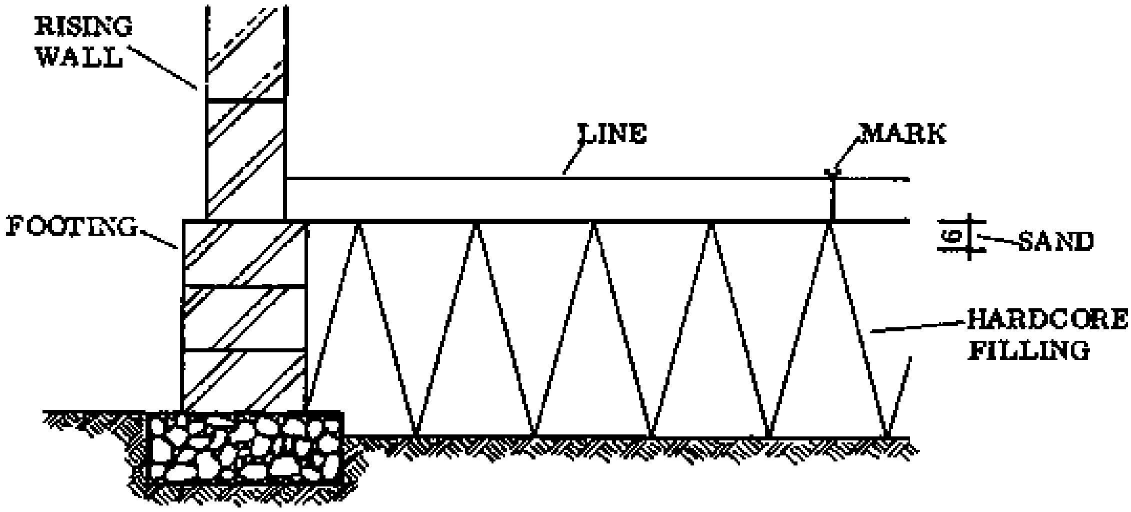


Fig. 3

d. Cut the edgeboards to the proper length. Note the arrangement of the boards shown above in Fig. 4 and in Fig. 6 below, and cut the boards so that they fit in this pattern.

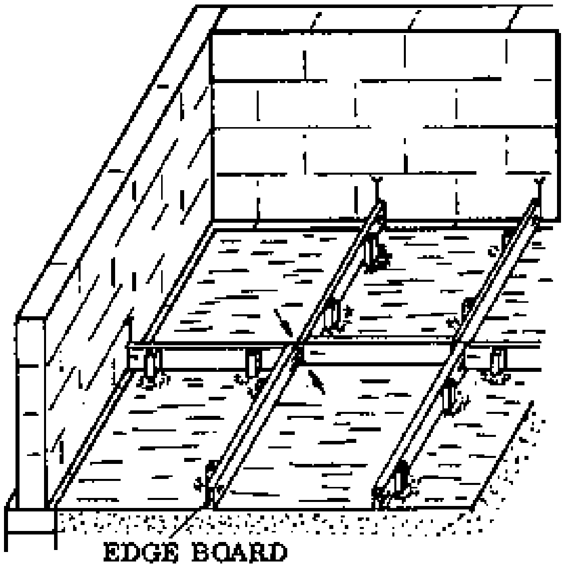


Fig. 4

e. Nail the pegs to the sides of the edge boards.

f. Place the edge boards as shown in Fig. 4, along the marks. The corners of the boards should meet as shown in Fig. 6 below.

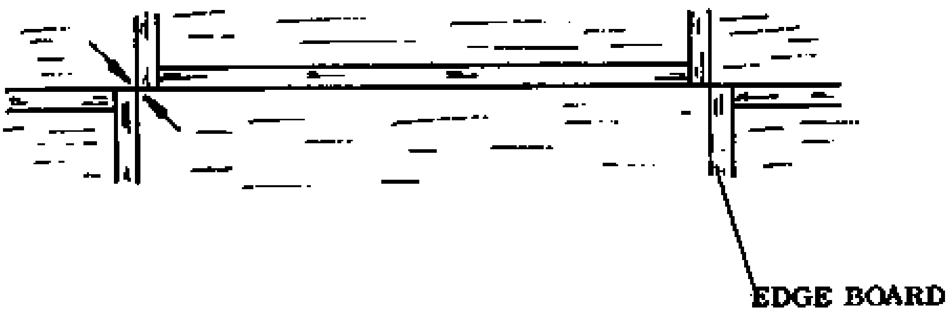


Fig. 6

g. Knock lightly on the pegs until the edge boards are level (check with the spirit level) and at the correct height (the tops of the boards should be level with the finished floor surface).

h. Pour the guide strips to the height of the base layer (approximately 8 cm) (Fig. 5). Level the tops of the guide strips (Fig. 7).

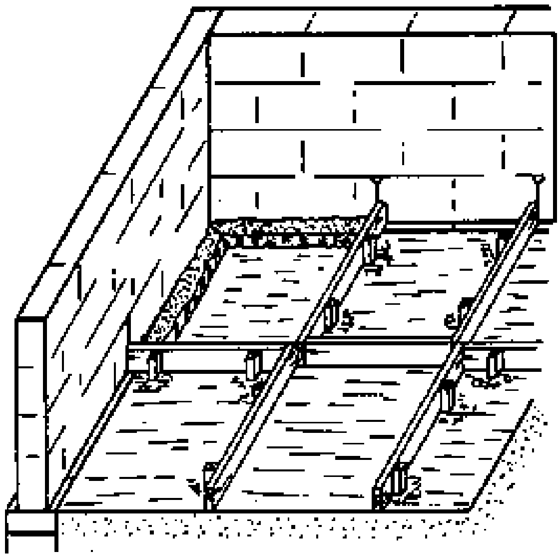


Fig. 5

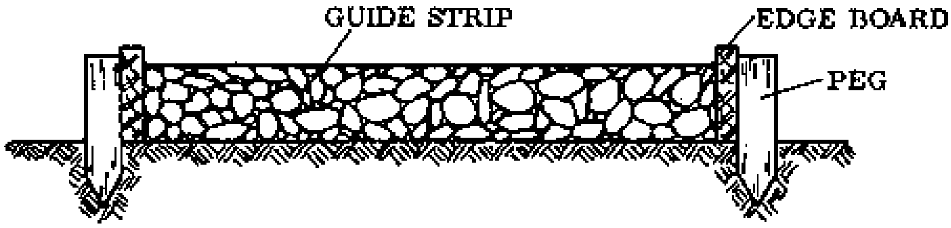


Fig. 7

i. Pour the concrete for the base layer of one bay, making sure that it is well distributed near the walls and corners especially. Mix proportions can be found in the Tables of Figures, Reference Book, page 234 (Fig. 1).

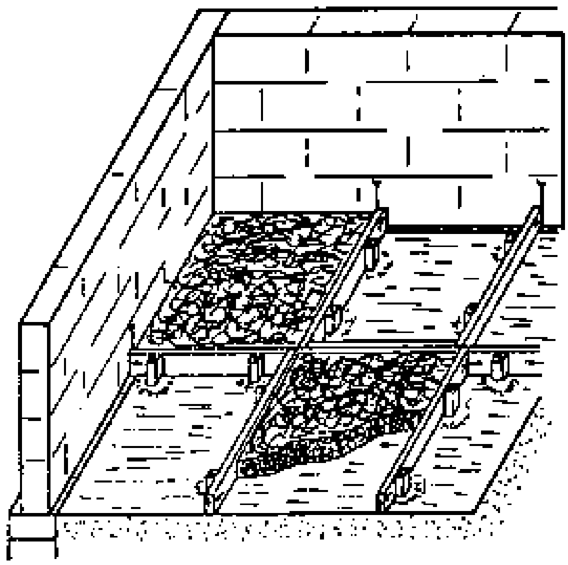


Fig. 1

j. Compact the concrete with a rammer, especially the corners and edges.

k. Use the notched strike board (Fig. 3) to level the surface by gently tamping until the layer is screed−thickness below the top of the edge boards.

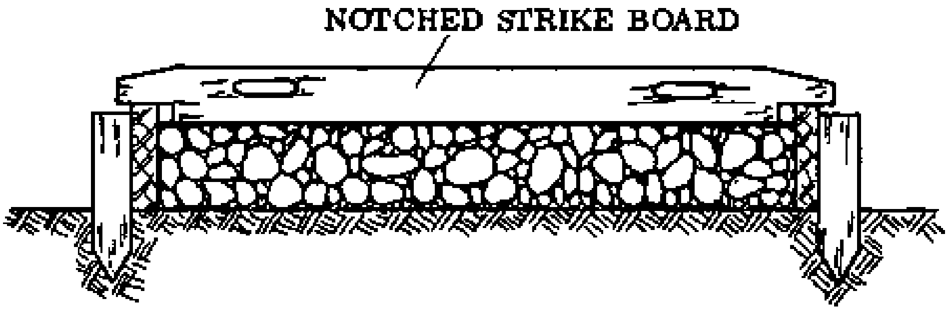


Fig. 3

l. Prepare the mortar for the screed layer. This should be moist but not wet.

m. Pour this mortar on top of the concrete. The screed is about 2 cm thick.

n. Tamp the screed down with a strike board until a level surface is obtained (Fig. 2).

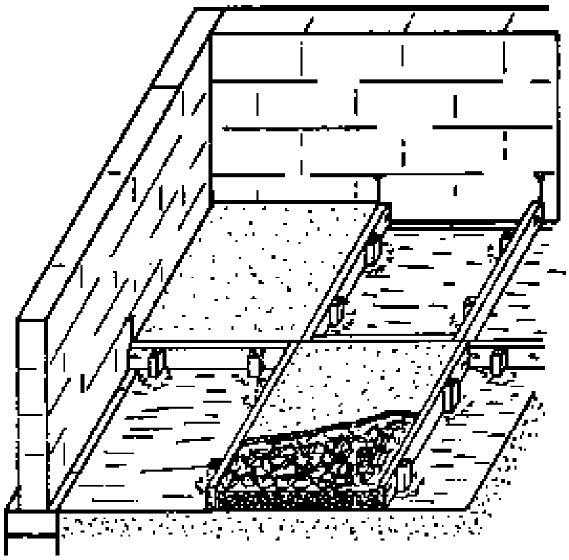


Fig. 2

o. Use the wood float to tamp the screed until the moisture from the concrete comes through. At the same time smooth the surface with the float. During this operation dip the float regularly in water and sprinkle water on top of the screed if necessary to make the work easier.

p. If a smoother surface is desired, finish off with a steel float. Make a chamfer along each edge next to the edge board to form half of the “V” groove above the shrinkage gap (Figs. 4 & 6).

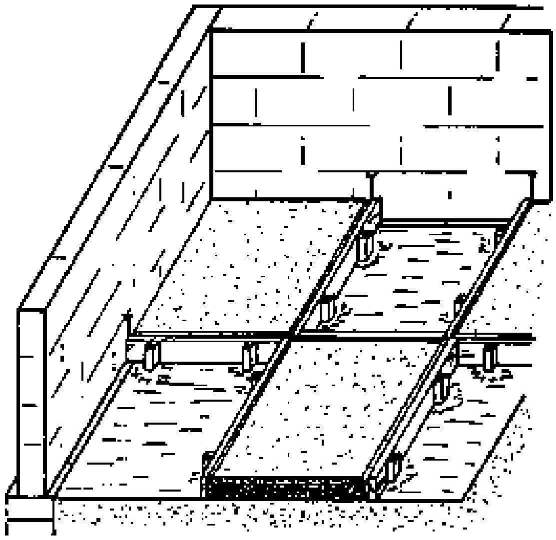


Fig. 4

Fig. 6

q. If blisters or bubbles appear when the concrete starts to harden, pop them and close the holes.

r. Let the floor harden for some hours, then sprinkle water over it. Keep the floor wet at all times.

s. The next day, put some clean sand on top of the floor and wet it thoroughly. Keep the sand wet until the hardening process is over in several days time.

t. Remove the edge boards and cast the remaining bays in the same way. Make sure that the bays are separate by putting pieces of plastic or paper between them before pouring the concrete in the other bays (Fig. 5). The tops of the finished bays act as guides for the strike boards, but be careful not to damage them (Fig. 7).

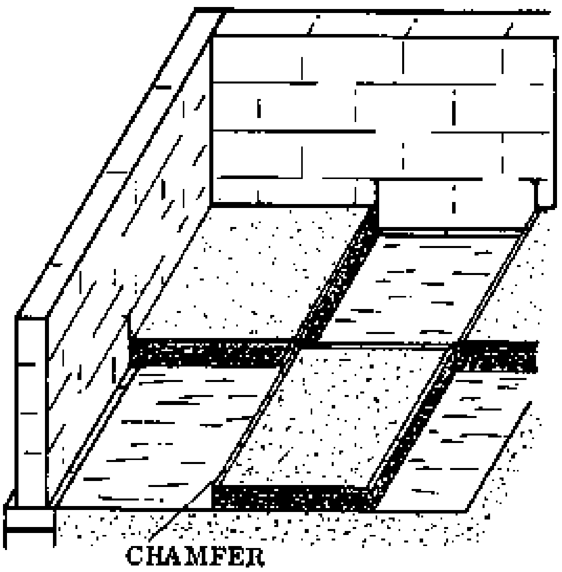


Fig. 5

Fig. 7

Verandah floors

The construction of a verandah floor is different from that of an inside floor in three particular ways.

– Usually the verandah floor is built with a small slope towards the outside so that rain water can run off quickly (Fig. 1, a).

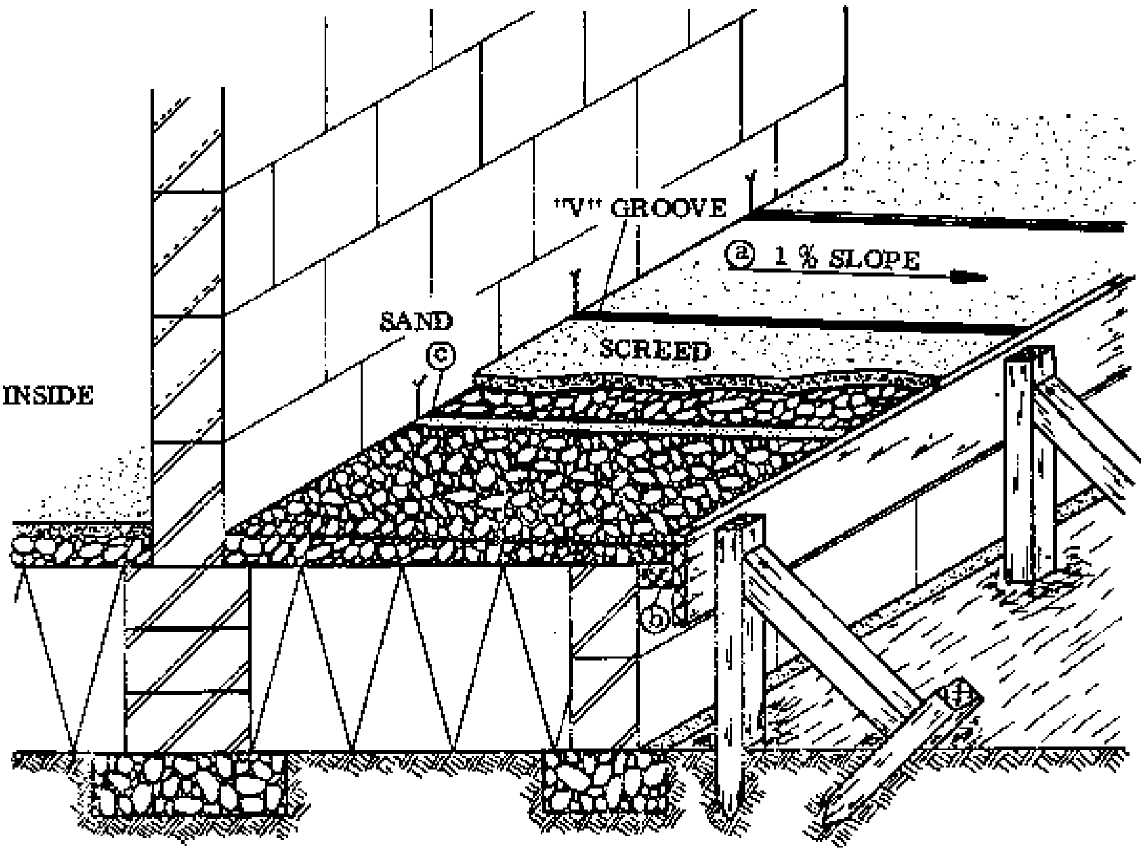


Fig. 1

– The verandah floor can have a projecting outside edge (Fig. 1, b).

– Because the floor is exposed to the sun, expansion gaps have to be made in it. This means that the floor must be made with the two–course method. (Fig. 1, c, and Basic Knowledge book, page 183).

– SLOPING FLOOR: Verandah floors may have a slope which is about 1%; no more than 2%, because this could cause problems in walking and working on it. The greater slope increases the danger of slipping when the surface is wet.

A slope of 1% means that the floor slopes 1 cm lower in every metre; in this case the slope is across the width of the floor.

The construction of the slope is done by simply setting the edge boards between the bays at the required slope.

– PROJECTING OUTSIDE EDGE: If the outside edge of a verandah floor is kept flush with the render of the footing (Fig. 2), then cracks would soon appear along the edge. This is prevented by constructing the floor so it projects past the footing by no more than 7,5 cm. The shorter the projection the better, because the floor is not reinforced.

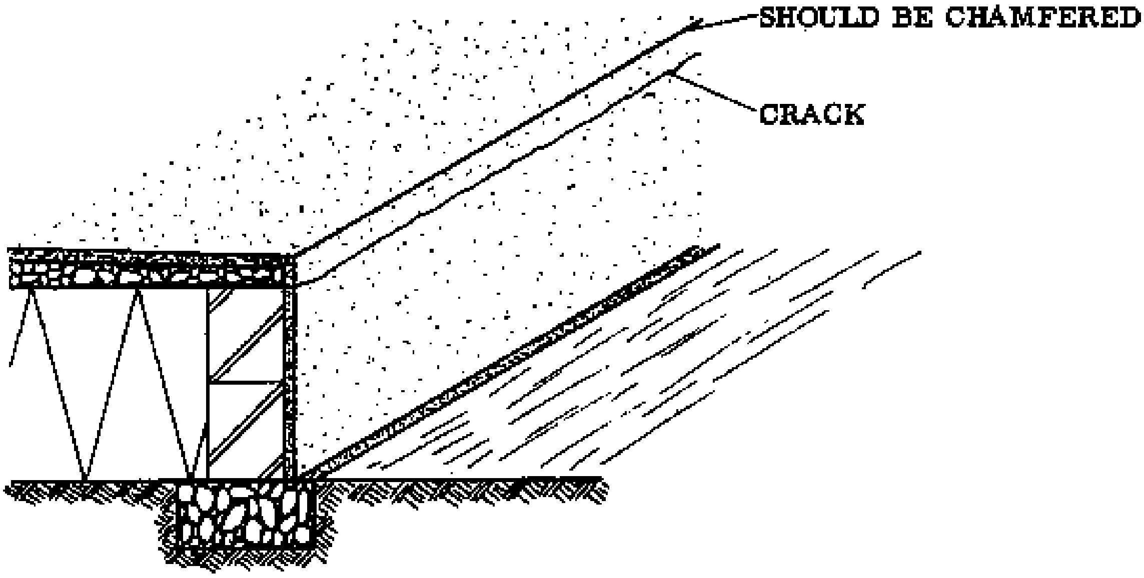


Fig. 2

NOTES:

STAIRS

A stair means a series of at least three steps, also called a flight of stairs. A stair can form the link between two storeys of a building. In Rural Building we are only concerned with one storey buildings, so the stairs are usually only needed up to the level of the floor of the building, which is normally not much higher than 60 cm above ground level.

– TECHNICAL TERMS: Fig. 1 shows the parts of a staircase.

– TREAD: The tread is the horizontal part of the step (a).

– RISER: This is the vertical part of a step (b).

– GOING: This refers to the width of the tread (c). The “going” of a flight of steps is the sum of the “goings” of all the steps of the flight.

– RISE: This is the vertical distance between two treads, equal to the height of the riser (d).

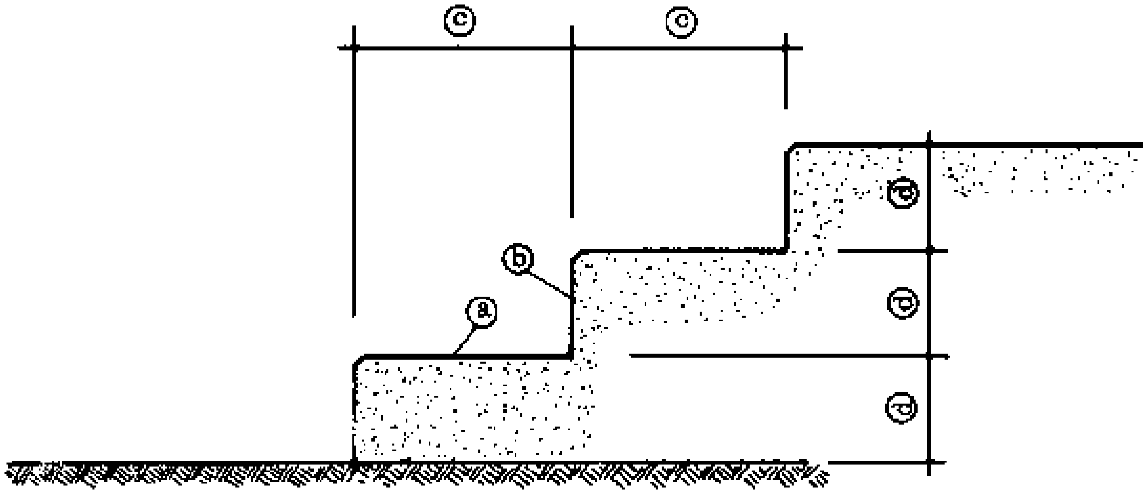


Fig. 1

Requirements

The short flights of stairs we make in Rural Building are usually built with sandcrete blocks or are cast out of concrete. Regardless of the materials and the method of construction, the steps must be all the same height and the same width. A staircase with steps of different sizes is likely to cause accidents.

The rise of the steps is usually 15 cm (approximately) and the width of the tread, the “going”, is usually about 30 cm for each step.

The steps in Fig. 2 are built with sandcrete blocks, so the rise of 17 cm is convenient because it fits in with the block size. The width of the tread can be about 28 cm, or slightly more than the half−block size.

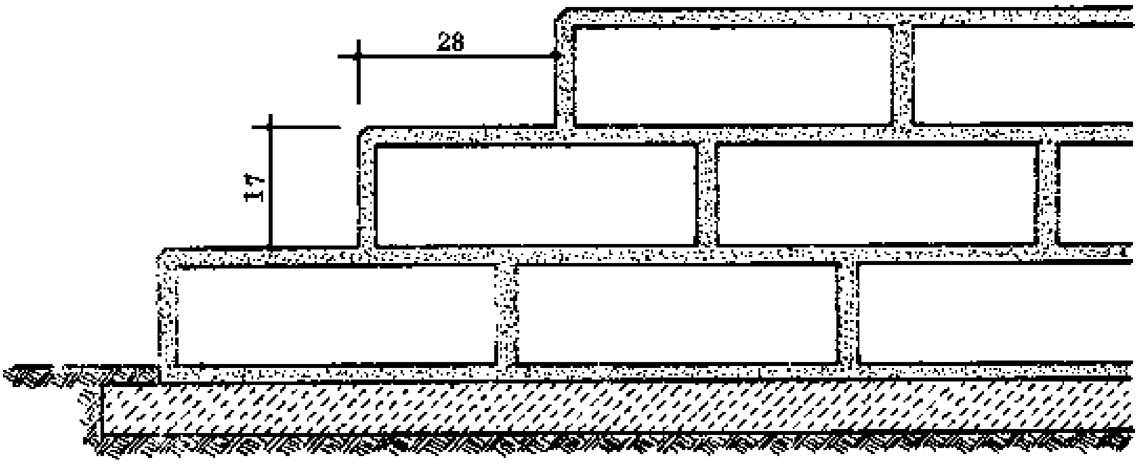


Fig. 2

Steps cast out of concrete can have any convenient rise, but normally the rise is about 15 cm high, and the width of the tread will be approximately 30 cm. The formwork for casting the steps is shown in Fig. 3.

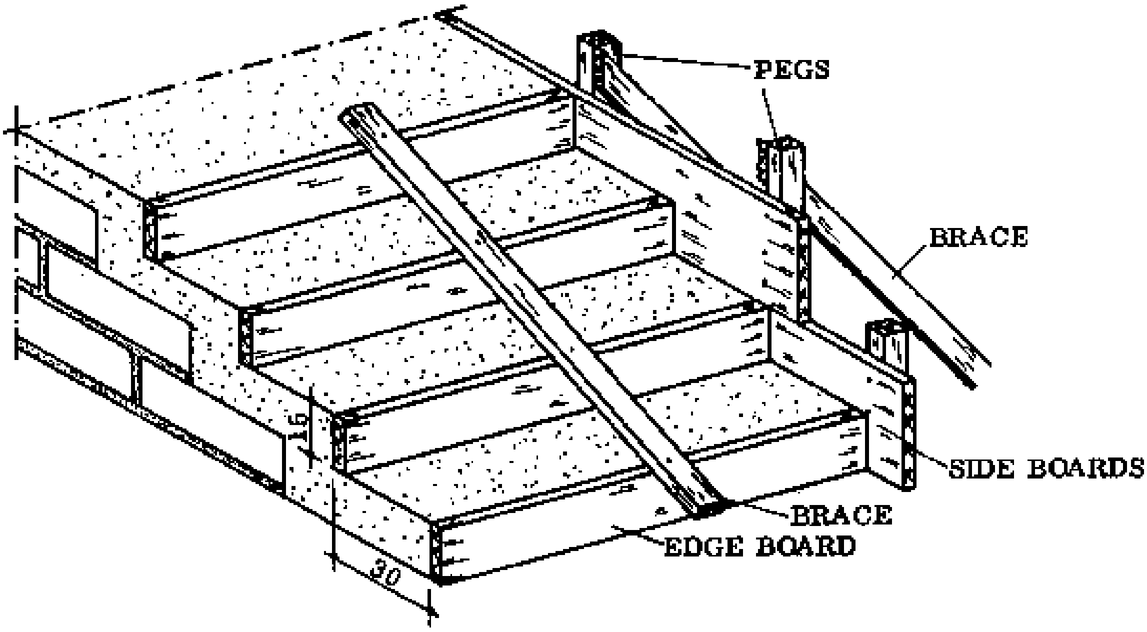


Fig. 3

Plan ahead. If the steps with a 15 cm rise do not reach the right level (measure the height before you start to make the steps) either change the height of the rise (to 14, 16, or 17 cm, etc); dig out some soil before to lower the height of the whole stair; or add a foundation slab to raise the whole construction by a few centimetres to the required height.

− REMEMBER: Never make steps of different sizes in the same stair.

FORMWORK

Formwork for copings

A free−standing wall which is not part of the building (not under the roof) needs to be protected against rain, which otherwise might penetrate at the top of the wall and damage it. This is done by adding a "coping" at the top of the wall.

− SADDLE−BACK COPING: This is placed on top of the wall as shown in Fig. 1. The formwork for the coping is shown in Fig. 2. The drip or throating is made by setting two pipes or smooth iron rods in the wet concrete. The correct position can be assured by using wooden spacers tied to the pipe (Figs. 2 & 2a).

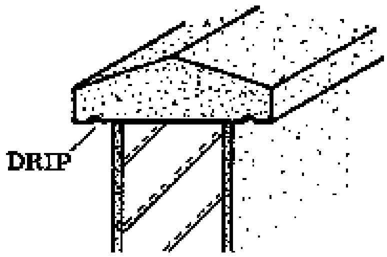


Fig. 1

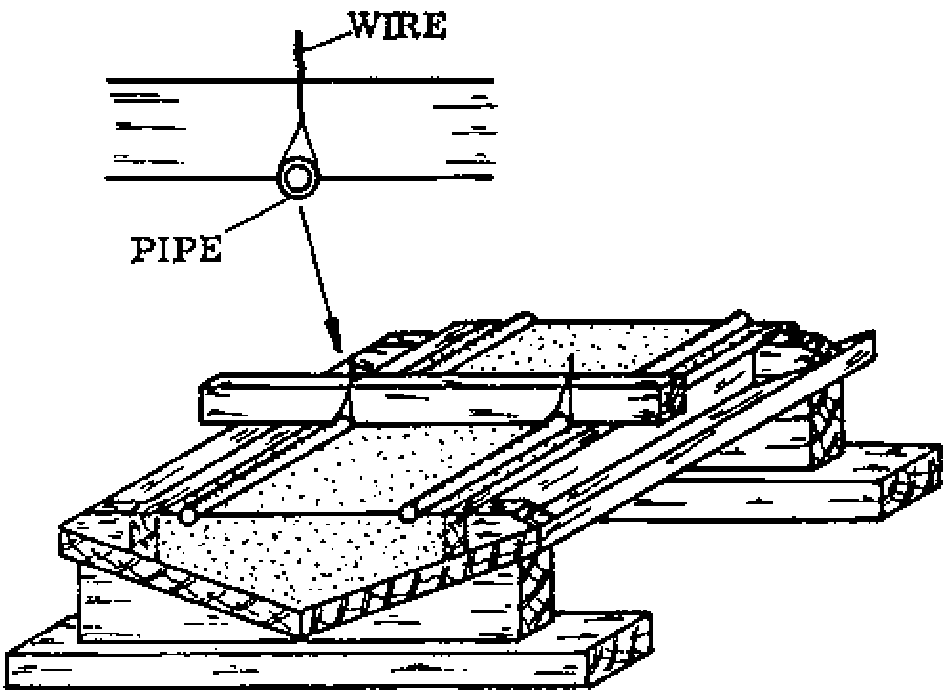


Fig. 2 & Fig. 2a

A second way of making the coping is shown in Fig. 3. A line is fixed at the height of the ridge and the surfaces are shaped with the steel float. The drip is made by fixing half−round beads onto the soffit board of the formwork (Figs. 3 & 3a).

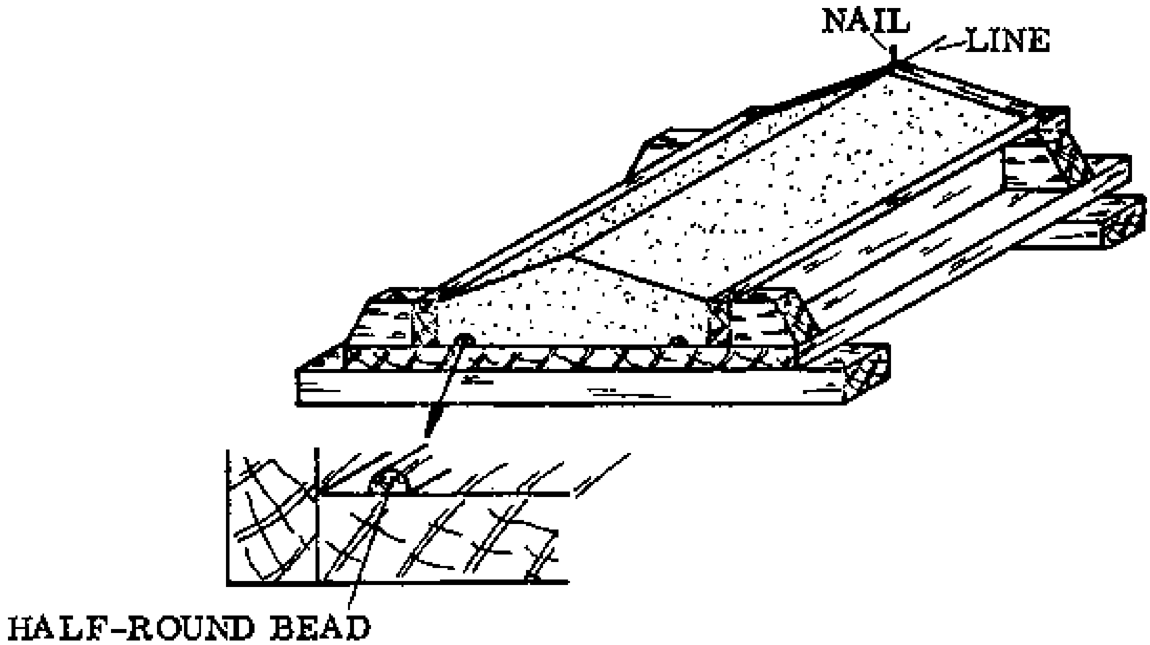


Fig. 3 & Fig. 3a

− SPLAYED COPING: The splayed coping in Fig. 4 can also be made in two ways, in a fashion similar to the saddle−back coping above (Figs. 5 & 6).

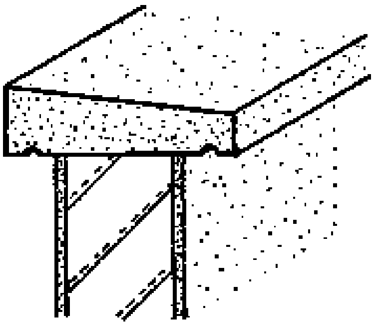


Fig. 4

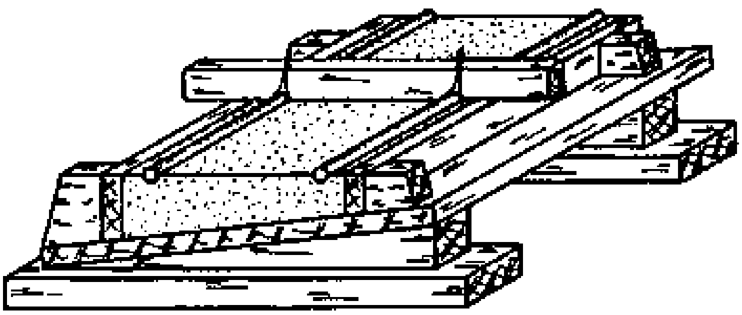


Fig. 5

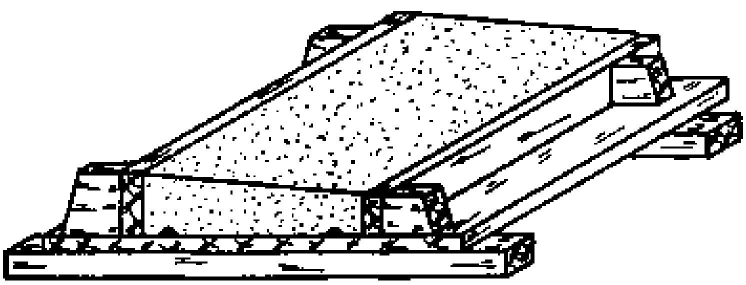


Fig. 6

Formwork for pillars

The formwork for a concrete pillar is shown in Fig. 7 below.

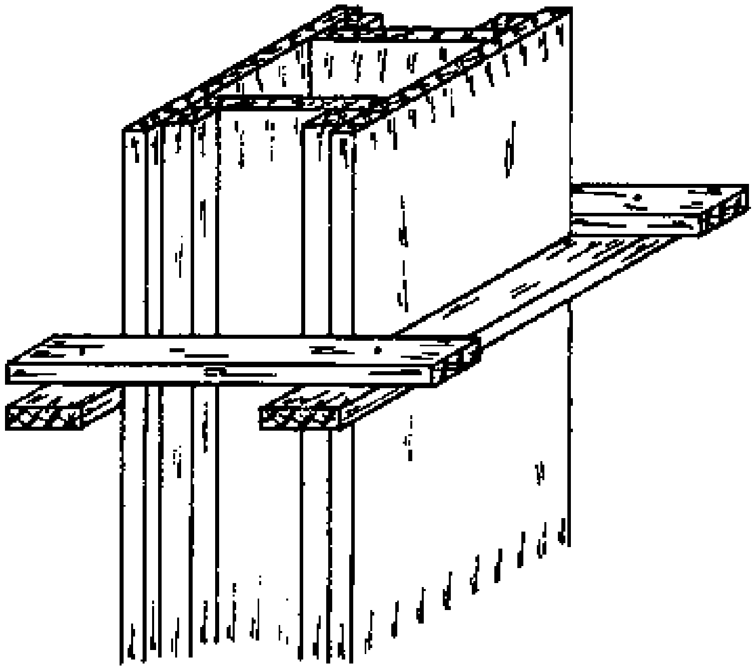


Fig. 7

Formwork for slabs

Fig. 1 shows an example of formwork for a slab. Paper should be set underneath before the concrete is cast.

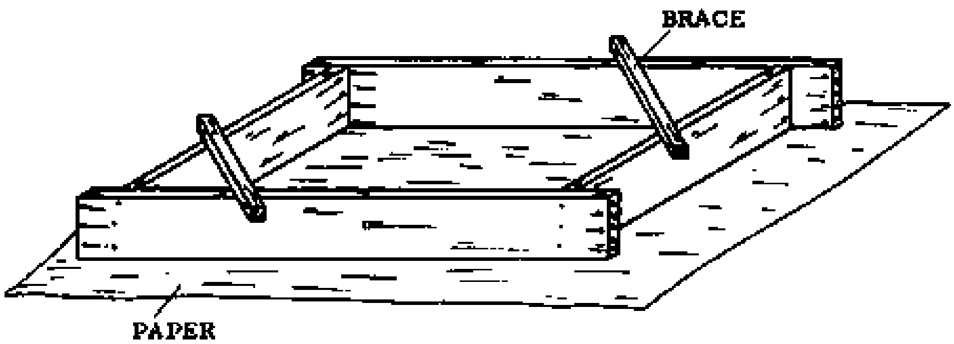


Fig. 1

Fig. 2 shows an example of the formwork for a slab with an opening in it.

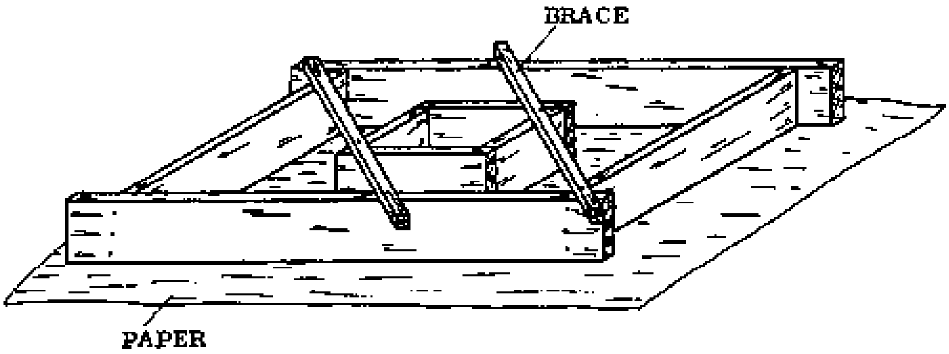


Fig. 2

General hints for formwork

– Use good, straight–grained wood.

– Make a sketch of the formwork before you start to make it.

– Design the formwork so it can be easily removed from the piece after curing.

– Use enough supports and braces to make the formwork rigid and strong.

– Be aware that the wood swells when it is in contact with the wet concrete.

– If the concrete will not be plastered later, plane the formwork members smooth where they are in contact with the concrete.

– Do not overnail the structure, and fix the nails so that they can be taken out easily.

– Oil the form lightly where it is in contact with the concrete.

– For precast members, put the form on the ground in a level spot, and put paper underneath it (old cement bags).

– Remove the formwork only when the concrete has hardened sufficiently (the time depends on the member which is cast).

– Be careful not to damage the edges and corners of the concrete piece when you remove the formwork.

– Clean off the formwork with a steel brush and take out all nails when you finish.

NOTES:

REINFORCED CONCRETE SLABS

In the northern part of Ghana a typical traditional house has a flat roof made of mud plastered over sticks, and supported by tree trunks. The flat roof is very appropriate for the area, but sometimes these traditional constructions have problems like leaking or even collapse during heavy rains.

In Rural Building we do not deal with the construction of flat roofs, even though these would be more appropriate to the local customs. The reason is because the materials to construct a safe, strong flat roof are expensive, and the construction of a reinforced concrete roof is very difficult and complicated.

Therefore, in this course we only treat the construction of relatively small reinforced concrete slabs such as manhole covers, latrine slabs, septic tanks, etc.

Construction

Reinforcement mats are a simple way of reinforcing slabs (Reference Book, page 173) but they are sometimes hard to obtain and they are expensive. The Rural Builder usually has to rely on single reinforcement bars to reinforce slabs.

Fig. 1 shows a typical arrangement for a circular slab, and Fig. 2 shows that for a rectangular slab.

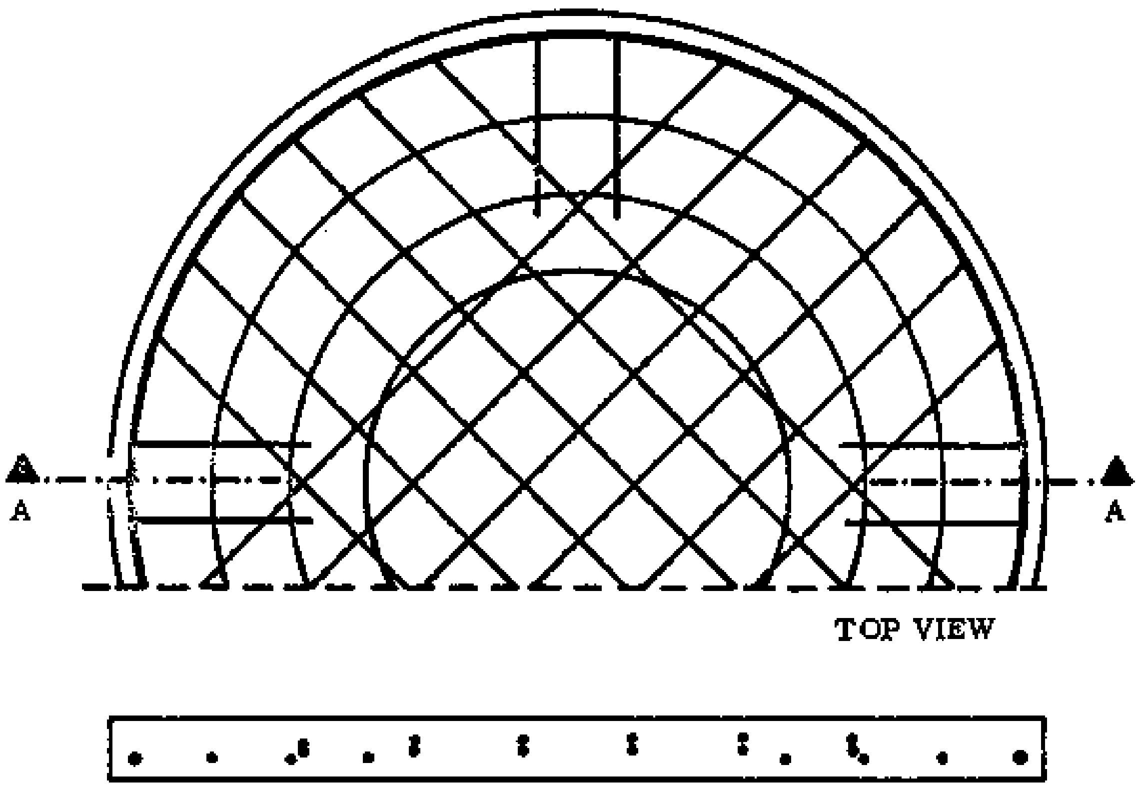


Fig. 1

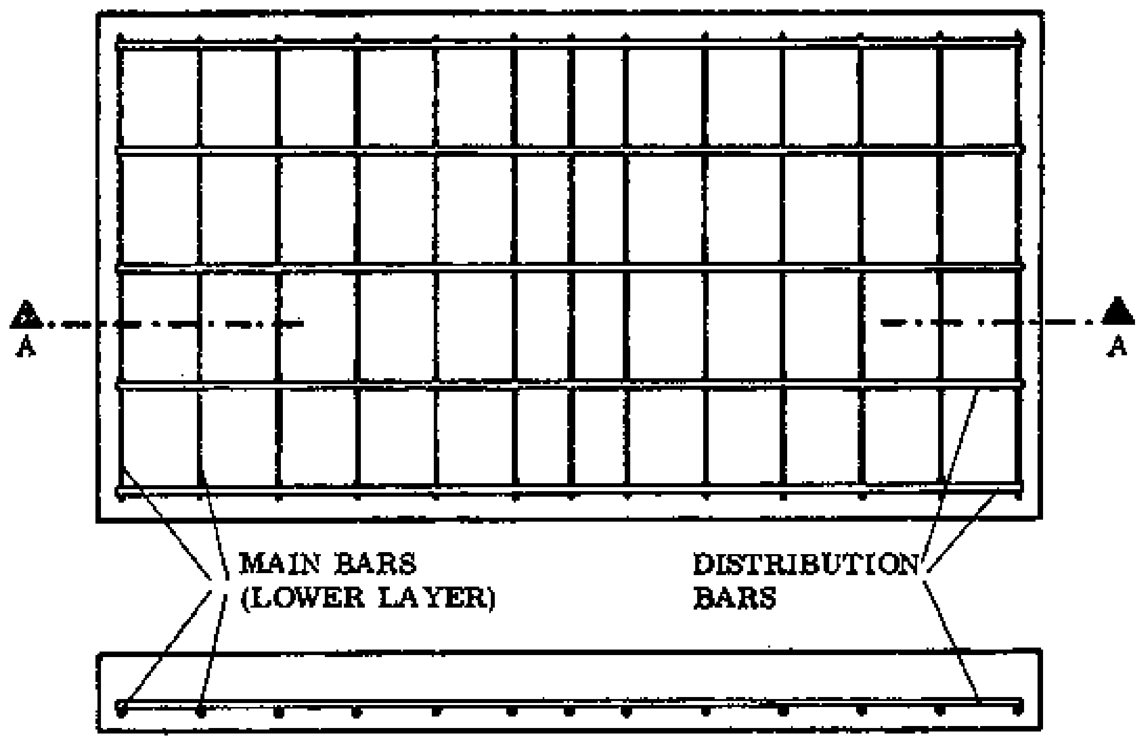


Fig. 2

The distance between the 12 mm main bars is never more than 10 cm. The thickness of the slab can vary between 7,5 cm for smaller slabs like manhole covers, and up to 15 cm for covers of septic tanks, or slabs on which people may walk.

– NOTE: This book is not meant to train engineers; it merely gives basic information. If you need to construct a larger reinforced concrete member, you are advised to seek help from a building expert.

NOTES:

HANGING DOORS AND WINDOWS

The first step in hanging a door is to make sure that the posts of the door frame are plumb. If the posts are not plumb the door will not hang properly. A door should remain in position, either open or closed, without the aid of a stop. It should not swing open or closed by its own weight. The same applies for window casements.

If the door posts are not plumb, the only solution is to fix the hinges in positions such that the door itself hangs plumb.

Hanging a door with butt hinges

Before you read the following section, look up butt hinges in the Reference Book, pages 219 to 221.

– SEQUENCE OF OPERATIONS:

a. Set the door into the door frame.

b. Check whether there is a sufficient clearance all around the door (at least 3 mm, more in the dry season).

c. Mark the positions of the hinges, then take the door down and mark the length of the hinges on the door (Fig. 1).

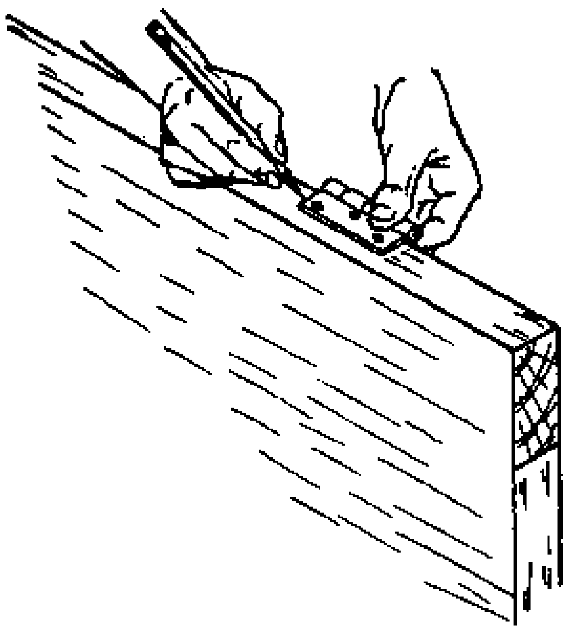


Fig. 1

d. Set the marking gauge from the middle of the pin of the hinge to the edge of the hinge leaf, and mark the distance on the edge of the door (Fig. 2).

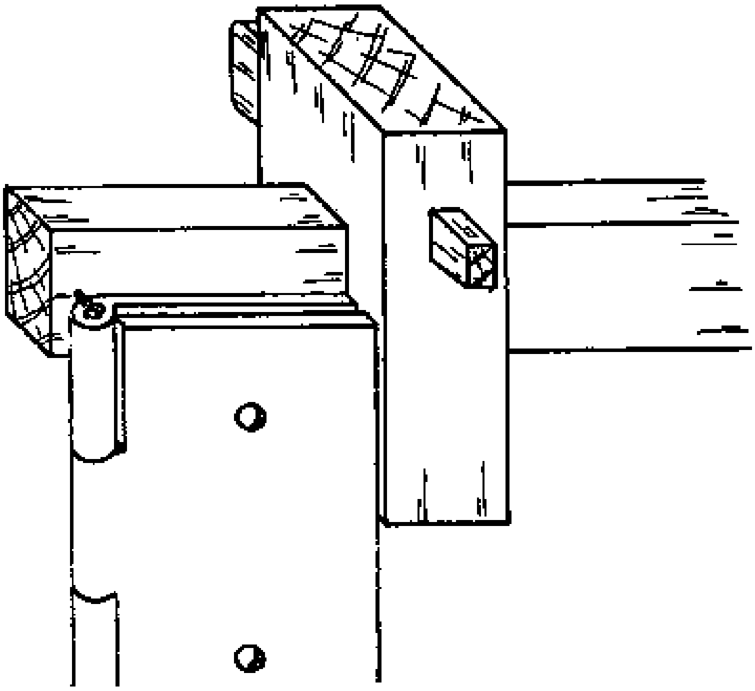


Fig. 2

e. Set the marking gauge to the thickness of one hinge leaf, and mark this on the face of the door (Fig. 3).

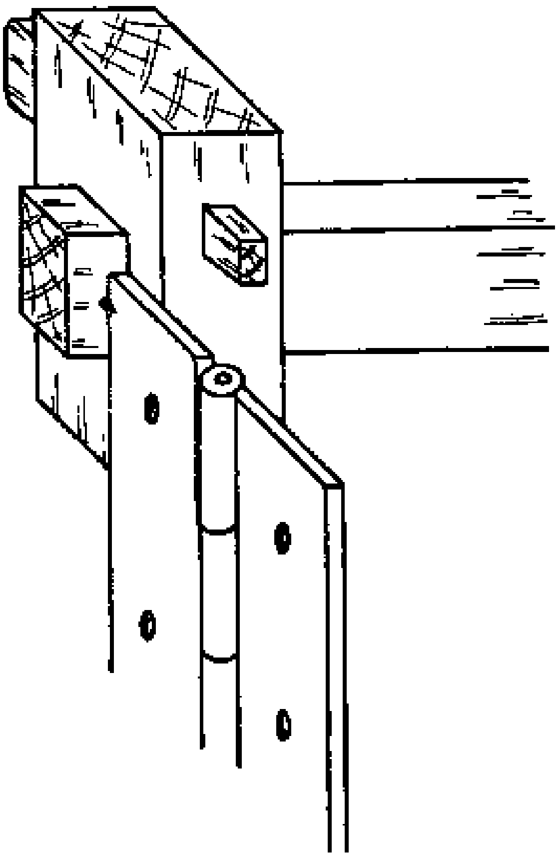


Fig. 3

f. Chisel the recesses for the hinges in the door, and fix each hinge with one screw (Fig. 4).

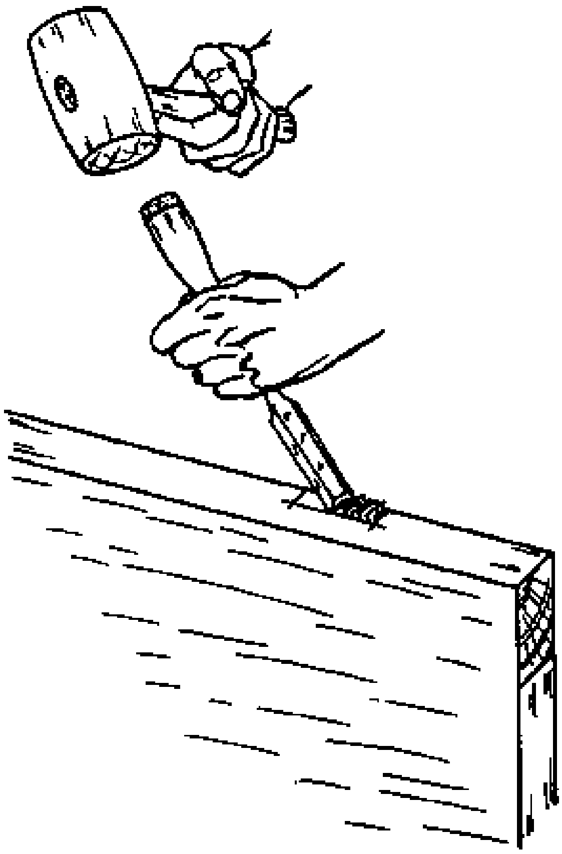


Fig. 4

g. Place the door in the door frame so that there is equal clearance around all the edges. A few thin pieces of wood between the door and frame will help to keep it in place.

h. Mark the positions of the hinges on the post. Remove the door.

i. Mark the depth and width of the hinge recess on the post, using the marking gauge.

j. Chop the recesses in the post.

k. Place the door in position and fix it to the door post with one screw in each leaf of the hinges. Close and open the door several times to see if it works smoothly. Notice in particular whether the door closes completely and does not scrape either post. It should stay closed by itself.

The same sequence as above also applies for casements.

– ADJUSTMENTS OF THE HINGES: Below are some tips for getting a door or casement to close properly.

– If one hinge recess is deeper than the other, loosen the screws and pack the deeper recess with thin strips of wood, until the depths of the recesses are the same.

– When a door binds (catches or rubs) on the hinge post, insert thin pieces of wood at the face edge of the hinges (near the pin) until the problem is relieved (Fig. 1). A strip about 1 cm wide and as long as the hinge will do.

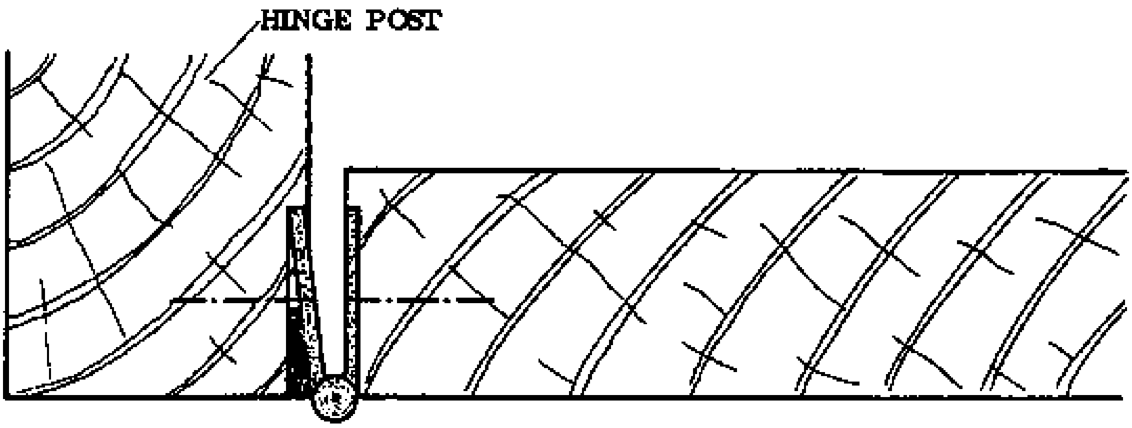


Fig. 1

– When a door binds on the locking post, insert the wood strip at the back of the hinge, to force the door away from the lock post (Fig. 2).

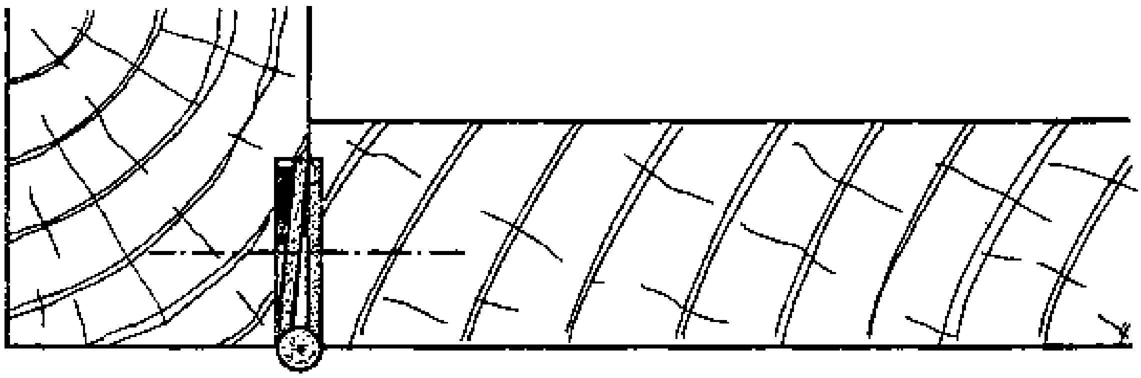


Fig. 2

– If the wood strips are not enough to relieve the problem, you will have to re move the door and plane something off, alter the hinge recesses or even move them a bit up or down.

– One possible reason that a door won't close well is that it is hinge bound/This means that the leaves of the hinges are set too deep. To remedy this, you must remove the hinge and place a thin piece of wood between the leaf and the post (Fig. 3).

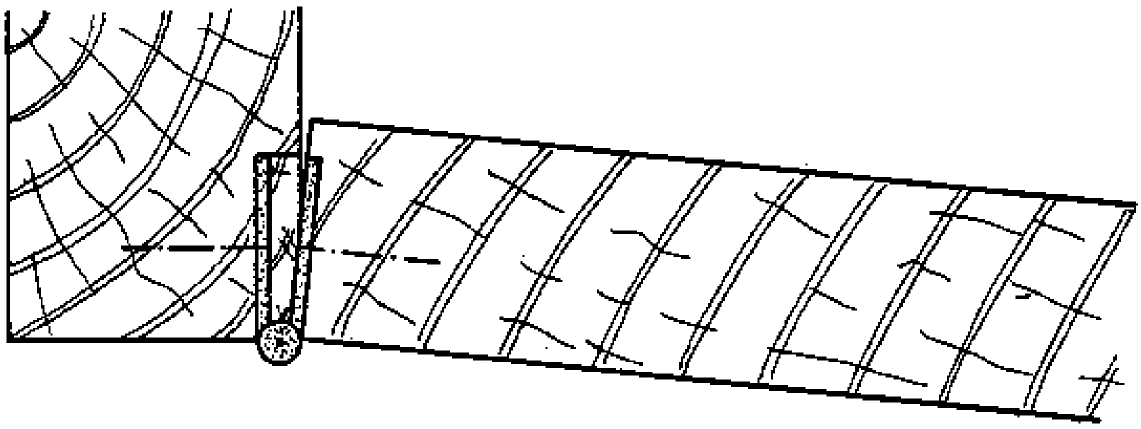


Fig. 3

– When the hinge is screw bound, the heads of the screws obstruct the door so that it can't close properly. This is often the case when the screws are too thick for the hinges, or the heads are too large. The only remedy is to fix the correct screws (Fig. 4).

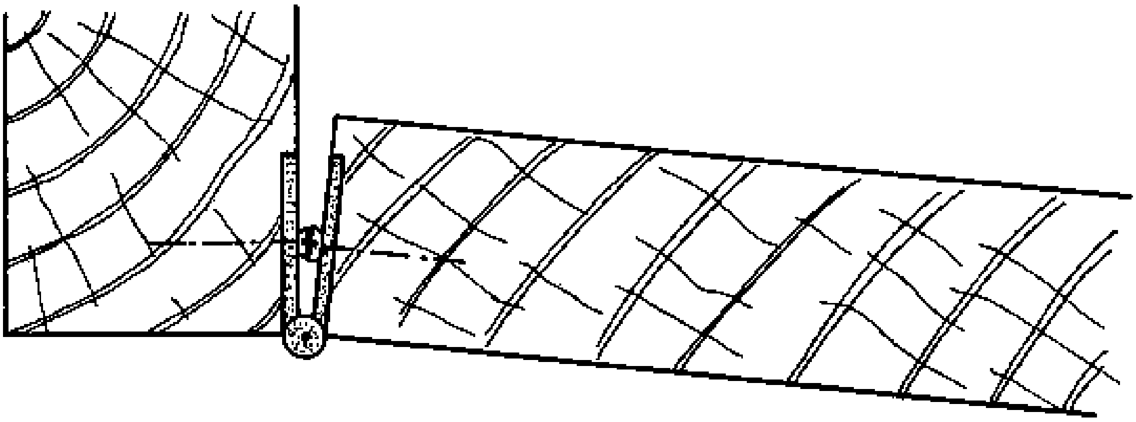


Fig. 4

NOTES:

LOCKS AND FITTINGS

Mortice lock

Before you read this section look up mortice locks in the Reference Book, pages 221 to 223. Pay attention to the names of the parts of the lock.

– SEQUENCE OF OPERATIONS FOR INSTALLING A MORTICE LOCK:

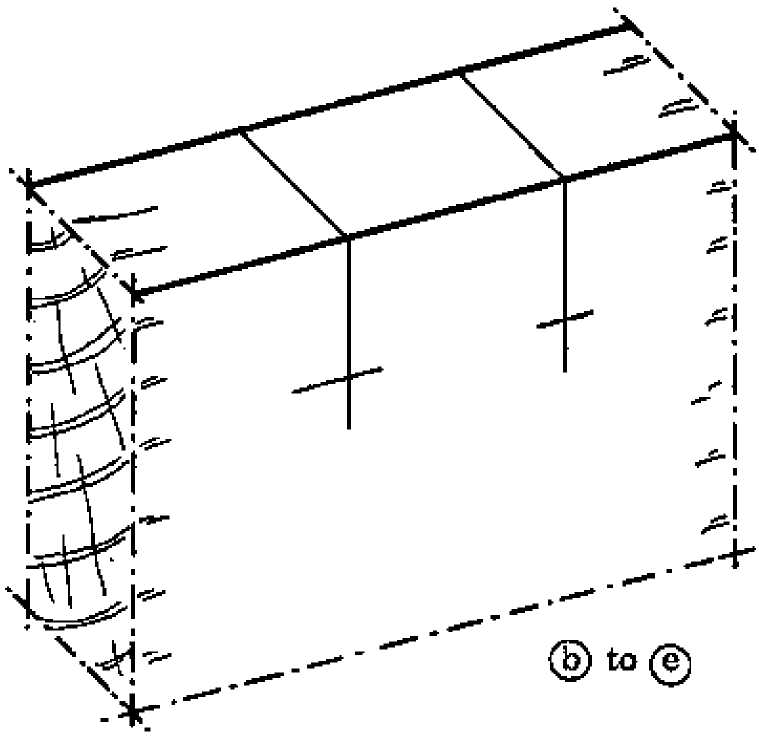
a. Place the door on edge against the side of the work bench, with one face against the bench and with the shutting stile upwards.

b. Mark the distance from the bottom edge of the door to the centre of the “bush” (the bush is the hole where the handle fits through, normally it is 105 cm from the bottom edge of the door).

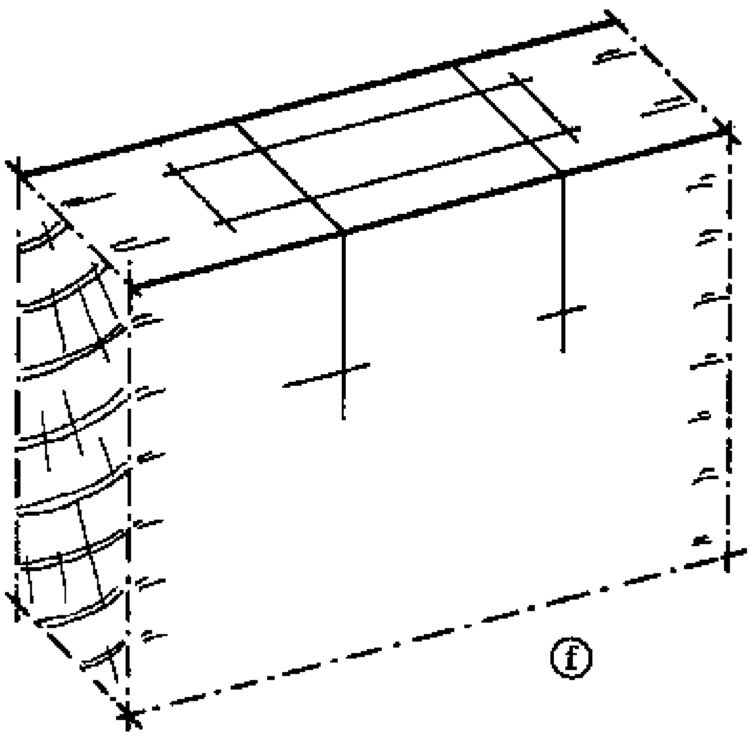
c. Square the positions of the key hole and the bush on the face and edge of the door.

d. Set a marking gauge with the distance from the outside edge of the lock face plate to the centre of the key hole. Add 2 mm allowance for planing off later.

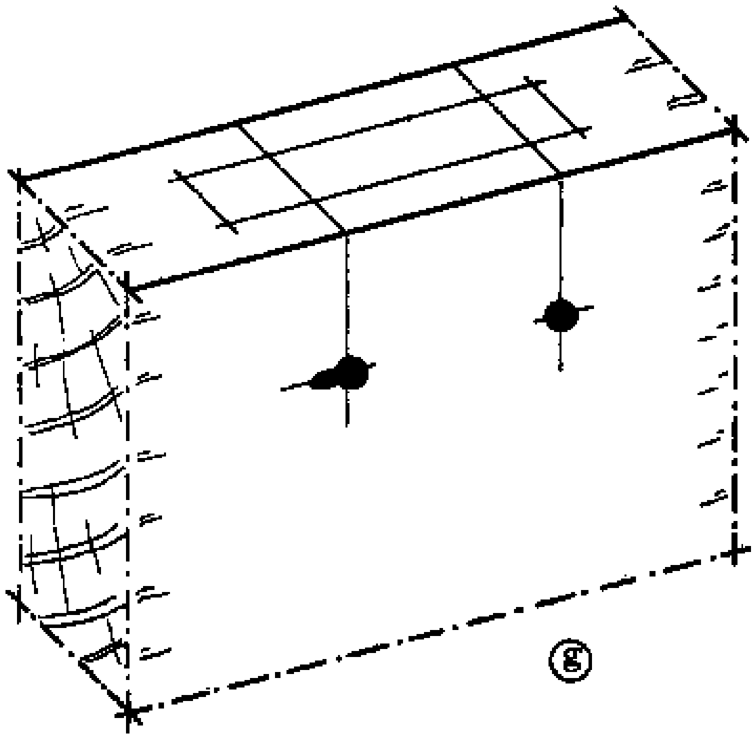
e. Mark this gauge setting on the door.



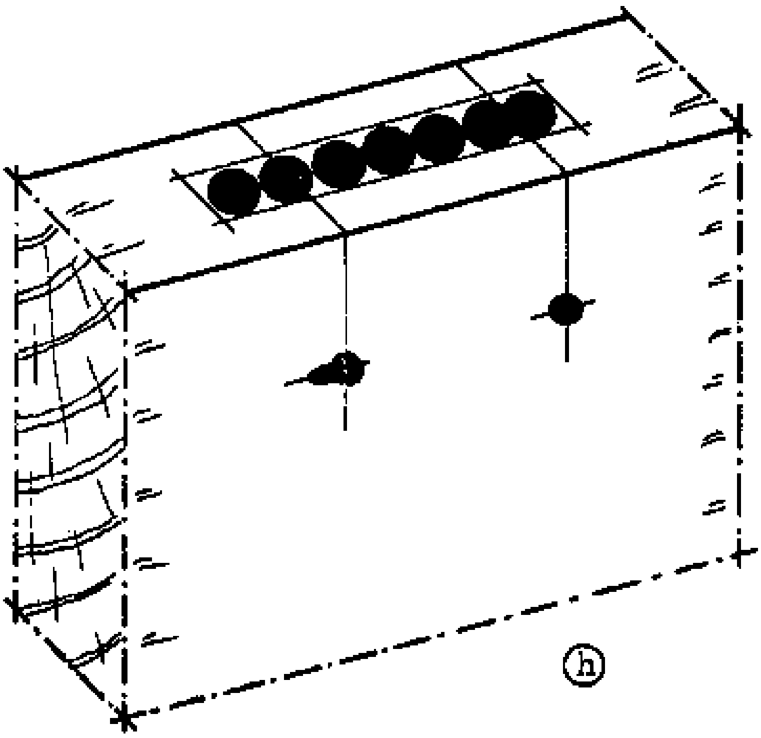
f. Mark the position of the lock stock onto the shutting edge of the door.



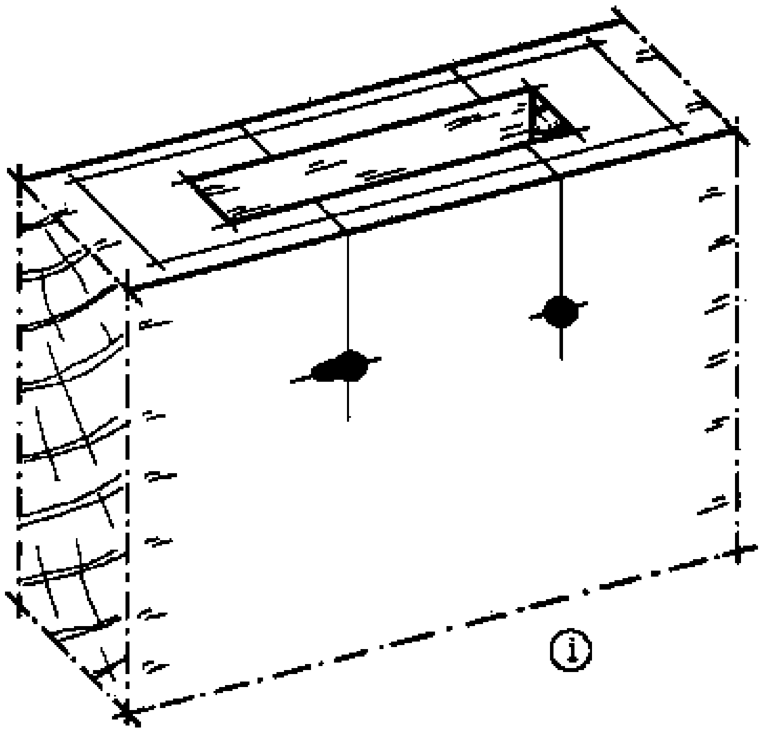
g. Clamp a piece of waste wood under the door to prevent splintering. Drill the bush hole and the keyhole. Complete the slot for the key hole with a chisel.



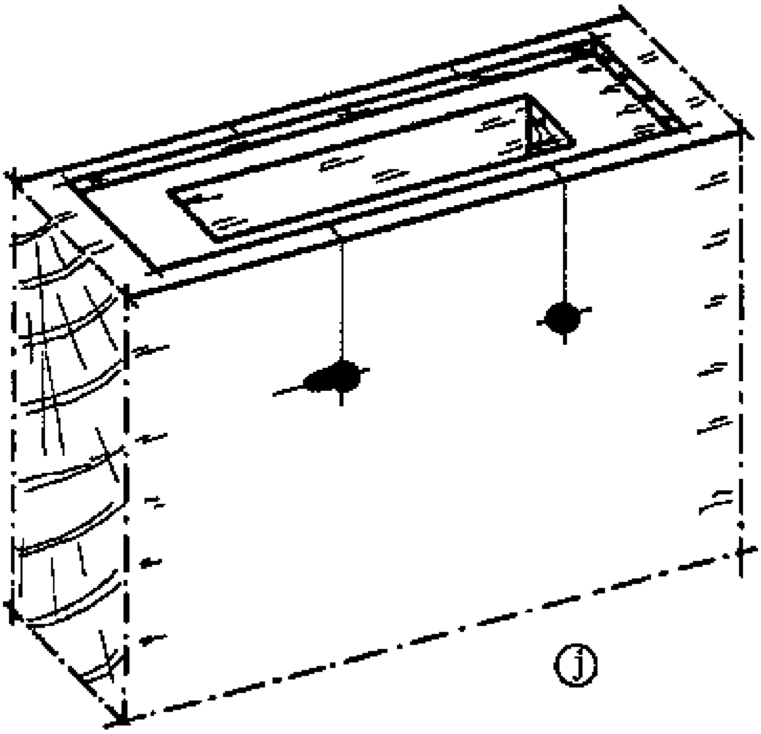
h. Chop the recess for the stock with a mortice chisel. Much of the waste can be bored away with a drill. Take care that the stock fits tightly against the sides of the mortice.



i. Drop the lock in the mortice and mark the position of the face plate on the door edge. Remove the lock.



j. Chop the recess for the face plate with a mortice chisel.



k. Drop the lock in again and insert the key and the handle with the fixed spindle. Check that there is nothing blocking the key and handle.

l. Attach the lock with screws.

m. Hold one leaf plate in position on the outside of the door. Insert the key and the handle with the spindle.

n. Attach the leaf plate to the door with screws.

o. Fix the leaf plate on the other side of the door in the same manner.

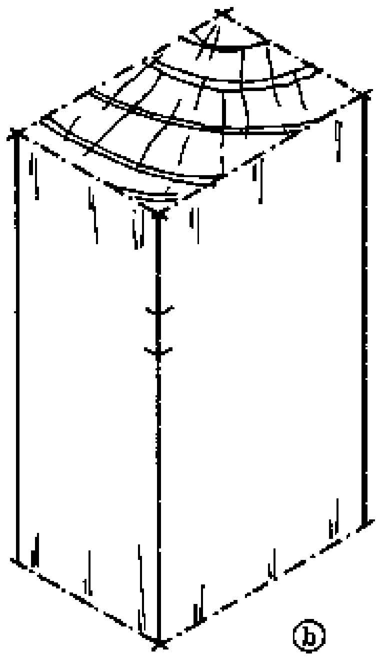
p. Secure the loose handle onto the spindle, with the pin.

The installation of a mortice lock with a cylinder is similar to the above procedure; but instead of a key hole, a hole is drilled for the locking cylinder.

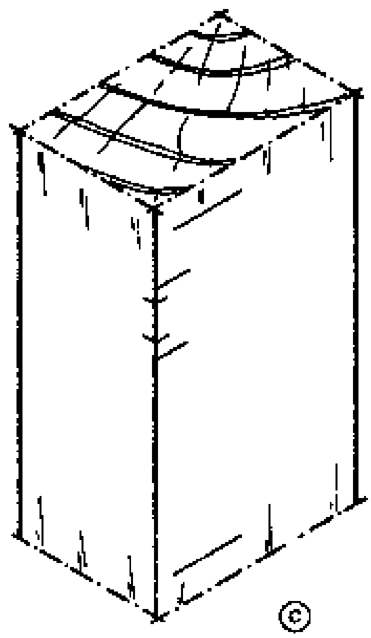
– SEQUENCE OF OPERATIONS FOR INSTALLING THE STRIKING PLATE:

a. Set the door with the mortice lock into the door frame.

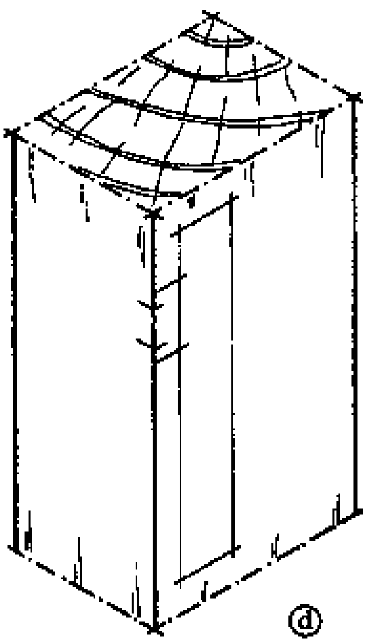
b. Mark the position of the latch bolt onto the door frame.



c. Hold the striking plate to the post in the correct position and mark the position on the post.

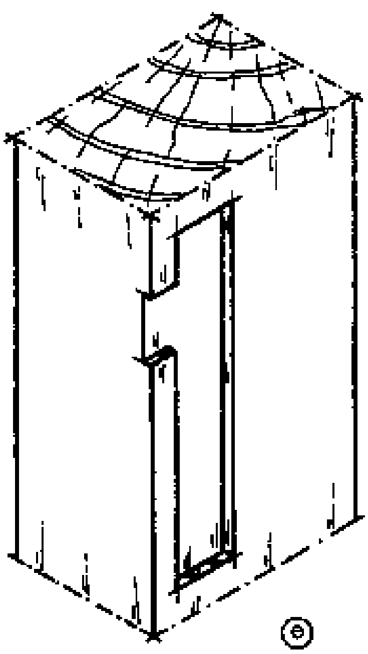


d. Set the gauge and use it to mark the vertical lines.



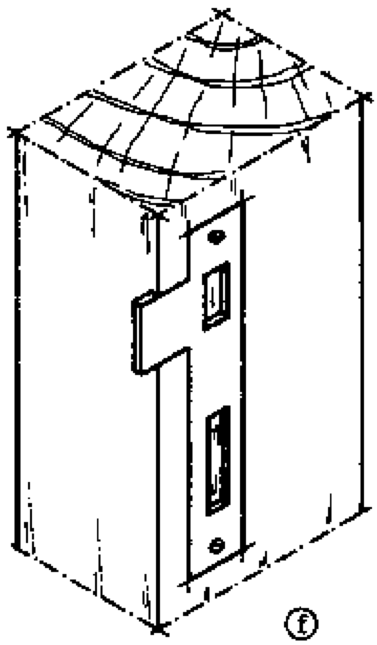
d

e. Cut the recess for the striking plate.



e

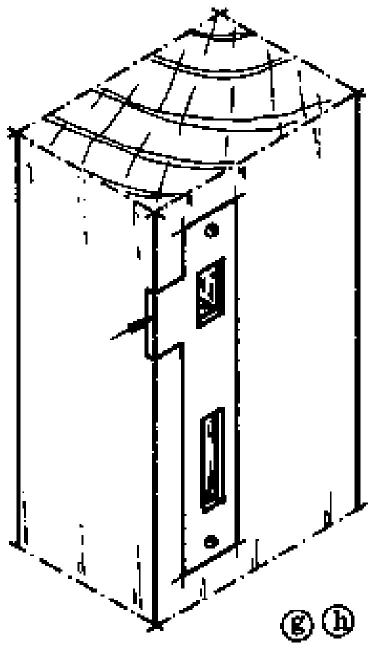
f. Fasten the striking plate to the post with screws.



(f)

g. Chop the recesses for the latch bolt and the lock bolt while the striking plate is in position.

h. Cut off the projecting lug of the striking plate (arrow).



(g) (h)

i. Close the door and check whether the latch bolt and the lock bolt can move freely and fit into their recesses.

In the case of a door frame with beads, the beads can be fixed after the door is properly hung and the locks installed.

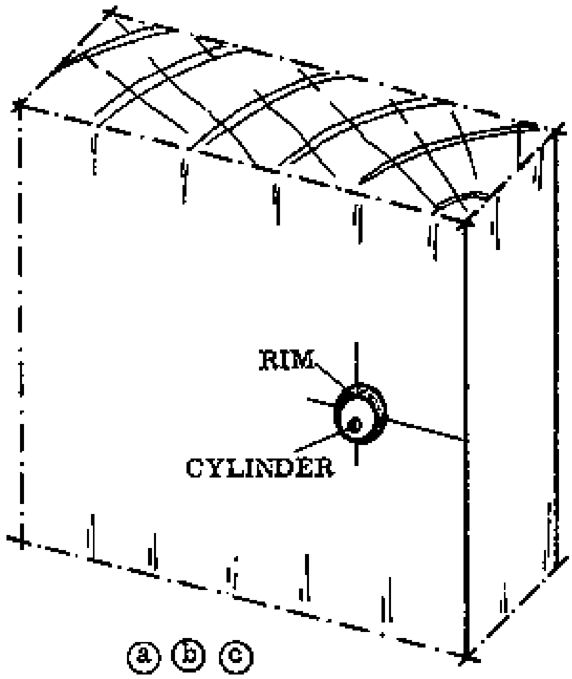
Rim lock

Look in the Reference Book, page 225, for information about this type of lock and its parts before you read on.

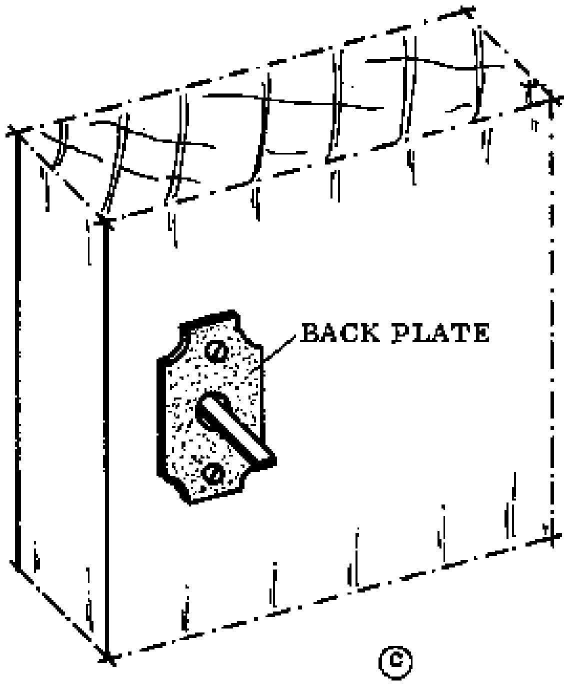
– SEQUENCE OF OPERATIONS FOR INSTALLING A CYLINDER RIM NIGHT LATCH:

a. Mark out the position of the cylinder on the door (normally 105 cm from the bottom of the door).

b. Drill a hole with the diameter of the shell.

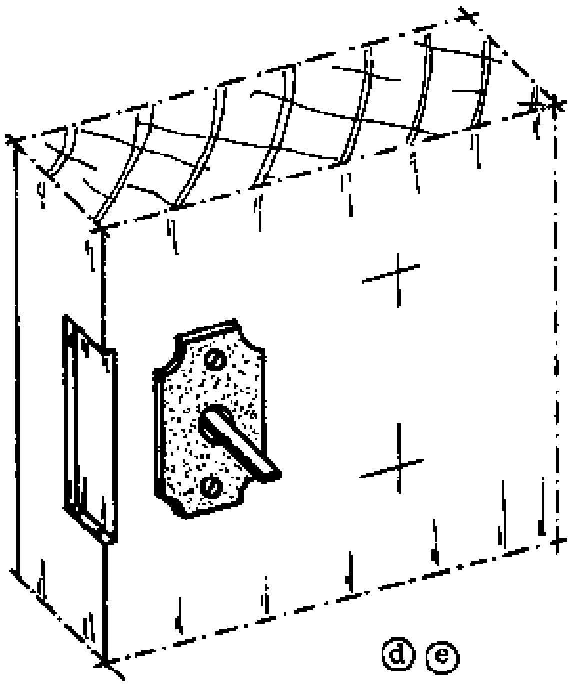


c. Insert the cylinder with the rim into the hole, and attach the back plate to the opposite side of the door with screws.

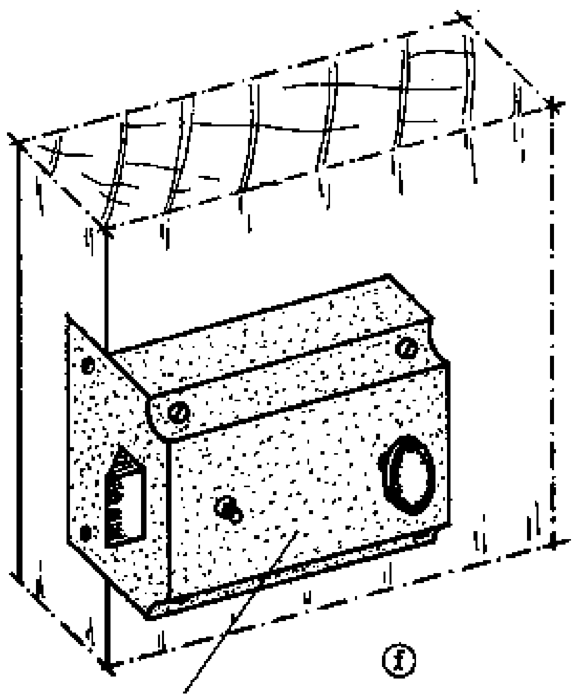


d. Mark the position of the latch and its face plate.

e. Chop the recess for the face plate.

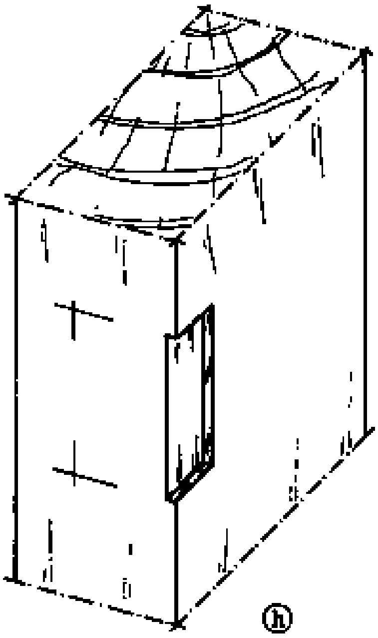


f. Attach the latch to the door with screws. Also use two screws on the face plate to attach the lock securely.

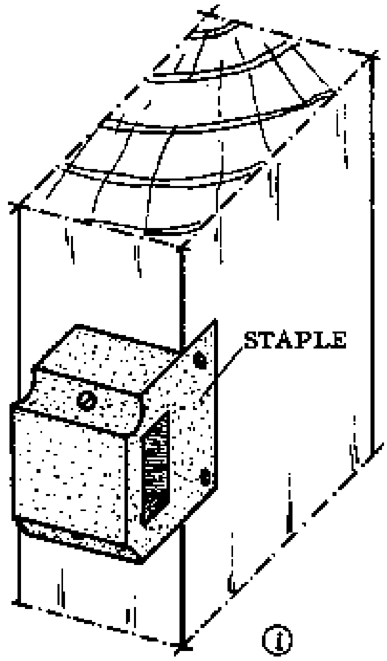


g. Turn the knob and check that the latch operates smoothly.

h. Mark the staple on the post and chop the recess for the staple face plate.



i. Attach the face plate to the post with screws.



j. Check that the bolt of the latch fits in the staple.

CEILINGS

The best method of keeping the building cool is to separate the rooms from the roof by a ceiling. The ceiling also keeps out dust and dirt, gives the room a nicer appearance, and makes it quieter.

In Rural Building, we deal only with plywood ceilings. These consist of sheets of thin plywood nailed to ceiling joists (the wooden beams which carry the ceiling). The edges where the plywood sheets join are covered by the ceiling battens (Fig. 1).

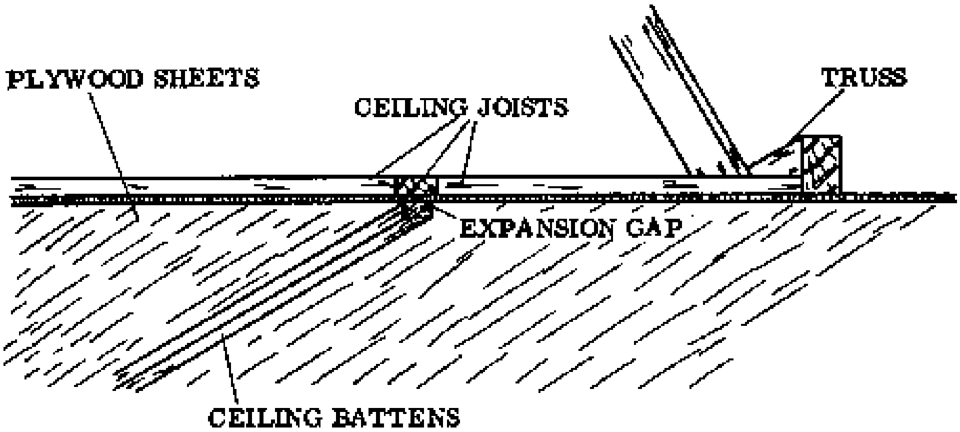


Fig. 1

– NOTE: Cross ventilation is extremely important. Every ceiling should be constructed so that there is cross ventilation between it and the roof. If this is not done, bats and other animals will make their homes above the ceiling; and also any dampness will soon cause the ceiling sheets to rot.

Cross ventilation keeps heat from building up between the roof and the ceiling, and thus the rooms are cooler (Fig. 2).

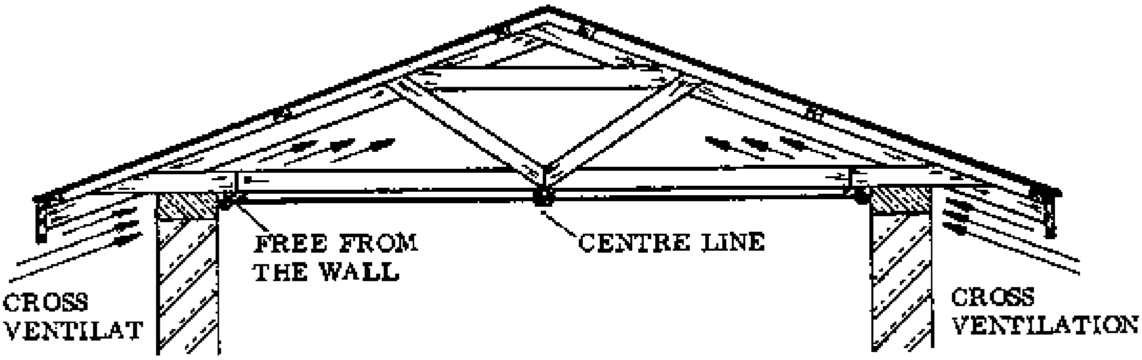


Fig. 2

Construction, parts and sizes of plywood ceilings

It is easiest to construct a ceiling under a roof with built−up trusses. If the soffits (undersides) of the trusses are level, the ceiling joists can be nailed between the tie beams. If the tie beams are not level, use battens nailed to the tie beams to build up until the surfaces are level (Fig. 3).

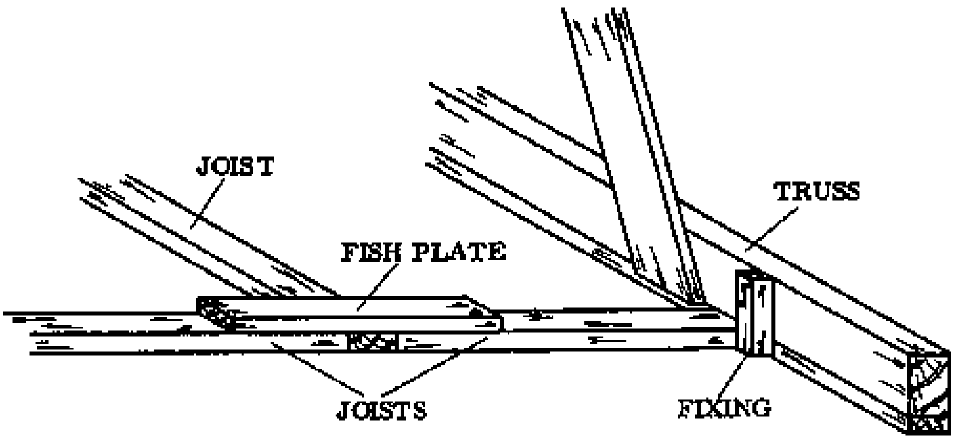


Fig. 3

If you want to fix a ceiling in a building with an ordinary pent roof (without trusses), a separate construction must be attached to the roof construction or to the wall, to provide support for the ceiling joists. Be sure to provide plenty of cross ventilation by some means (ventilation blocks could be used).

The distance between the ceiling joists should be no less than 122 cm. The joists can be left rough, because they are out of sight behind the plywood sheets.

When possible, design the rooms with the plywood sheet size in mind, just as the roof plan is made according to the size of the sheet material. Plan the size of the verandah and the positions of the inner walls so that the rooms are a convenient size and the plywood sheets fit without unnecessary waste.

NOTES:

– INSTALLING THE PLYWOOD CEILING SHEETS: Always start by fixing a line to show the exact centre of the room (Fig. 2, previous page). Start fitting sheets from this line. In case the sheets will not fit exactly in the room without being cut, start by putting one whole sheet in the centre of the ceiling, then divide the remaining space into equal areas.

There should be expansion gaps between the sheets to allow for changes in size with the changes of humidity. These gaps are covered by the ceiling battens. The battens are about 1 by 2,5 cm in size. Paint the ceiling and the battens before fixing the battens.

PAINTING

Paint preserves building materials from rot, rust, and general decay. Timber especially needs some finishing treatment, whether it is used inside or outside the building. Paint helps keep the wood from swelling or warping.

Protective finishes such as oil paints or varnish (Reference Book, pages 200 to 201) cover the wood with a protective “skin”. In order to be effective this skin must be undamaged, and so we have to repair and maintain these finishes periodically.

Which type of finish is used depends on whether the wood will be used outside or inside the building and on the particular function of the wood piece.

The selection of the colours for the inside and outside of the building is important because it affects the temperature of the building. Light colours keep the building cooler.

Preparation of surfaces for painting

Surfaces to be painted should be dry and clean; free from mud, dust, dirt, grease, rust, and old scaly paint.

All the boring, cutting, and shaping should be finished before the paint is applied.

Timbers should be well seasoned to prevent cracking. Paint with cracks in it is worse than no protection at all; water can enter the wood through the cracks, but it cannot evaporate off through the skin of paint so it causes the wood to rot.

If cracks appear in painted wood, sandpaper the wood before you apply new paint, to prevent the cracks from coming back. When you cut painted wood, don't forget to repaint the ends.

How to paint

Paint when the weather is good for drying, and when there is little or no wind or dust in the air. Paint should not be applied in wet weather or when the wood is damp. In new buildings first make sure that they are not damp. New masonry must be thoroughly dry before paint is applied to it. Drying, especially of floors, can take up to 6 months.

Mix the paint thoroughly before you apply it.

Painting is done with a brush. Dip the brush into the paint up to about 1/3rd of the length of its bristles, and remove the excess paint. Never dip the whole brush into the paint because the excess paint will drip out and be wasted.

Use long sweeping strokes and brush the paint well to form an even coating. Start at the top of a surface at one edge, and work across and down. Try to finish each day's work at a corner of the building or at a window. If you stop in the middle of a wall the mark will show where you resume painting the next day.

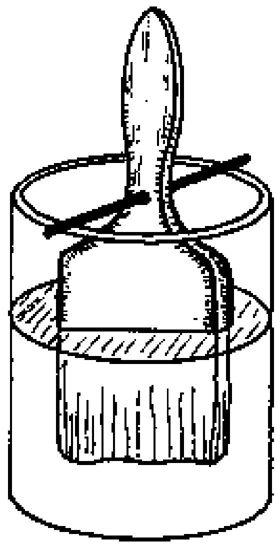
All new work, either of wood or masonry, requires three coats of paint. Surfaces which have been painted before need only two coats.

Before you apply a new coat, the previous coat has to be thoroughly dry. With most paints, the first two coats may be diluted with thinner to allow a better distribution and penetration. Only the final coat must be undiluted.

If wood is unprotected from the rain and sun, it will be necessary to repeat the application of finish from time to time. Take care that the end grain absorbs as much paint as possible.

Never allow a brush to rest upright on its bristles. If you stop work for a few minutes, remove the excess paint from the brush by wiping it on the edge of the tin, then lay it flat across the top of the tin or on a smooth clean surface.

If work is stopped for a longer time (overnight or for a few days), put the brush in a tin of kerosene. Here is an illustration of a good way to keep the paintbrushes; note that the bristles are covered with kerosene but they do not rest on the bottom of the tin. Simply drill a hole in the brush for the stick to pass through.



How to apply timber preservatives

There are two practical methods for applying timber preservatives:

- By painting (as described in the previous two pages)
- By soaking or dipping.

Different types of timber preservatives are required for different situations. The different kinds are described in the Reference Book, page 145.

– SOAKING OR DIPPING: Soaking or dipping is a much more efficient method than painting for applying any kind of timber preservative, because the chemical can penetrate deeper into the wood. This method can also be used for protective finishes such as oil paint.

Use a bucket or other suitable container to soak the wood for several hours or days. This method is only practical for smaller pieces like the ends of fence posts or frame pieces.

In cases where you are repeating the application of a preservative, use a preservative from the same group as the first application. Remember that the waterborne preservatives cannot penetrate over oil preservatives, but it is possible to apply an oil preservative over a waterborne one.

Only waterborne preservatives should be used if the wood will be painted later.

Take care that the end grain and splits absorb as much preservative as possible.

– NOTE: Be careful; most finishes are poisonous and can be fatal to human beings. Paints and paint thinners are often flammable.

NOTES:

APPENDIX

The following pages contain information and designs for constructions which do not necessarily fit under the topic of Rural Building, but which are nevertheless important for the Rural Builder to know about, at least in general. One of the purposes of this course is to prepare the Rural Builder to become a part of the development process in the rural areas, and this includes not only the construction of safe, healthy and comfortable buildings, but also the provision of safe water supplies, sanitation methods, and even the storage of the agricultural produce which is indispensable to rural life.

The following simple designs can be adapted and should be useful to almost any rural community.

NOTES:

WATER PURIFICATION

A water source is important in planning any building. The source can be a well, deep bore hole, spring, stream, or rain water collected from a roof and stored in a tank. The importance of water needs no explanation: it is worth spending both time and money to make sure that pure water is available at all times.

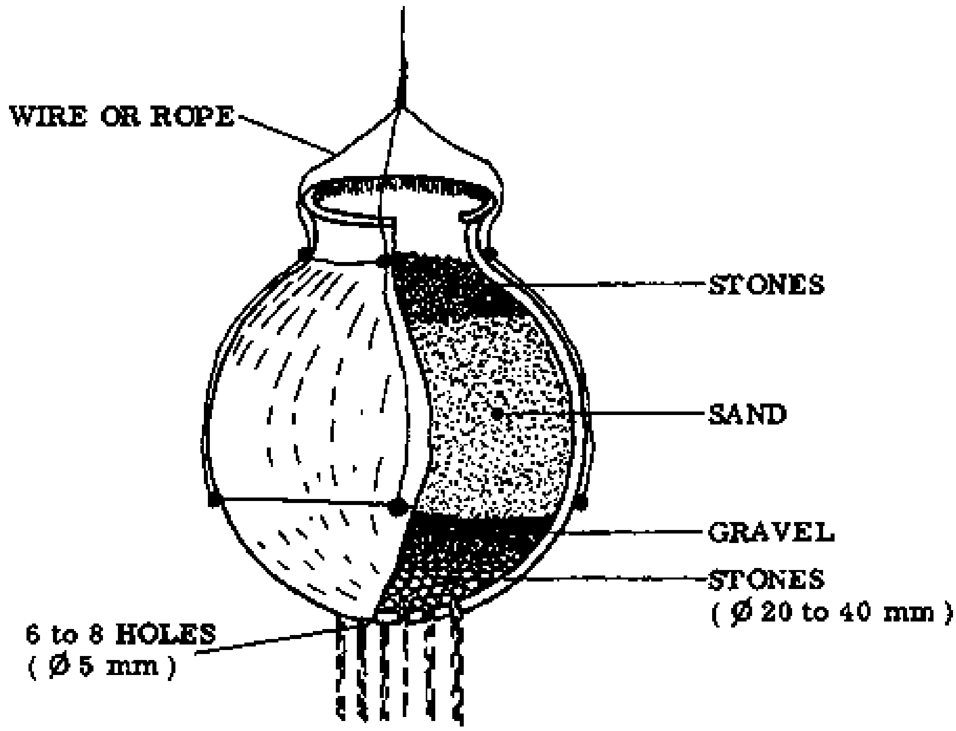
Many diseases come from drinking impure water. The danger of disease can be reduced by taking such precautions as boiling and/or filtering drinking water. Water obtained from a clean source such as a properly dug well or a borehole should carry no disease in it.

There is much that the Rural Builder can do to help the people in his community to have clean water to drink.

Small water filter

One way to improve the quality of water is to use a water filter. A simple design for a filter which can be made by anyone is shown below. It is used for small amounts of water. The filter consists of a locally made pot which hangs from wires or ropes.

The pot is partly filled with layers of fine sand, gravel and stones. The water sinks down through this and drains off through holes in the bottom of the pot. The diameter of the holes should be small enough so that the stones can't pass through.



Large water filter

A built−up water filter (Fig. 1) can be used to purify larger amounts of water. Its size depends on the amount of purified water that is needed.

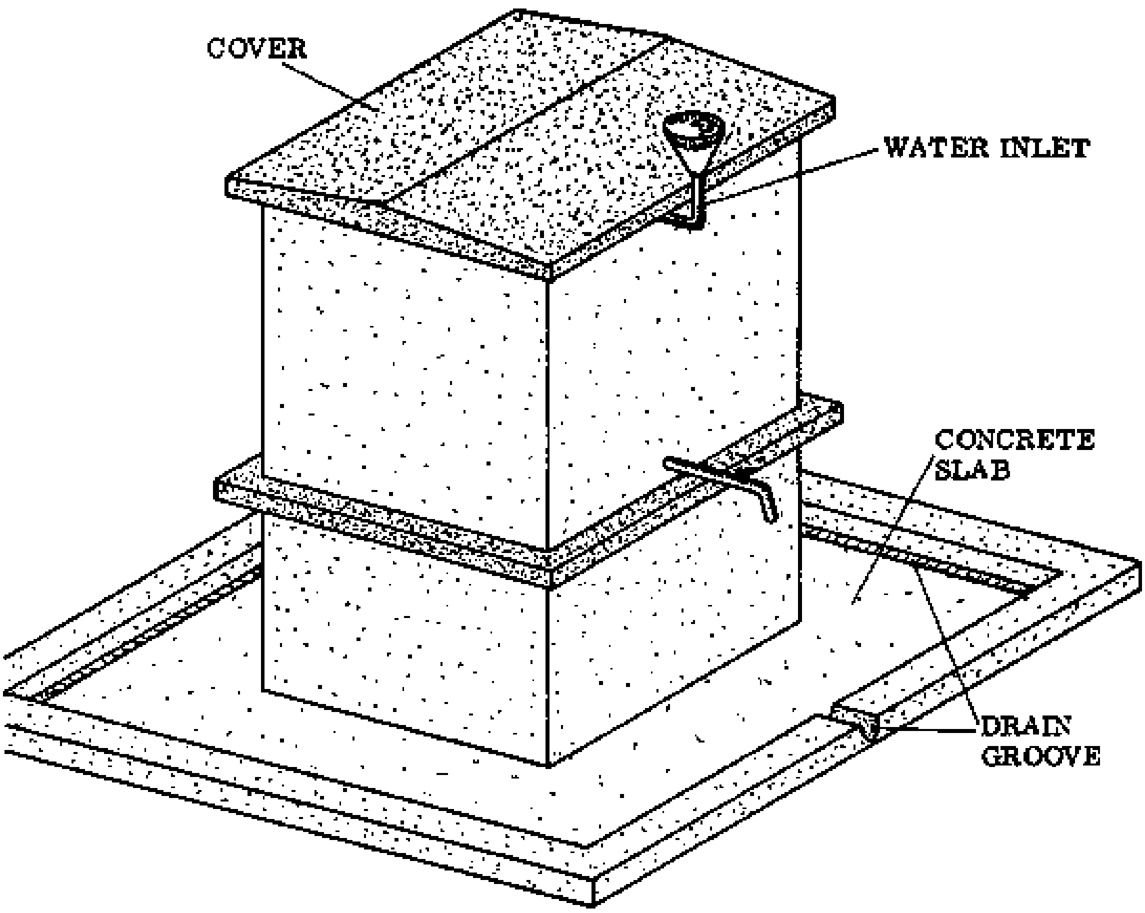


Fig. 1

The cover can be removed to allow the user to clean the filter materials and the entire inside of the tank. If the cover is very heavy it can be made in two halves.

The water inlet also acts as a ventilation opening. The top of the funnel should be covered with copper or aluminium mosquito wire to keep insects out of the tank. The distribution pipe inside (Fig. 2) has many fine holes to make sure that the water is spread evenly over the sand. If necessary install more distribution pipes so that the whole top surface of the sand can be soaked with water; thus using all of the filter materials inside the tank rather than overloading a small area.

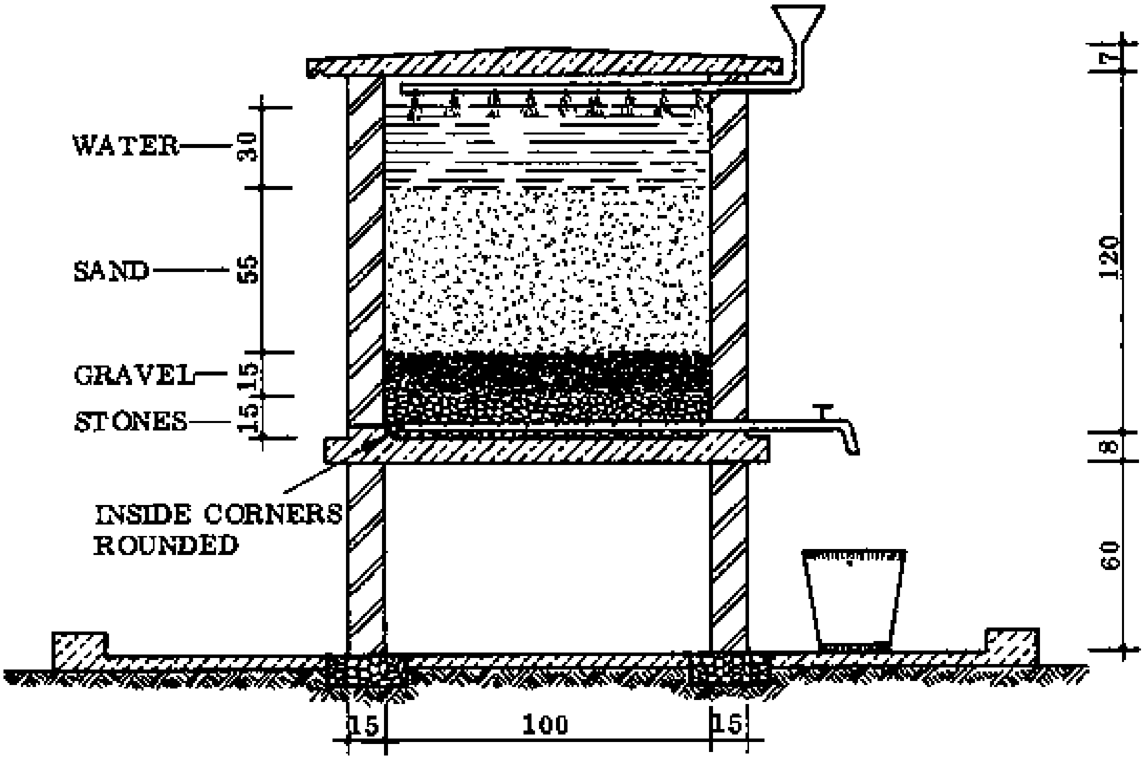


Fig. 2

The space of 30 cm at the top for water storage may be increased if necessary. The depths of the different layers of filter materials should be no less than indicated. If the layers are made deeper still the water will be filtered more thoroughly, but generally the indicated depths are sufficient (also see Drawing Book, page 120).

At the bottom of the tank a piece of pipe with holes in it allows the filtered water to drain off. There should be plenty of holes, and the diameter of the holes should be small enough to prevent the fine gravel from entering the drain pipe. At the end of the pipe a valve can be used to stop or start the flow of water. It drains into a container which is placed under the pipe.

The floor of the tank should be constructed with a rim all around (Fig. 2), which carries the walls and projects at the base of the walls, so that there is no crack between the walls and the floor. The whole inside should be plastered smooth to make it easy to clean.

The filter should be built off the ground so that the water can drain easily into buckets. It is advisable to concrete the area surrounding the filter and to provide a drain for spilled water (Fig. 1).

When the filter needs cleaning the water flow will become very slow. To clean the filter it is only necessary to take off the top 2 cm of sand and replace it with clean sand. Depending on how clean the water is at the start, the filter may need cleaning only after several weeks or even months.

NOTES:

HAND−DUG WELLS

The hand−dug well is the most common kind of well. Unfortunately, most wells are dug according to very basic “hole−in−the−ground” methods, and they can become health hazards as they are easily infected by parasites and bacterial diseases. With modern methods and materials, hand−dug wells can safely be made up to 60 m deep and will give a permanent source of good water.

Untrained workers, if they are properly supervised, can safely dig a deep well with simple light equipment. The basic method is outlined here. This information is intended to help you to dig more safely, and also to make a well that will not become contaminated by surface water. However, there are other problems concerning well digging that are not covered here, and you are advised to seek the help of an experienced well digger when you make a well by this method.

Lining wells

Masonry or brickwork are widely used in many countries to line the walls of wells. These can be very satisfactory in the right conditions. In bad ground however, unequal pressures can make the lining bulge or collapse. Building with these materials is slow, and a thicker wall is required than with concrete linings. There is also the danger of the blocks moving during the construction in loose sandy soil or shale, before the mortar has set firmly between them.

This danger is prevented with concrete linings because the form is left in place to support the lining until the concrete has set hard.

Lining (Fig. 1) prevents the hole from collapsing; keeps out contaminated surface water; and supports the pump platform if there is a pump.

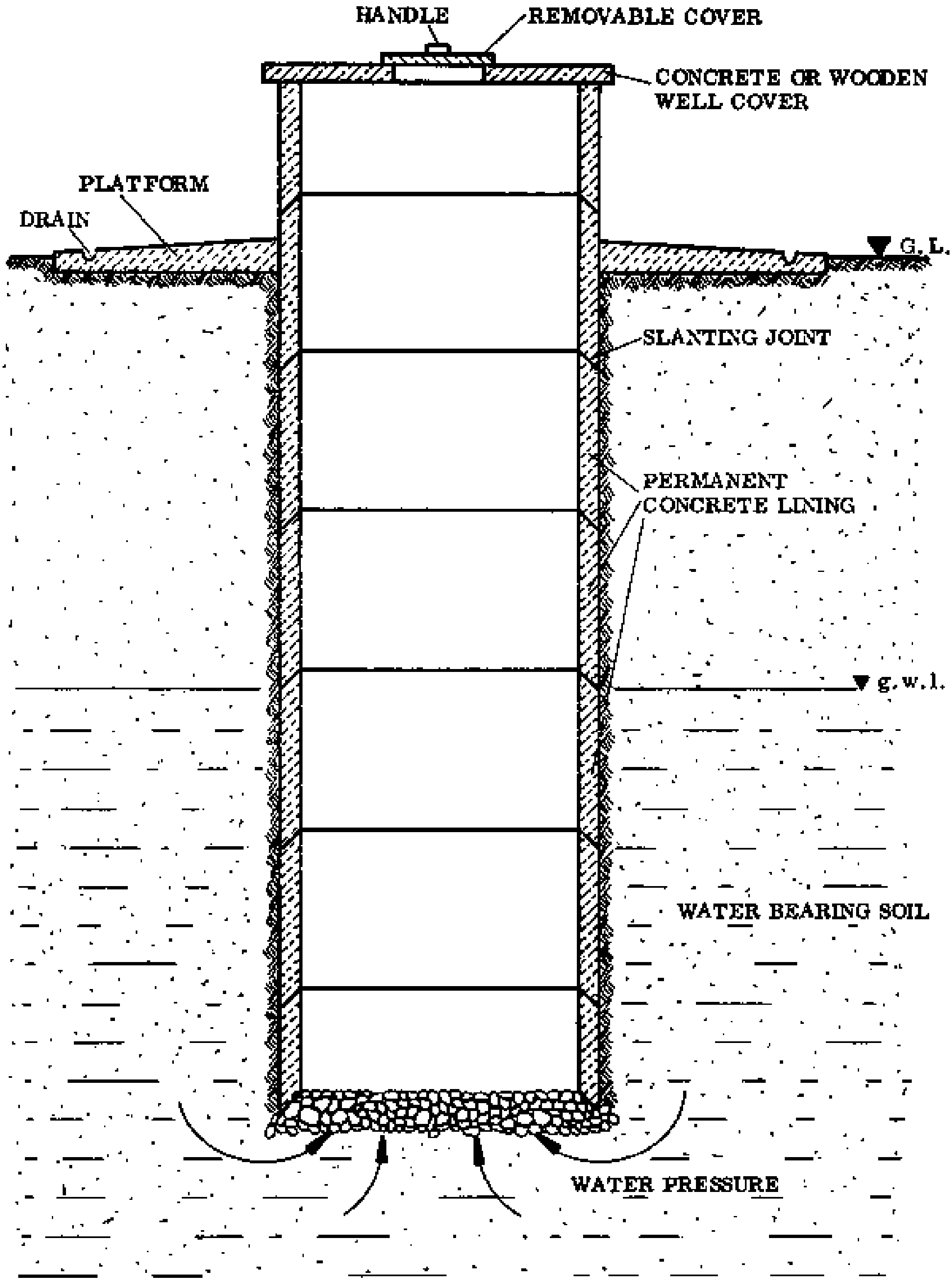


Fig. 1

It is usually best to build the lining as the well is dug, since this avoids the need for temporary supports and also reduces the danger of cave−ins during digging.

There are two methods for doing the lining:

− As the hole is dug, the sections of lining are built into their permanent positions. This is the method explained on the following pages.

− Precast sections of lining are added at the top and the whole lining moves down as the hole is dug and earth is removed from under it.

NOTES:

Tools and materials needed

– Shovels
– Pick–axes
– Buckets
– Ropes and pulley
– Steel forms and bolts
– Wooden or steel tripod
– Cement
– Reinforcement bars
– Sand
– Gravel
– Oil

Construction

Experience has shown that when one man is digging, he will be able to dig most efficiently if the well is about 100 cm in diameter. However if two men are digging together, a 150 cm diameter is best, and the two can dig more than twice as fast as one man. Thus two men in the larger hole is usually best, also for safety reasons.

– NOTE: Do not construct a well near a latrine, septic tank, or other source of contamination. The well should be as far away from these as possible; at least 30 m, and it should never be downhill from a source of contamination.

– SEQUENCE OF OPERATIONS:

a. Erect a wooden or steel tripod to support a pulley and bucket for bringing out soil from the hole.

b. Dig down until you reach ground water level (g.w.l.).

c. Make the first concrete ring section just above the g.w.l. (Fig. 1, A)

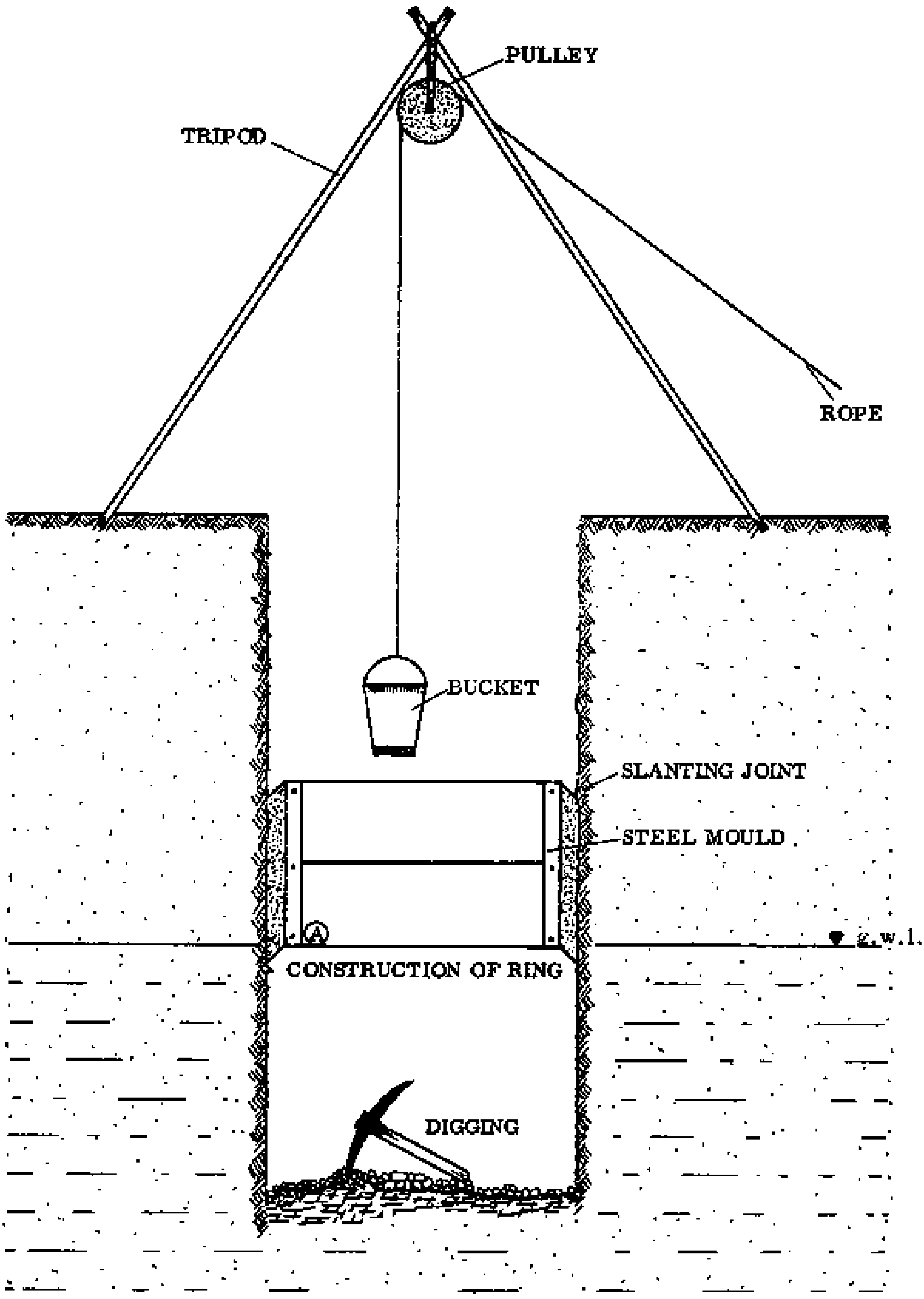


Fig. 1

d. While the first section cures, proceed with digging the hole for the second section. The rings should be made with slanting edges as shown in Fig. 1, so that the joints between the rings slant downwards.

e. Continue constructing ring sections until the well is deep enough.

f. The other rings above ring A can be constructed during the digging.

g. When the concrete lining is completed, the walls of the whole well should be waterproof, so that surface water can't enter the well. A concrete plat form with a groove for drainage should be constructed, and a wall around the edge to keep people and animals from falling in. Either blocks or rein forced concrete can be used for the wall (Fig. 1, previous page).

h. The well is closed off with a wooden or concrete cover, with a small opening for buckets to go through (Fig. 1, previous page).

i. If possible, disinfect the entire well by adding a chlorine solution to it. Use about 1 heaping tablespoon of bleaching powder to 2 buckets of water and mix. Make up three buckets of the solution to wash the walls of the well thoroughly, and pour the remainder into the well. Make up another three buckets and put that into the well too. Leave it overnight before using the water.

– NOTE: Since there is a lot of water in the soil, don't use too much water in mixing the concrete for the lining. Be careful that there are no voids (empty pockets) in the concrete lining. These give surface water and soil a path to enter the well.

– MOULDS: A steel mould (Fig. 1) or a wooden mould (Fig. 2) is used to support the sections of concrete lining during construction and curing. After the ring has hardened sufficiently, the wooden lock pieces are removed and the mould is taken out and used for the next ring (Fig. 3).

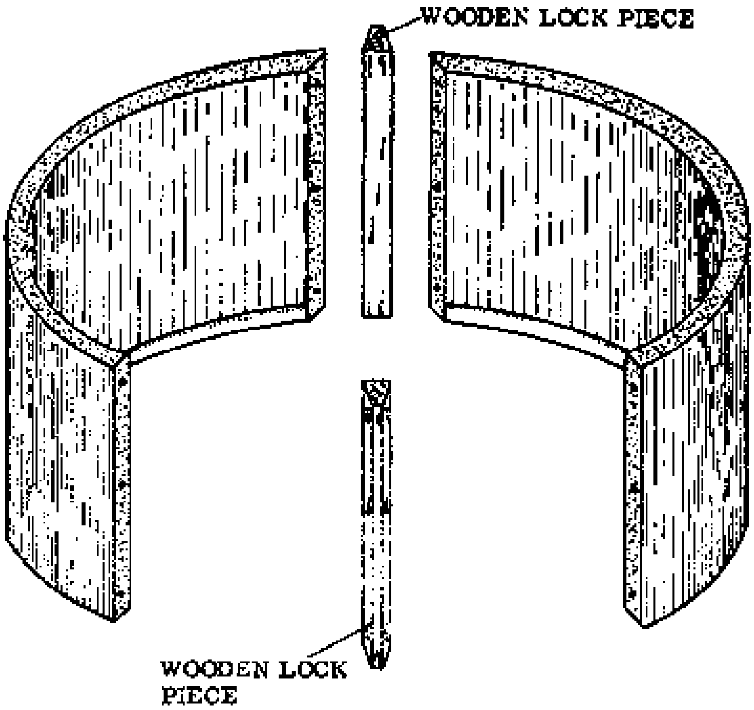


Fig. 1 STEEL MOULD

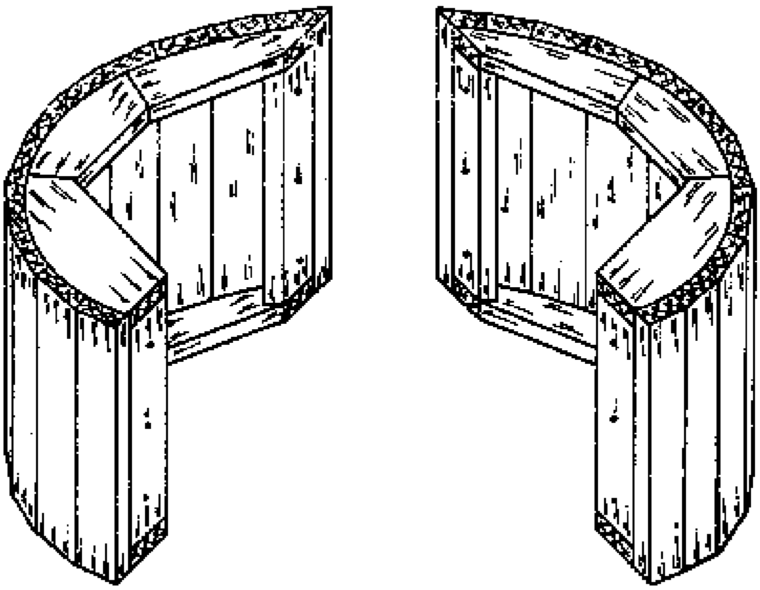


Fig. 2 WOODEN MOULD

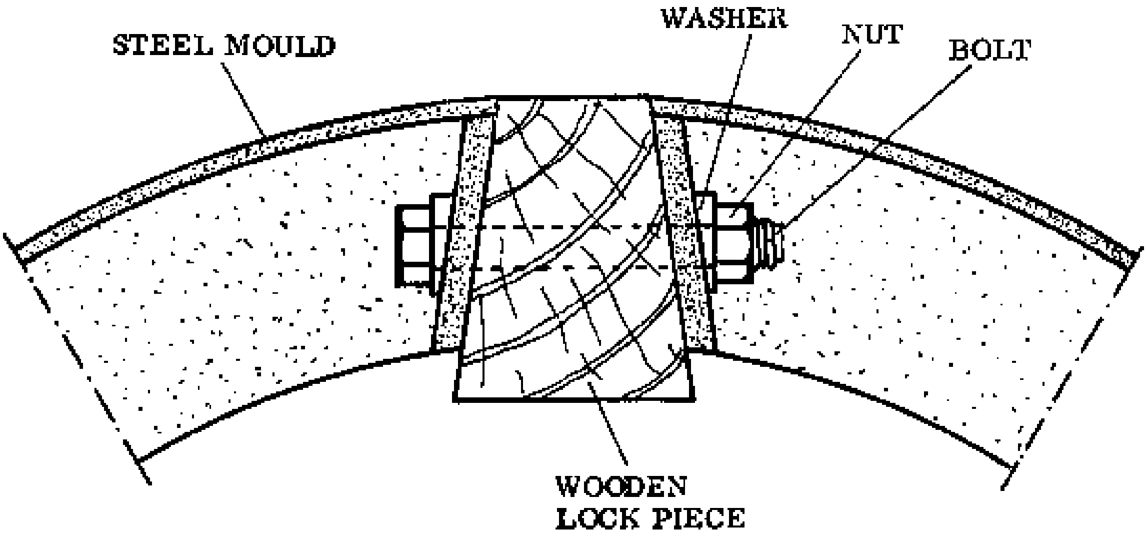


Fig. 3

When you assemble the mould, be sure that the wooden mould or wooden lock pieces are first soaked in water so that the wood does not expand when it contacts the wet concrete. If the pieces expand they will crack the concrete ring, and it will be very difficult to get the mould out again.

GRAIN STORAGE SILO

Often traditional storage methods result in the loss of valuable grain, because insects or mice etc. get into the grain. To help farmers with this problem the Garu Agricultural Station in the Upper Region has developed a new type of grain silo. This silo requires a few bags of cement plus stones or gravel to construct. It can hold between 9 and 16 bags of grain.

Compared to some types of traditional storage, the silo gives better protection to the grain against mice and insects. When the silo is closed so that no air gets in, CO_2 gas develops from the grain and stops the insects from developing.

Construction of a silo

Sun−dried laterite blocks are used for the walls of the silo. The blocks are made in the same way as any other mudblock.

Cast the topslab before starting to construct the rest of the silo, so that it will be cured and ready to use when you need it. Construct a frame for casting the slab, with an inner frame for the manhole (Fig. 1, next page). Reinforce the slab with some rods. For measurements, refer to the Drawing Book, page 118. Note that the top of the slab slopes to the outside. Also note that the edge of the slab is fitted with a groove underneath so that rainwater drips down instead of running back under the slab (Fig. 1, left).

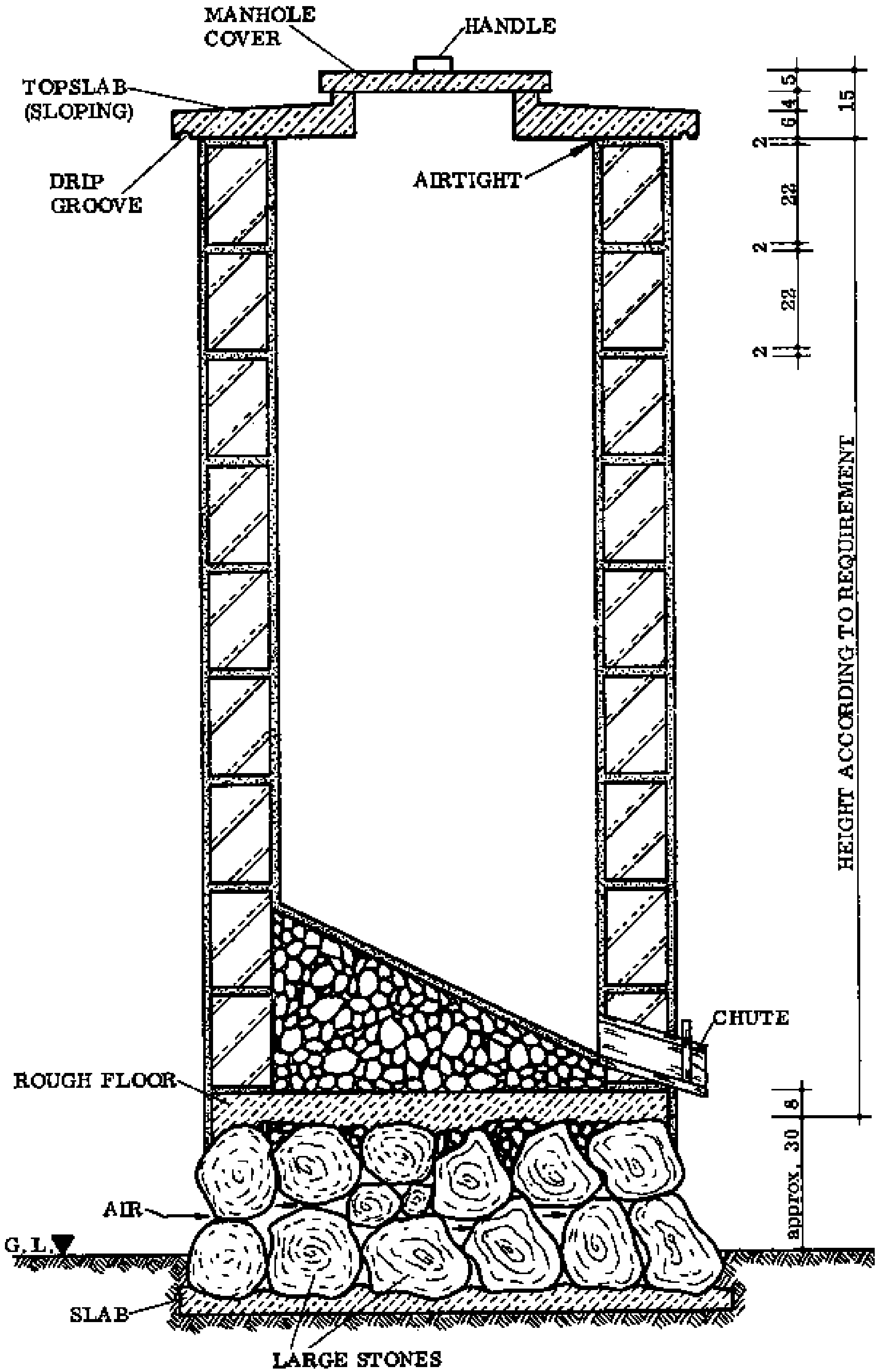


Fig. 1

Also make a frame for the manhole cover and cast this piece. Use a piece of iron rod set in the concrete for a handle (Fig. 1).

Place wet paper under the frames before you begin to pour the concrete. The concrete has to remain in the frame for three days. Water it twice daily so that it hardens well without cracking. After the concrete hardens (cures) remove the frames carefully so that they can be used again.

– FOUNDATION AND FOOTING: Dig out the top soil and make a concrete slab if needed (if the soil is soft). The slab will be 125 cm in diameter and about 6 cm thick. The footing is made of large stones set on the slab or on the ground. The stones should be placed in such a way that air can circulate freely between them and they should be built to a height of 30 cm above ground level. On top of and in between the large stones, small stones are used to fill in the gaps to form a surface for the floor to rest upon (Fig. 1).

– FLOOR: The floor is poured directly onto the footing. This floor is a working surface only and the top should be left rough so as to give a good grip to the slanting floor (Fig. 1, previous page).

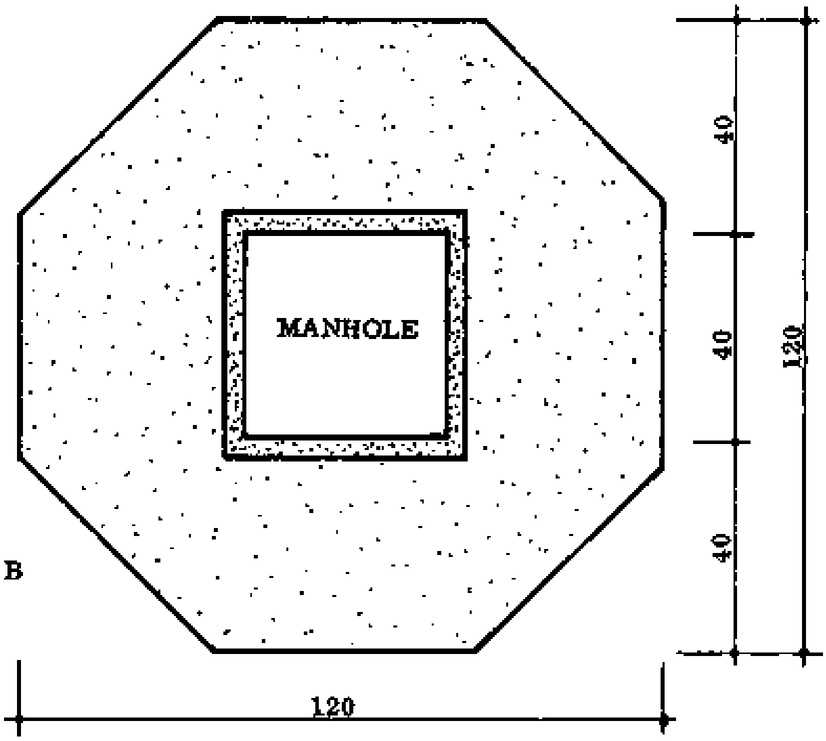
– FIRST COURSE: Place the chute in position. The chute is a kind of open–ended box made from wood, with a sliding closure that can be locked (Fig. 1, previous page). Now proceed to lay the first blocks. The section after this one describes the procedure for laying blocks in a round structure.

– SLANTING FLOOR: Build up four courses, then pack the slanting floor on top of the rough floor. The mixture for this slanting floor should not be too rich, so it doesn't crack. After the mixture is poured into the silo, pack it down well and plaster the top of the slanting floor smoothly. To do this apply some cement powder and add some water, then smooth with a steel float.

– WALLING: Build the walls up straight, using a plumb bob on all sides and for each course. The height of the silo depends on the required storage area. When the desired height is reached, plaster the inside of the silo. The inside plaster should be very smooth and without holes or cracks, so that the silo is airtight.

– TOPSLAB: Provide a mortar bed for the topslab on top of the wall. Then place the slab into position. The slab will be heavy, so several people will be needed for this operation. One man should be inside the silo to direct the operation.

– PLASTERING OUTSIDE: When the slab is set in position you can do the plastering on the outside of the silo. This has to make the silo waterproof, so the finish should be smooth and without cracks.



TOPSLAB

Using the silo

Dry the grain very well before you put it in the silo. Moist grain will rot, the silo will crack, and all the food will be lost. Distribute the grain well and fill the silo to the top.

Put the cover on the manhole and seal the edges with mud or cow dung. Also seal the chute so that nothing can enter the silo.

Keep the footings and the area around the silo clean.

Check the silo often for cracks, especially when it is full. Replaster any cracks immediately. The wooden chute should always close tightly and the plaster around it should not be cracked.

Paint the silo white or whitewash it. This makes it cooler inside and gives it a nice appearance.

When the silo is emptied, take care to empty it completely. Left−over grain attracts insects and rodents.

Before the silo is filled up again next year, it should be clean and insect free. Light a small bundle of grass on fire inside the silo. The smoke and heat will kill any insects or insect eggs. Sweep out the ashes and dust, and clean the entire silo thoroughly.

Circular masonry work

A section on circular work is included here because in Rural Building circular work applies mostly to structures like silos or protective walls around wells.

Here we describe a sequence which might be used to construct a silo. It may be adapted for other structures as well.

Regular blocks are used. Wedge−shaped blocks can be specially made for the job, but the shape of the wedge has to be calculated exactly according to the size of the circle.

NOTES:

Sequence of operations

a. Determine the centre of the circle. Drive an iron rod into the ground at this point (Figs. 1 & 2, a). The rod should be a little higher than the top of the first course of the future rising wall.

b. The inner and outer curves of the foundation are marked on the ground by fixing a mason line to the rod and describing circles with this at the desired radii (Fig. 1, b).

c. The foundation is completed, then the inner curve of the footings is marked on the top of the foundation using the same method (Fig. 1, c).

d. The footing blocks are laid so that the inside corners of each block touch the marked circle (d). The next course is marked on top of the first course and laid in the same manner.

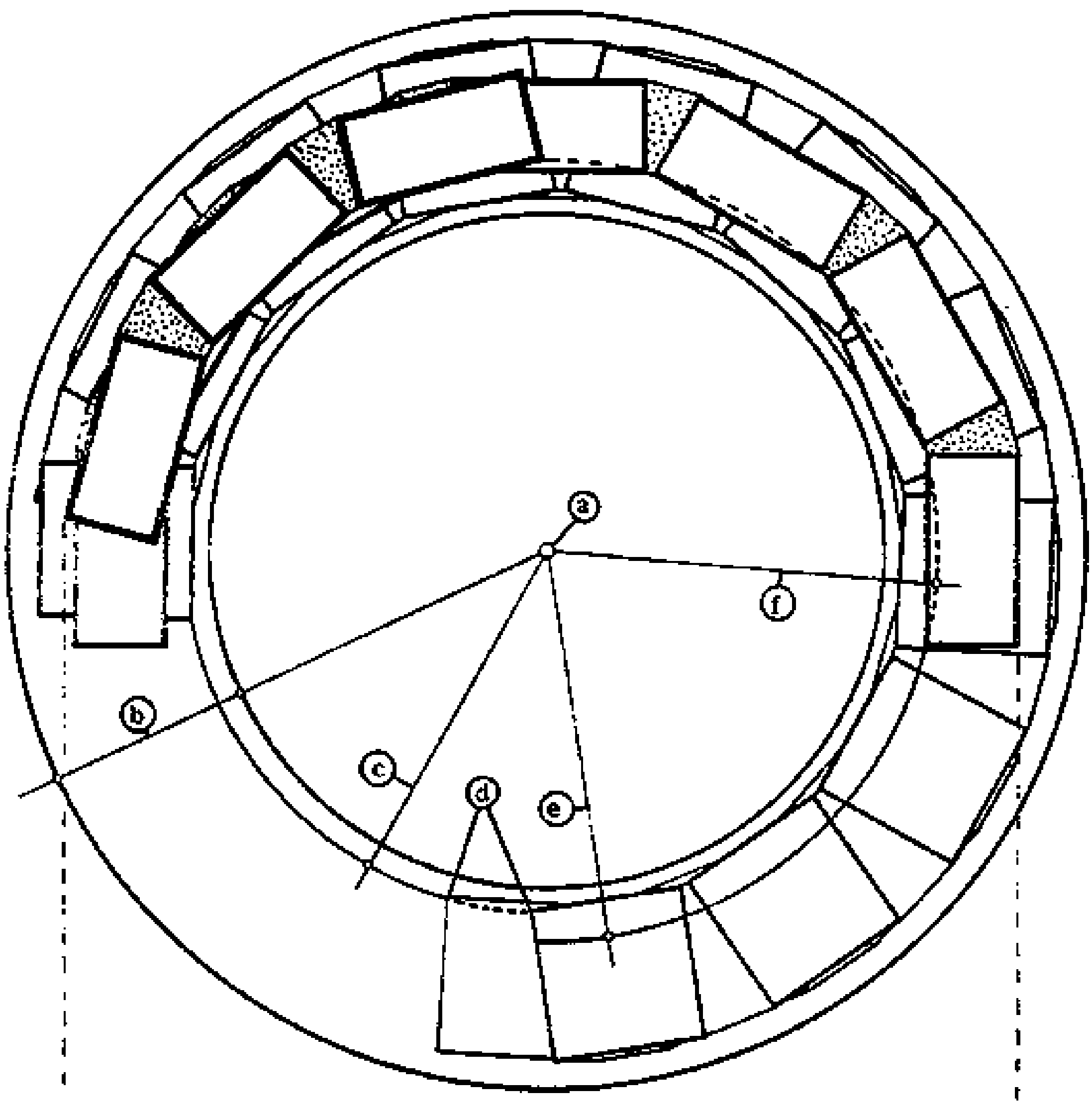


Fig. 1

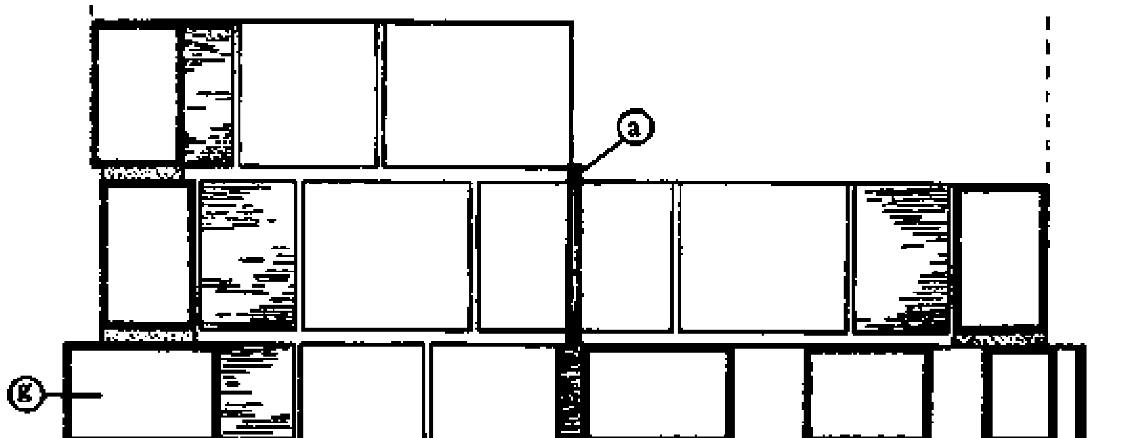


Fig. 2

NOTE: In this construction the footings are made with blocks, unlike the silo described in the preceeding pages, where the footings where made of large stones. If a silo is to be built on top of the footings, the cross joints between the blocks are not filled in; this permits cross ventilation. The space up to the top of the footings is filled in with large stones and the floor is made on top of these, as in the silo described before. Remember to set the chute in place on top of the footings before you continue with the rising wall construction. Only two footing courses are necessary to reach the required height of 30 cm for the silo floor.

e. When the footings are completed, the rising wall is laid out on top of the footings with the line and peg as before (Fig. 1, e). The blocks are positioned with the corners touching the circle as before.

f. The second course of the rising wall is laid out on top of the first course (Fig. 1, f), and the blocks are laid as before.

g. The following courses are laid with the aid of the plumb bob. All cross joints are 1 cm thick along the inner curve. Each course of the rising wall is plumbed according to the course two courses below it (3rd to 1st, 4th to 2nd, 5th to 3rd, etc.).

Fig. 2 shows a side view of Fig. 1, but only the last footing course is shown (g).

NOTES:

PIT LATRINE

Latrines, and especially pit latrines, are the most common and simple sanitation systems. A pit latrine is practical for rural areas because it is the cheapest possible system and the easiest to build.

One major problem with pit latrines is the limited capacity: only a certain number of people can use the latrine, or else it becomes full too quickly and another pit must be dug. Another problem is that the latrine, if it is improperly made or made in the wrong place, can contaminate nearby wells or surface water. Also, if the ground water level is near the surface it may not be possible to dig a deep pit.

Capacity

The volume of the pit may be planned by using the rough figure of at least 0,06 cubic meters per person per year. Thus a pit which is 1 m square and 3 m deep may serve a family of five for about 6 years, before it becomes two−thirds full and a new pit has to be dug.

Pit latrines of the type shown on the opposite page (Figs. 1 & 2) should not be used by large numbers of people unless there is space available to dig several pits. If many people use the same pit it will quickly become full, and the ground around it can become contaminated.

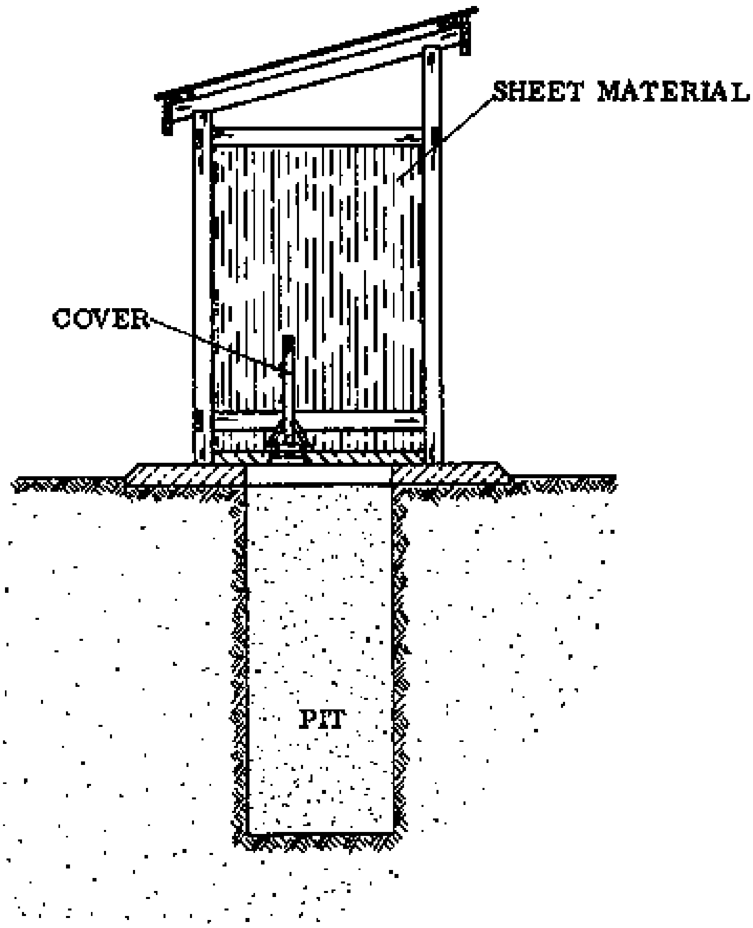


Fig. 1 ORDINARY PIT LATRINE

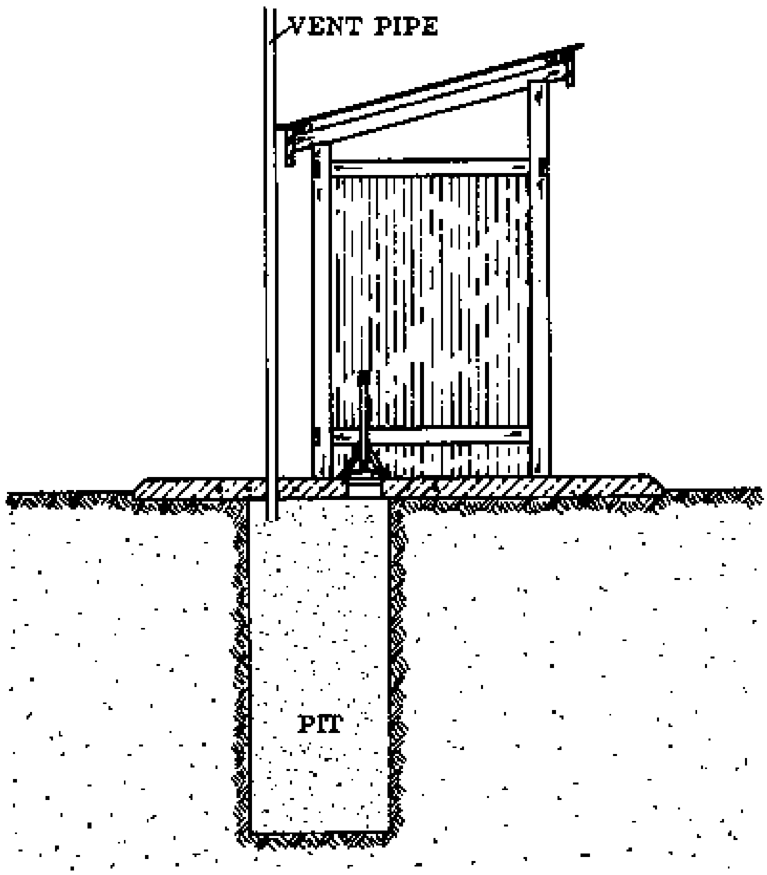


Fig. 2 VENTILATED PIT LATRINE – ADVANTAGE: LESS SMELL DUE TO VENT PIPE

It is a good idea to dig two pits at once, so that when one is 2/3rds full it can be closed, filled to the top with soil, and left there for 6 months to a year; by which time the harmful, disease–causing organisms in it will have been destroyed. The sludge can be taken out and mixed with compost, making a very valuable (and non−imported) fertilizer for gardens or farms.

− NOTE: Human wastes which have not been composted for at least 6 months should never be used as a fertilizer for food crops, because disease can be spread that way.

Location

The pit latrine should be located at least 6 m away from any house, and at least 30 m away from any water source: well, bore hole or stream. The latrine should never be located uphill from a water source − this is extremely important.

NOTES:

Design and construction of the squatting slab

The squatting slab should be designed with easy cleaning in mind. It is made out of concrete reinforced by iron rods as shown in Fig. 1. The rods should be about 8 mm in diameter.

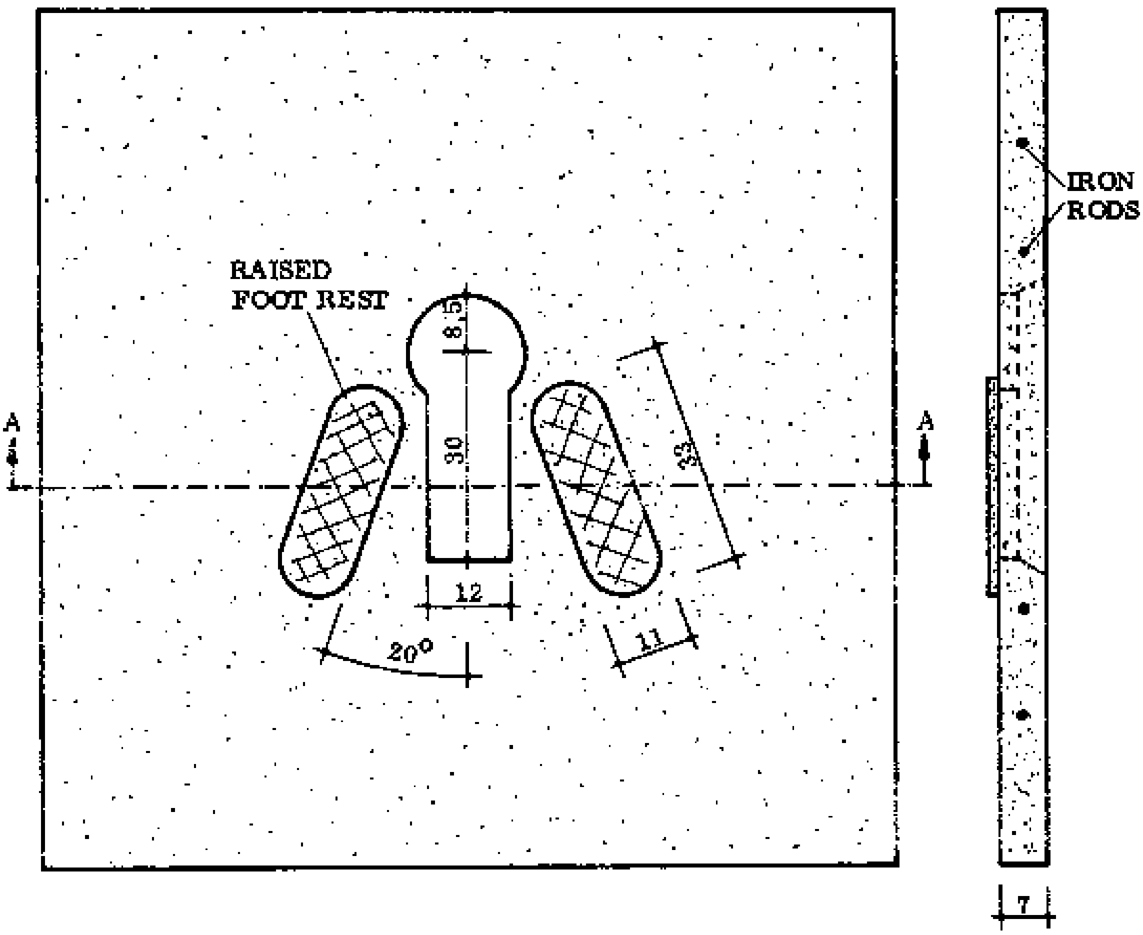


Fig. 1

The slab may be square, round, or rectangular in shape. A common size is 100 by 100 cm. The whole slab will weigh about 140 kg. The advantage of a round slab is that it can easily be rolled around the site and into place. The slab should be about 7 cm thick. The raised foot rests make the slab easier to clean. The shape of the hole and foot rests may vary; a typical arrangement is shown here. The hole should be at least 36 cm long to prevent soiling of the slab, and less than 18 cm wide so that small children can't fall through.

The distance from the back of the hole to the back wall of the latrine should be at least 15 cm, so that it is not necessary to lean against the wall when squatting.

Make a cover for the latrine hole out of wood, with a long handle (Fig. 2).

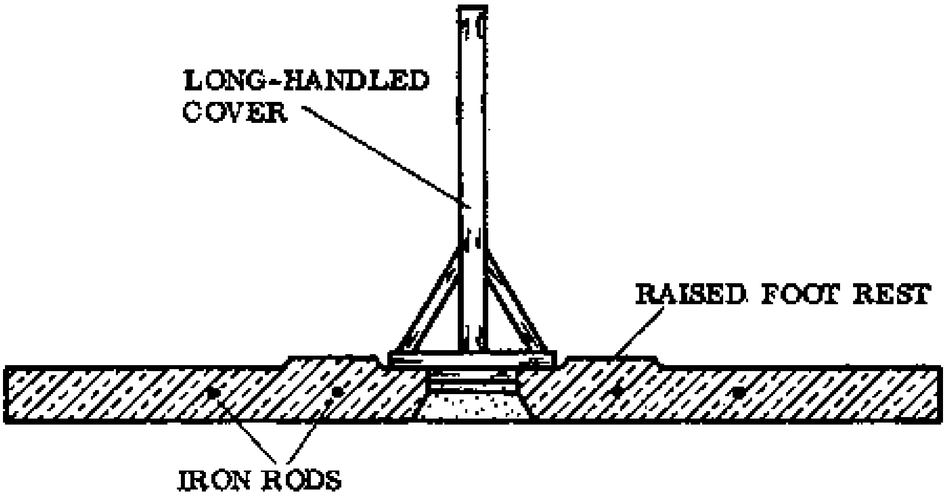


Fig. 2 CROSS SECTION A–A

NOTES:

Construction

The first step is to precast the squatting slab, as described on the previous page.

Make the hole for the latrine large enough so that it won't become full too quickly. The soil should be firm enough so that the weight of the latrine structure won't cause the hole to collapse. If the soil is firm enough, the foundation slab can be poured around the edge of the hole (first remove the top soil) (Fig. 1). If the soil is a bit soft, reinforce the foundation slab.

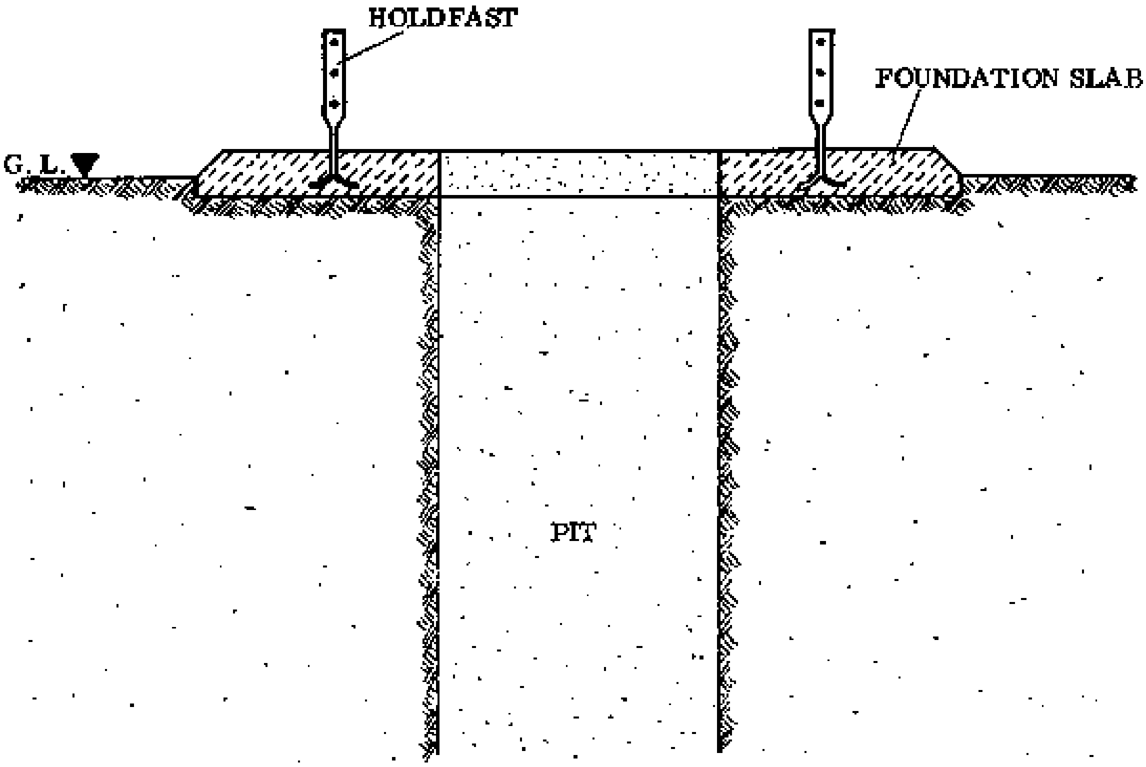


Fig. 1

If the soil is very soft, it will not be able to bear the weight of the construction. Then it will be necessary to construct a lining for the hole to be sure that it will not collapse. The lining can be made with blocks; or in a round hole with concrete rings, as described under the section on wells, page 279. The foundation slab then rests on top of the lining and cannot sink down into the soft soil (Fig. 2).

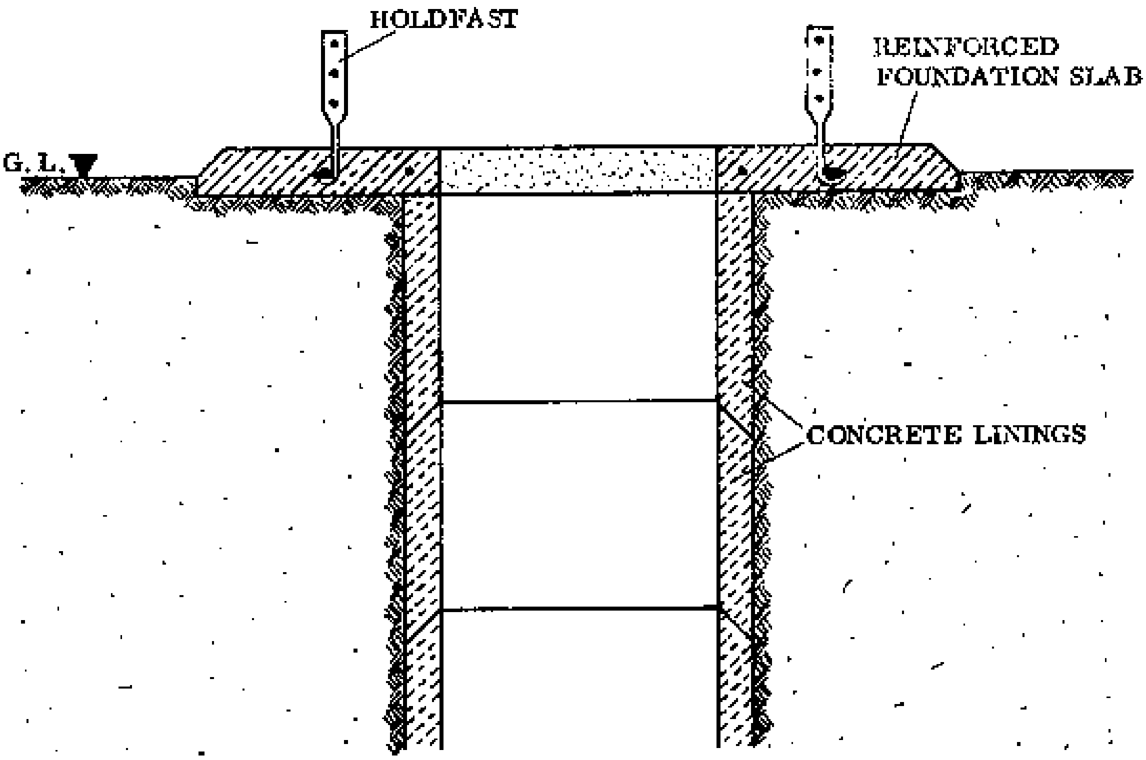


Fig. 2

When you construct the foundation slab, fix some steel rods or holdfasts in the concrete, as shown in Figs. 1 & 2. These can be used later to anchor the wooden structure of the toilet.

When the foundation slab is cured, place the precast squatting slab on top of the foundation and secure it in place with a weak mortar (Fig. 3).

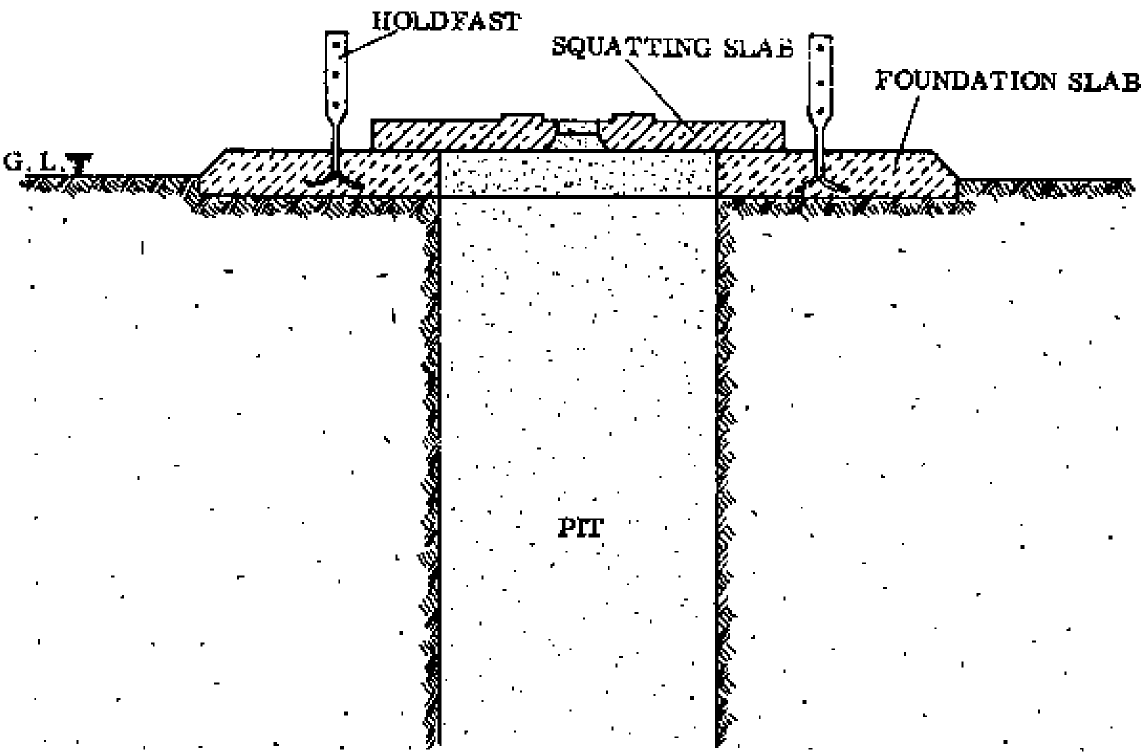


Fig. 3

Toilet room

The toilet room can be built from mud or landcrete blocks, and plastered with mud. However, be sure that the foundation can support the walls because they are heavy, and in soft soil they may sink down and collapse the hole. Also, when the hole is full and a new one has to be dug, the walls have to be built completely new.

Because of the above problems with block walls, it is advisable to construct a light−weight structure out of timber and metal sheets. The light−weight structure can be removed when the pit is full and installed again over a new pit. The squatting slab can also be re−used (Fig. 1).

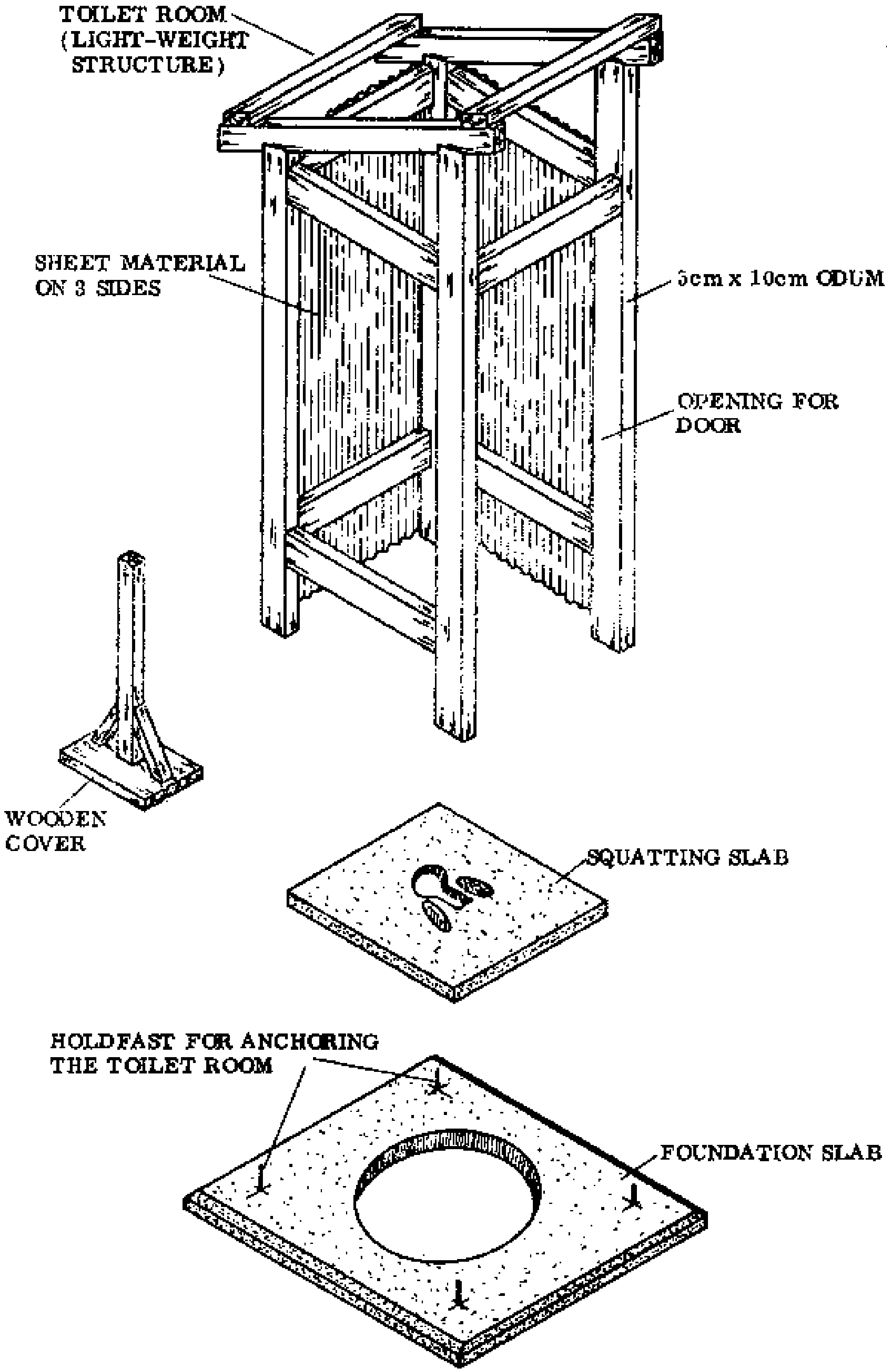


Fig. 1

The structure must be anchored well to the foundation slab so that it is not blown away in strong winds.

Toilet partitions

If a community latrine with several compartments is needed, use the system drawn on page 124 of the Drawing Book.

First do the setting out. Then dig the round pits and make foundation slabs around the pits. Construct arches or lay a reinforced concrete beam across the center of each pit.

There are four squatting slabs over each pit. Lay each one carefully so that one edge rests on the concrete beam and two other sides rest on the foundation slab. Use some weak mortar between the slab and the supports, to ensure that the slabs are flat and stable.

The partitions between the toilets should be light−weight structures of timber and metal sheets or waterproof plywood. The outside walls can be constructed from landcrete blocks or mud.

Many of the materials from the above structure can be re−used after the holes become 2/3rds full and new pits are dug. The light−weight partitions, the squatting slabs and the reinforced beams can all be taken out and used in the new construction.

NOTES:

Permanent latrine

If the latrine is constructed so that the pit can be cleaned out when it becomes two−thirds full, then it is no longer necessary to dig a new pit every few years. In the design explained here, the pit contents are removed through a manhole from the outside of the toilet room.

Make a reinforced concrete beam or an arch across the pit (Figs. 1 & 2) to support the back wall of the toilet, the floor, and the concrete manhole cover (see also the Drawing Book, pages 121 and 124).

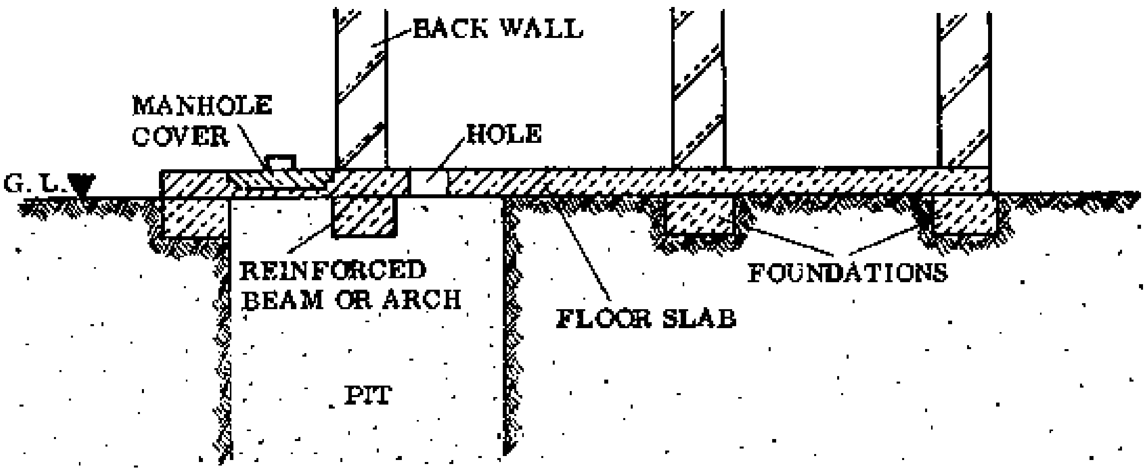


Fig. 1

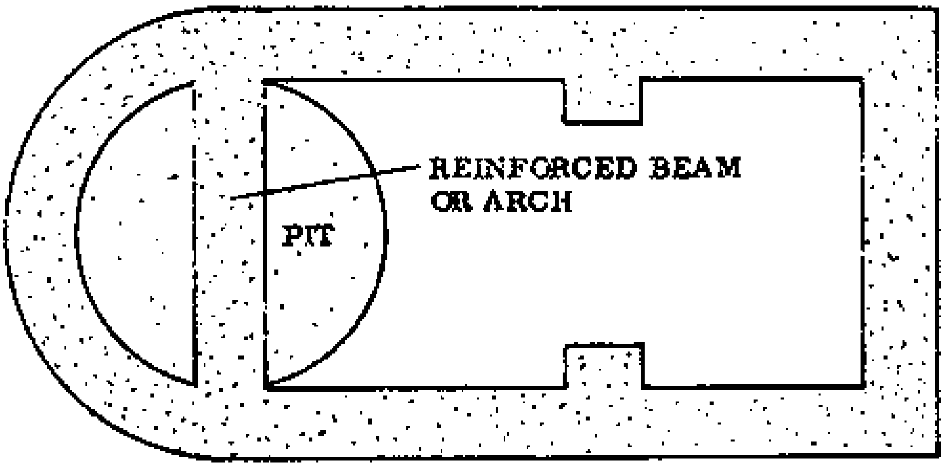


Fig. 2 FOUNDATIONS

Cast the foundations around the pit and under the future walls of the toilet (Figs. 1 & 2). On top of the foundations cast the floor slab with the openings for the manhole and toilet. The toilet can be made with the same squatting slab design as the other latrines, or a seat may be constructed above the hole (Fig. 3).

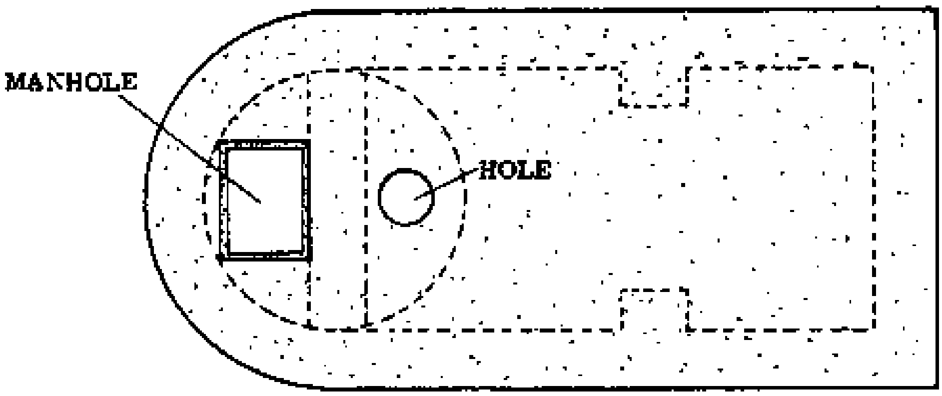


Fig. 3 FLOOR SLAB

The rising walls are constructed directly on top of the floor slab (Fig. 4). They may be built out of mud, sandcrete or landcrete blocks, since the structure will be permanent. Make sure that the toilet room is well ventilated and the roof is securely anchored to the building. The wall in front of the entrance can be built up to about 180 cm high (Fig. 4).

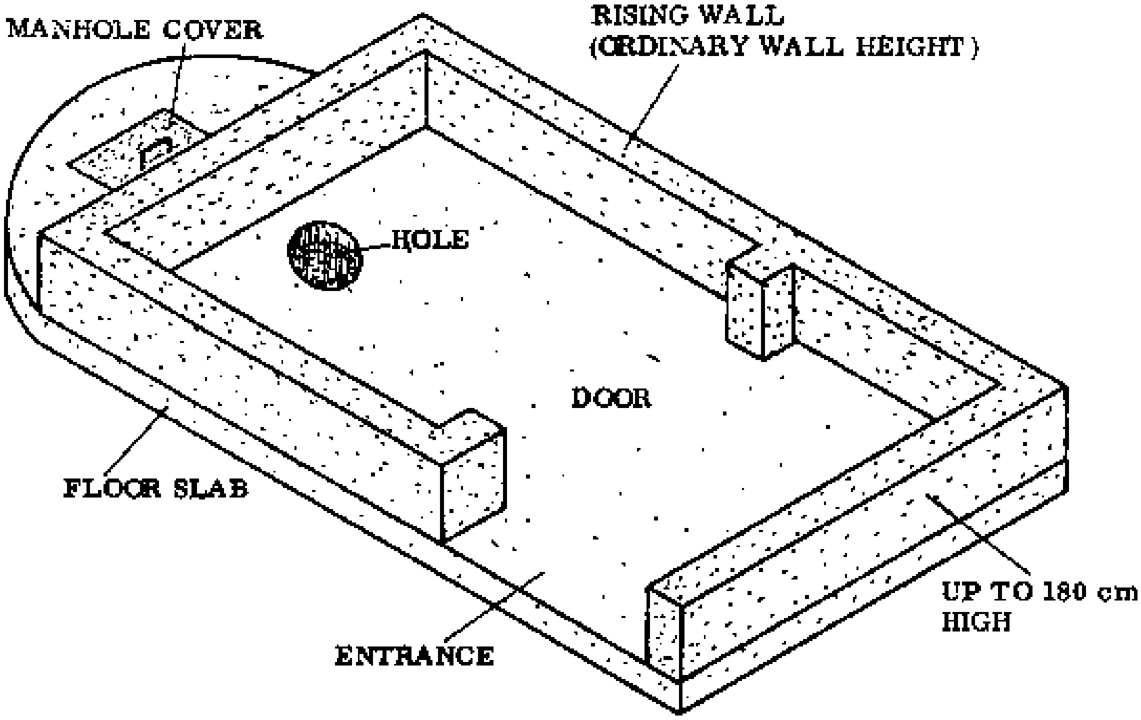


Fig. 4

BUCKET LATRINE

One of the oldest and generally least cleanly systems for waste removal is the bucket latrine. As in the cross section in Fig. 1, the squatting slab is set over a collection chamber with a bucket. The chamber should be closed off with a removable fly screen. The bucket should fit into a niche on the floor, so it is always returned to position directly under the hole in the slab when it is replaced after cleaning.

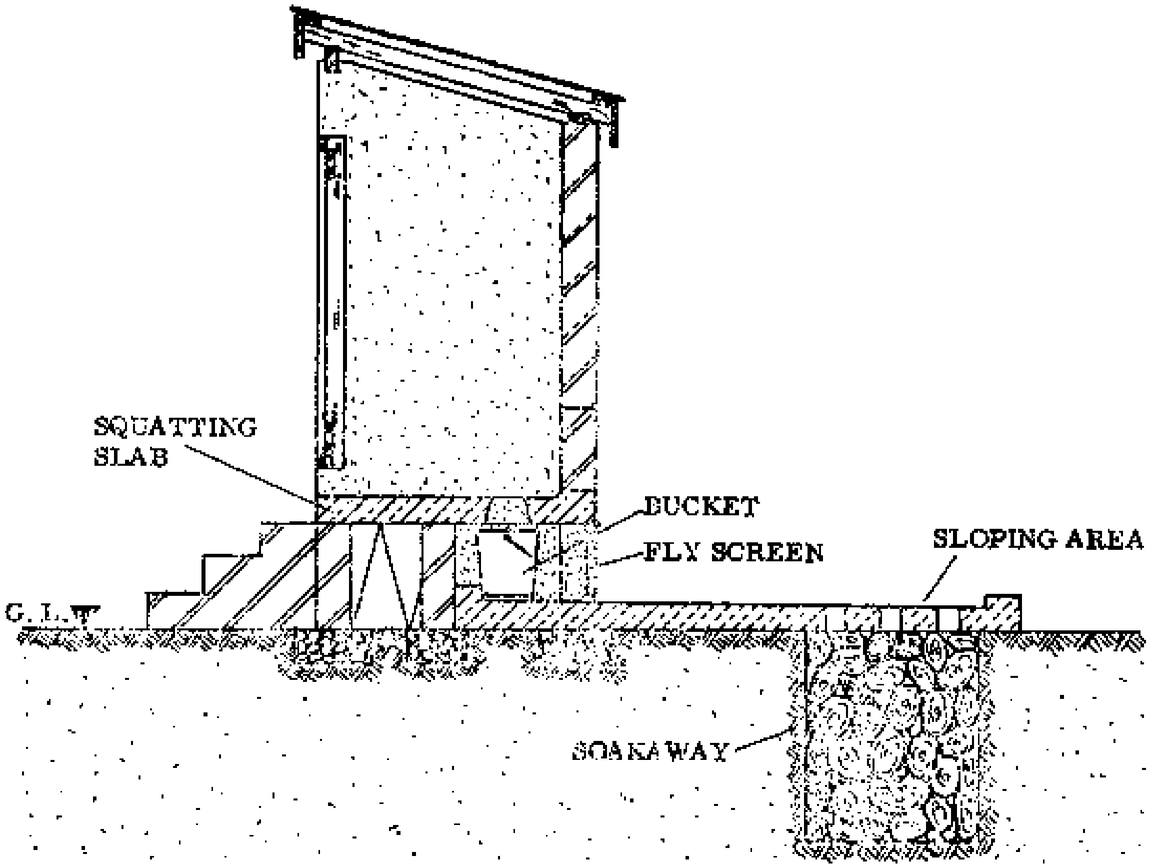


Fig. 1

The area behind the latrine should be paved, and a drain and a soak away should be made to get rid of the water used for cleaning the toilet and collection chamber.

The bucket latrine system is only possible where there is an organized system for regular collection and disposal of the bucket contents. This is usually not possible in rural areas.

AQUA PRIVY SYSTEMS

An aqua privy is basically a septic tank directly under a latrine. Its advantages are that it has fewer problems with smells, flies, and disease spreading than a regular latrine. However, at least two buckets of water must be poured into the privy every day for it to operate properly, and this can be a problem where there is no water source nearby.

An aqua privy for the use of one family may have a pit which is about 1 cubic meter in volume (about 0,15 cubic meters per person). The manhole should be large enough so that the sludge can be removed from the pit from time to time; whenever the tank is one−third full. If the tank is not emptied in time the drain pipe will become blocked and the system will fail.

Add some reinforcement to the squatting slab over the tank to support the back wall of the toilet. Make sure that the inside of the tank is waterproof, because if it leaks the water level cannot be maintained and smells can pass through the chute. If necessary paint the inside walls of the tank with waterproof paint. Make sure that there is a good ventilation system, with a fly screen over the end of the pipe which ventilates the tank (Fig. 2).

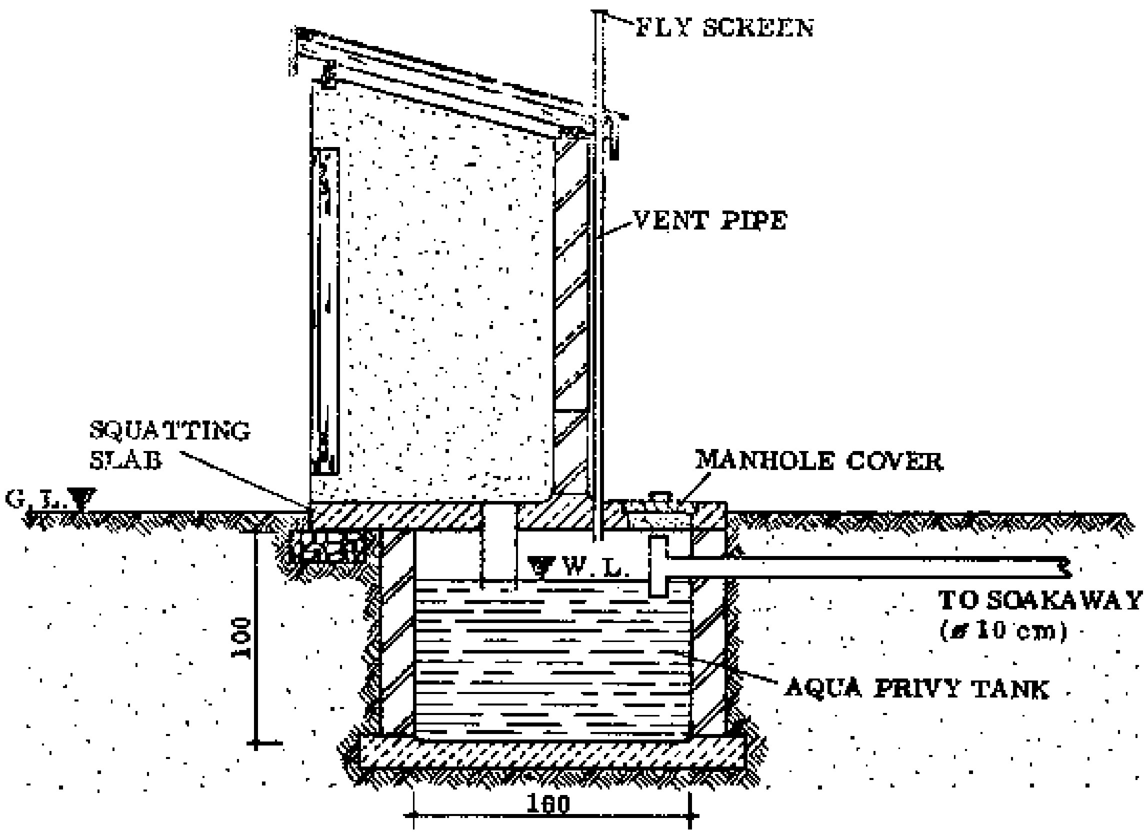


Fig. 2

It is very important to maintain the water level within the tank. If possible, washing facilities can be made nearby and connected with the tank, so that the water from the sink or shower room goes into the tank and maintains the water level.

SOAKAWAYS

A soakaway is basically a hole in the ground filled with stones, through which water can seep away into the surrounding soil instead of forming a pool on the surface of the ground where mosquitos can breed.

Dig a hole and fill it with large stones at the bottom and smaller ones at the top. Drain pipes from bathing areas, etc. can lead into the pit; they should end up in the centre. Cover the soakaway with soil, but make sure that the soil does not enter between the stones and block the drainage pipe. The soakaway can be covered with a layer of concrete to keep the top soil out (Fig. 1, previous page).

Soakaways should be at least 30 m away from wells or streams, and never uphill from a water source.

MANHOLES

Sometimes manholes are needed where long pipes have to be inspected at intervals. Manholes give easy access to the pipe junctions. A typical manhole layout is shown in the Drawing Book, page 125. This manhole can also serve as a kind of junction hole, from which more than one pipe can cross. The slope should be the same for pipes entering and leaving the manhole (Figs. 1a & 1b).

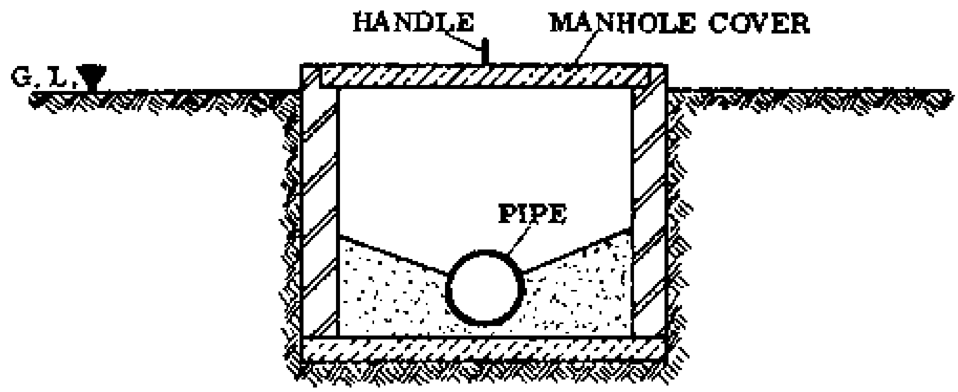


Fig. 1a

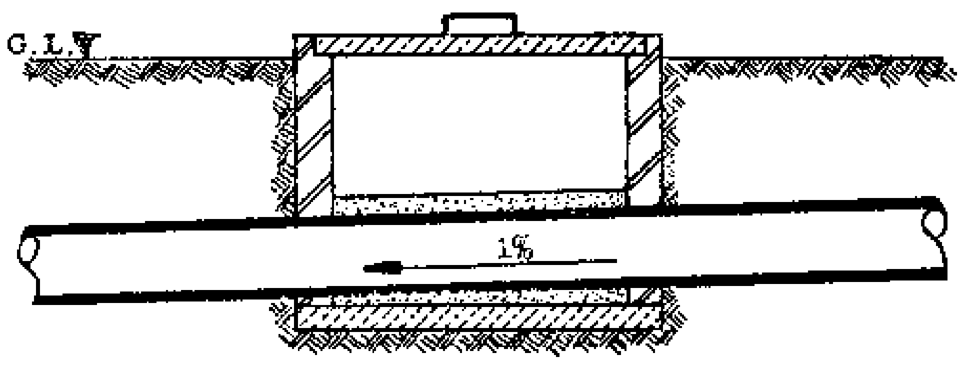


Fig. 1b

SEPTIC TANKS

Septic tanks are designed in such a way that the water takes at least 24 hours to pass through the system. During that time the heavier solids will settle to the bottom, forming the sludge. In the tank the solids are gradually broken down and become much reduced in volume.

Septic tanks should have two compartments (Fig. 2). The first compartment is twice the size of the second compartment. Intermediate walls are sometimes made in order to reduce the speed of the water flow, and to make the distance that the water has to travel longer (Drawing Book, page 126).

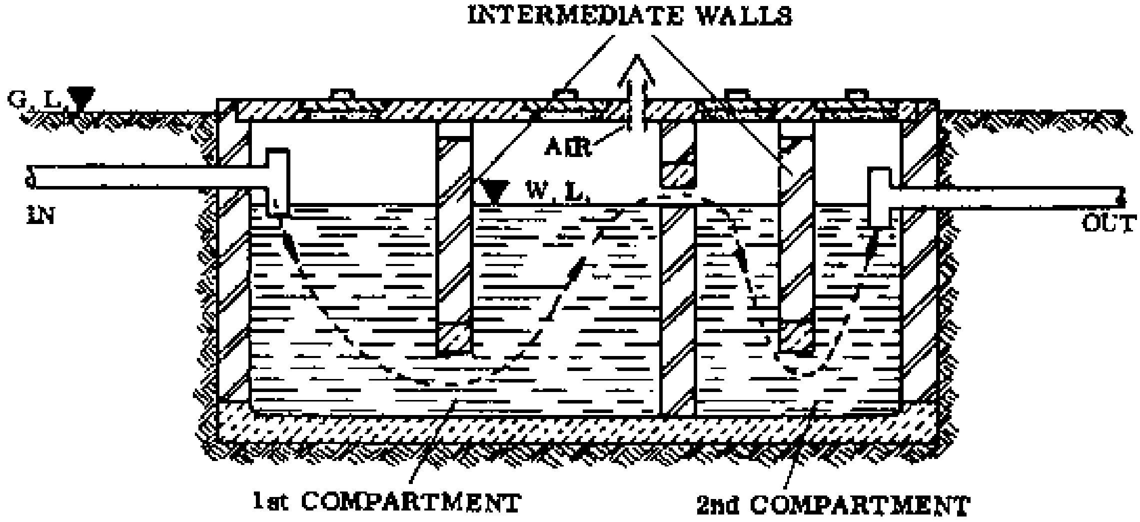


Fig. 2

The sludge has to be removed from the tank every few years, whenever it becomes 1/3 full. This sludge will not be safe to use as fertilizer until it has been composted for several months. The water flowing out from the tank will also be contaminated with bacteria and disease organisms.

Rural Building – Drawing Book

Table of Contents

Rural Building – Drawing Book

PREFACE

This official text book is designed purposely to meet the needs of trainees who are pursuing rural building courses in various training centres administered by the National Vocational Training Institute.

The main aim of this book is to provide much needed trade information in simple language and with illustrations suited to the understanding of the average trainee.

It is the outcome of many years of experiment conducted by the Catholic F.I.C. brothers of the Netherlands, and the German Volunteer Service instructors, in simple building techniques required for a rural community.

The National Vocational Training Institute is very grateful to Brothers John v. Winden and Marcel de Keijzer of F.I.C. and Messrs. Fritz Hohnerlein and Wolfram Pforte for their devoted service in preparing the necessary materials for the book; we are also grateful to the German Volunteer Service and the German Foundation For International Development (DSE) – AUT, who sponsored the publication of this book.

We are confident that the book will be of immense value to the instructors and trainees in our training centres.

DIRECTOR: National Vocational Training Institute, Accra

INTRODUCTION TO A RURAL BUILDING COURSE

Vocational training in Rural Building started in the Nandom Practical Vocational Centre in 1970. Since then this training has developed into an official four year course with a programme emphasis on realistic vocational training.

At the end of 1972 the Rural Building Course was officially recognised by the National Vocational Training Institute. This institute guides and controls all the vocational training in Ghana, supervises the development of crafts, and sets the examinations that are taken at the end of the training periods.

The Rural Building programme combines carpentry and masonry, especially the, techniques required for constructing housing and building sanitary and washing facilities, and storage facilities. The course is adapted to suit conditions in the rural areas and will be useful to those interested in rural development, and to farmers and agricultural workers.

While following this course, the instructor should try to foster in the trainee a sense of pride in his traditional way of building and design which is influenced by customs, climate and belief. The trainee should be aware of the requirements of modern society, and the links between old and new techniques, between modern and traditional designs –– and how best to strike a happy medium between the two with regard to considerations like health protection, storage space, sewage, and the water supply. The trainee should be encouraged to judge situations in the light of his own knowledge gained from the course, and to find his own solutions to problems; that is why this course does not provide fixed solutions but rather gives basic technical information. The instructor can adapt the course to the particular situation with which he and the trainee are faced.

This course is the result of many years of work and experimentation with different techniques. The text has been frequently revised to serve all those interested in Rural Development, and it is hoped that this course will be used in many vocational centres and communities. It is also the sincere wish of the founders of this course that the trainees should feel at the completion of their training that they are able to contribute personally to the development of the rural areas, which is of such vital importance to any other general development.

We are grateful to the Brothers F.I.C., the National Vocational Training Institute, and the German Volunteer Service for their support and assistance during the preparation of this course.

LAY–OUT OF THE RURAL BUILDING COURSE

The Rural Building Course is a block–release –system course, which means that the trainee will be trained in turn at the vocational centre and at the building site. The period of training at the centre is called "off–the–job training", and the period on the building site is called "on–the–job training". Each will last for two years, so that the whole course will take four years and will end with the final test for the National Craftsmanship Certificate.

BLOCK RELEASE SYSTEM

YEAR	TERM 1	TERM 2	TERM 3
1	X	X	X
2	O	O	O
3	O	X	O
4	X	O	X

X = OFF–THE–JOB TRAINING
O = ON–THE–JOB TRAINING

The total "off–the–job" training period lasts approximately 76 weeks, each week 35 hours. During this training about 80% of the time is spent on practical training in the workshop. The remaining 20% of the time is devoted to theoretical instruction.

The total "on–the–job" training period lasts approximately 95 weeks, each week 40 hours. During this period the trainee does full–time practical work related to his course work. In addition some "homework" is assigned by the centre and checked by the instructors.

A set of books has been prepared as an aid to the theoretical training:

Rural Building, Basic Knowledge (Form 1)
Rural Building, Construction (Forms 2, 3, 4)
Rural Building, Drawing Book (Forms 1, 2, 3, 4)
Rural Building, Reference Book

All these books are related to each other and should be used together. The whole set covers the syllabus for Rural Building and will be used in the preparation for the Grade II, Grade I, and the National Craftsmanship Certificate in Rural Building.

BOOK INTRODUCTION

The drawing book is divided into four sections, corresponding to the four forms in the Rural Building curriculum.

The lessons are planned to last approximately 90 minutes, during which the instructor should spend some time going over mistakes made in the drawings from previous lessons. Then the instructor can give the introduction to the new lesson, following this by a discussion of the how and why of the lesson. At the end of the session, the instructor should furnish the trainees with the technical data for the new drawing they are assigned for that week. Assignments should be handed in a few days before the next lesson so the instructor has time to correct them and make himself acquainted with the general difficulties which appear as a result.

Tests should be given at intervals. The drawings should then be made within the time specified in the book. The instructor can write the necessary technical data on the blackboard.

In the first part of the book much emphasis is put on the techniques for oblique and orthographic drawings. This kind of drawing has to be mastered early for the trainee to be able to understand drawings made on the blackboard during lessons. Sketching is important because during practicals many explanations are made with the aid of sketches. Plenty of time should be allowed for these exercises, and it is only at the end of the first year that the trainee should attempt drawings of simple frames. The instructor can add other drawings or sketches as needed to help the trainees to understand.

The last three parts of the book are oriented towards the course content for Rural Building. In these parts the trainee will find the lay−out of a whole building from the foundations to the roof construction, with the plans, elevations and cross sections; and building design is discussed as well. Here too, the instructor should feel free to change the sequence of the lessons if necessary to fit them together with the practicals in the workshop. During the lessons the instructor is advised to visit building sites with the trainees so that they can compare the drawings with the actual structures.

Ability to read drawings is also very important and ample time should be spent to help the trainees master this. It is helpful at times to have the trainees exchange drawings and correct each other's work.

SYLLABUS FOR RURAL BUILDING DRAWING

FORM I

Drawing equipment

DRAWING BOARD

A drawing board should be made from well seasoned wood or good quality plywood. One edge of the board − usually the left edge − should be very straight so it can be used with the T−square.

T−SQUARE

T−squares are rulers with a cross piece or stock fixed on one end to form the letter "T". The stock is either glued or attached to the blade by screws. Like drawing boards, T−squares should be made from materials which do not warp easily.

SET SQUARES

Set squares are triangular shaped tools which are used with the T−square. Two angles are available; 45 degrees and 60 degrees.

RULERS

Rulers used for drawing have 30 centimetre (cm) scales, subdivided into 300 millimetres (mm).

PENCILS

Pencils used for drawing are usually 2H, 3H, or 4H. The higher the number, the harder the lead. Sharpen pencils with a pocket knife. Cut the wood at a low angle to expose about 7 mm of lead, then sharpen the lead by carefully rubbing it on a piece of sandpaper.

Pencil lines must be fine, light and clear. It is a good habit to rotate the pencil as you draw a line, to keep a sharp point on the lead. When drawing lines follow the instructions on page 3.

DRAWING PINS

Drawing pins are used to fix paper to the board. The pins should have short fine points so that they don't make large holes in the drawing board. The pins should have large flat heads so that they can be removed easily. Because drawing pins can damage the T–square, various types of adhesive (sticky) tapes are often used instead of pins.

THE COMPASS

The compass is a precision instrument used to draw circles. One of the legs has a pointed end; this point must be thin and sharp so that it makes only a small hole in the paper. Especially when drawing small circles, make sure that the pencil point is the same length as the steel pin.

ERASERS

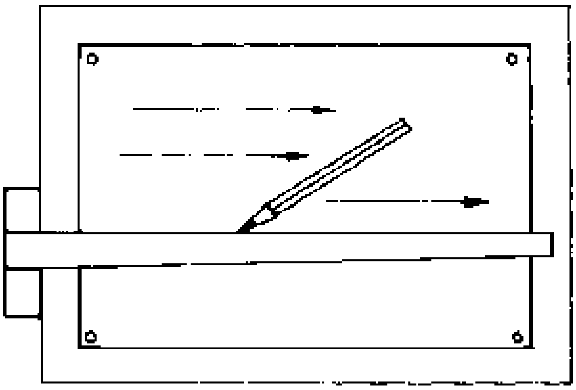
An eraser should be soft and of good quality so it does not damage the paper. The eraser should be used very little, and only with great care. If the corners of the eraser are rounded, it is a good idea to cut one end sharp again if you need to erase very exactly.

DRAWING PAPER

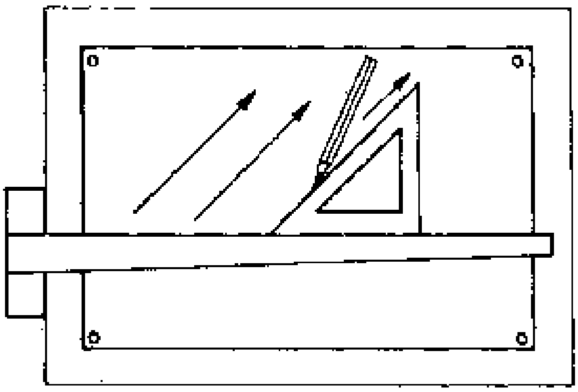
Drawing paper is special paper and it is cut to standard sizes.

Lines and lettering

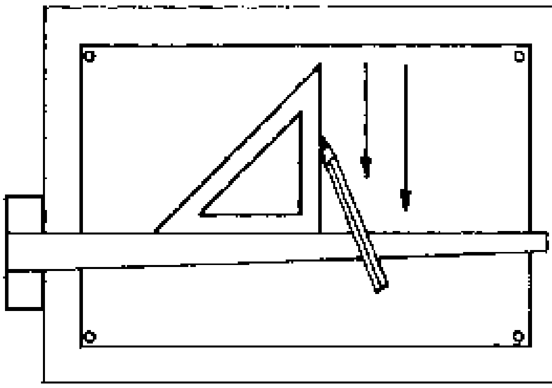
ALWAYS "DRAG" THE PENCIL – NEVER "PUSH" IT



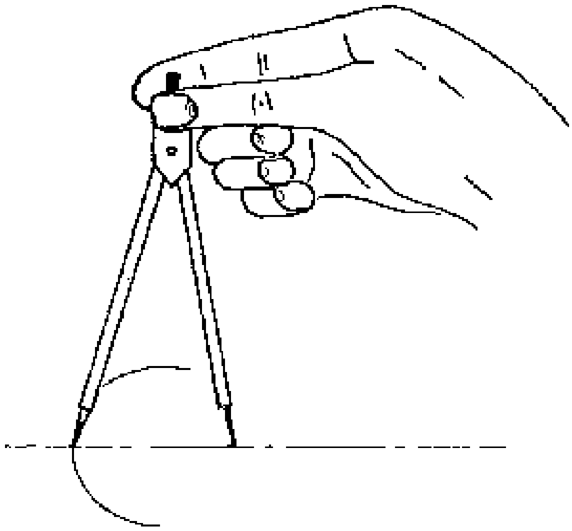
HORIZONTAL LINES



SLANTING LINES



VERTICAL LINES



CORRECT USE OF THE COMPASS

LETTERING

Any writing which is done on a drawing is always in the form of lettering and never in ordinary writing. Make sure that all the lettering on a drawing is the same height, with the exception of the title, which may be in larger capitals.

GUIDELINES

Guidelines are made to show the height and proper alignment of the letters on a drawing. They should be ruled very faintly with a sharp pencil so that they can be erased easily. For pencil lettering use an H or HB pencil.

TYPES OF LINES

Various types of lines are used on drawings; these are shown in the examples on the right.

A– FAINT LINES: These should stand out very fine and clear.

B– VISIBLE OUTLINES: These are bold continous lines and they should stand out clearly.

C– HIDDEN OUTLINES: These are chains of short, sharp lines.

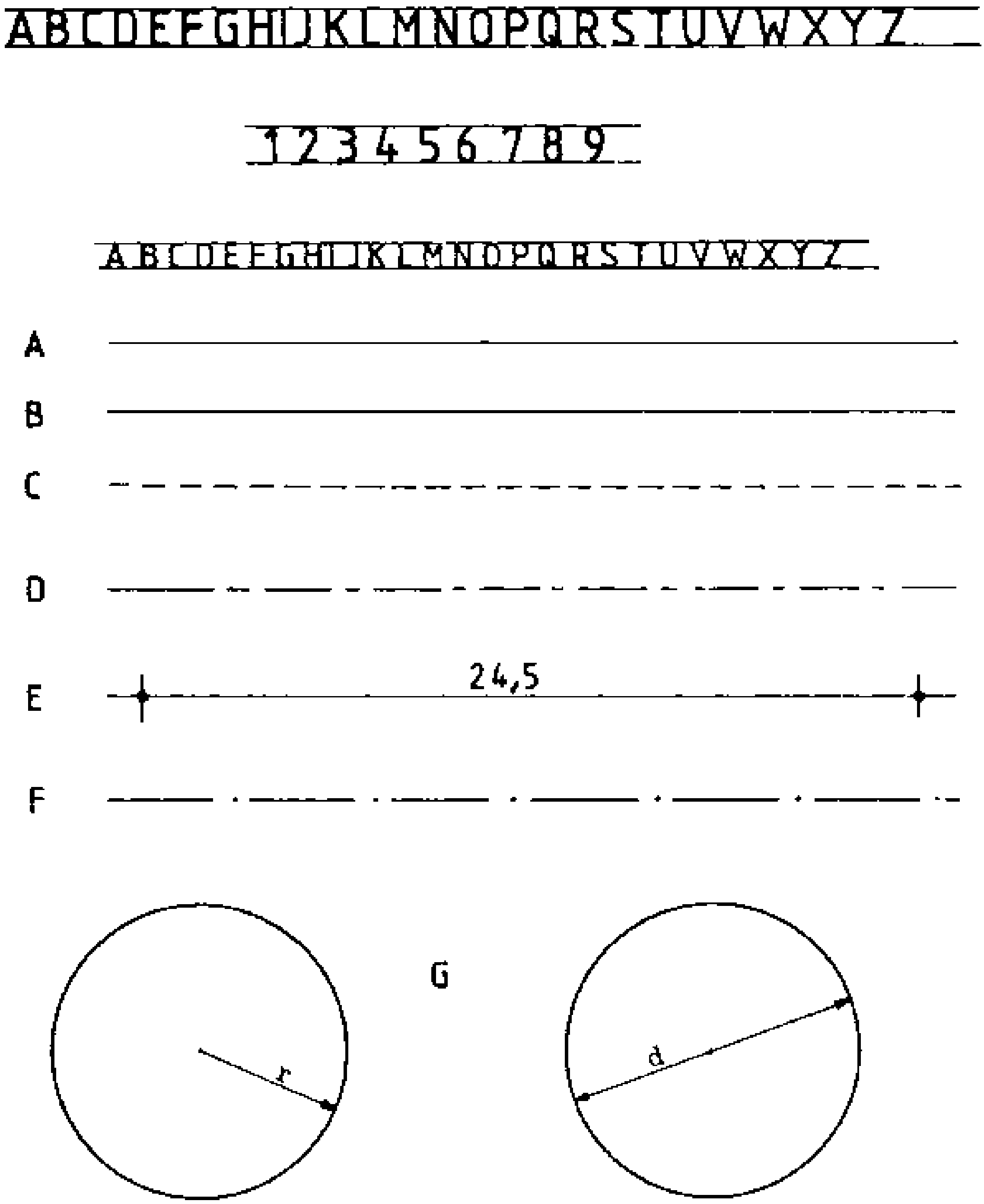
D– SECTION LINES: These show the plane on which an object is cut for the section view.

E– DIMENSION LINES: These lines always have a number on them, giving the length of a part of the object.

F– CENTRE LINES: These show the centre line of an object and are usually used in sketching.

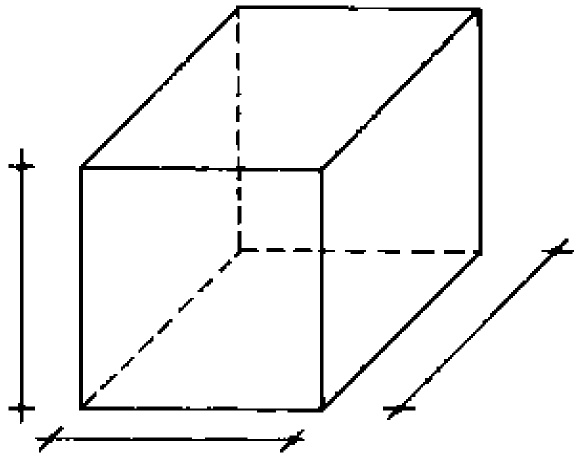
G– RADIUS AND DIAMETER LINES: In drawing circles, two lines are particularly important; these are the radius and diameter of the circle.

WHICH KIND OF LINES DO YOU SEE IN DRAWINGS 1, 2, AND 3?

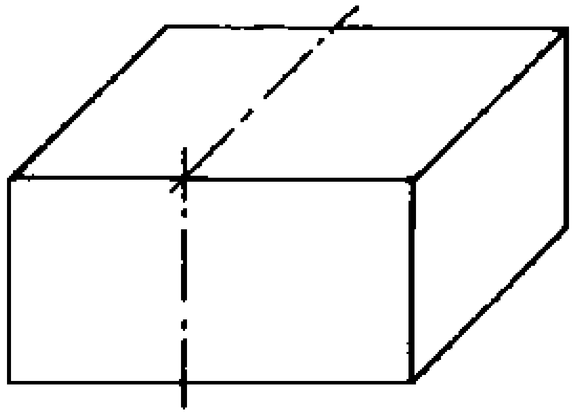


r = RADIUS

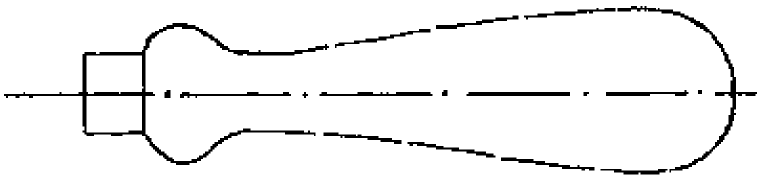
d= DIAMETER



1



2



3

Orthographic drawing

An orthographic drawing shows an object by means of a number of different views. Each view shows one side of the object as it is seen if looked at straight on. The diagram here shows a rectangular solid (A) along with an orthographic drawing of it (B).

– If a certain view will be the same as another view, you need draw only one of the views (compare the left side view and right side view from A).

– If certain measurements on one view are the same as measurements on another view, you should not label these measurements on both views. It is better to arrange the views so it is clear that the measurements are the same. The drawings on the right show how this is done (B & D).

In making an orthographic drawing, it is necessary to first choose the "front view". Any side can be choosen as the front view (even the top!) although it is usual to choose the most important side of the object.

– THE IMPORTANT POINTS TO REMEMBER IN MAKING AN ORTHOGRAPHIC DRAWING ARE:

– Space the views an even distance apart.

– Make accurate measurements.

– Make clear lines. Make sure that the outlines are darker than the dimension lines.

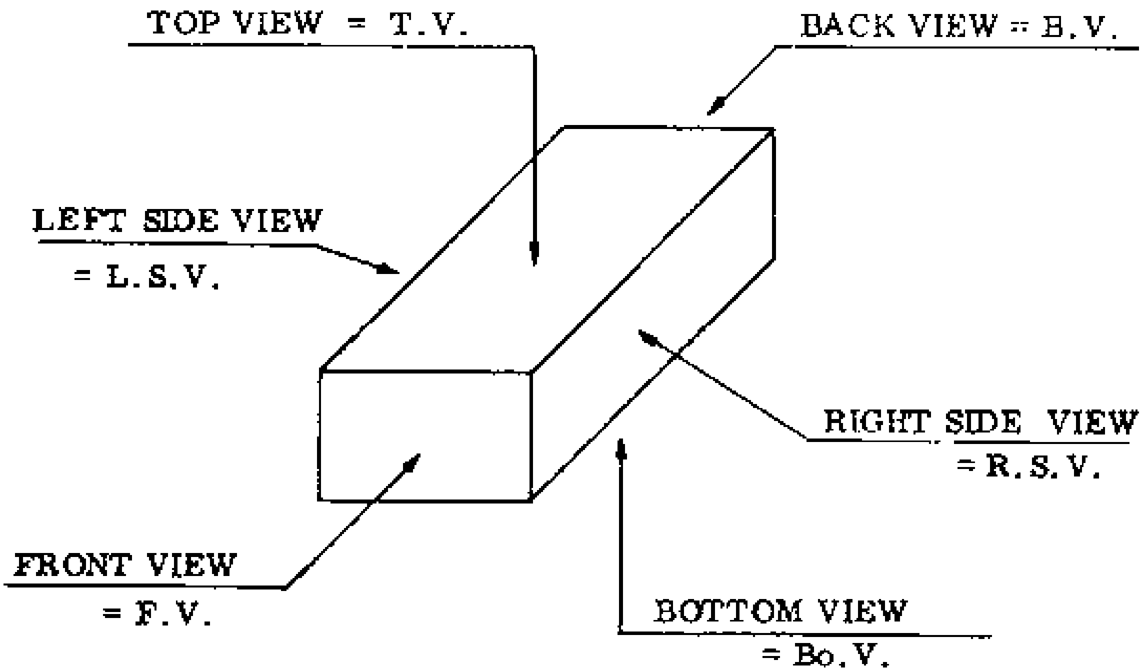
– The scale, in cm or mm, should be mentioned in the title block of the drawing (see page 9).

– The lettering must be uniform and clear.

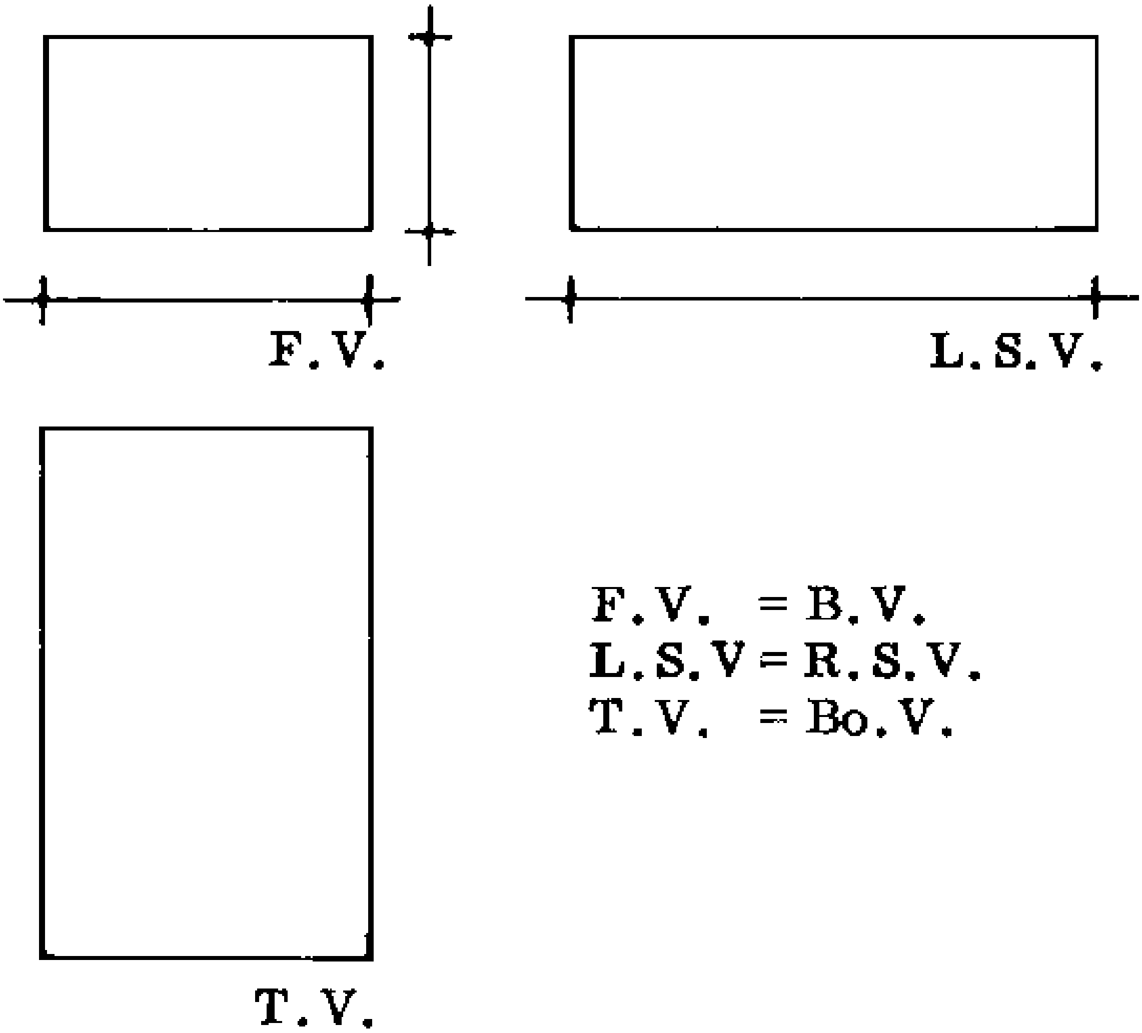
– STUDY: Look at solid A and orthographic drawing B. You need only three views for the drawing. Why is this?

Look at solid C and orthographic drawing D. Why do you need more views in orthographic drawing D?

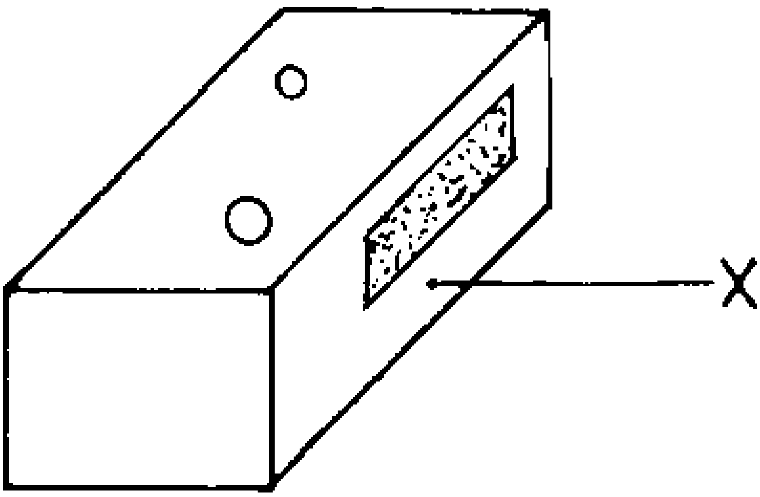
– DRAW: Make an orthographic drawing of solid C with side X as the front view.



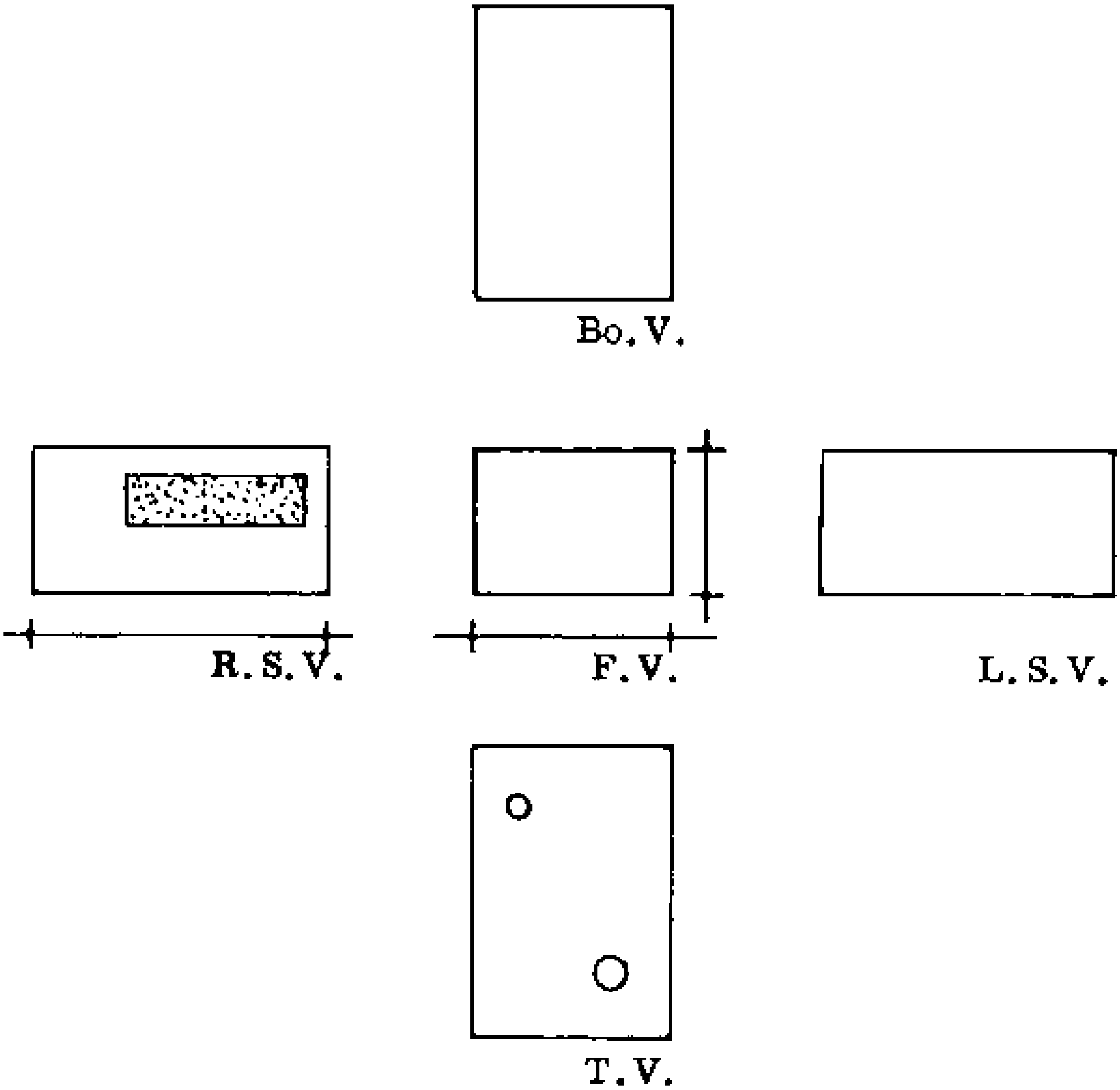
A



B – ORTOGRAPHIC DRAWING



C – OBLIQUE DRAWING



D – ORTOGRAPHIC DRAWING

SETTING OUT THE DRAWING

When you set out the different views of an object on the paper, make sure that they are evenly spaced. Never squash them all on one side. Leave enough space for the necessary titles, sub–titles, and descriptions.

The name of each view should be written on the lower right side of the view. Abbreviations of the view names can be used:

F.V. = front view	B.V. = back view
T.V. = top view	Bo.V. = bottom view
L.S.V. = left side view	R.S.V. = right side view

MARGIN LINE

A margin line should be drawn around the paper, 1 cm from the edge.

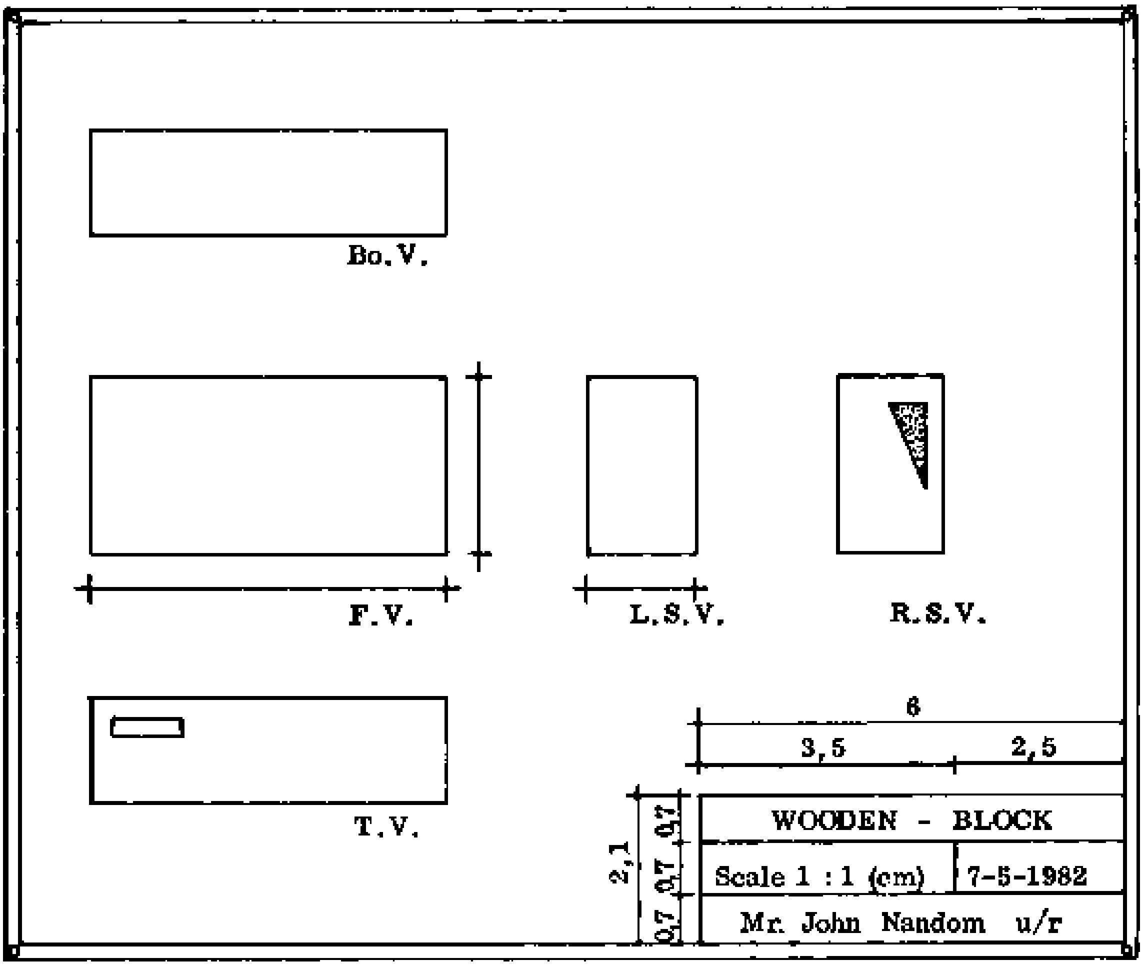
DIMENSIONS

No drawing is complete unless the dimensions or lengths of all the sides are given. The illustration on the right shows how dimensions are given on a drawing. Make sure that no dimensions are left out or repeated.

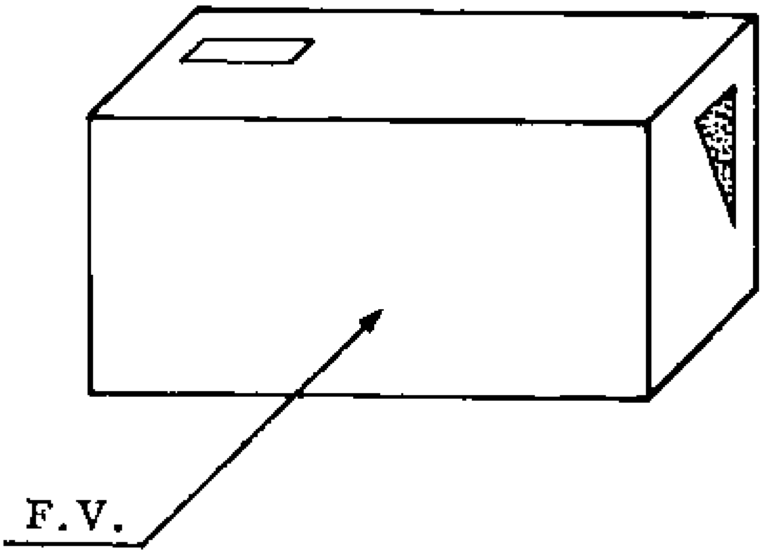
TITLE BLOCK

When the drawing is complete, the last thing that has to be done is to make a title block in the bottom right corner of the paper. The title block gives the title of the drawing, the scale used, the date on which it was drawn, and who drew it. The standard size of the title block is given in the drawing on the right.

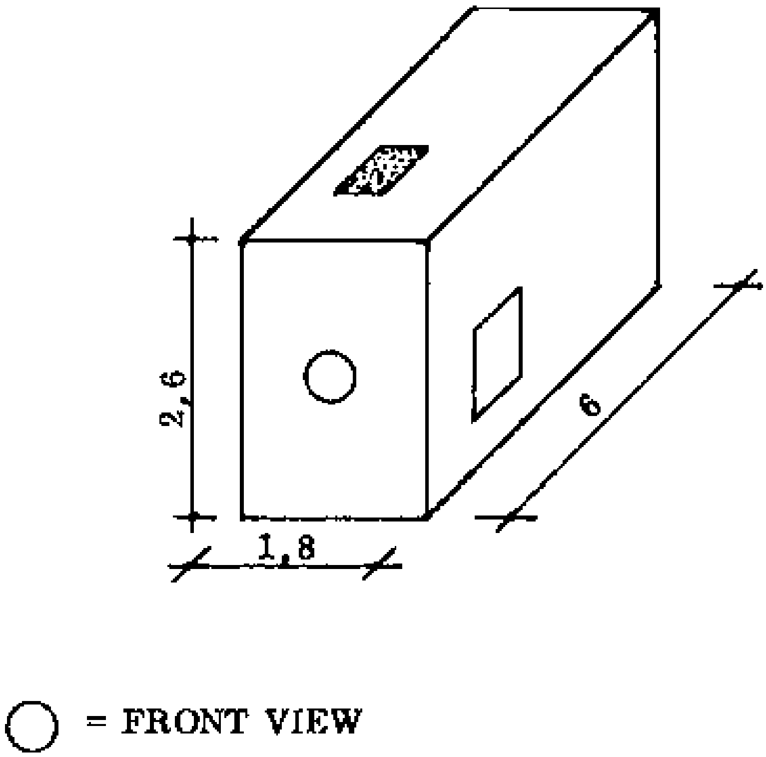
– DRAWING: Make an orthographic drawing of solid A.



CORRECT SPACING OF THE VIEWS



OBLIQUE EXAMPLE



A

MAKE AN ORTOGRAPHIC DRAWING OF THIS SOLID.

Oblique drawing

An oblique drawing is a pictorial representation of an object. The difference between oblique and orthographic drawings is that in oblique drawings the object appears as a single drawing and looks like it does in real life. It is important that you be able to understand both types of drawing and be able to turn one type of drawing into the other.

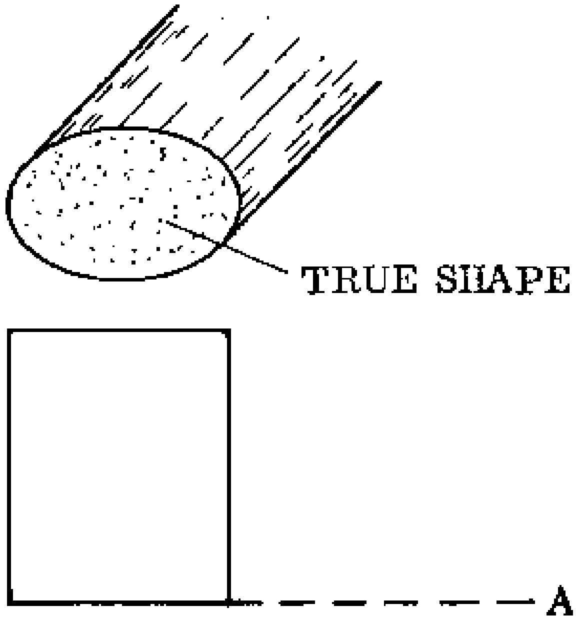
In oblique drawing one face of the object is drawn in its true shape. This face is always the front view. The rest of the drawing is then built up using three "axes" or directions. One axis is always horizontal (A); another axis is always vertical (B); but the third axis (C) can be at any other angle. It is usual, however, to have the third axis at 45 degrees. These are shown in the illustration on the right.

Oblique drawing can be done step by step.

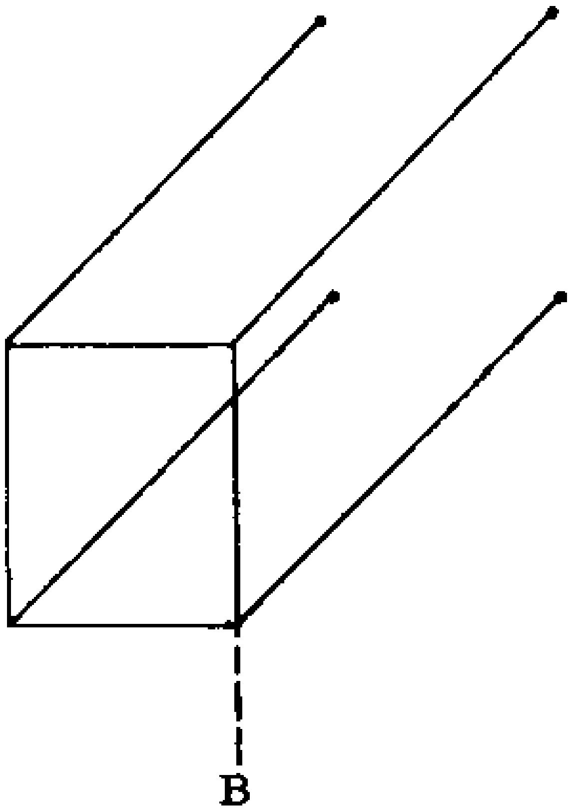
1 – Choose the front view. Draw it faintly on your paper.
2 – Draw the oblique lines at 45 degrees. Make sure that they are all the same length.
3 – Connect the oblique lines together using vertical lines or horizontal lines as needed.
4 – Erase all unnecessary lines.
5 – Mark all dimensions.
6 – Redraw the outline of the object with an HB pencil to make it darker.

<u>CURVED OBJECTS</u>

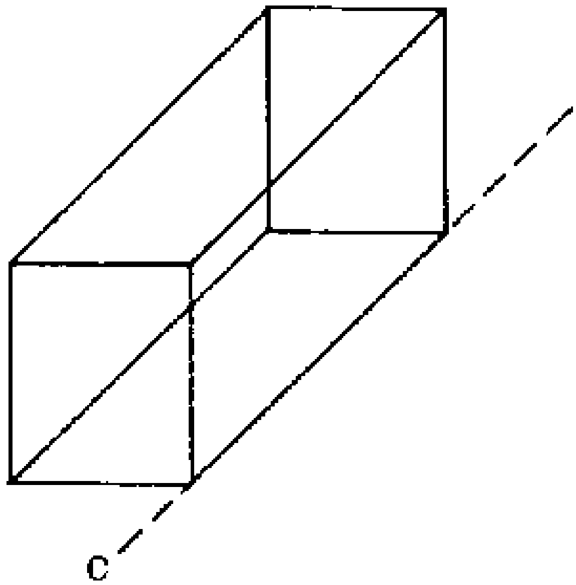
An object with a curved surface can easily be shown in an oblique drawing. To do this, draw the shape of the curve in the front view, so that the curve appears in its true shape. Finish off by drawing the oblique lines etc. as usual (see below).



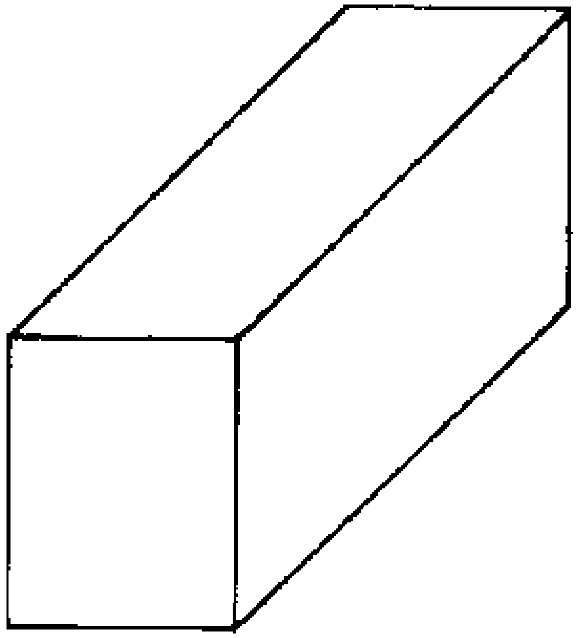
1 FRONT VIEW



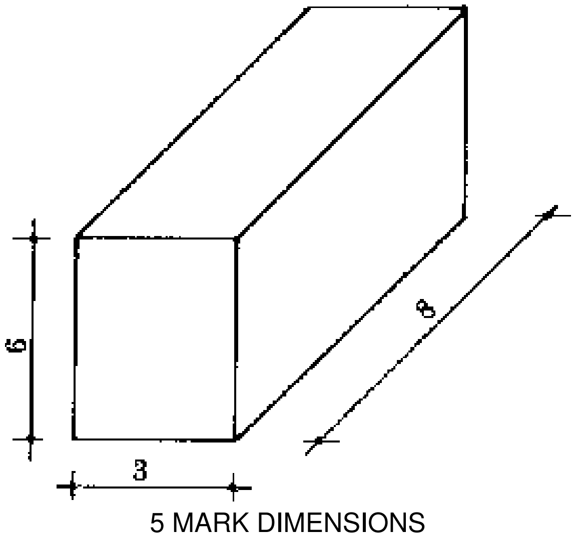
2 OBLIQUE LINES



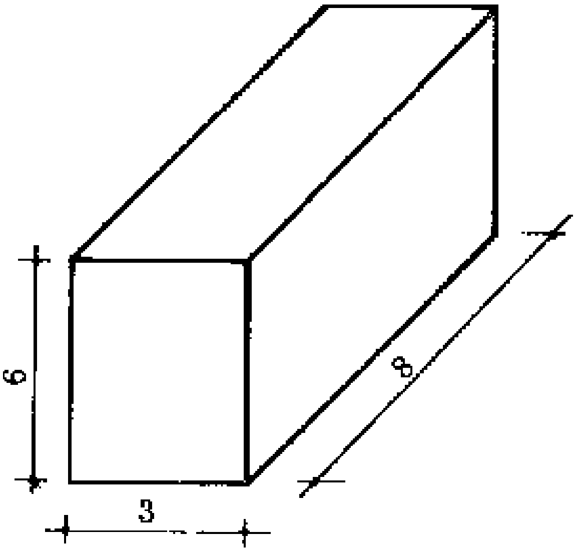
3 CONNECT LINES



4 ERASE UNNECESSARY LINES



5 MARK DIMENSIONS



6 REDRAW OUTLINES

TECHNIQUES IN OBLIQUE DRAWING

There are some techniques and conventions that you need to know to make good oblique drawings. The most important of these is choosing the best view of the object. The best view is the one that gives you the most information about the object. A good rule to follow is: the best view is the one that is the hardest to draw.

On the next page you can see four different drawings of the same object. They all have the same front view but they are all projected in different directions. You should see that they all give different amounts of information about the object (A).

- Which view gives you the most information?
- Which view is the hardest to draw?

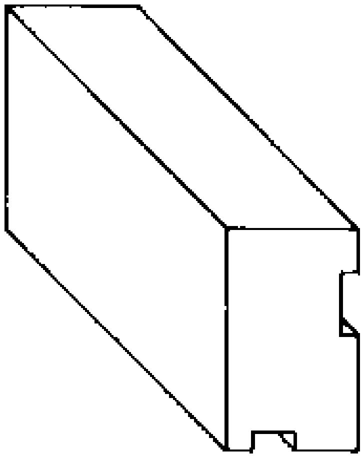
The answer is "B", for both questions.

– CONVENTIONS: All types of drawing have their own conventions. At first the conventions may seem unnecessary, but you will soon find that they all help you to understand a drawing better. One of the most important conventions in oblique drawing is the marking of dimensions. The drawing here (B) shows how this should be done. Remember that the dimensions are given simply as numbers on the drawing itself, and that the unit (cm, mm, etc.) is given in the title block.

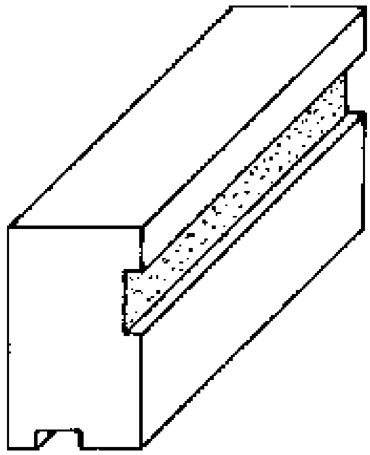
For example: if the length of a block is 6 cm, the dimension in the drawing is given as "6"; and the unit "cm" is recorded in the title block.

– DRAW: Draw or sketch several solids, as in the following pages. Judge which side should be the front view. Decide up on the position in which the solid will be drawn.

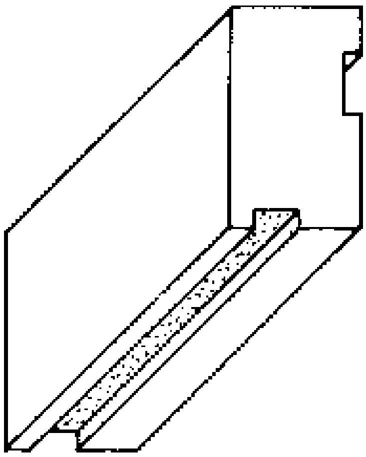
T.V./F.V./L.S.V.



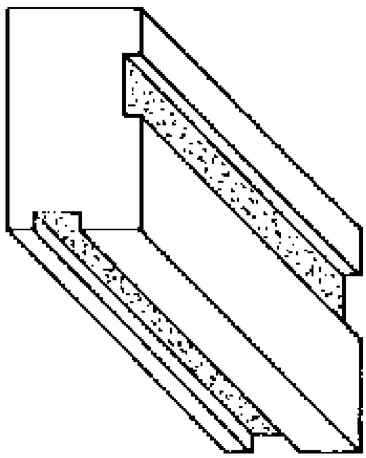
T.V./F.V./R.S.V



F.V./L.S.V./Bo.V.

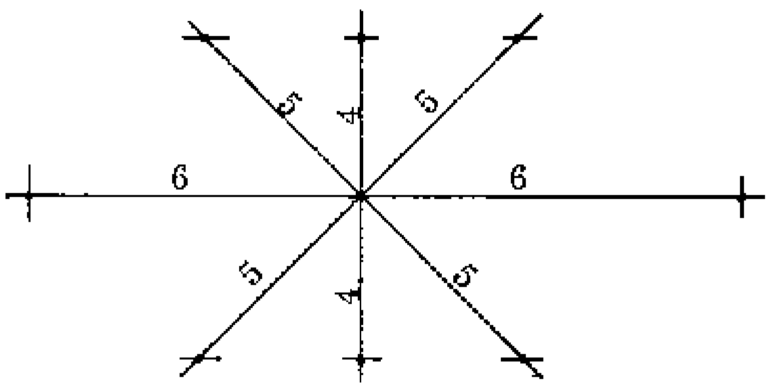


F.V./R.S.V./Bo.V.

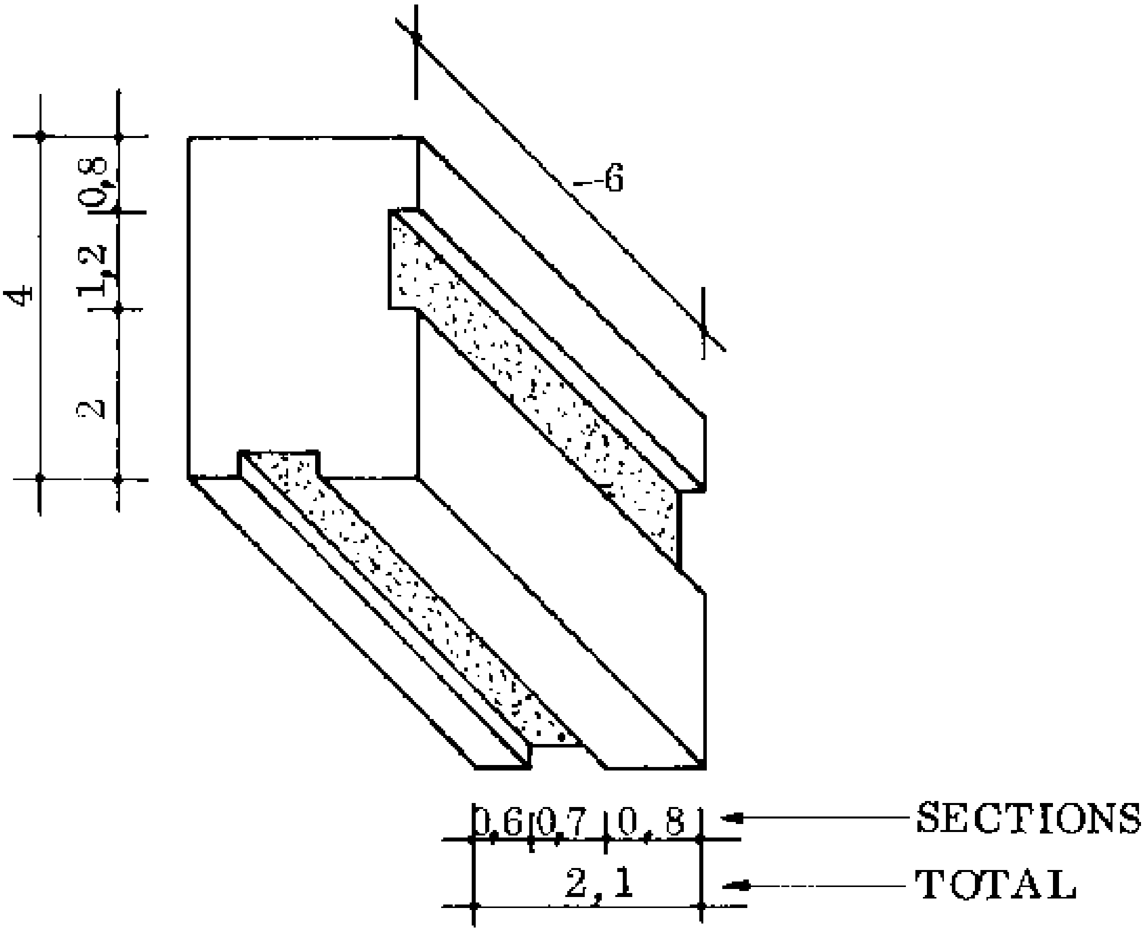


A – FOUR DIFFERENT POSITIONS IN OBLIQUE

WHICH POSITION IS THE BEST?

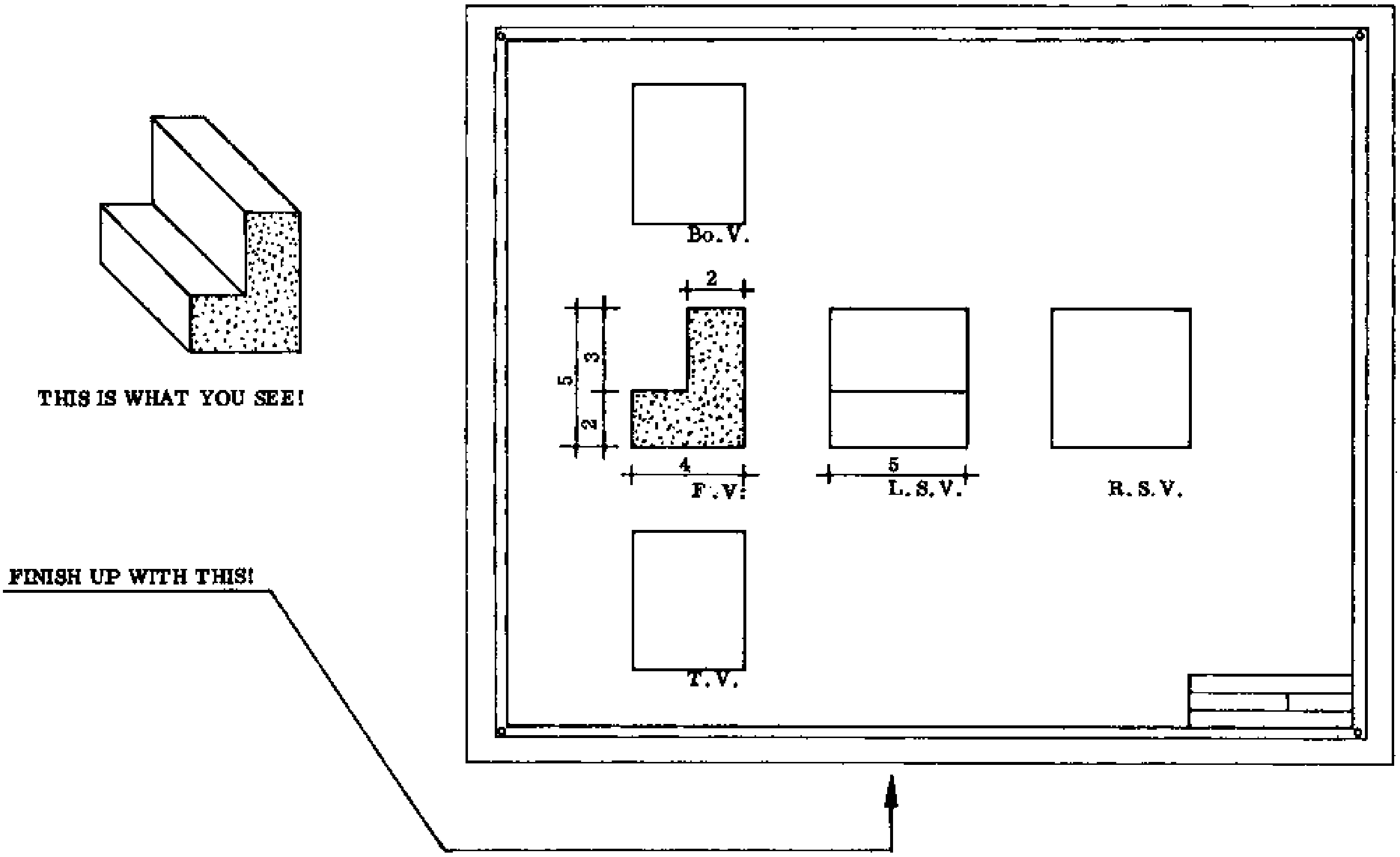


MARK DIMENSIONS LIKE THIS!

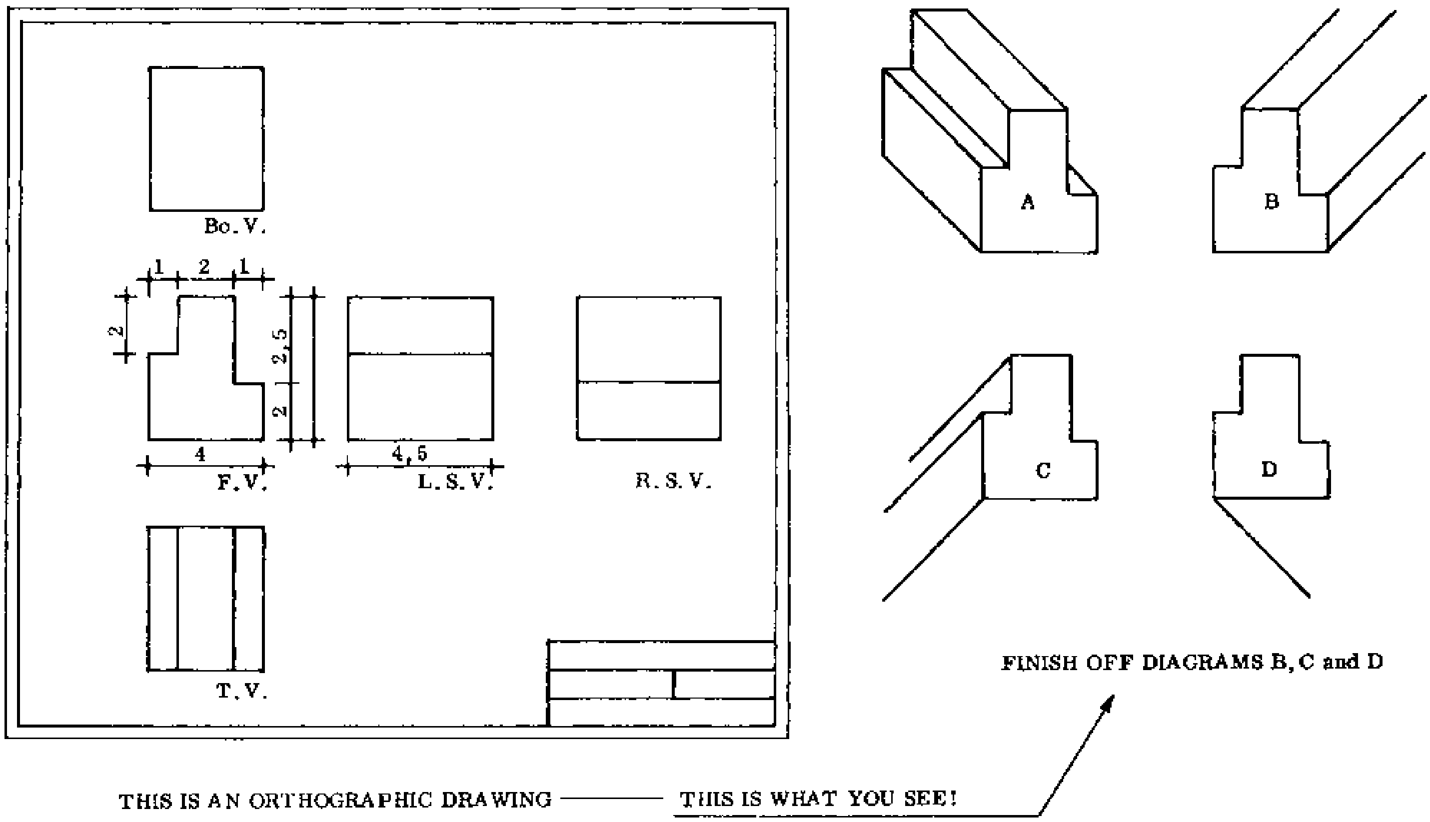


F.V./Bo.V./R.S.V.
B

Oblique drawing to orthographic drawing and orthographic to oblique



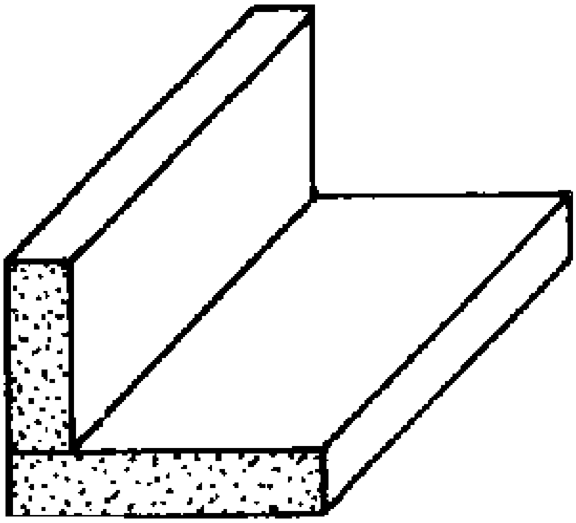
OBLIQUE TO ORTHOGRAPHIC – 40 MIN



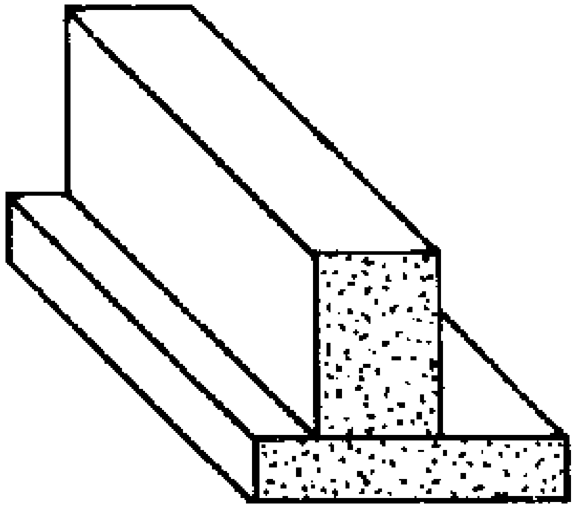
ORTHOGRAPHIC TO OBLIQUE – 60 MIN

EXERCISE: OBLIQUE TO ORTHOGRAPHIC – 50 MIN

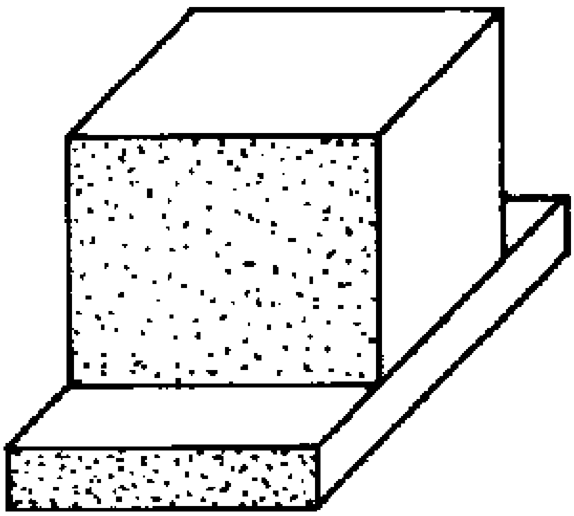
1 – MAKE ORTHOGRAPHIC DRAWINGS OF EACH BLOCK.
2 – DRAW EACH BLOCK USING AT LEAST TWO DIFFERENT FRONT VIEWS.



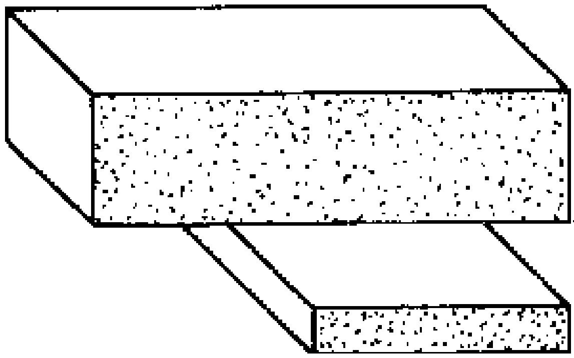
1



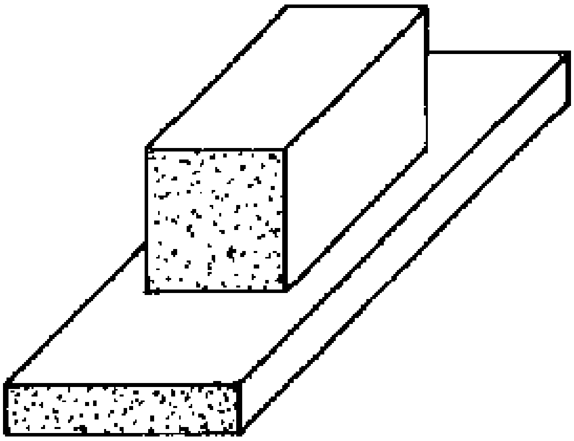
2



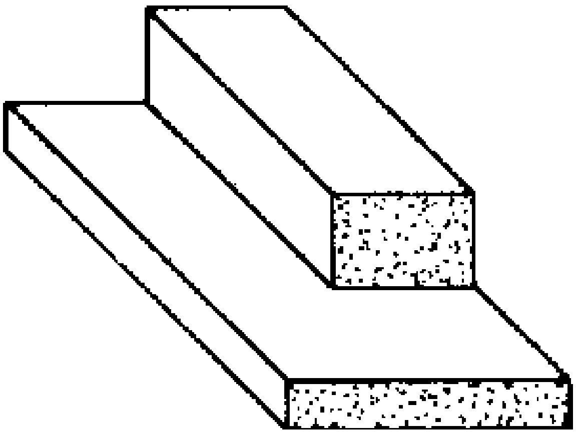
3



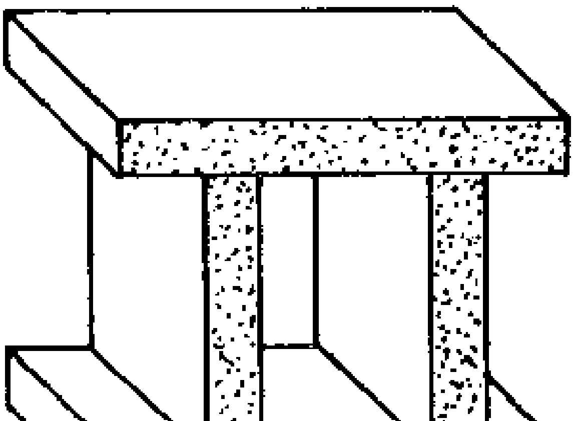
4



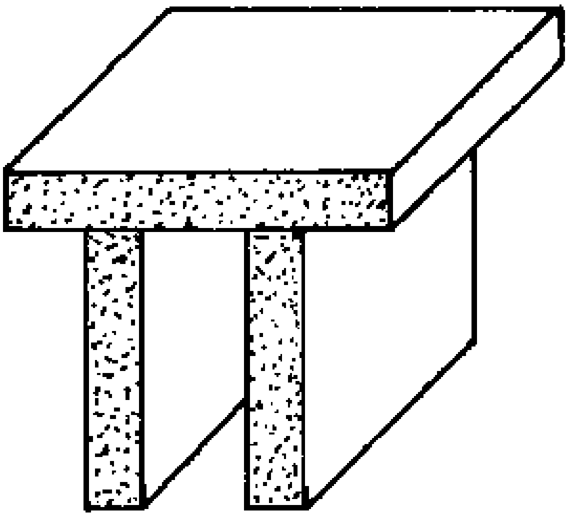
5



6



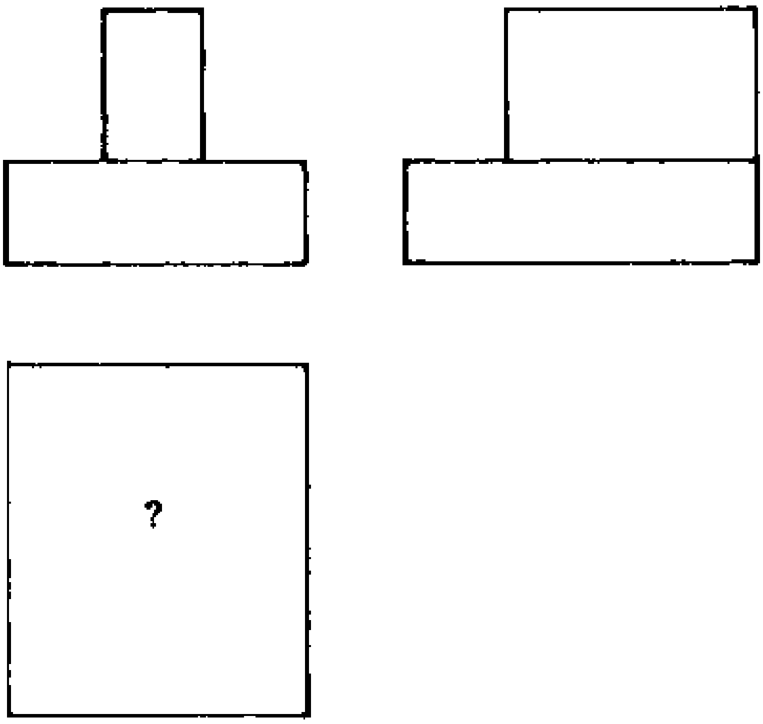
7



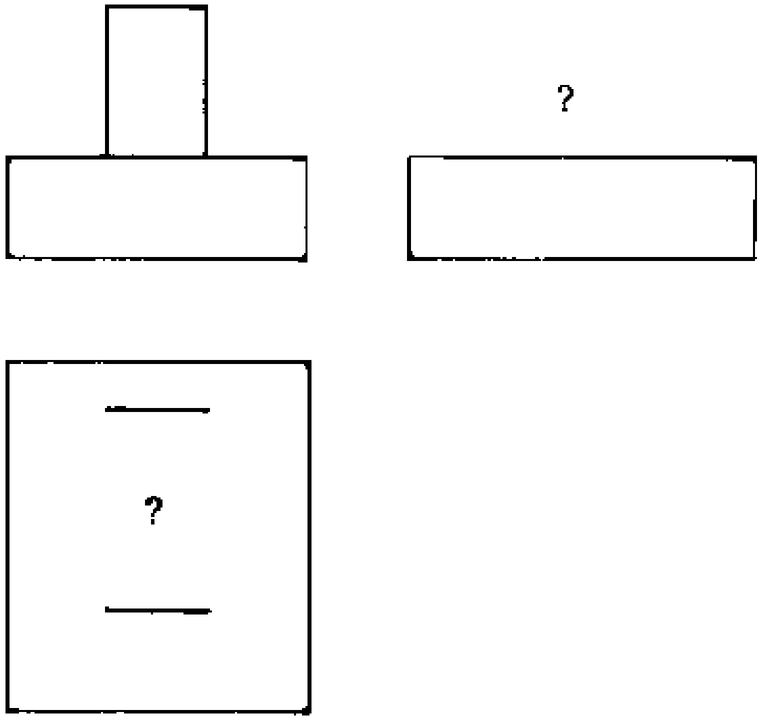
8

EXERCISE: ORTHOGRAPHIC TO OBLIQUE – 30 MIN

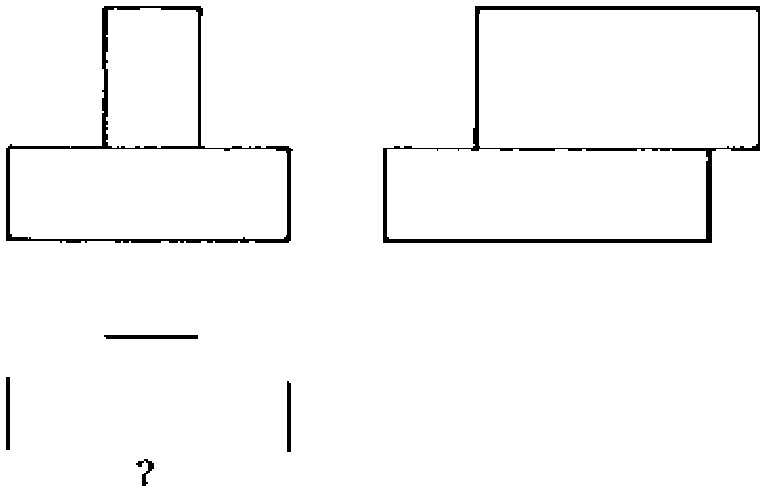
– COMPLETE ALL VIEWS.
– NAME ALL VIEWS.
– FILL IN ALL DIMENSIONS.
–MAKE OBLIQUE DRAWINGS FROM THESE ORTHOGRAPHIC DRAWINGS. SCALE 1:2 (cm)



1



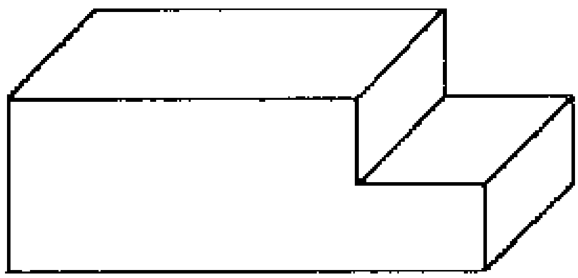
2



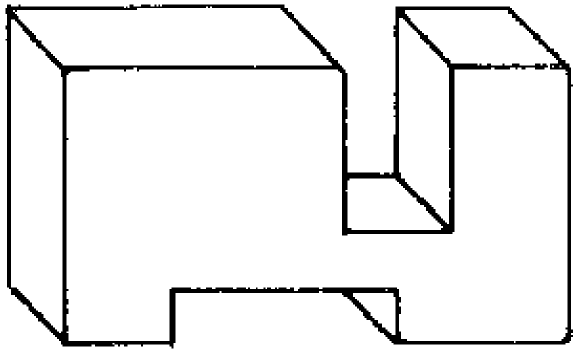
3

EXERCISE: OBLIQUE TO ORTHOGRAPHIC – 40 MIN

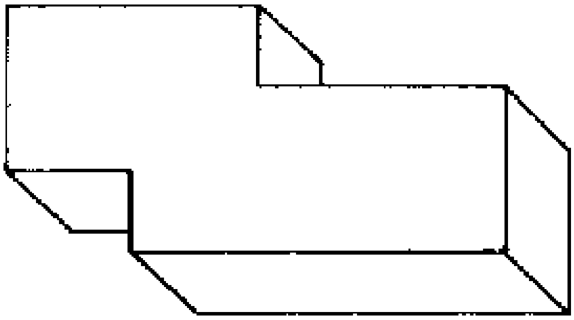
- MAKE AN ORTHOGRAPHIC DRAWING OF EACH BLOCK.
- MARK ALL DIMENSIONS OF THESE 8 BLOCKS.
- DRAWINGS SCALE 1:5 (cm)



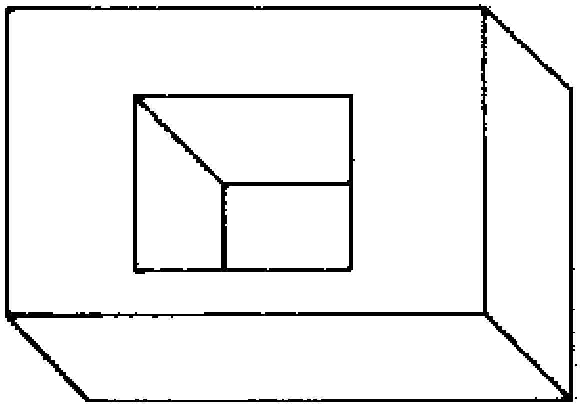
1



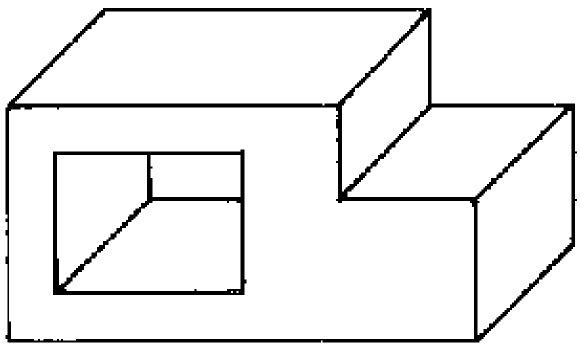
2



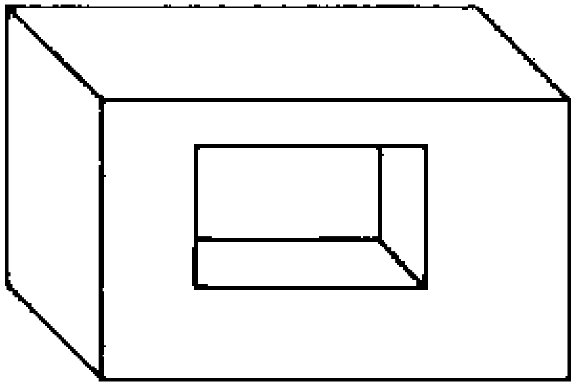
3



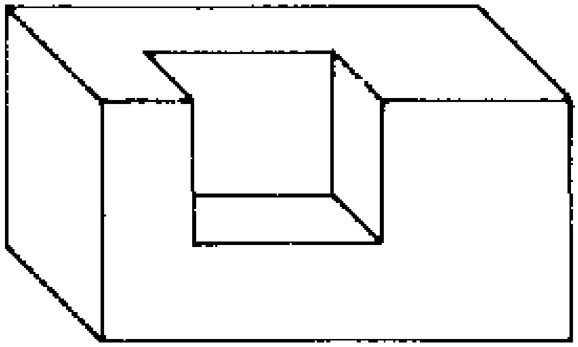
4



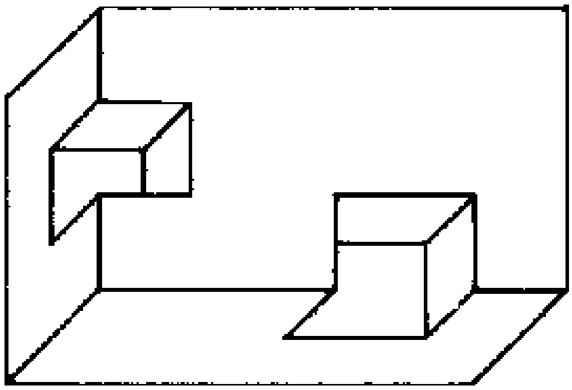
5



6



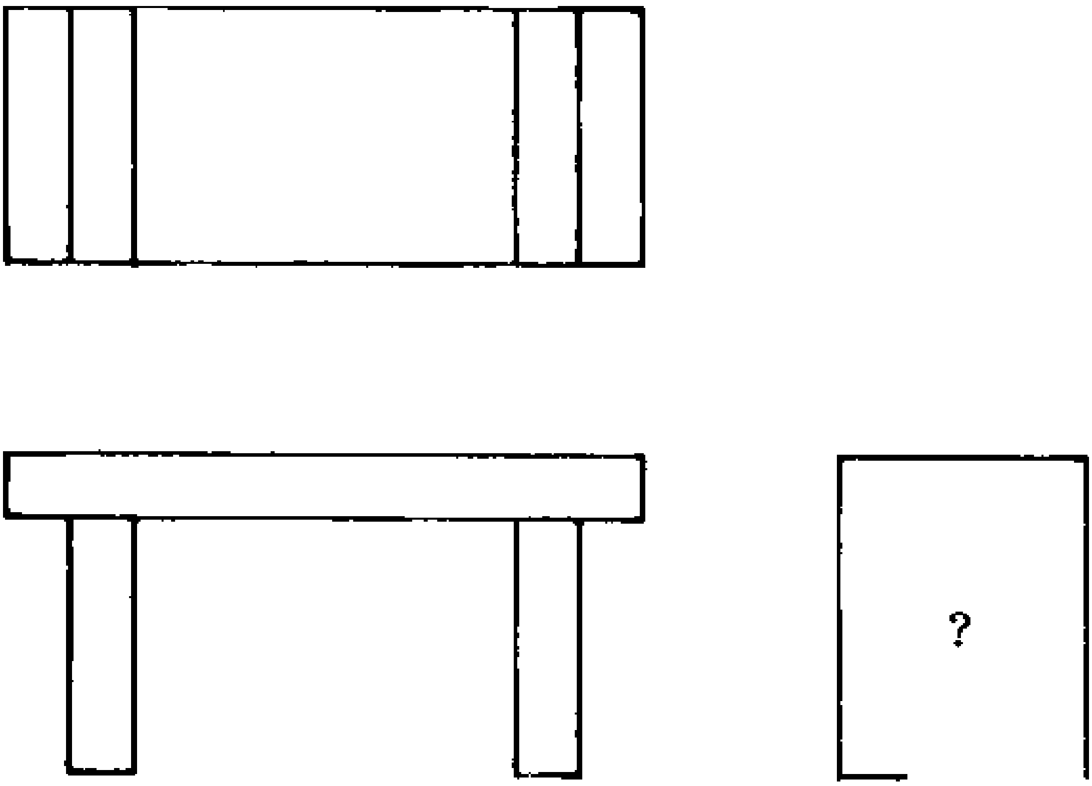
7



8

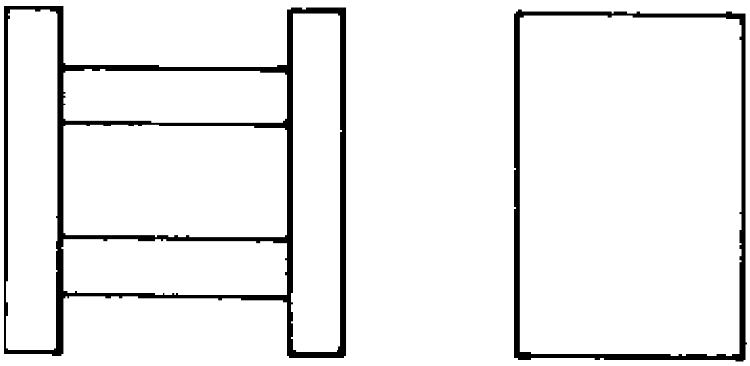
EXERCISE: ORTHOGRAPHIC TO OBLIQUE – 40 MIN

– COMPLETE ALL VIEWS.
– NAME ALL VIEWS.
– MARK ALL DIMENSIONS.
– MAKE OBLIQUE DRAWINGS. SCALE 1:2 (cm)
– PRACTICE DIFFERENT POSITIONS.
– TAKE DIFFERENT DIMENSIONS AND DIFFERENT SCALES.

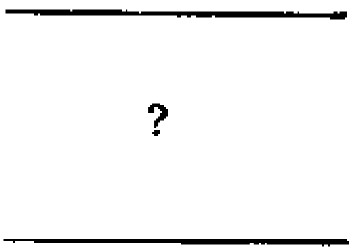


F.V. Do you need L.S.V and R.S.V ?

1

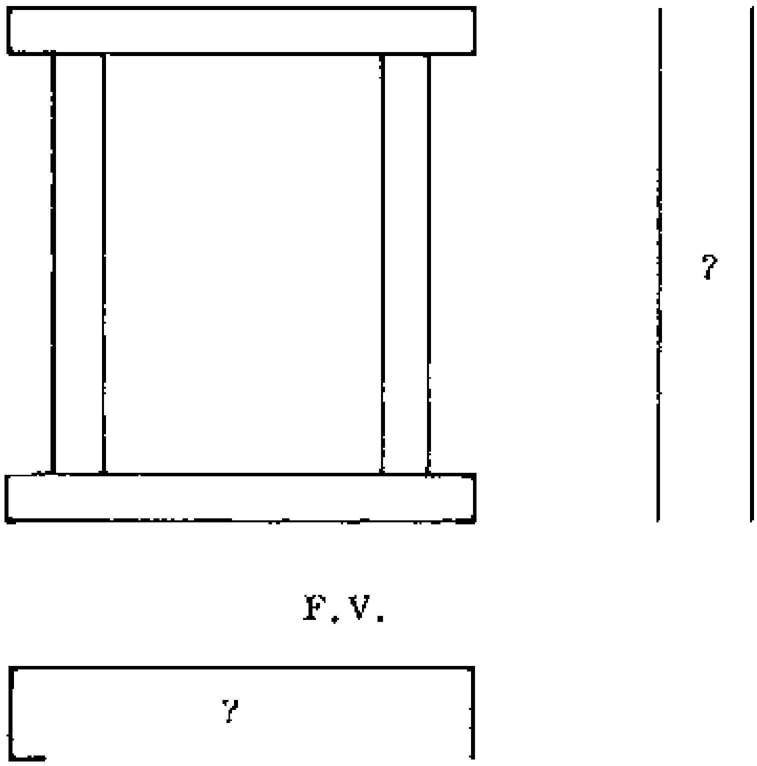


F.V.

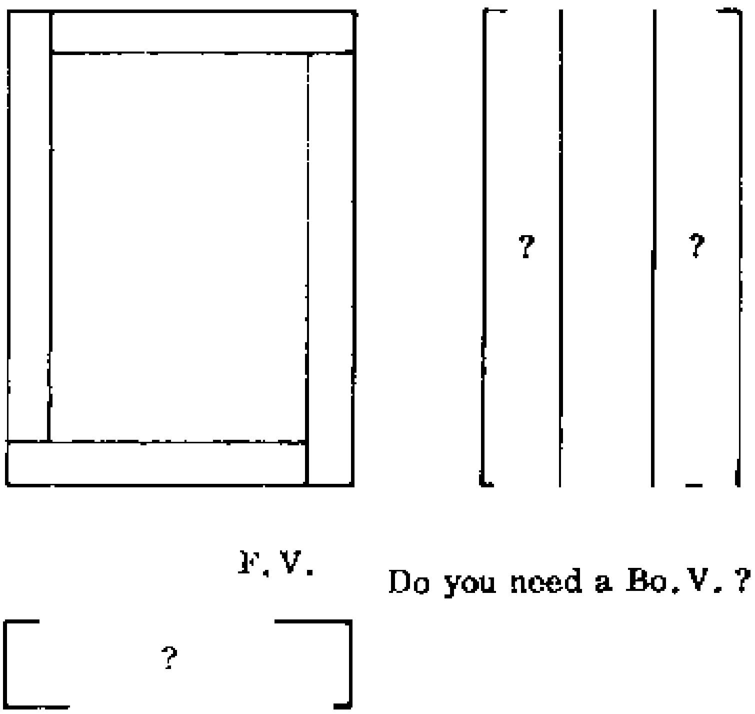


Do you need R.S.V. and L.S.V. ?

2



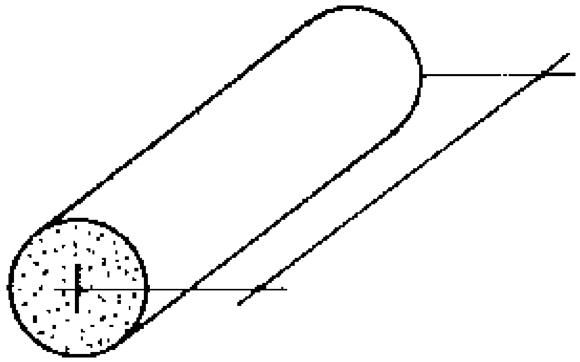
3



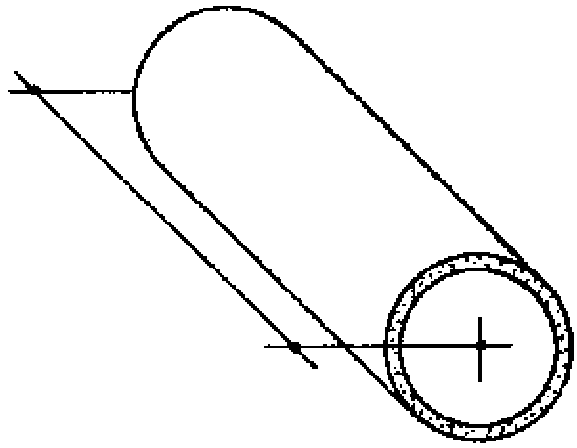
4

EXERCISE: OBLIQUE TO ORTHOGRAPHIC – 60 MIN

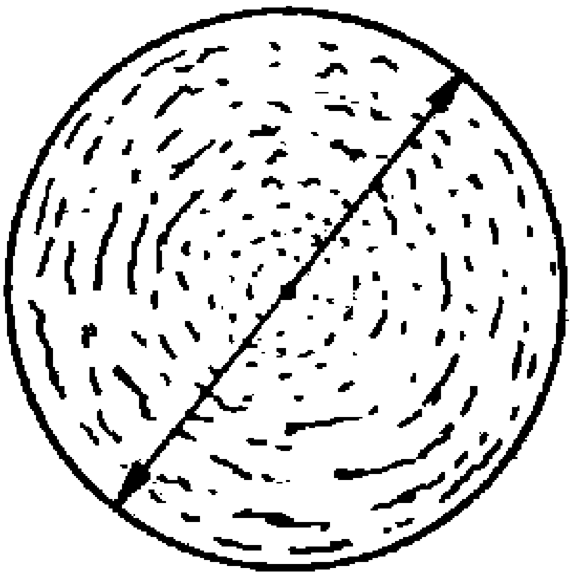
– MARK IN ALL DIMENSIONS.
– MAKE AN ORTHOGRAPHIC DRAWING OF EACH BLOCK. SCALE 2:1 (cm)



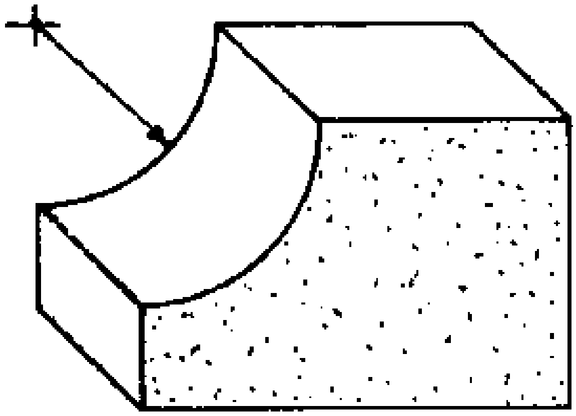
1

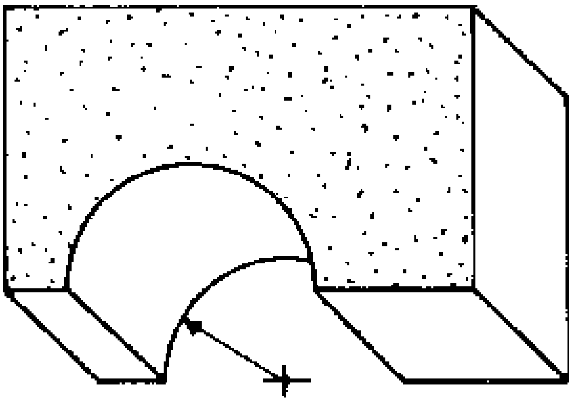


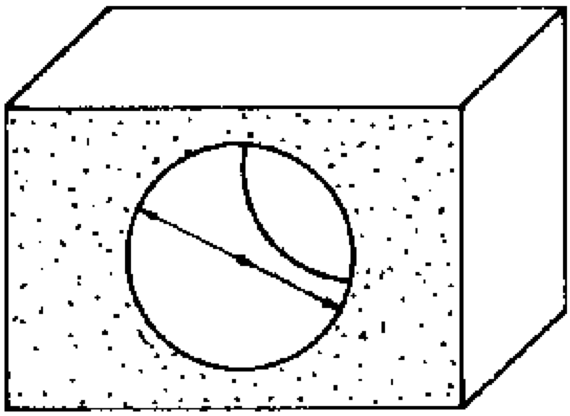
2

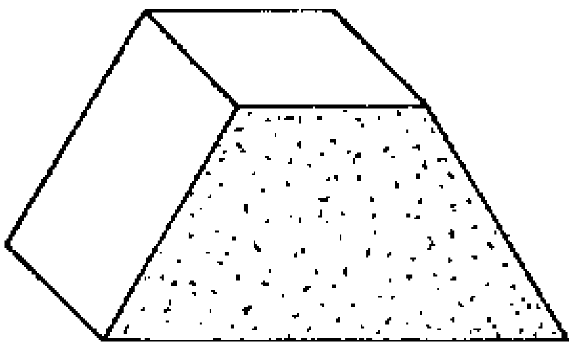


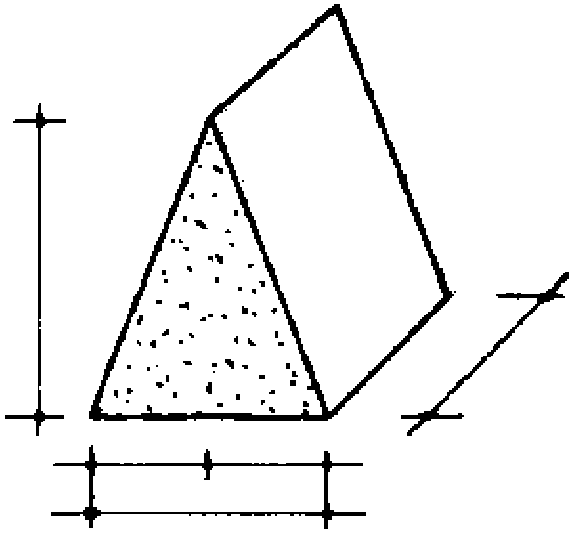
3


4


5


6

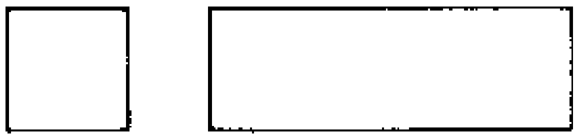

7



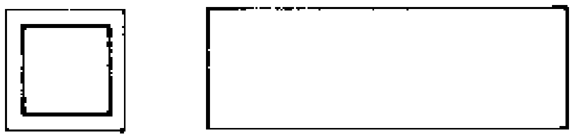
8

EXERCISE: ORTHOGRAPHIC TO OBLIQUE – 40 MIN

– NAME ALL VIEWS.
– MARK ALL DIMENSIONS.
– MAKE OBLIQUE DRAWINGS

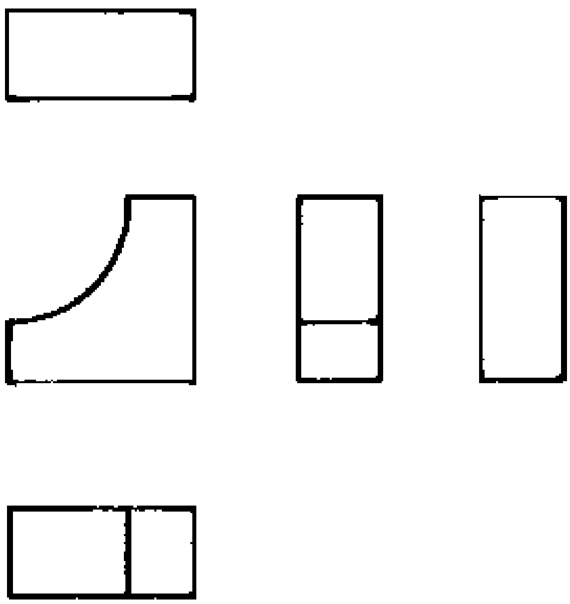


1: FV–TV–LSV

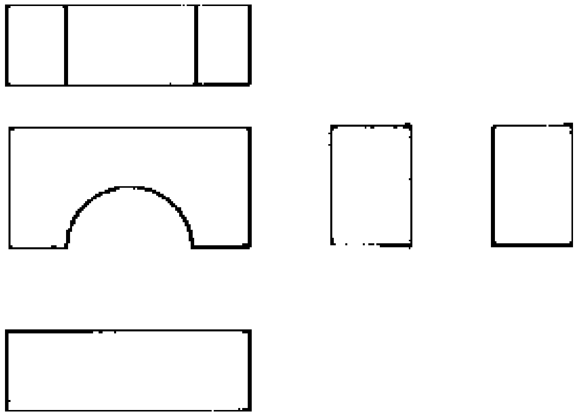


2: FV–BoV–RSV

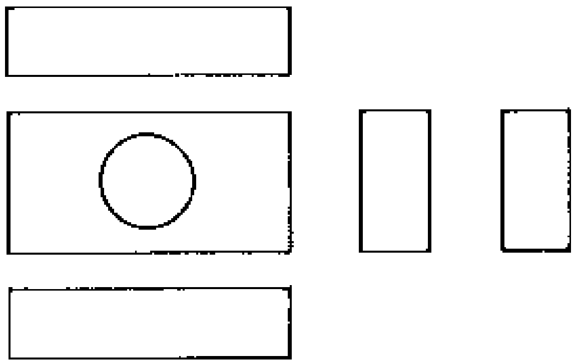
3: FV–TV–RSV



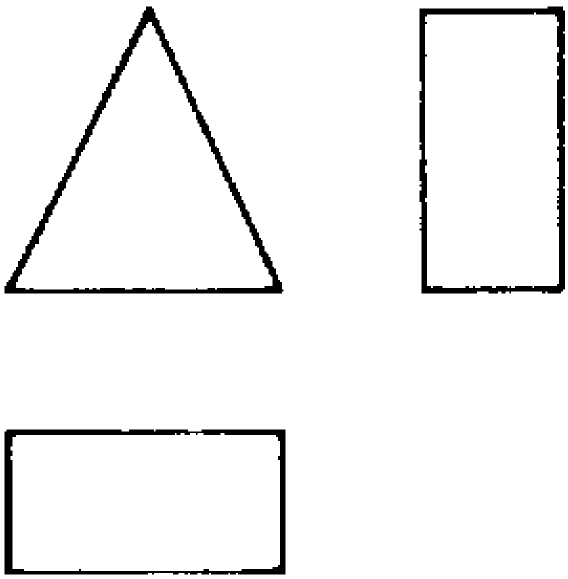
4: FV–TV–RSV



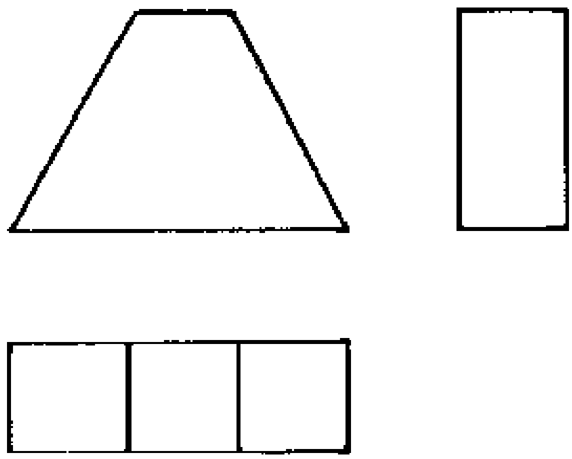
5: FV−BoV−LSV



6: FV−BoV−RSV



7: FV−BoV−LSV



8: FV–TV–RSV

Scale drawing

Before you start to make any kind of workpiece, it is necessary to make a drawing showing how it should be made. This drawing is usually called the "layout". When making a layout it is important to use the correct scale. The scale tells you how much bigger or smaller the actual object is, compared to the drawing.

– Large objects have to be drawn smaller than they actually are: in this case you have to use a REDUCED SCALE.

– Very small objects have to be drawn larger than they actually are so that all the details can be seen. In this case you have to use an ENLARGED SCALE.

– If the object is neither very large nor very small, it may be drawn as it actually is. In this case you use FULL SCALE.

<u>SCALES</u>

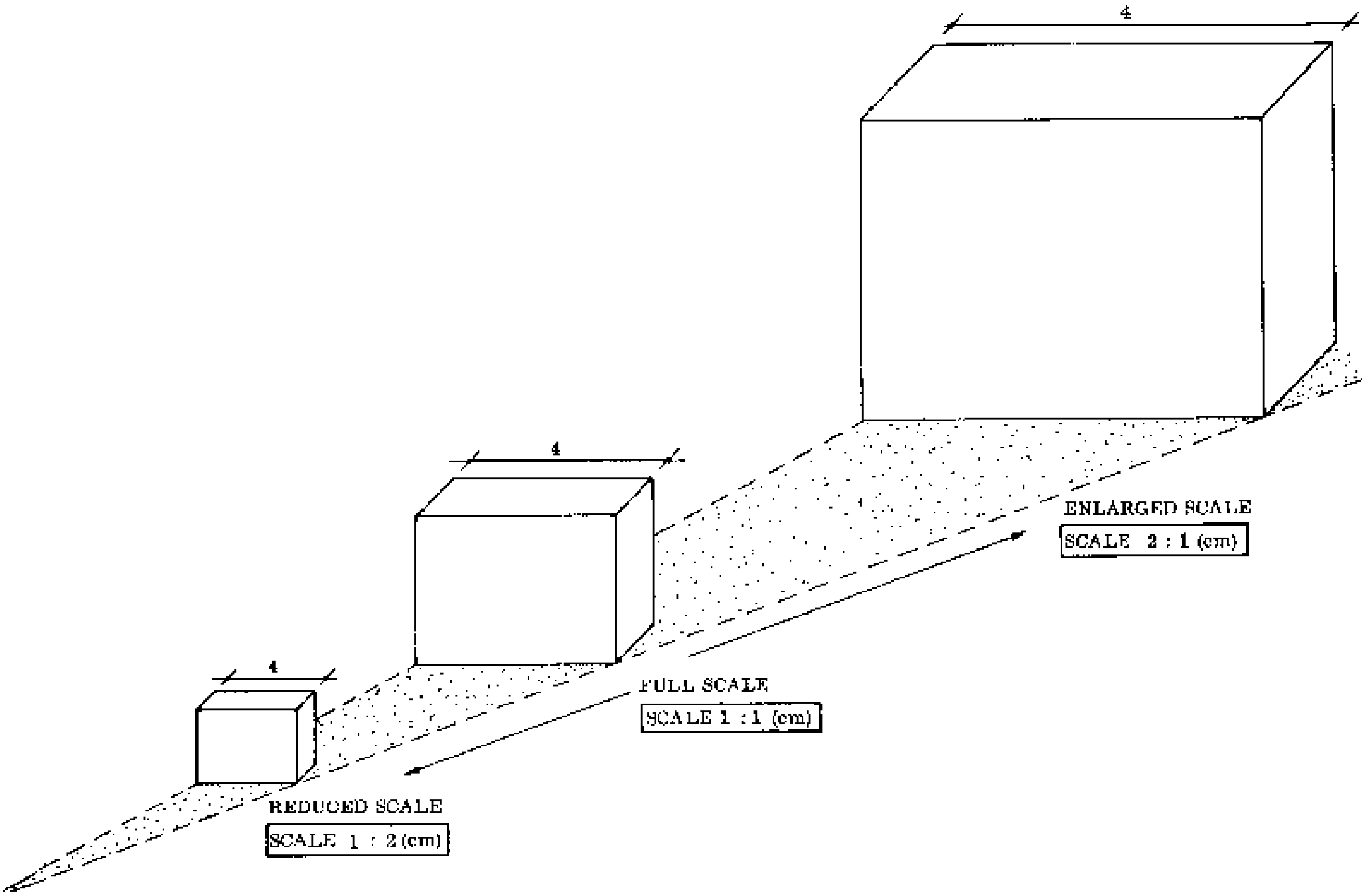
The scale affects the size of every side of the object in the drawing. Make sure that you draw all lengths, widths, and to. the correct scale.

– EXAMPLES OF SCALE: A scale of 1 : 5 (mm) tells you that 1 mm on the drawing represents 5 mm in real life. In other words, the drawing shows the object as 1/5th of its real size, with all dimensions in millimetres.

A scale of 2 : 1 (cm) tells you that 2 cm on the drawing represents 1 cm in real life. In other words, the drawing shows the object as twice its actual size, and all the dimensions are in centimetres.

What do the scales 1 : 10 (m) and 5 : 1 (cm) tell you?

– COMMON SCALES: Some commonly used scales are 1:2; 1:5; 1:10; 1:20; and 1:50.



SCALE DRAWING

NOTICE, THE NUMBERS REMAIN THE SAME.

Inside and outside dimensions

If you measure the inside of a box, you will find the measurements are smaller than the outside measurements. This is because of the thicknesses of the sides of the box. Look at the drawing on the next page (A) and note that the outside length of the box is equal to the inside length plus TWICE the thickness of the walls. The same applies to houses: the outside dimensions of a room will always be larger than the inside dimensions.

– EXAMPLE: A box has inside dimensions of 30 x 55 cm and is made of boards which are 3 cm thick. What are the outside dimensions of this box ? (see A).

FRAMES

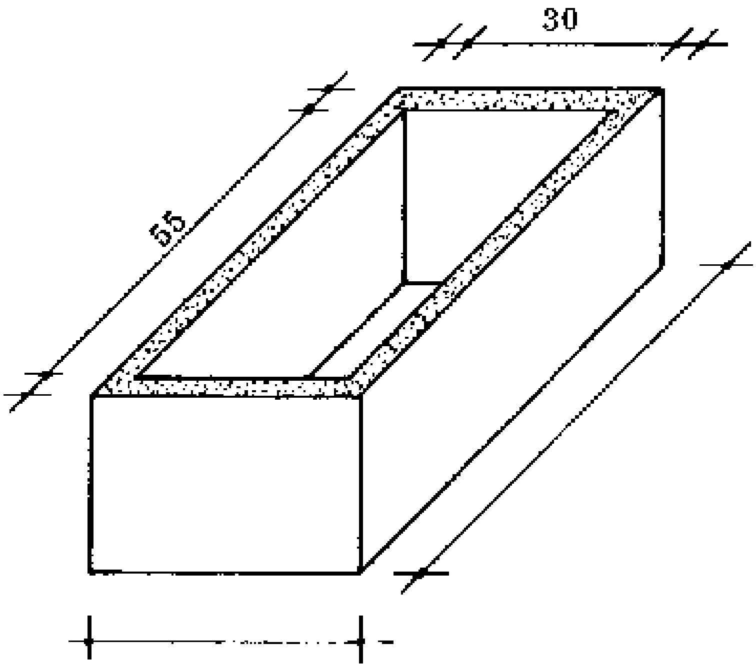
Many articles such as windows and doors can be bought as ready made pieces. These have certain sizes. Both doors and windows usually need a frame around them, and this has to be taken into account when the plans are made for the house.

Figs. B and C on the next page show some ready made articles. Below each you see the same article with a frame around it. In both cases the frame is 6 cm thick.

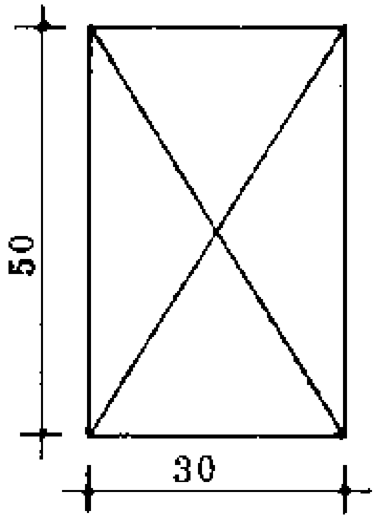
Fig. B shows a single article such as a casement. The frame goes all the way around the casement, which means that the window opening in the wall must be 12 cm longer and 12 cm higher than the casement itself, so that there is room for the frame.

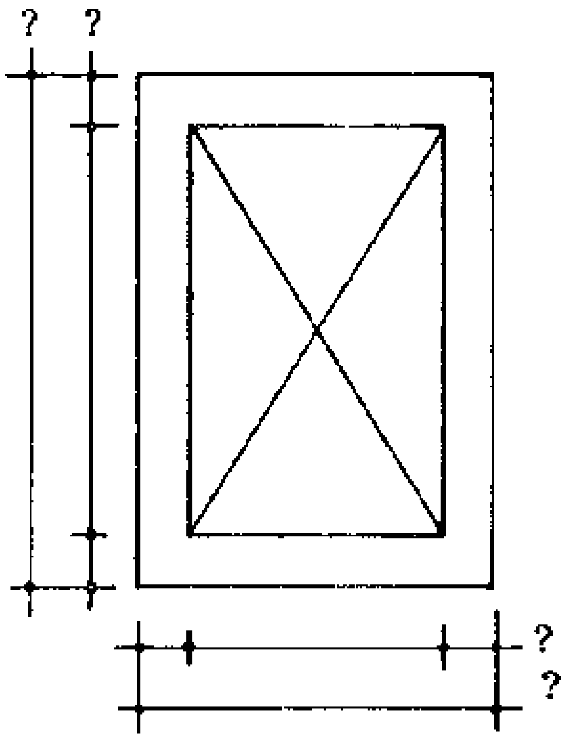
Fig. C shows a pair of casements. In this case the frame goes all the way around the casements and also between them. This means that the window opening in the wall must be 18 cm longer and 12 cm higher than the casement itself.

EXERCISE: IN AND OUTSIDE DIMENSIONS

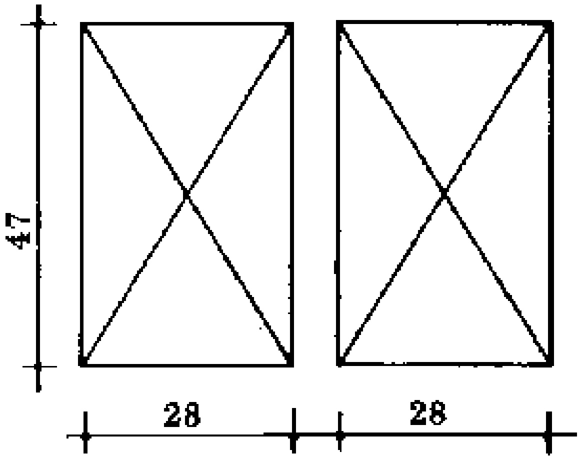


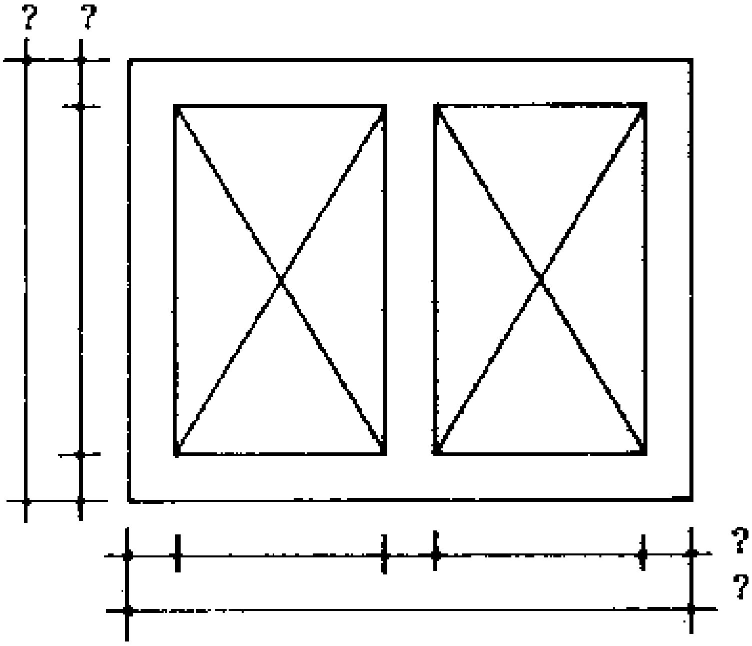
A – THE BOX HAS WALLS THAT ARE 3 cm THICK. MARK IN THE OUTSIDE DIMENSIONS.





B – MARK IN ALL DIMENSIONS.





C – MARK IN ALL DIMENSIONS.

Designing from sketches

You will often have people coming to you with a rough sketch of something they want you to make, for example a set of casements. In order to make the frame around the casements and to know the size of the opening which has to be made in the wall, there are two important things to notice about most rough sketches:

- The dimensions are the <u>outside</u> dimensions of the casements.
- The thickness of the frame has been left out.

Someone may come to you with a rough sketch of a complicated box with many partitions. In order to be able to construct the box, you have to notice two important things about the sketch:

- The dimensions are the <u>inside</u> dimensions of the partitions.
- The thickness of the partitions and the sides of the box has been left out.

As a craftsman you have to turn these types of sketches into good plans. The plans you draw should have inside and outside dimensions, as well as the thicknesses of the members of the frame or partitions.

– BUILD UP YOUR PLAN IN THE FOLLOWING WAY:

– Draw two planning lines, one vertical and one horizontal (lines A and B).

– On line A, start at the left and mark the thickness of the frame member; then the width of the casement. Next mark the thickness of the central frame member and then the width of the right casement. Finally mark the thickness of the right frame member.

– Starting from the bottom, do the same thing on line B. Your marks should indicate in order: frame; casement; frame; casement; frame; casement; frame.

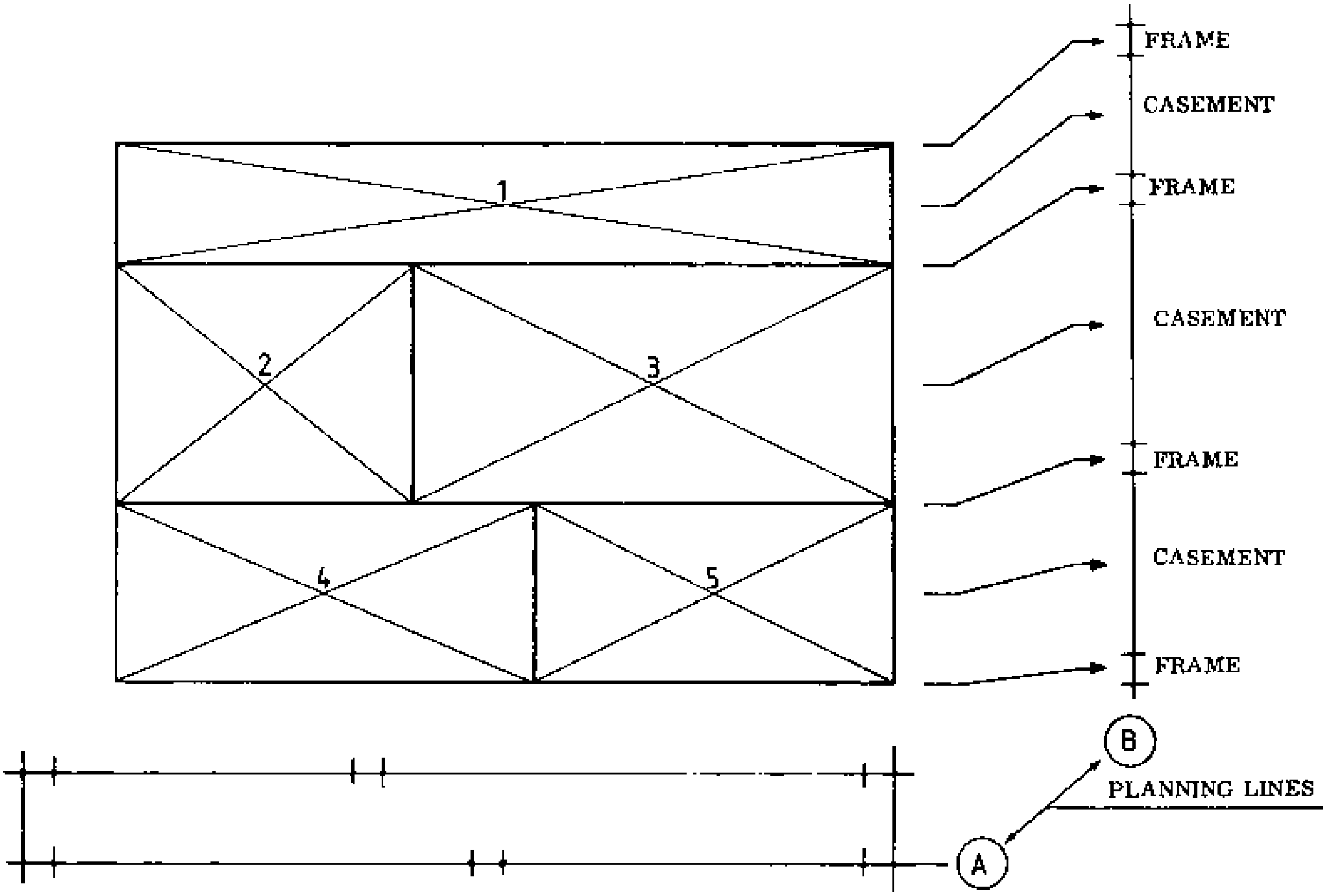
– Transfer lines A and B onto your drawing paper so that they form a right angle (page 28).

– You should now be able to finish the drawing as shown on page 29.

In the original sketch here, it looks as though the large space at the top of the sketch was 259 cm long. On your final drawing you will see that it is 269 cm long. Can you see why?

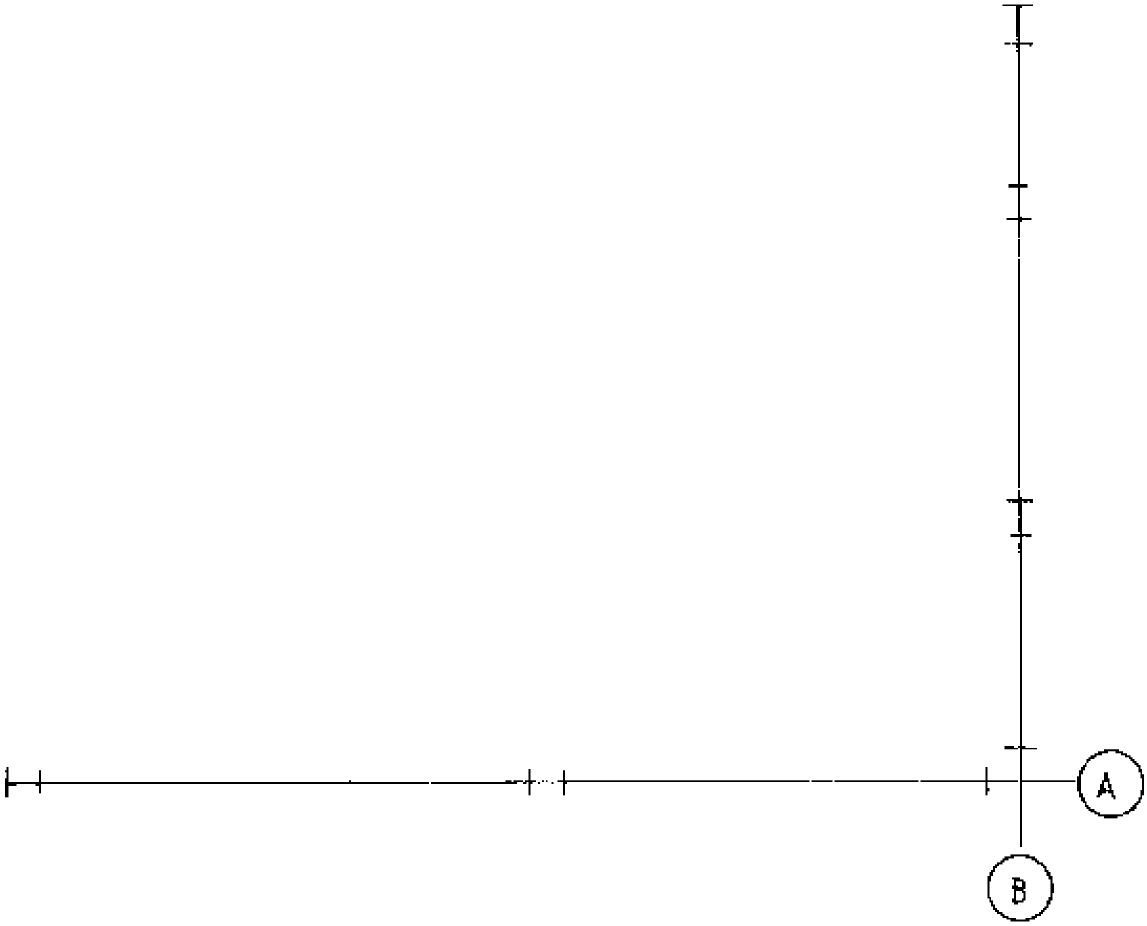
ORIGINAL SKETCH OF CASEMENT ARRANGEMENT

– SKETCH IS DRAWN IN A SCALE OF 1:20 (cm).
– FRAME MEMBERS ARE 10 cm THICK.
– MARK IN ALL DIMENSIONS!



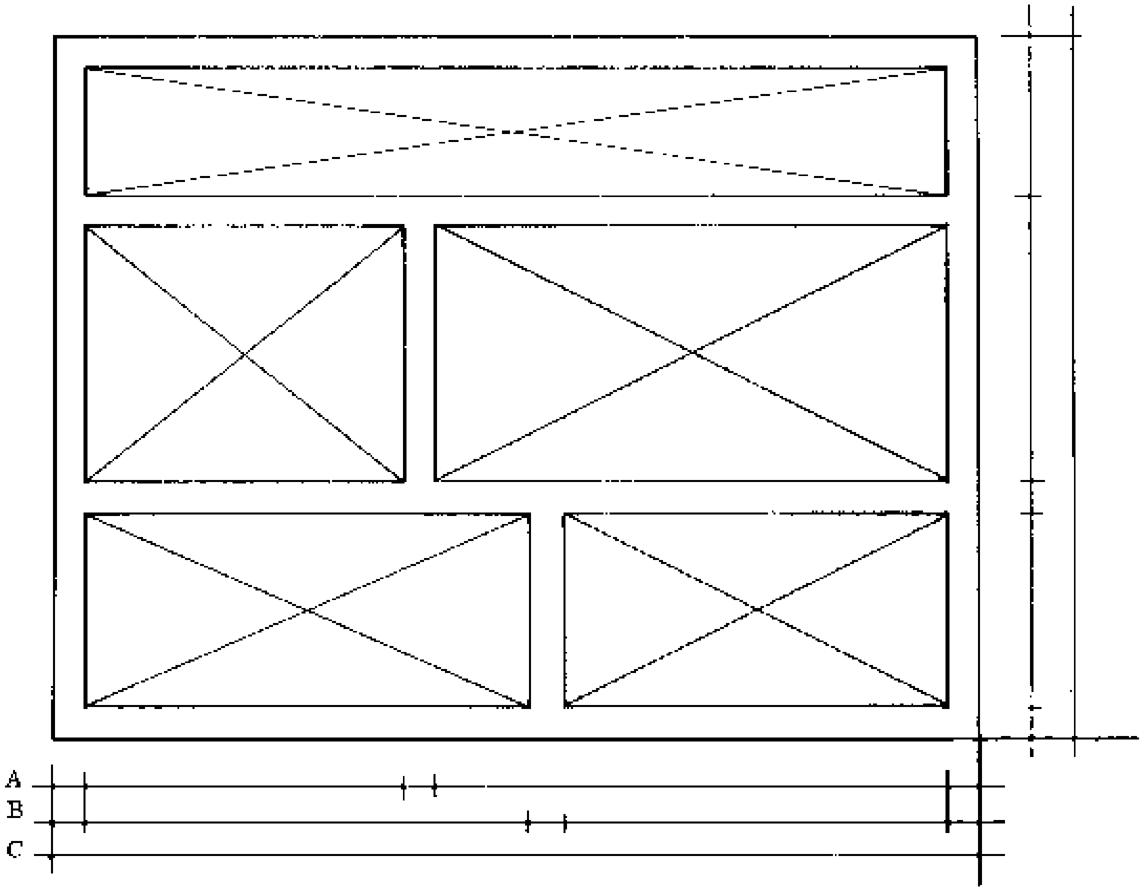
PLANNING LINES FOR CASEMENT ARRANGEMENT

– PLANNING LINES SCALE 1:20 (cm)
– FINISH THIS PLAN (see page 29)



FINISHED PLAN OF CASEMENT ARRANGEMENT

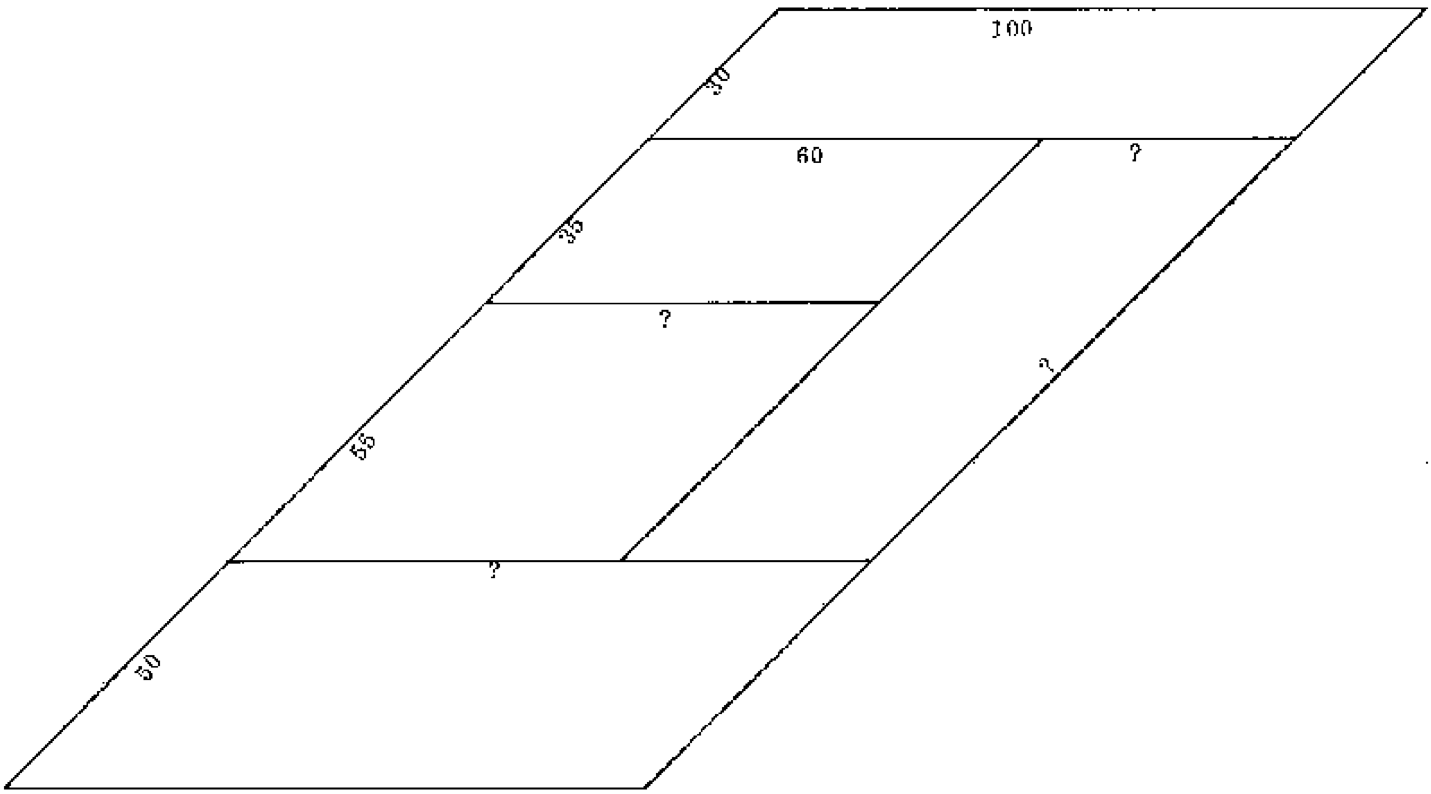
– DRAWING SCALE 1:20 (cm)
– MARK IN ALL DIMENSIONS.



DESIGN – 30 MIN

FRAME THICKNESS IS 7 cm

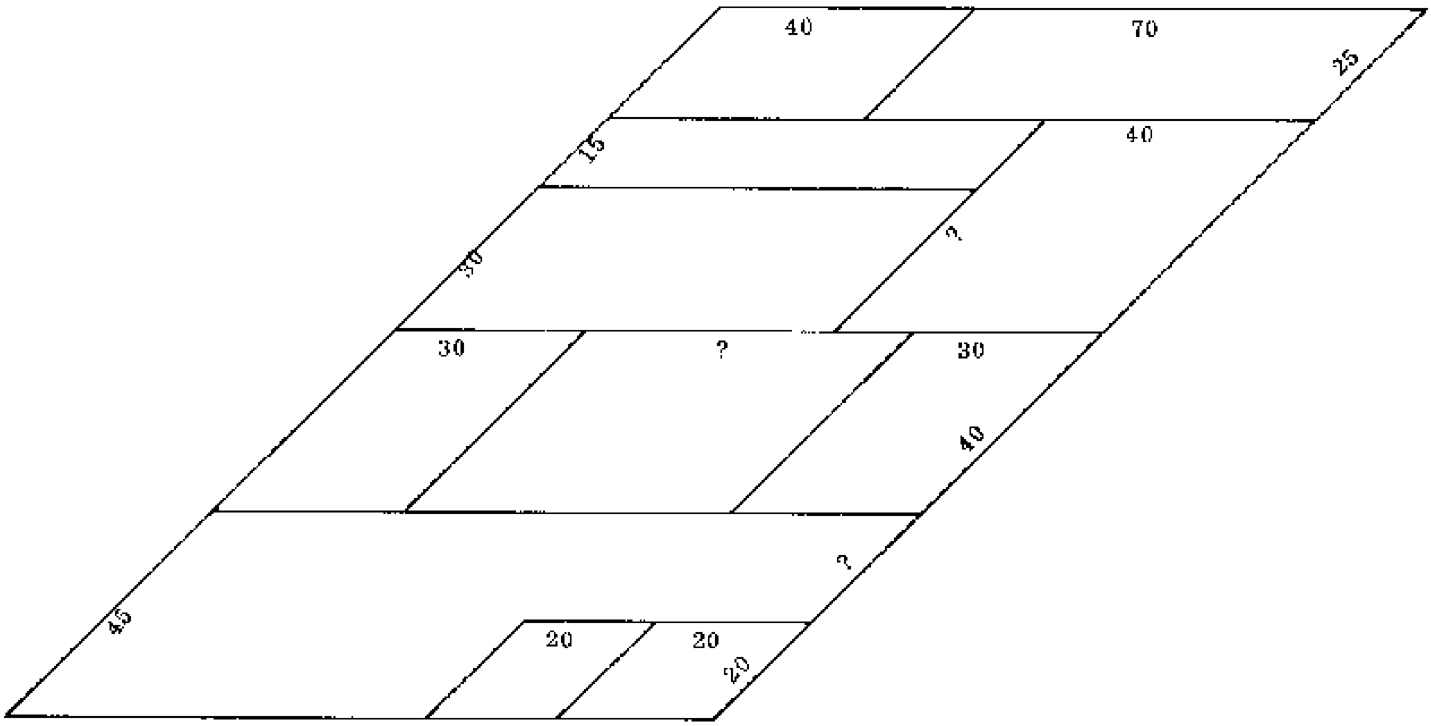
– DRAW THIS DIAGRAM AS A PLAN.
– DRAW THE NECESSARY PLANNING LINES.
– REDRAW THE DIAGRAM TO INCLUDE A FRAME.



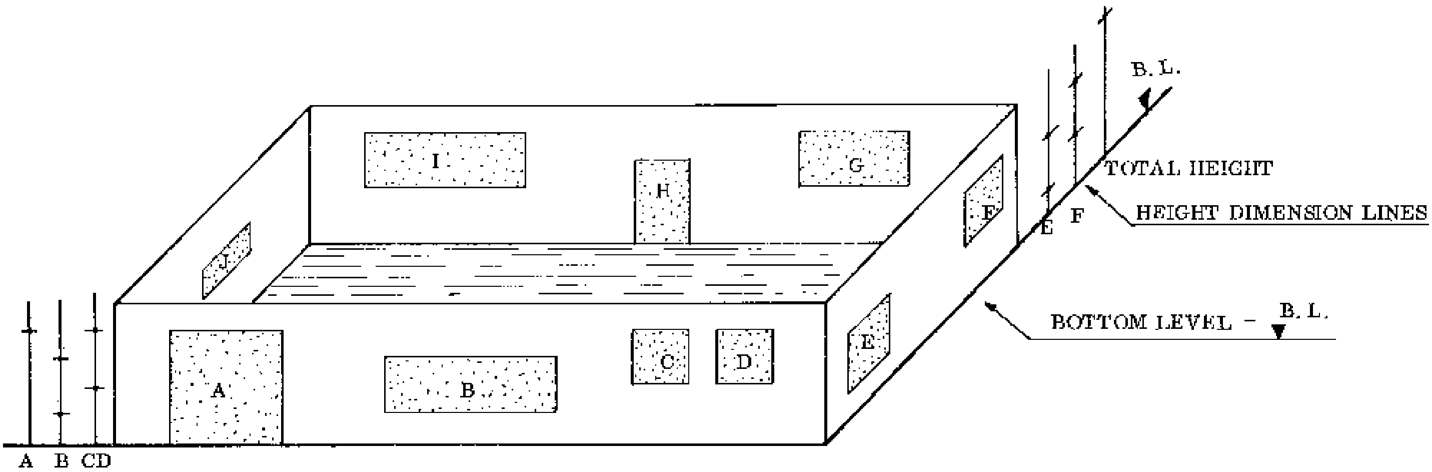
DESIGN – 35 MIN

FRAME THICKNESS IS 8 cm

- – DRAW THIS DIAGRAM AS A PLAN.
- – DRAW THE NECESSARY PLANNING LINES.
- – REDRAW THE DIAGRAM TO INCLUDE A FRAME.



Oblique and orthographic drawings of a box–like object

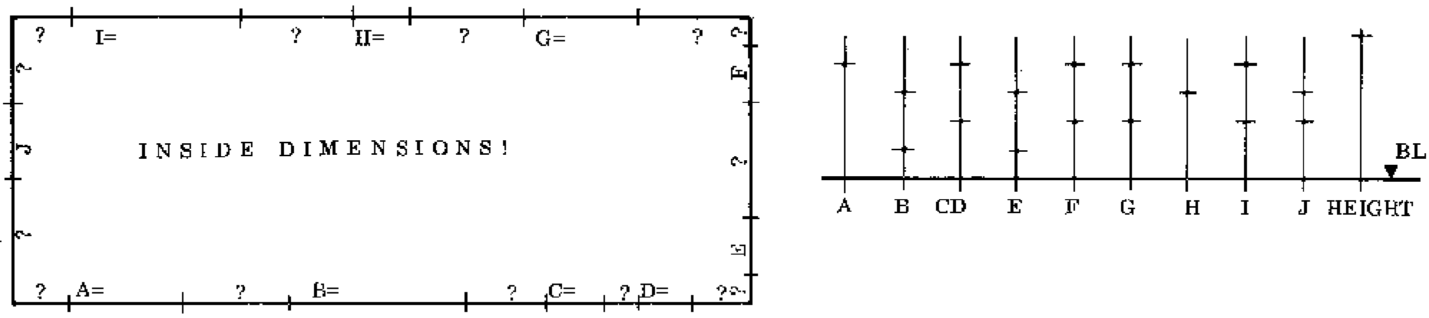


1 OBLIQUE DRAWING OF A BOX–LIKE OBJECT

TECHNICAL DATA

SKETCH = SCALE 1:10 (cm)

- – FILL IN ALL DIMENSIONS.
- – FULL DRAWING ON PAGE 33

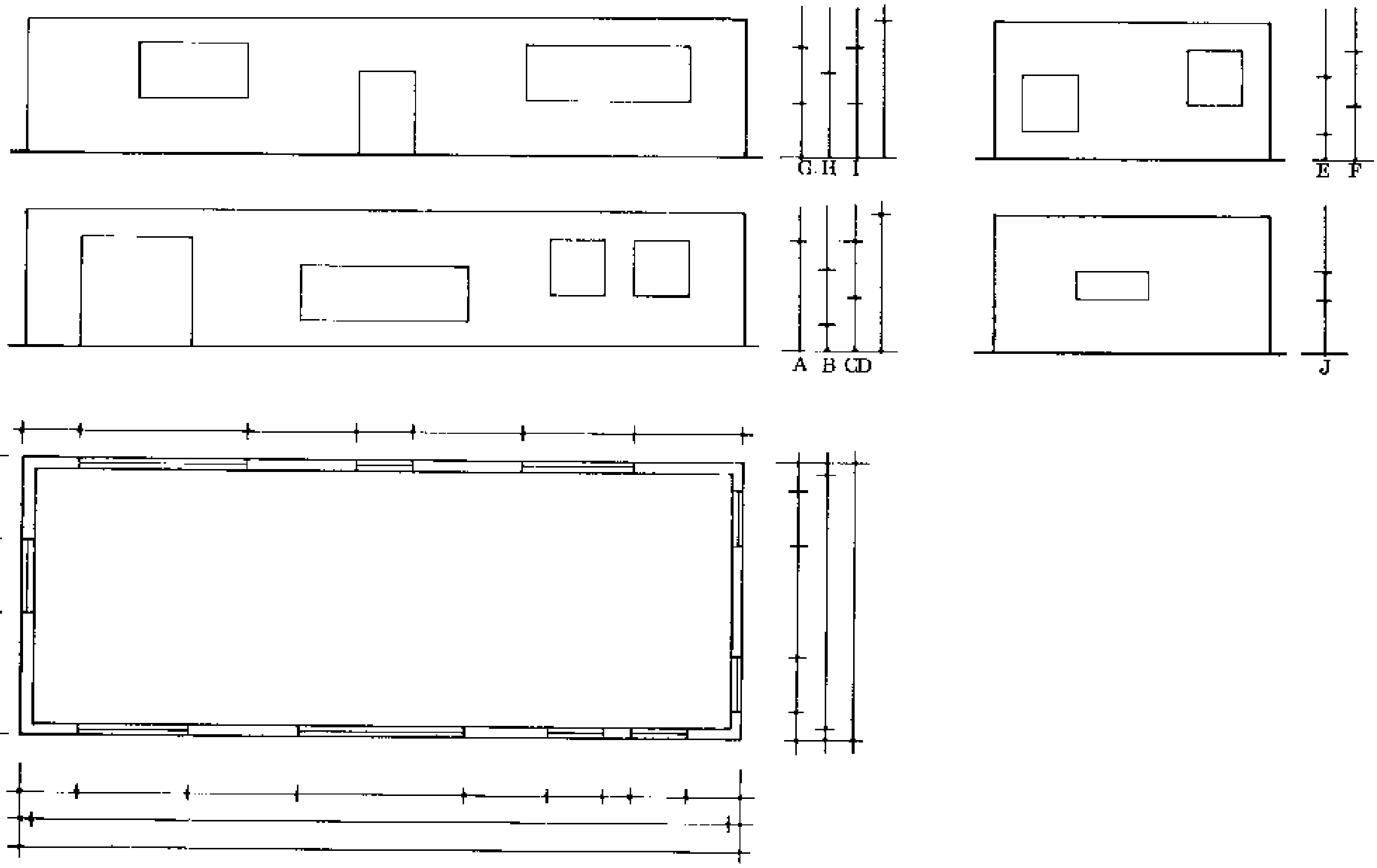


2 SKETCH PLAN

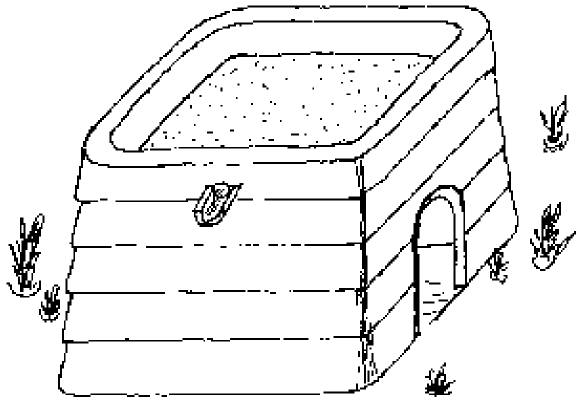
ORTHOGRAPHIC DRAWING – 2 HOURS

ORTHOGRAPHIC DRAWING SCALE 1:10 (cm)

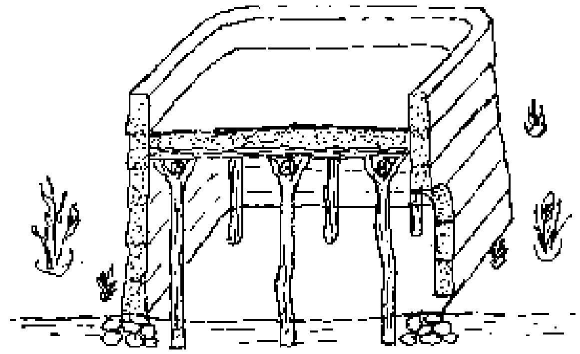
- – FILL IN ALL VIEW NAMES.
- – MARK IN ALL DIMENSIONS.
- – MARK THE CORRECT LETTERS IN THE BLOCKS.
- – MAKE OTHER DESIGNS.



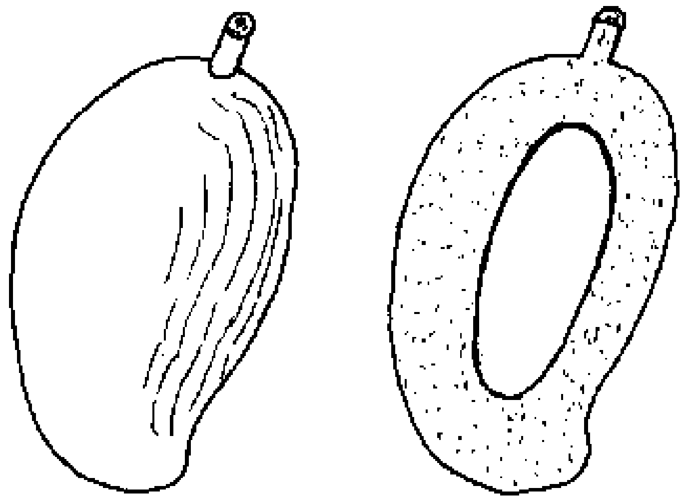
Cross sections



SIDE VIEW OF A HOUSE



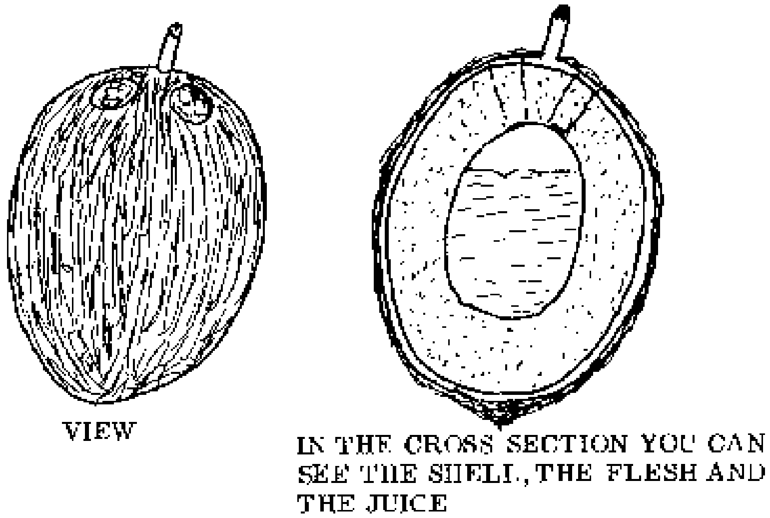
THE CROSS SECTION SHOWS THE INTERIOR OF THE WHOLE HOUSE



VIEW

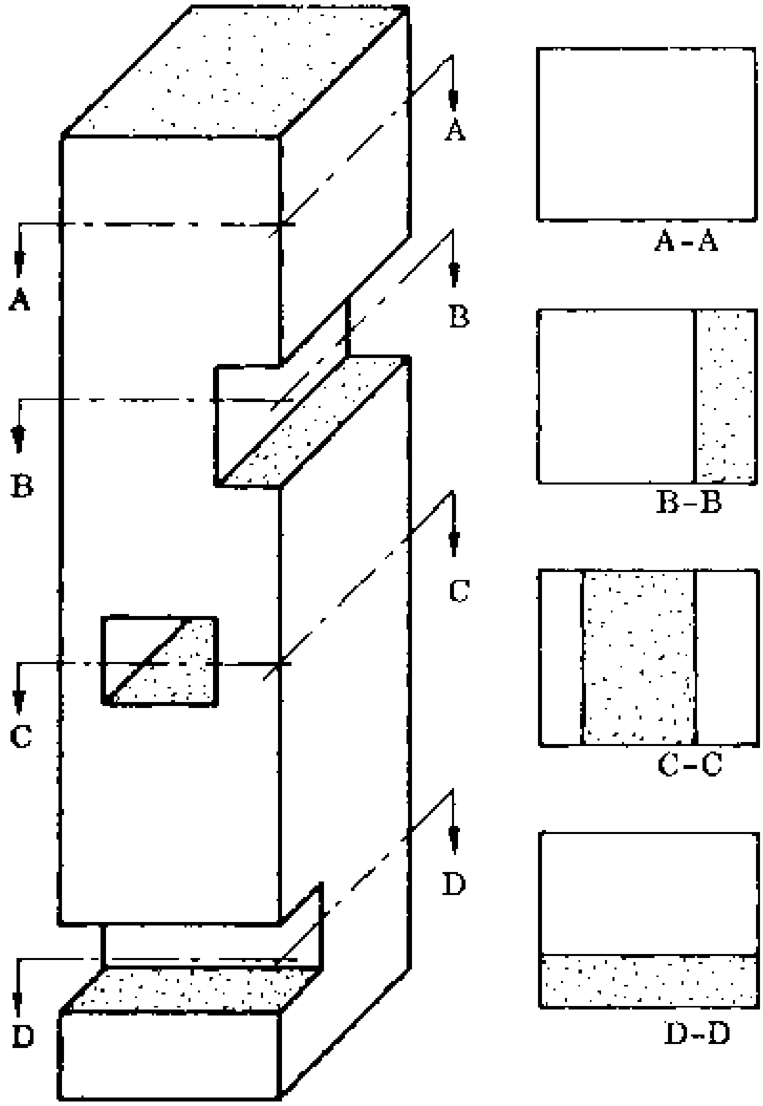
IN THE CROSS SECTION YOU CAN SEE THE FLESH AND THE STONE

MANGO



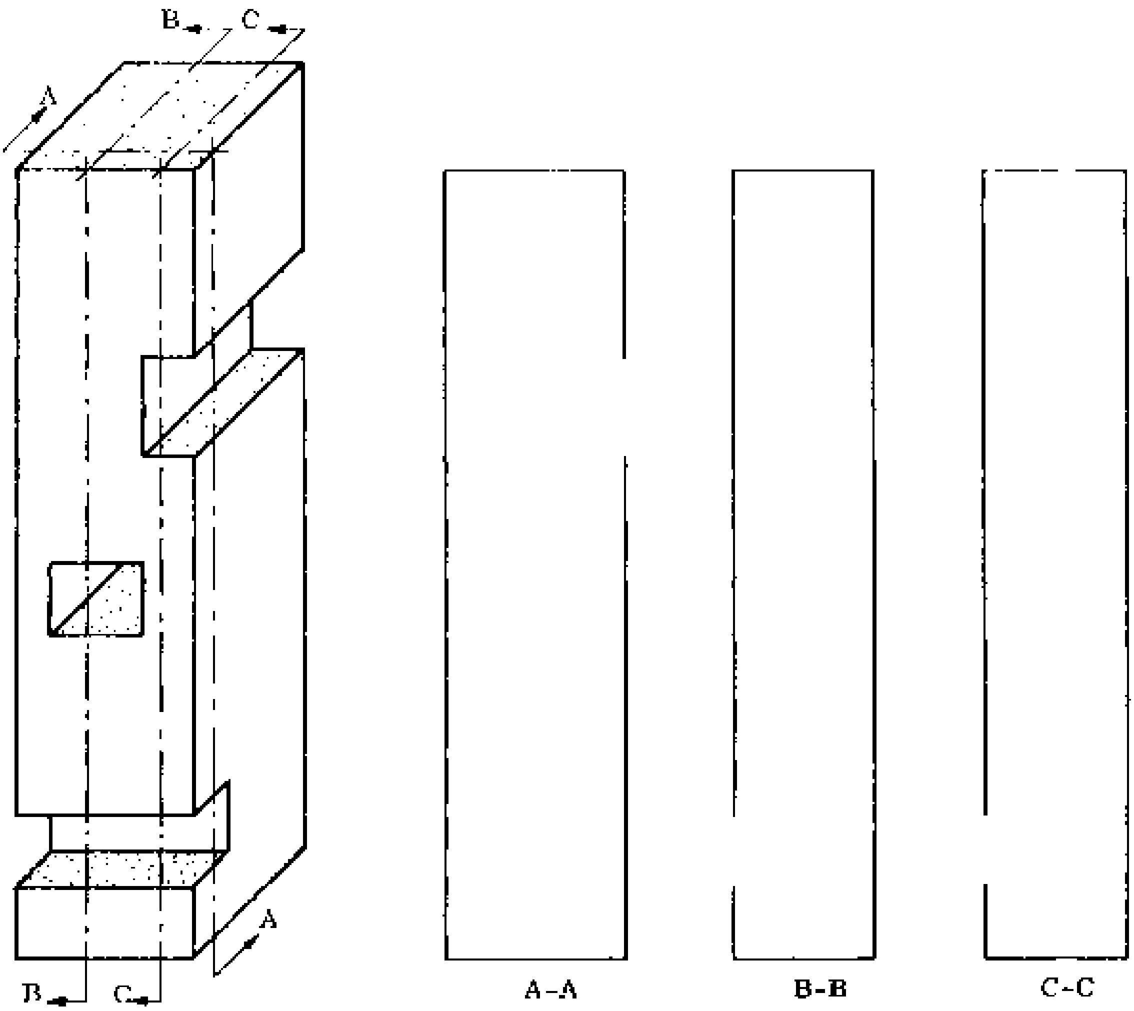
COCONUT

HORIZONTAL SECTIONS AND CROSS SECTIONS



1 HORIZONTAL SECTIONS

– AT SECTION C–C YOU CAN SEE THAT THE HOLE GOES THROUGH THE BLOCK.
– THE ARROW SHOULD POINT IN THE DIRECTION YOU WANT TO SHOW.



2 COMPLETE THESE CROSS SECTIONS

AS A RULE TAKE THE SECTIONS AT THOSE POINTS WHICH WILL SHOW THE GREATEST AMOUNT OF DETAIL.

Sketching

You will often find that you will have to make a rough drawing in which accurate dimensions are not really necessary. In this case it is usually best to make a sketch. To sketch means to make a drawing without using drawing instruments like rulers, etc. You will find that this type of drawing is much quicker than technical drawing with the drawing instruments. However, sketching is probably harder than technical drawing, especially at first. It requires a steady hand, a sense for proportions, and an appreciation of detail.

Sketching is the art of putting ideas into pictures and is especially useful for understanding technical drawings and making rough plans.

The only equipment you need for sketching is an H pencil, an eraser, and some paper. Use plain paper for sketching.

– TECHNIQUE: Practice makes perfect. Practice drawing straight lines and curves. After a while you will find that your straight lines look almost as if they were drawn with a ruler! On the next page you can see the best way to draw horiz ontal, vertical, and inclined lines, and the best way to draw a circle.

– REMEMBER:

– Take your time while sketching, be careful.

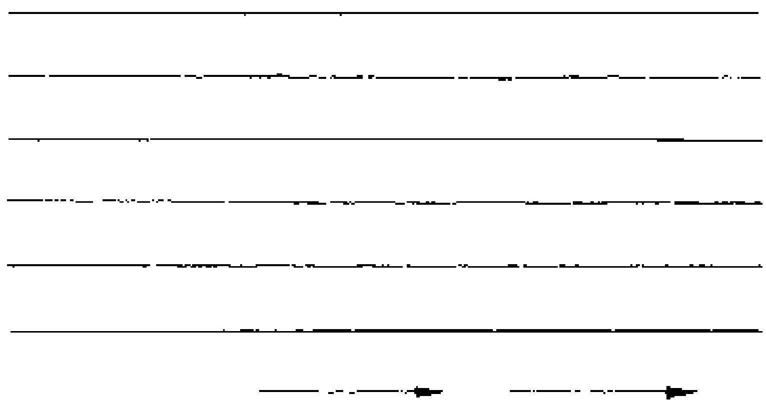
– Don't try to draw long lines with one motion.

– Rest only the side of your hand on the paper.

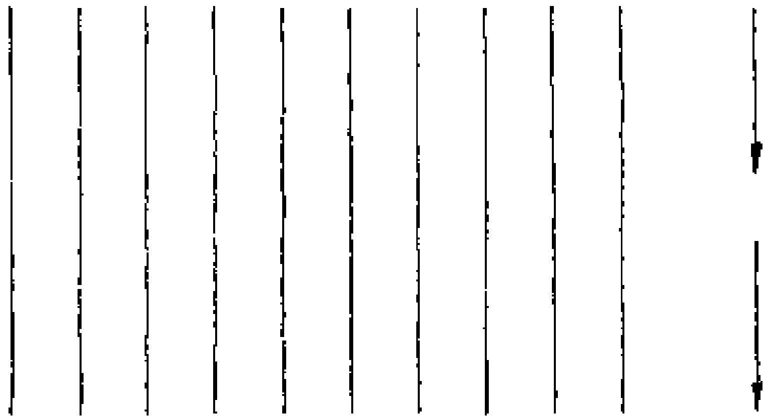
– Don't turn the paper while you are sketching. You should be able to draw all your lines with the paper in the same position.

EXERCISE: FREE HAND SKETCHING

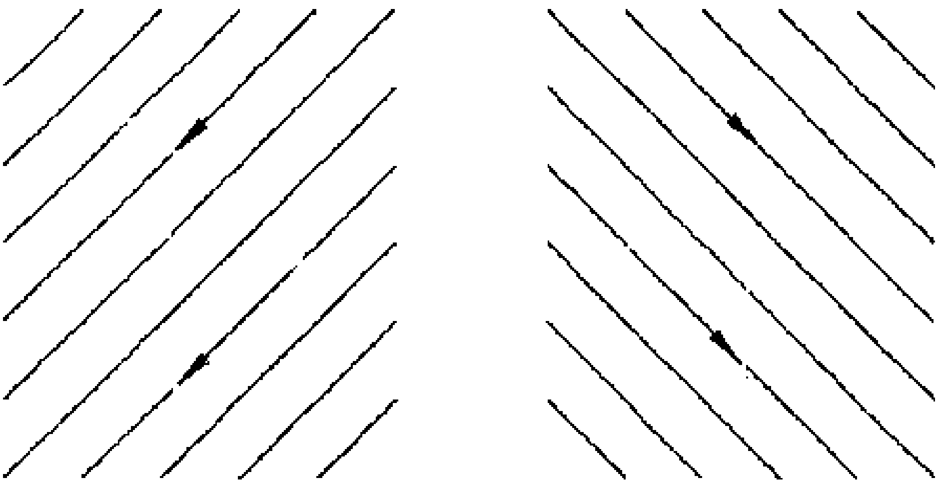
NOTICE: THE DIFFERENT DIRECTIONS IN WHICH THE LINES ARE DRAWN. LINES ARE NOT ONE LONG LINE.



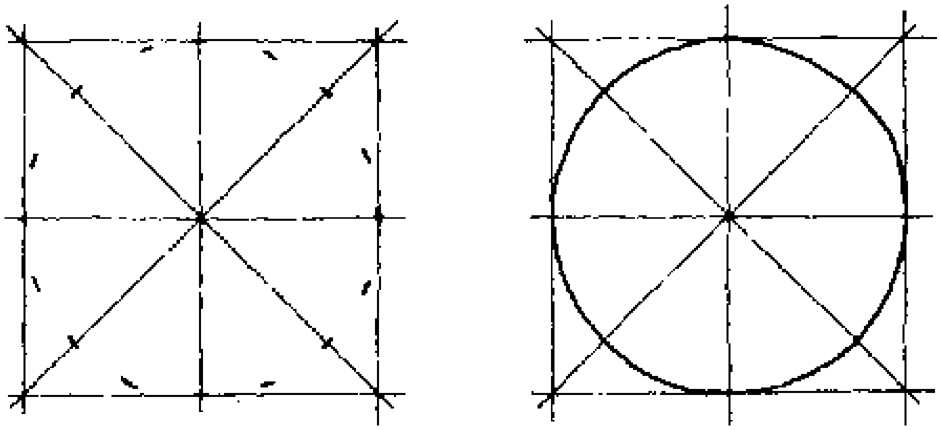
HORIZONTAL LINES



VERTICAL LINES



INCLINED LINES

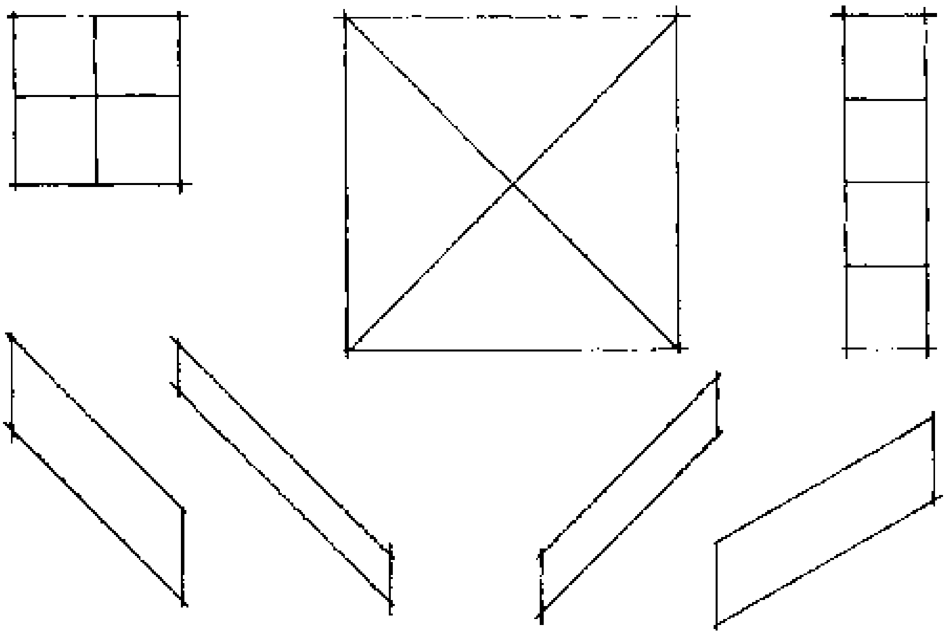


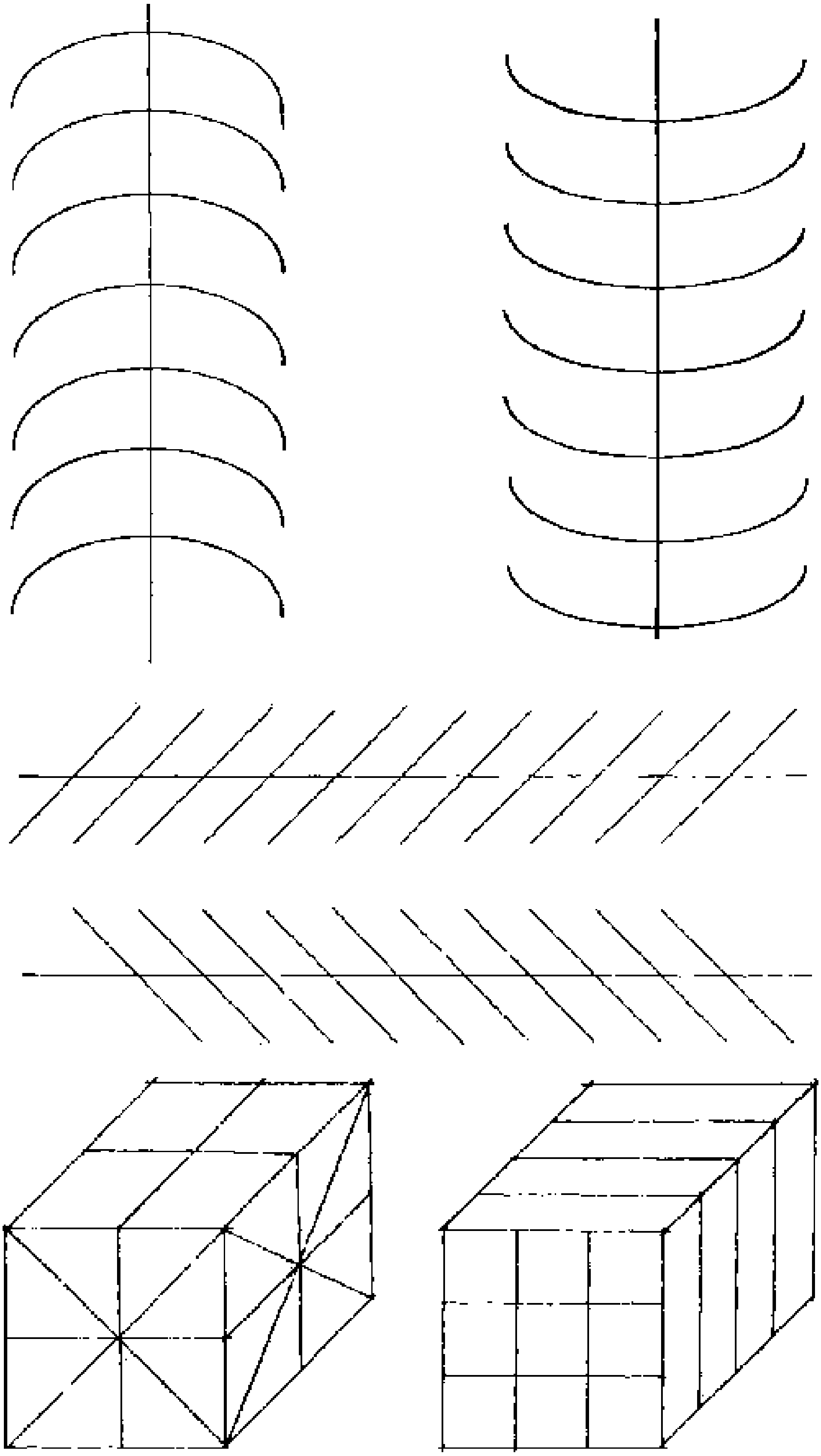
CIRCLES

EXERCISE: FREE HAND SKETCHING

REPEAT THESE EXERCISES, USING DIFFERENT ANGLES.

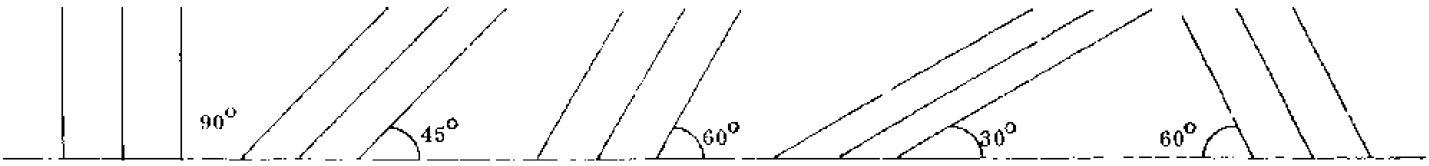
DRAW ARROWS TO SHOW THE DIRECTION IN WHICH YOU SKETCH ALL OF THESE LINES.



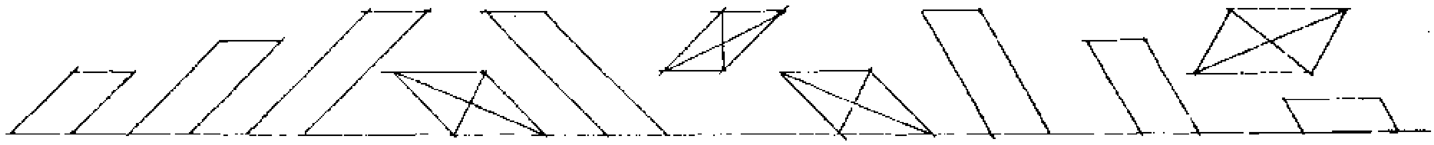


EXERCISE: FREE HAND SKETCHING

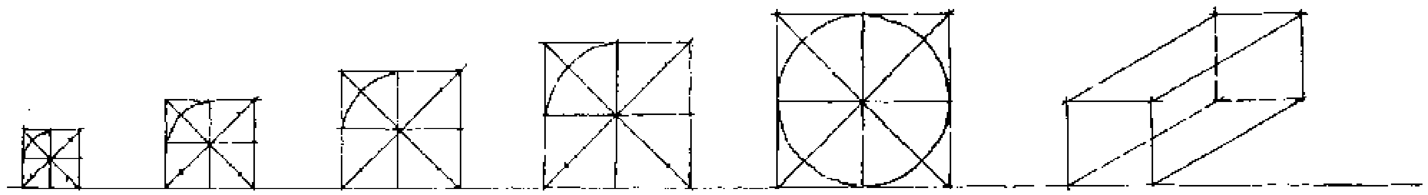
REPEAT THESE EXERCISES USING DIFFERENT ANGLES.



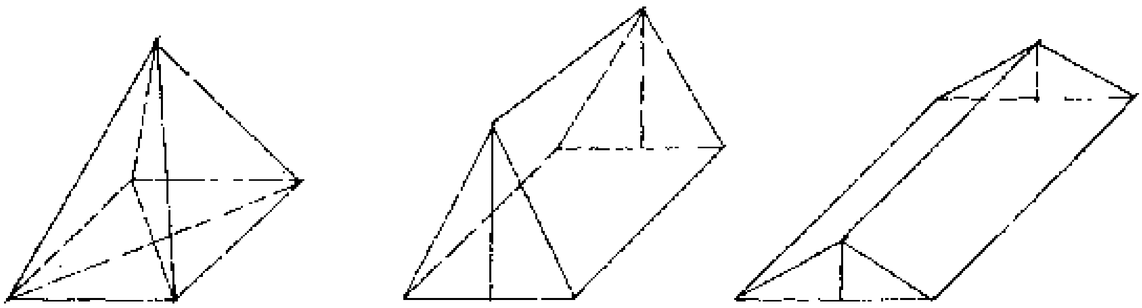
A



B



C



Window frames

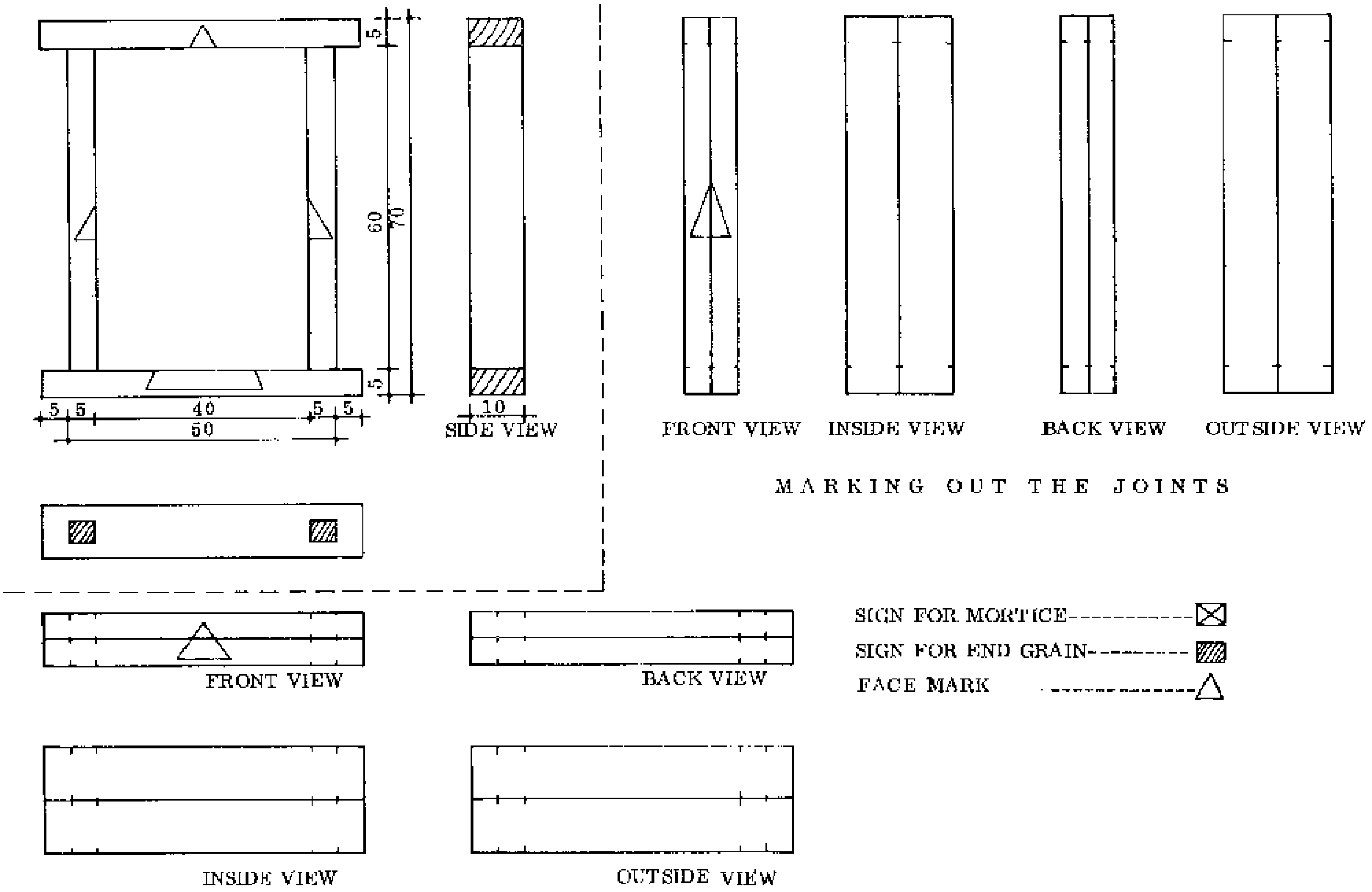
WINDOW FRAME (BASIC LAYOUT)

INSIDE AND OUTSIDE DIMENSIONS OF FRAME ARE VERY IMPORTANT (in cm).

MAKE SURE THAT THE LINES ON ALL VIEWS MATCH UP WITH THE FRONT VIEW.

CHECK THIS WITH THE AID OF A RULER.

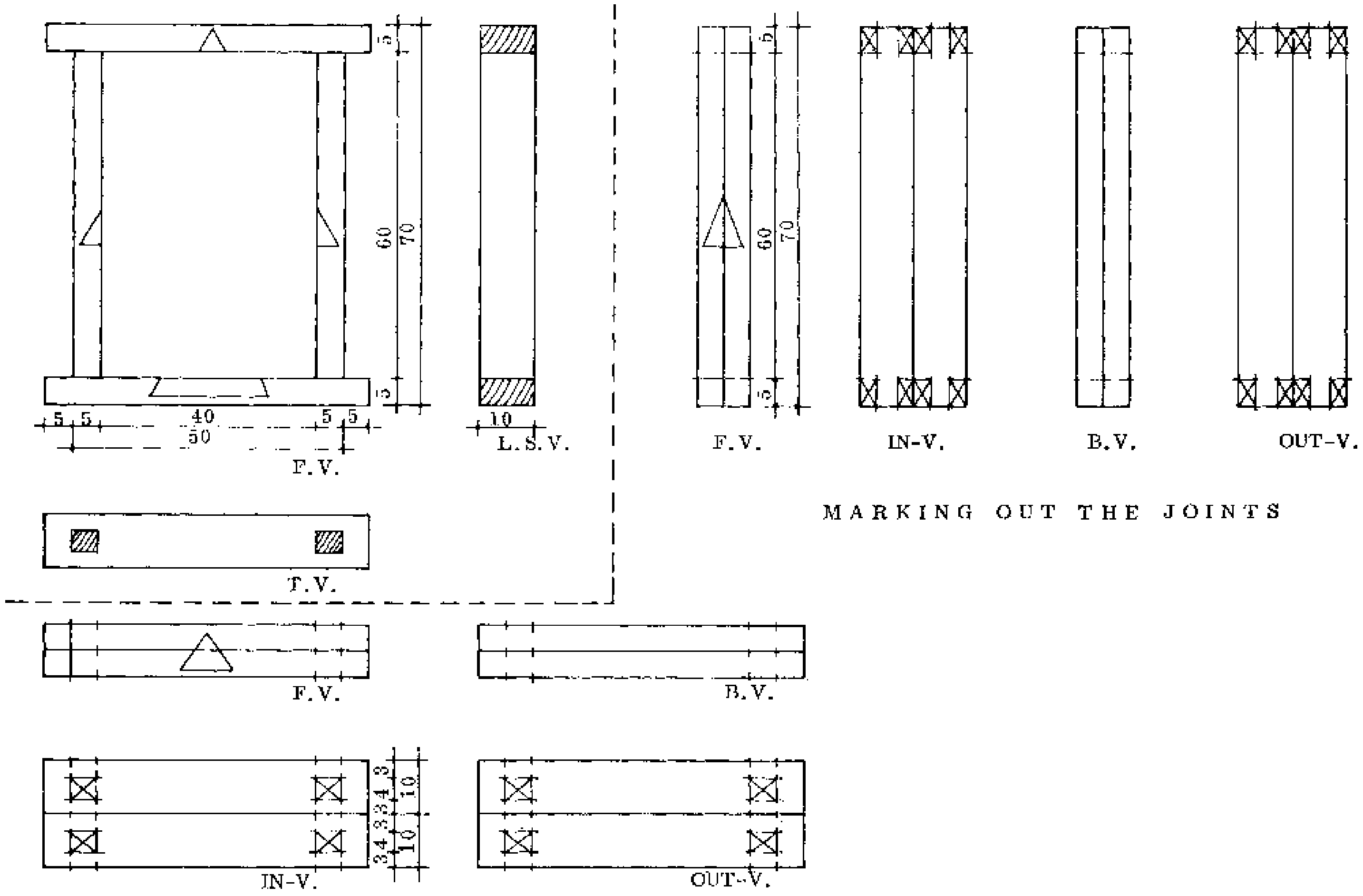
<u>MARK IN ALL MORTICES AND TENONS.</u>



WINDOW FRAME (MARKED OUT FOR JOINTS) – 2 ½ HOURS

MAKE AN ORTHOGRAPHIC DRAWING FROM A WINDOW FRAME WITH DIFFERENT MEASUREMENTS.

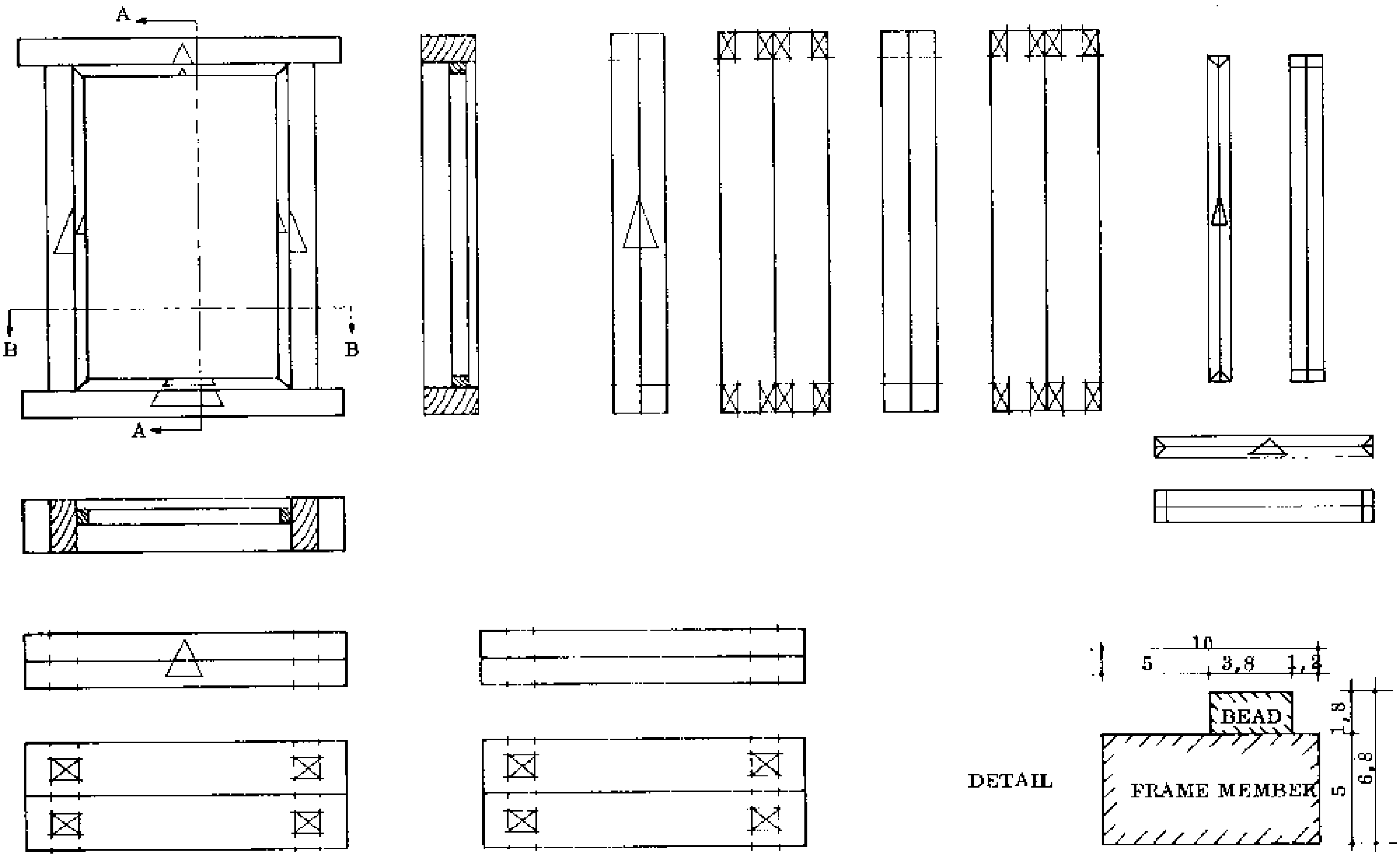
DRAW ALL THE MEMBERS AND MARK THE JOINTS OUT ON THE DRAWING.



WINDOW FRAME SCALE 1:10 (cm) – 2 ½ HOURS

– NAME ALL VIEWS.
– DRAW ALL DIMENSION LINES.
– MARK ALL DIMENSIONS.
– MARK THE POSITIONS OF THE BEADS.

MAKE A DRAWING OF A WINDOW FRAME WITH DIFFERENT DIMENSIONS.

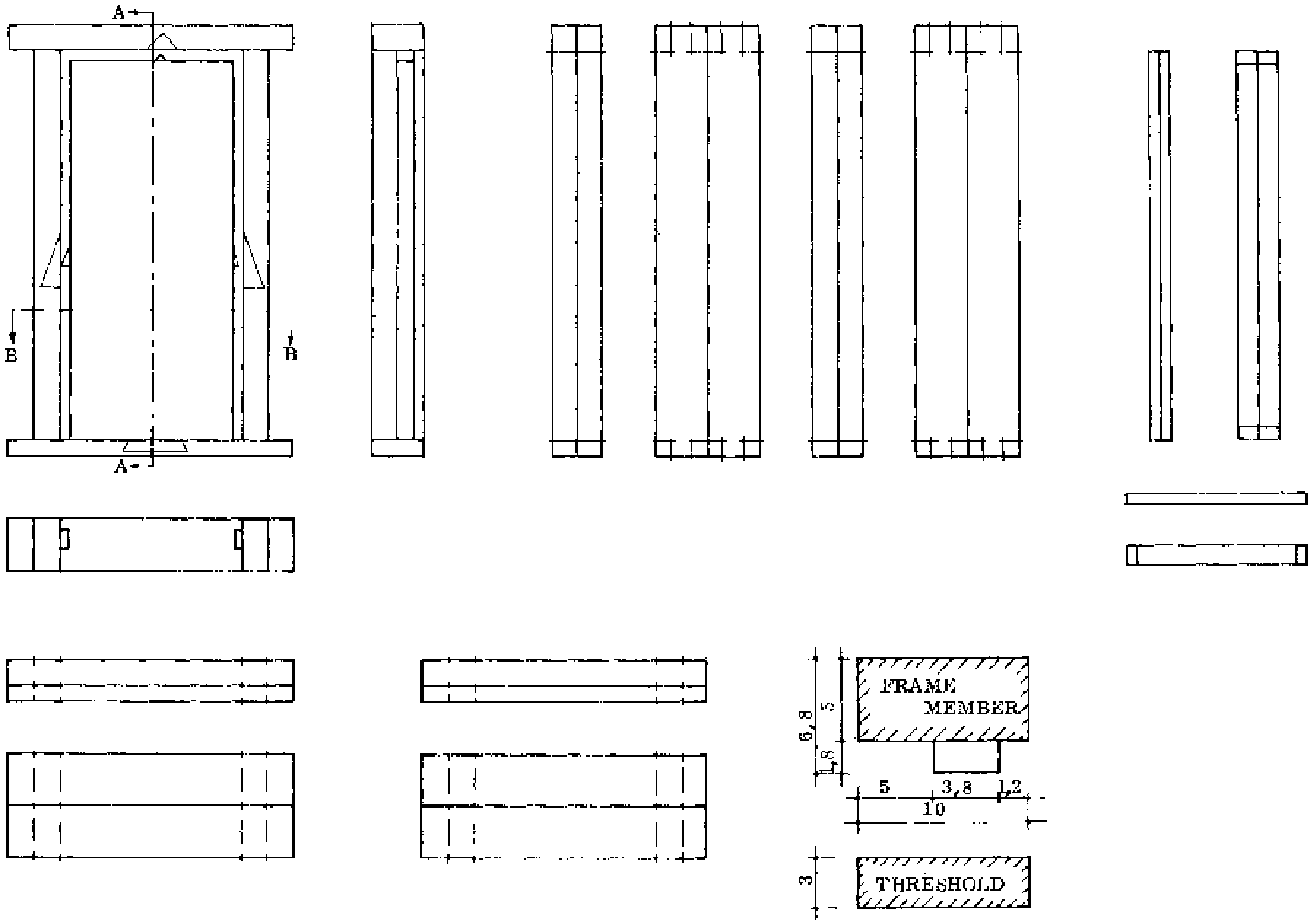


Door frames

DOOR FRAME FOR A SMALL DOOR SCALE 1:10 (cm) – 2 ½ HOURS

– NAME ALL VIEWS.
– DRAW ALL DIMENSION LINES.
– MARK ALL DIMENSIONS.
– MARK THE POSITIONS OF THE BEADS.
– MARK THE JOINTS.

MAKE A DRAWING OF A DOOR FRAME WITH DIFFERENT DIMENSIONS.



Frames and joints

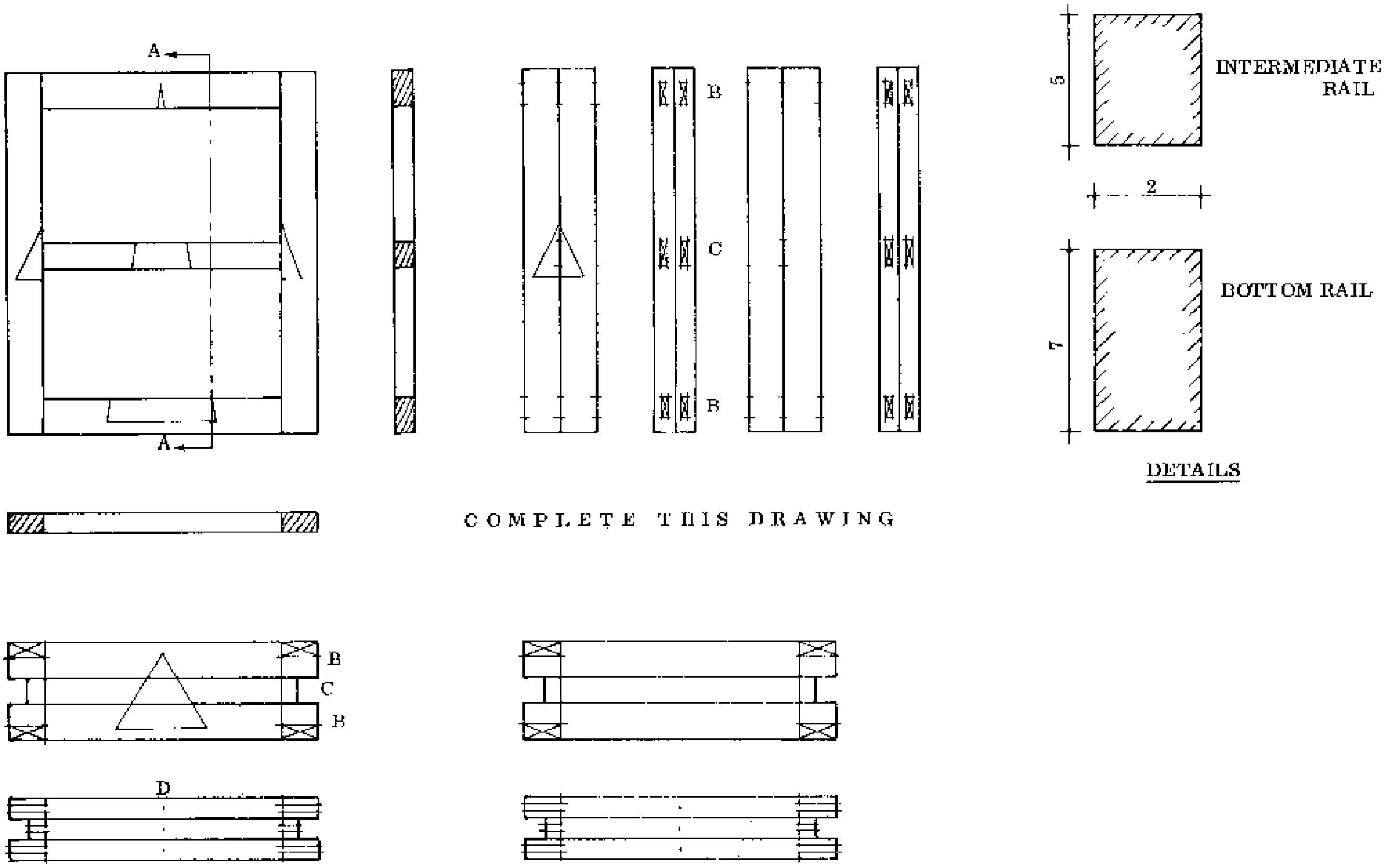
WOODEN FRAME SCALE 1:10 (cm) – 2 ½ HOURS

NOTICE:

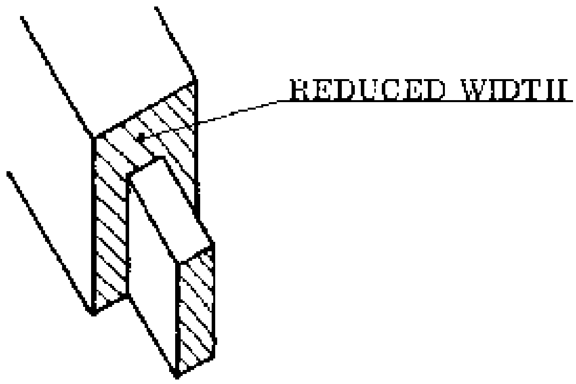
- THE FACE MARK OVER THREE MEMBERS
- THE INTERMEDIATE RAIL
- WIDTH OF THE MORTICE AND TENON
- THROUGH MORTICE AND TENON
- STOPPED MORTICE AND TENON
- VENTILATION HOLES AT D

<u>MAKE A DRAWING OF A FRAME</u>

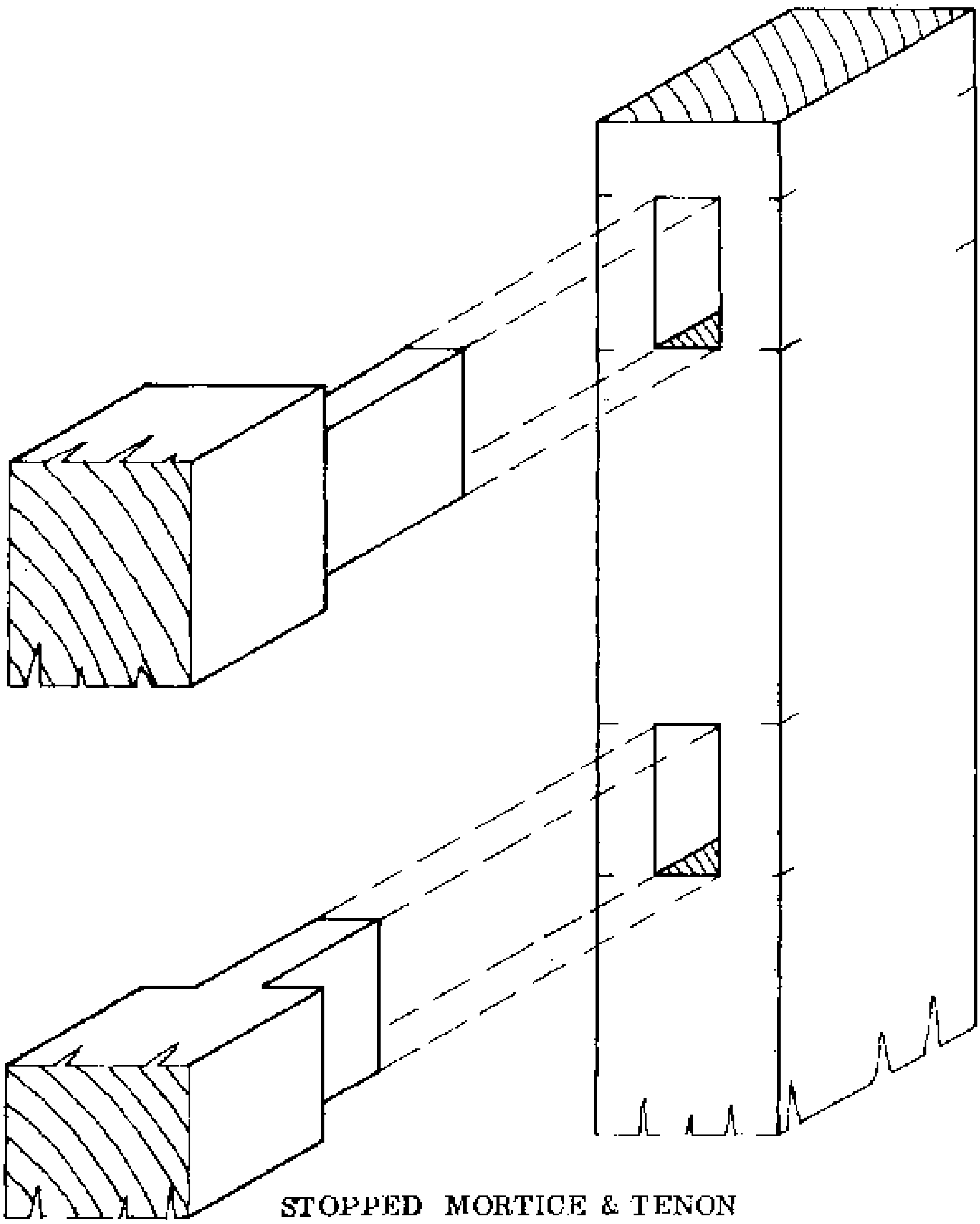
- SCALE 1 : 10 (cm)
- USE DIFFERENT DIMENSIONS
- CORNER JOINTS: HAUNCHED MORTICE AND TENON
- OTHER JOINTS: STOPPED MORTICE AND TENON



MORTICE AND TENON JOINT



A

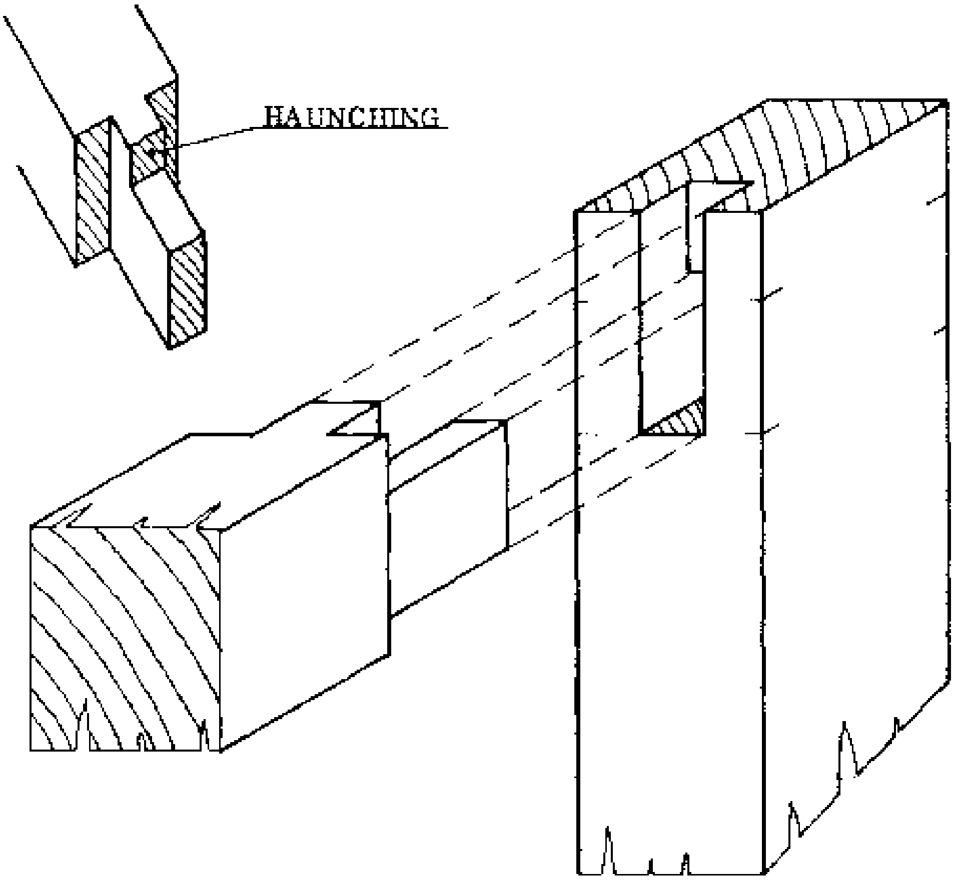


C

HAUNCHED MORTICE AND TENON JOINT

– MAKE AN OBLIQUE DRAWING OF:

A STOPPED HAUNCHED MORTICE AND TENON JOINT. USE DIFFERENT POSITIONS.



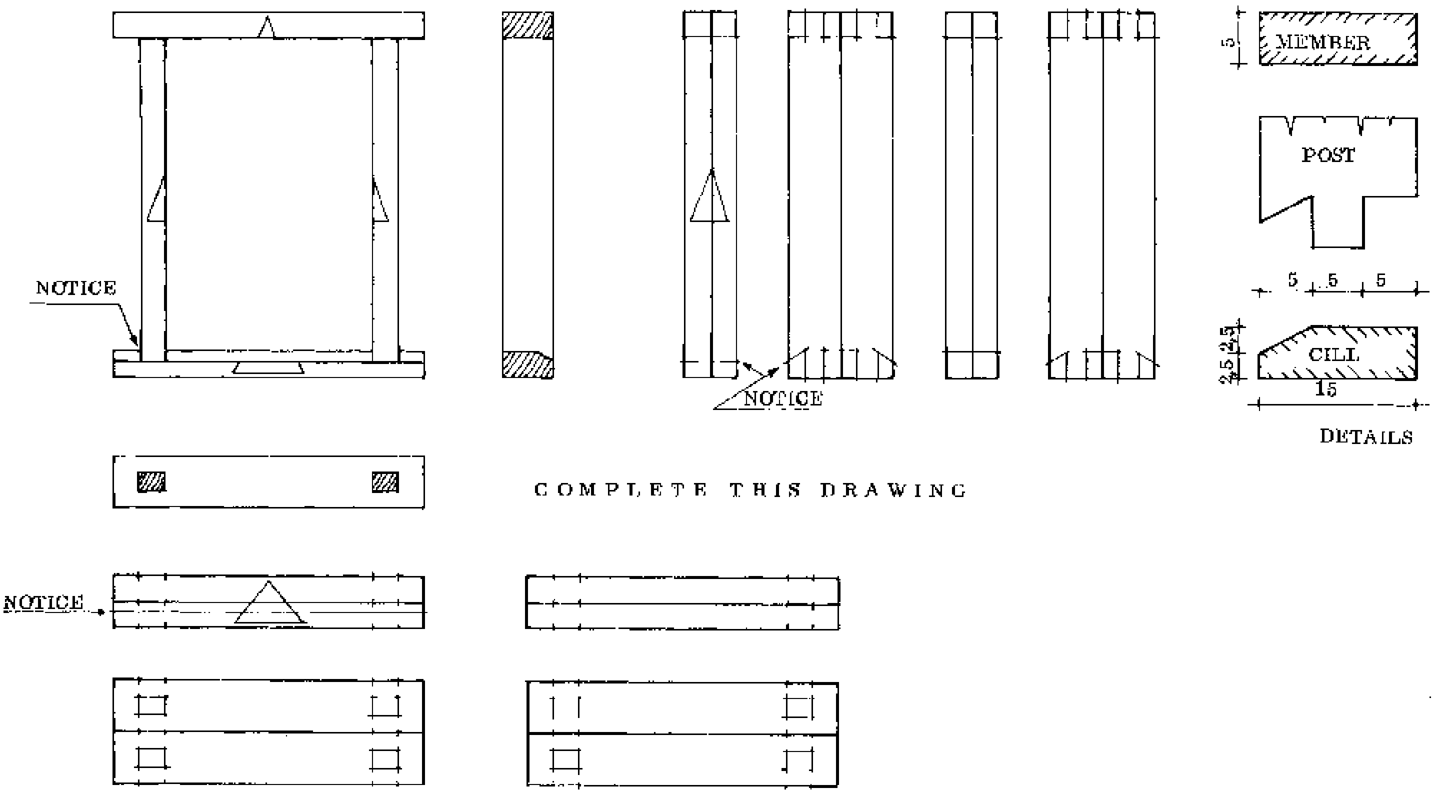
B

WOODEN FRAME WITH SLANTING CILL – 2 ½ HOURS

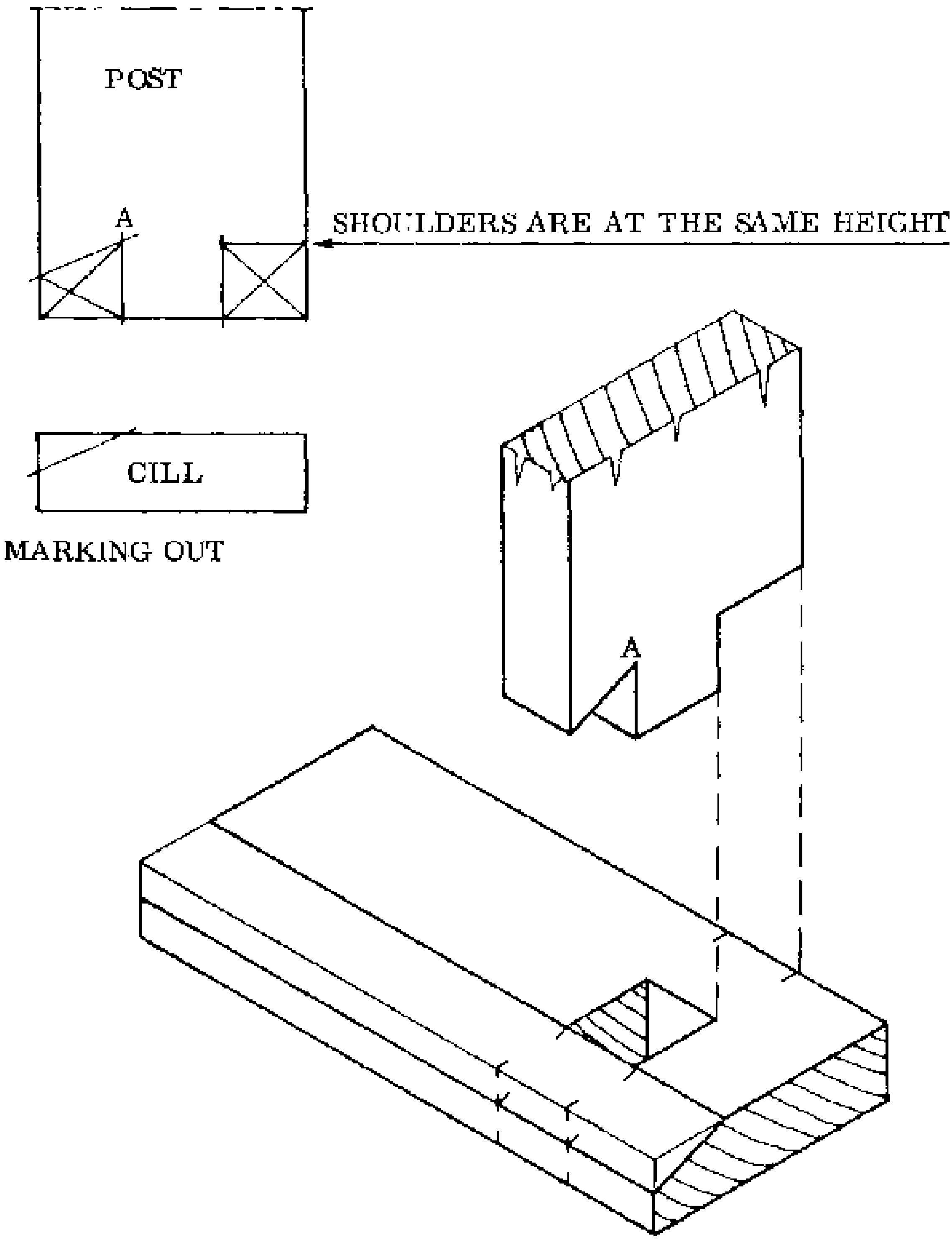
<u>NOTICE</u>

CILL & POST CONSTRUCTION
MARKING OUT OF JOINTS
MARKING OF CILL

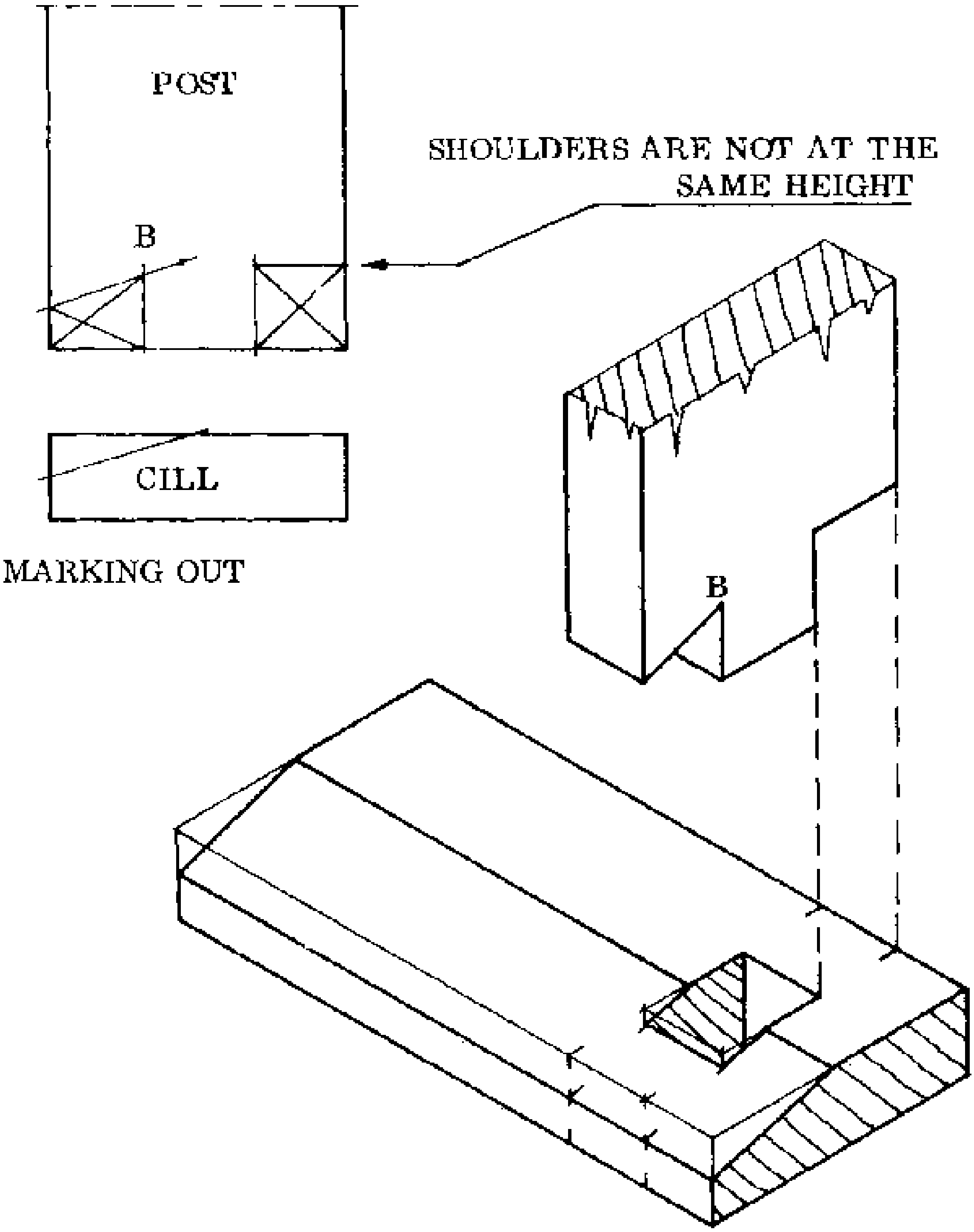
MAKE A NEW DRAWING WITH DIFFERENT DIMENSIONS AND CILL SHAPE.



OBLIQUE DRAWING OF "C ILL–POST" CONSTRUCTION



SLANTING 1/3 OF THE WIDTH



SLANTING MORE THAN 1/3 OF THE WIDTH

FORM II

General building information

REMEMBER

NOW THIS BOOK IS REALLY YOURS! FOR YOU IT OPENS MANY DOORS TO KNOWLEDGE. ON ITS PAGES WRITE NOTES TO HELP YOU UNDERSTAND, MAKE LIGHT SKETCHES AND DRAWINGS ALL YOUR OWN.

THOUGHTS OF YOURS, LIKE SEED ARE SOWN FRUITS COME LATER UNDER SUN AND RAIN IN THE FORM OF BUILDINGS WITH DOORS, ROOF AND WINDOW−PANE.

KEEP YOUR WORK BOLD, CLEAR AND CLEAN THIS BOOK WILL BE YOUR PRIDE, AND GUIDE TO ALL YOU'VE LEARNT AND SEEN.

Building drawing key

FORM 2: GENERAL BUILDING INFORMATION

The important rules for a Rural Builder to remember in general are:

− PLAN CAREFULLY EVERYTHING THAT YOU MAKE OR BUILD.

− DRAW ALL IDEAS OUT ON PAPER FOR THE BENEFIT OF THOSE WHO WILL HAVE A PART IN THE PROJECT BEFORE, DURING AND AFTER CONSTRUCTION.

− ALWAYS TAKE INTO ACCOUNT MATERIALS WHICH ARE LOCALLY AVAILABLE, AND WHEN POSSIBLE USE THESE RATHER THAN EXPENSIVE IMPORTED MATERIALS.

− TAKE INTO ACCOUNT THE SIZES OF READY−MADE MATERIALS WHEN YOU ARE PLANNING THE BUILDING.

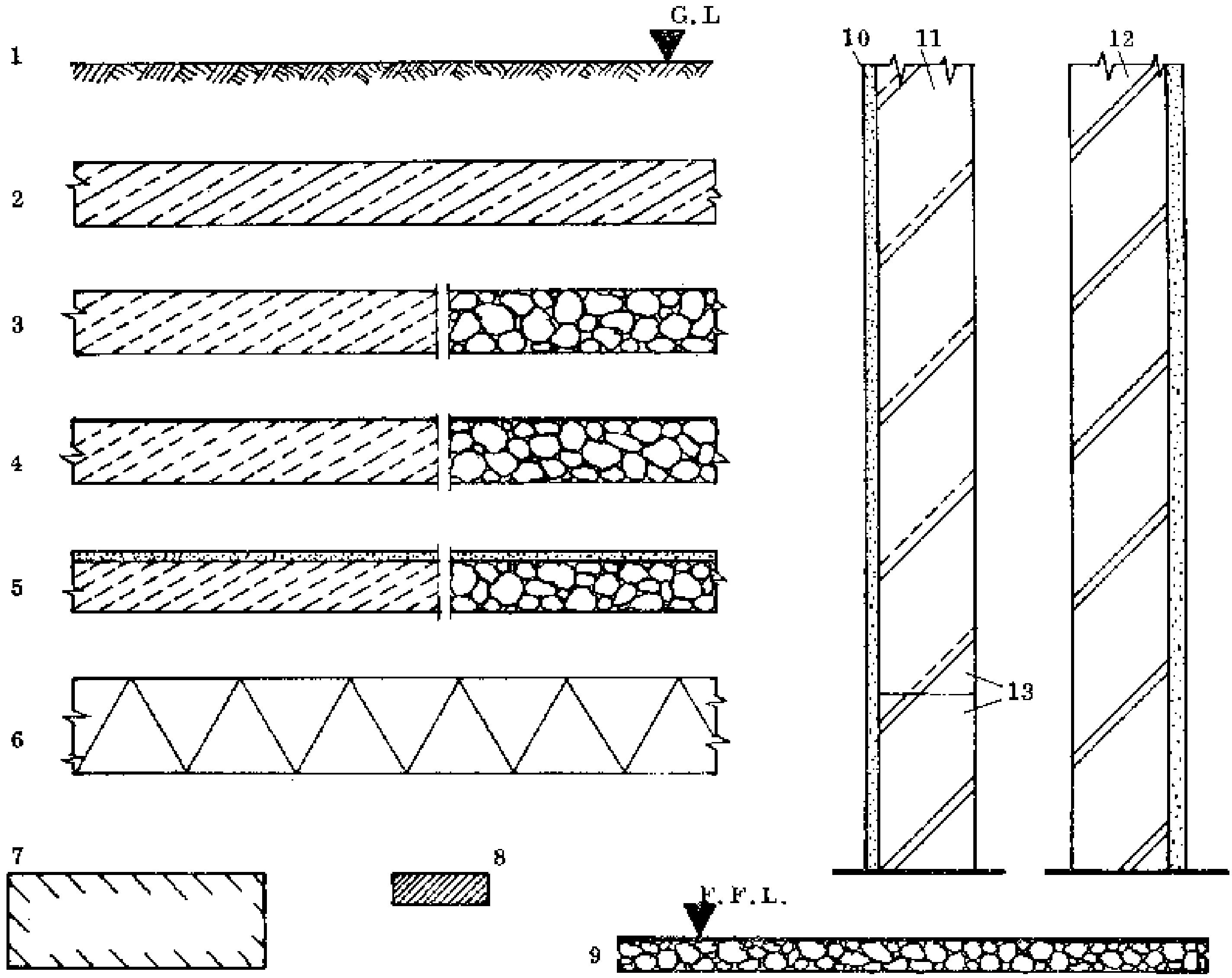
− BE AWARE OF THE REQUIREMENTS OF THE ENVIRONMENT AND THE LOCAL CUSTOMS.

Drawings should be precise and clear and should take account of the sizes of all the ready−made materials, so as to avoid unnecessary waste. It is therefore important to be informed about all the materials which are available for Rural Building, and their sizes. These can be found in the Reference Book, Materials and Products sections.

Remember that a building is an investment and the construction should be long−lasting. Proper construction, using good materials, will avoid unnecessary expense, inefficiency, and dissatisfaction.

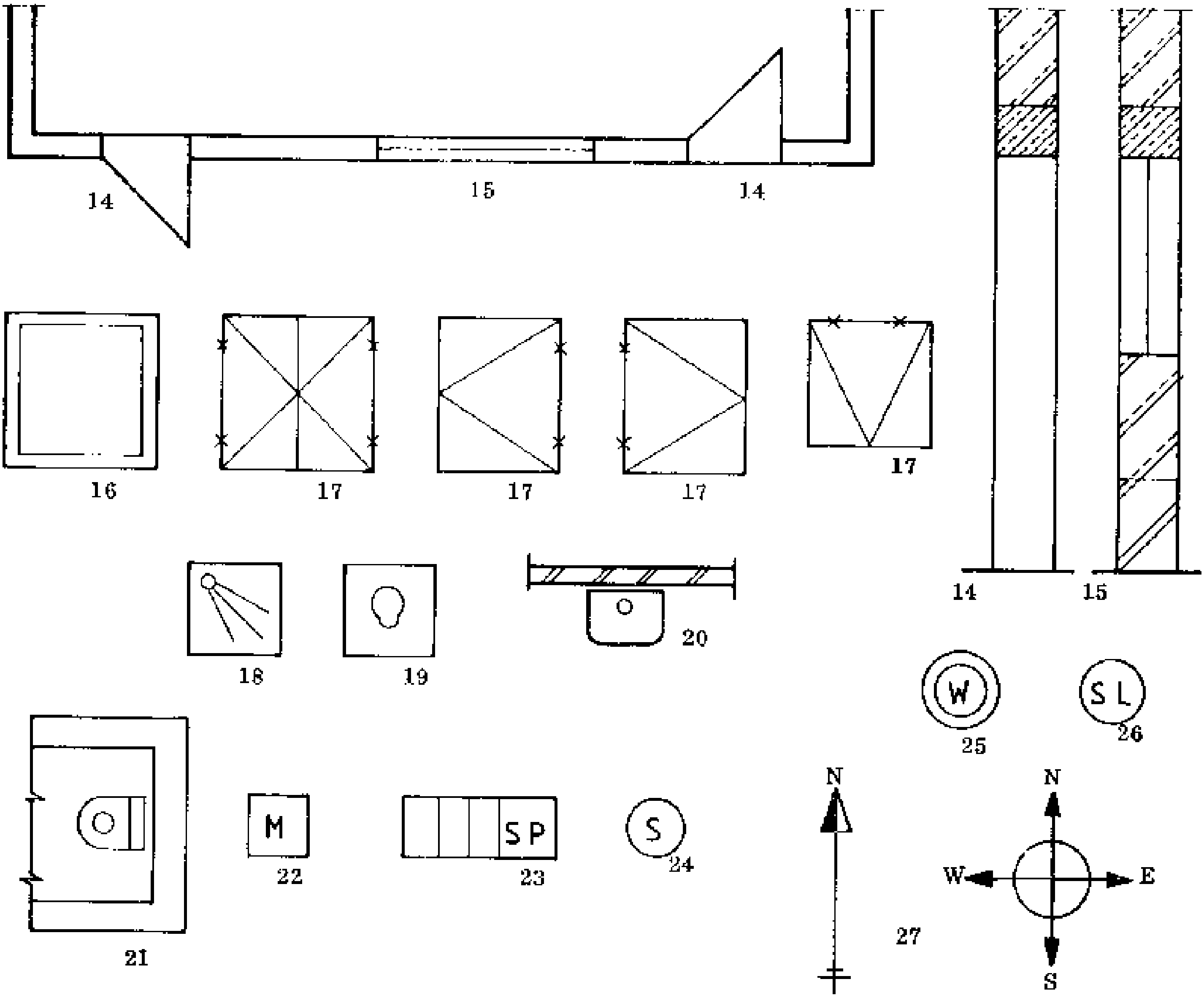
As a rule, mistakes in design or construction are costly, obvious, and permanent.

BUILDING KEY



BUILDING KEY

1 = GROUND LEVEL
2 = REINFORCED CONCRETE
3 = CONCRETE
4 = ONE COURSE WORK
5 = TWO COURSE WORK
6 = HARD CORE FILLING
7 = WOOD (large)
8 = WOOD (small)
9 = FINISHED FLOOR LEVEL
10 = PLASTER
11 = LANDCRETE WALL
12 = SANDCRETE WALL
13 = SANDCRETE TO LANDCRETE



BUILDING KEY

14 – DOORS (without threshold)
15 – WINDOW (plan)
16 – WINDOW (front view)
17 – HINGE POSITIONS
18 – SHOWER
19 – PIT LATRINE
20 – SINK
21 – FLUSH TOILET
22 – MANHOLE (sewage)
23 – SEPTIC TANK
24 – SOAKAWAY (waste water)
25 – WELL
26 – SILO
27 – DIRECTIONS

How buildings are drawn

<u>SCALE</u>

When you draw a plan of a building on paper you will find that you have to use a scale, to make the plan small enough to fit on the paper. Scales were explained earlier, but here are some examples to help you remember how to use them.

– EXAMPLES: A scale of 1:50 (cm) tells you that 1 cm on the drawing represents 50 cm in real life. In other words all the dimensions on the drawing are l/50th of their real size and all the dimensions are in centimetres.

A scale of 1: 500 (cm) tells you that all the dimensions on the drawing are l/500th of their real size and that all the dimensions are in centimetres.

Both of these scales make the drawing smaller than the actual building size. These types of scales are called "reduced scales".

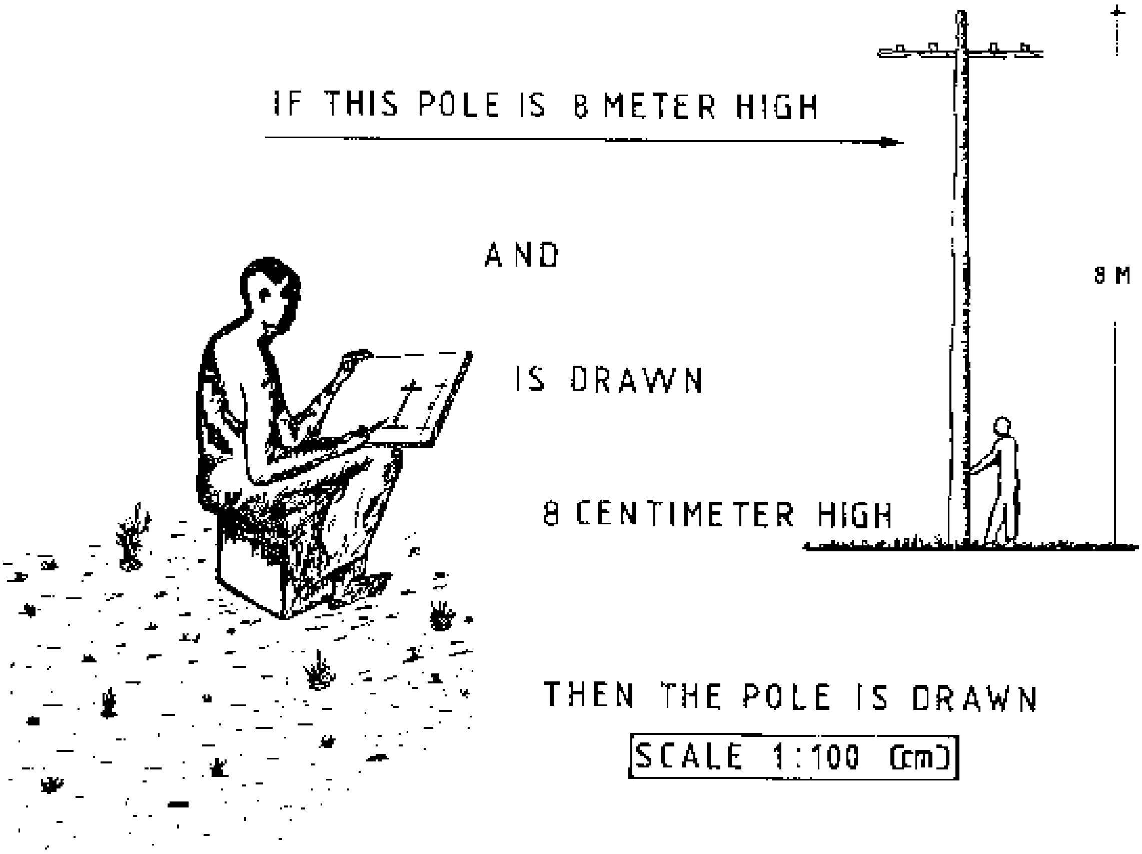
The man you see on the next page is making a scale drawing of an electricity pole. The pole is 800 cm high and the man is using a scale of 1 : 100 (cm) which means that his drawing will be 8 cm high. The 8 cm on the drawing represents 800 cm in real life.

If the crossbar on the pole is 150 cm long, how long will the man draw it on his paper?

All building drawings are made in reduced scale. Here are some examples of drawings used in building, and the scales commonly used with them:

- LOCATION PLAN 1 : 500
- DESIGN DRAWING 1 : 100
- FINAL DRAWING 1 : 50
- DETAIL DRAWING 1 : 20; 1 : 10, or 1 : 5

Always remember to include the UNITS of the scale you have used; these are usually "cm" or "mm".



WORKING DRAWINGS

Three different types of drawings are needed to show the builder exactly how the building should look, on the inside and the outside. These include the elevations and sections, as well as the plans. Here we describe the different types of plans which have to be made: the foundation plan, floor plan, and roof plan.

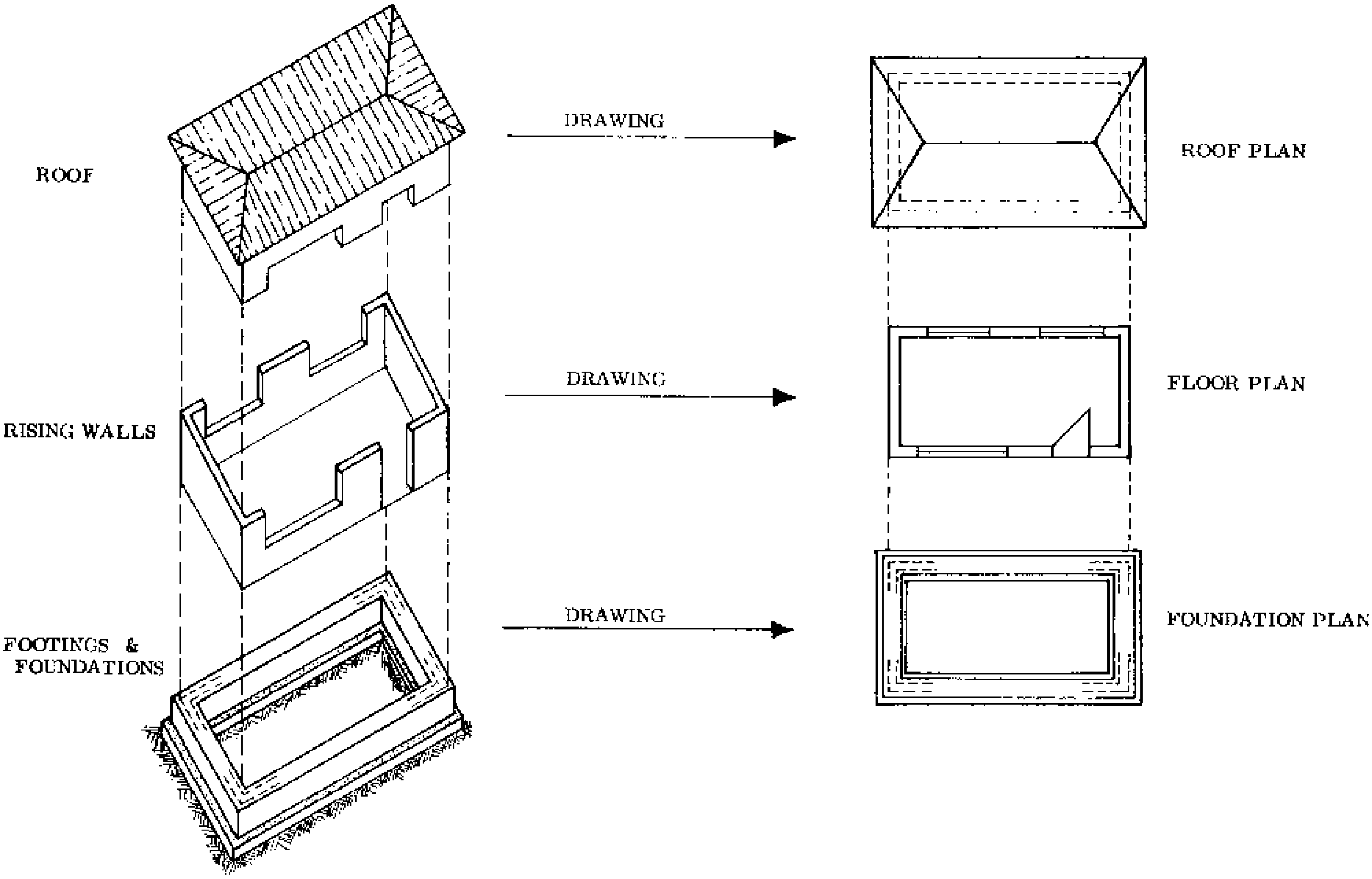
- FOUNDATION PLAN: A foundation plan, along with its sections, shows the builder how deep the foundations should be laid and gives all the dimensions for the foundation and the footings. Sometimes the corners of the rising walls are indicated on the footings.

- FLOOR PLAN: This plan should show the builder the size of the building and the verandahs, the thickness of the walls, and where to place the doors and windows. It also shows which way the doors are meant to open.

- ROOF PLAN: Roof plans are made to show the builder what shape the roof should be and how it is to be built. The roof plan should contain such information as the angle of the roof, the shape, and the materials to be used.

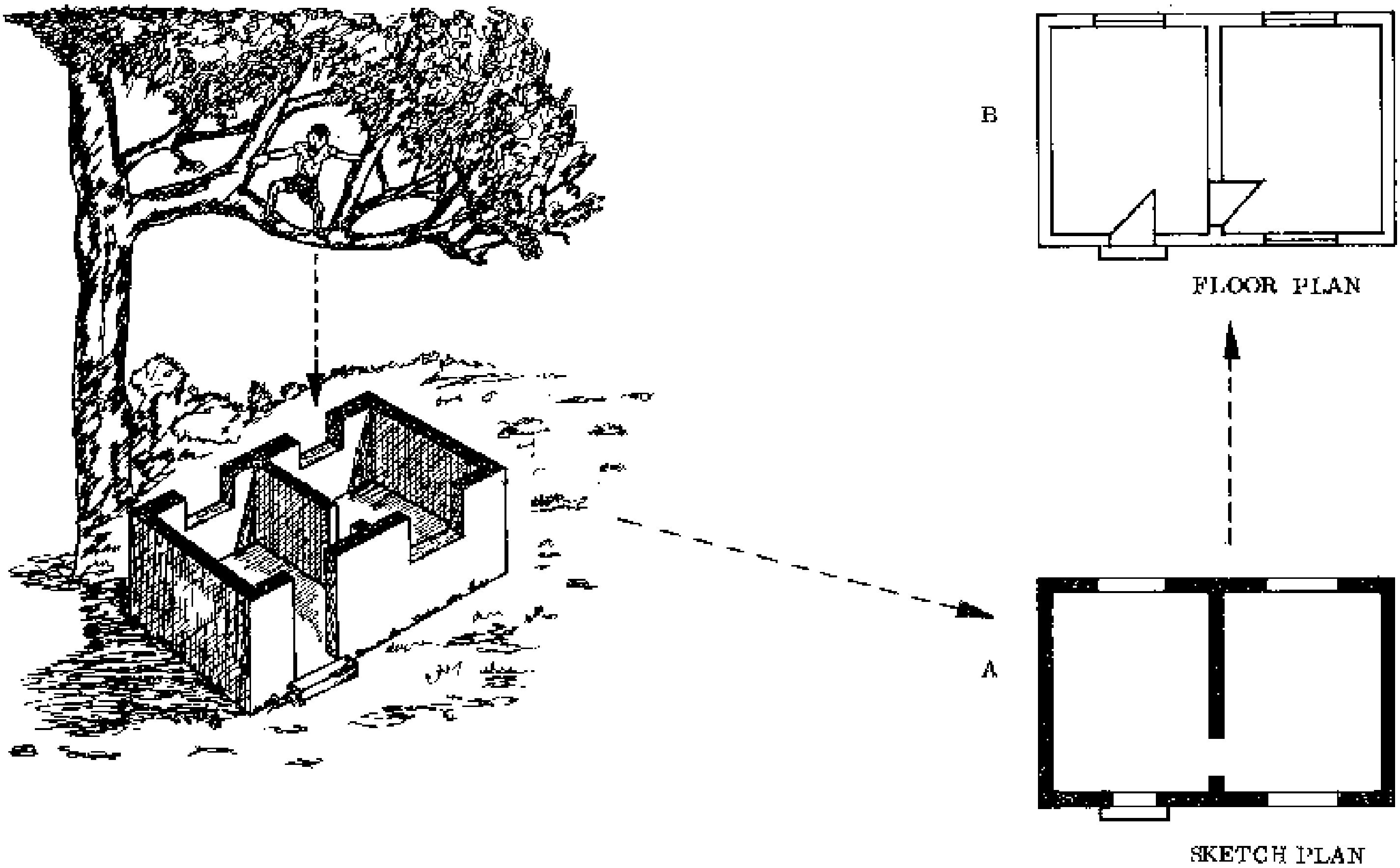
The drawing here illustrates the types of plans and what it is they show to the builder.

Elevations and cross sections are of course essential parts of the working drawings. These are examined in detail after some further examples of plans in the next pages.



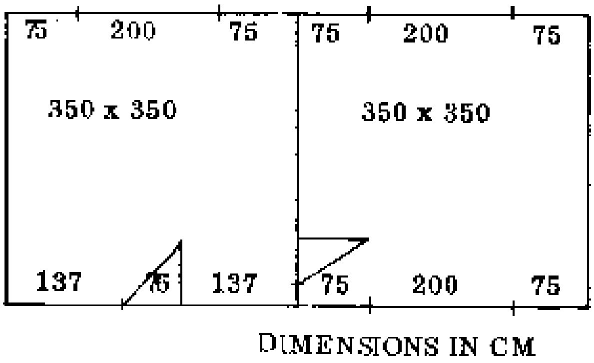
PLANS

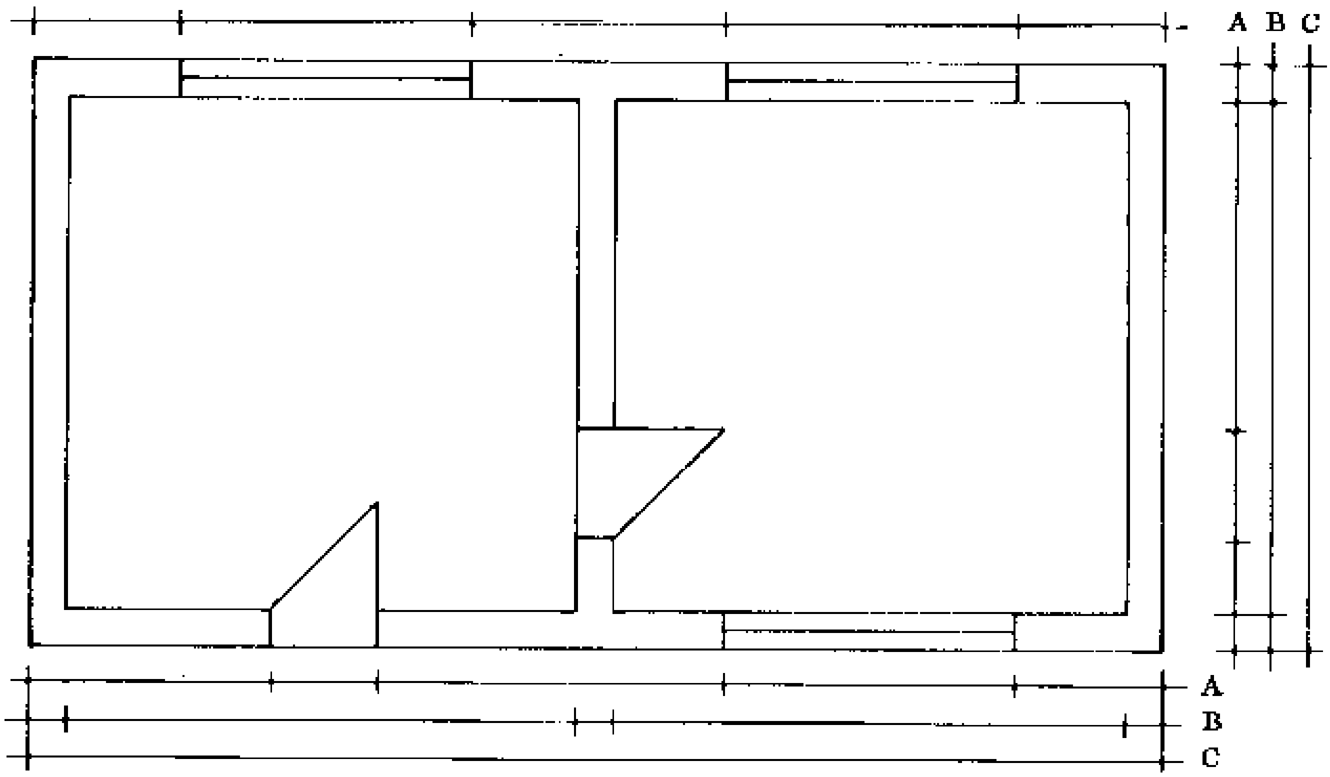
Floor plans



FLOOR PLANS

IF YOU WERE UP IN A TREE AND LOOKED STRAIGHT DOWN AT THIS HALF-BUILT HOUSE IT WOULD LOOK LIKE "A". YOU SHOULD DRAW IT LIKE "B".





FLOOR PLAN

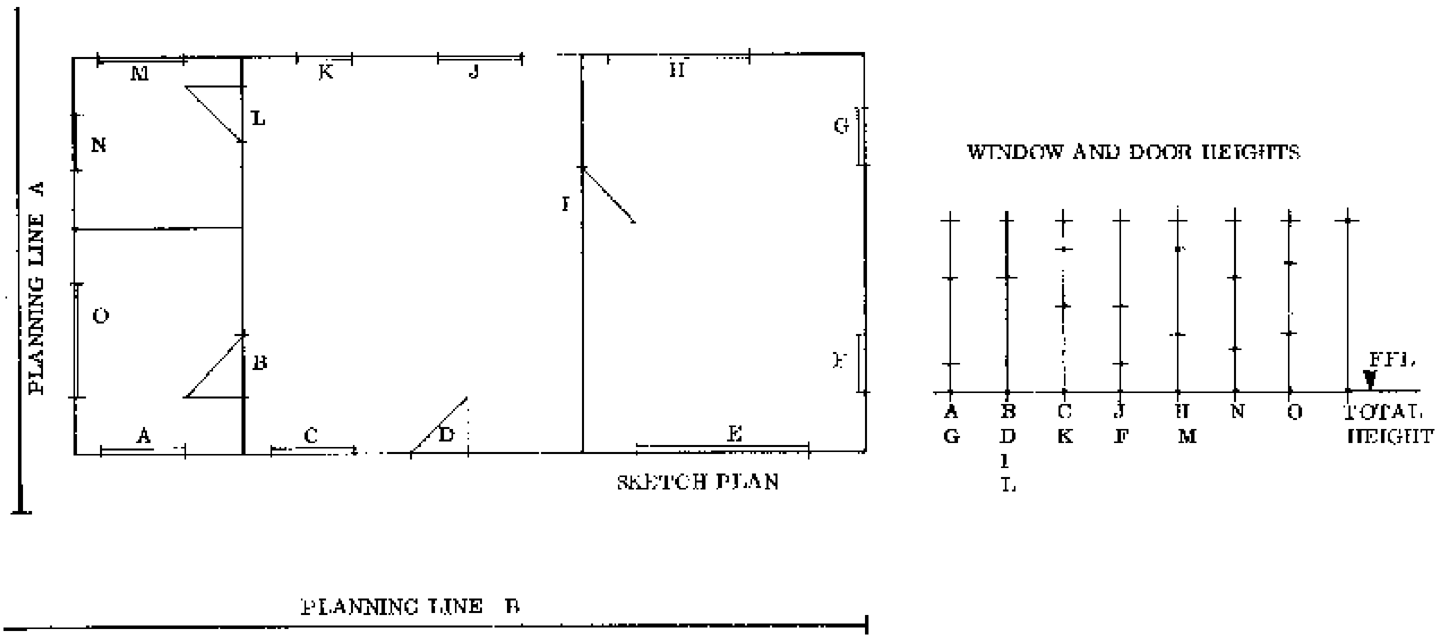
DIMENSION LINE A = OPENINGS
DIMENSION LINE B = WALLS
DIMENSION LINE C = TOTAL LENGTH

<u>TECHNICAL DATA</u>

WALL THICKNESS = 15 cm
WIDTH OF FOOTINGS = 30 cm
WIDTH OF FOUNDATION = 45 cm

<u>EXERCISE</u>

MARK IN ALL DIMENSIONS.



FLOOR PLAN

MEASUREMENTS OF AREAS ARE ALWAYS INSIDE MEASUREMENTS!

EXERCISE

- MARK IN ALL DIMENSIONS ON PLAN.
- MARK IN ALL DIMENSIONS FOR DOOR AND WINDOW HEIGHTS.
- MARK IN PLANNING LINES A & B.
- FIND THE TOTAL LENGTH AND WIDTH (SCALE = 1:100 cm).

SKETCHES FOR FLOOR PLANS – 1 ½ HOURS

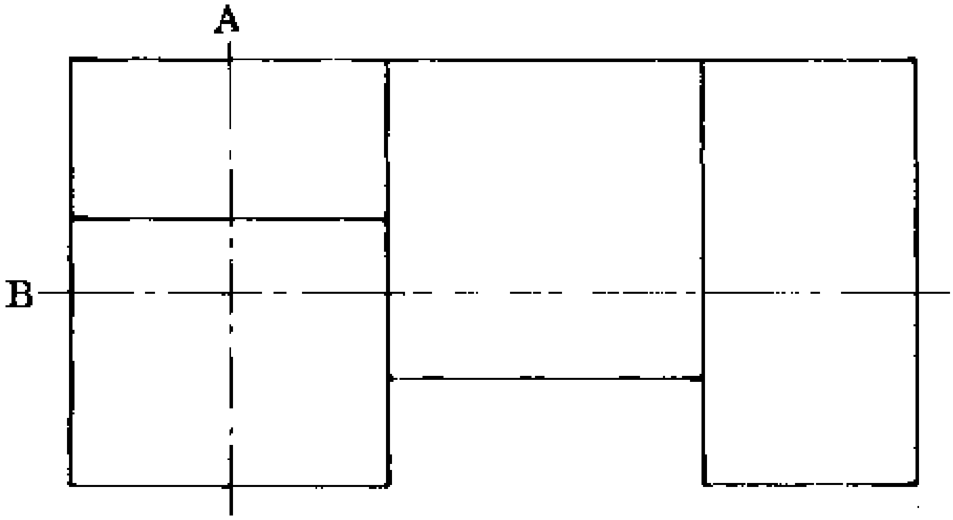
EXERCISE

- DRAW THESE FOUR BUILDING PLANS: SCALE 1:50 (cm) INCLUDE DOORS AND WINDOWS IN THE POSITIONS OF YOUR OWN CHOICE.

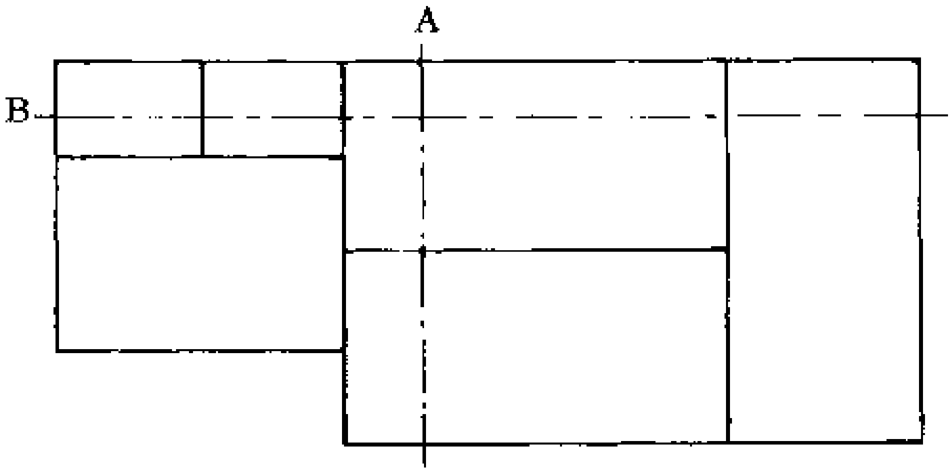
TECHNICAL DATA

THE RISING WALLS ARE 15 CM THICK AND 200 CM HIGH.

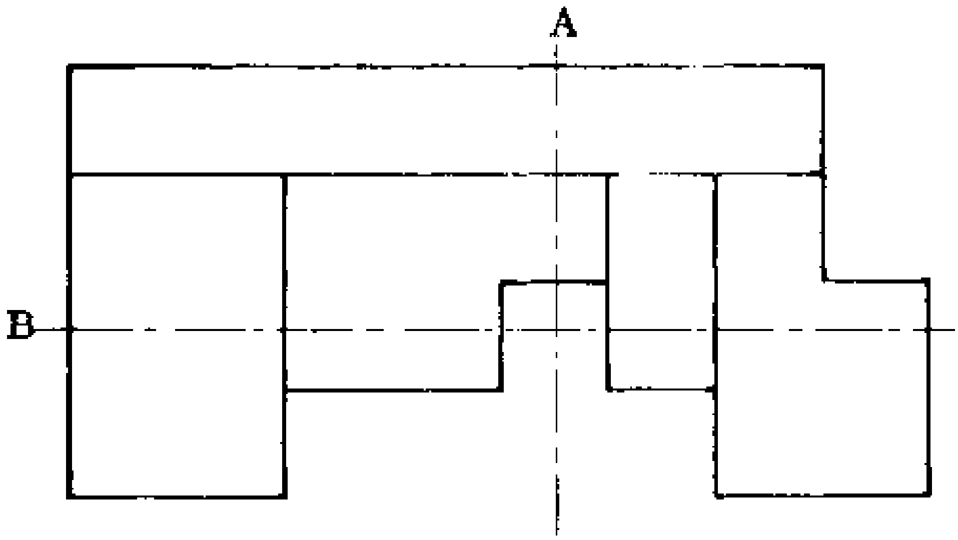
NOTE: PLANNING LINES (LINES A & B) ARE POSITIONED WHERE THEY WILL SHOW THE MOST DETAIL.



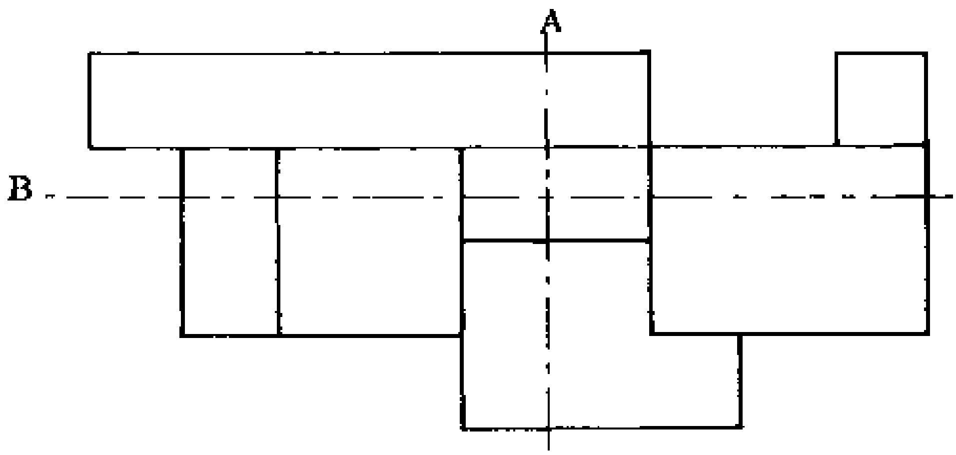
SKETCH 1



SKETCH 2



SKETCH 3



SKETCH 4

Elevations

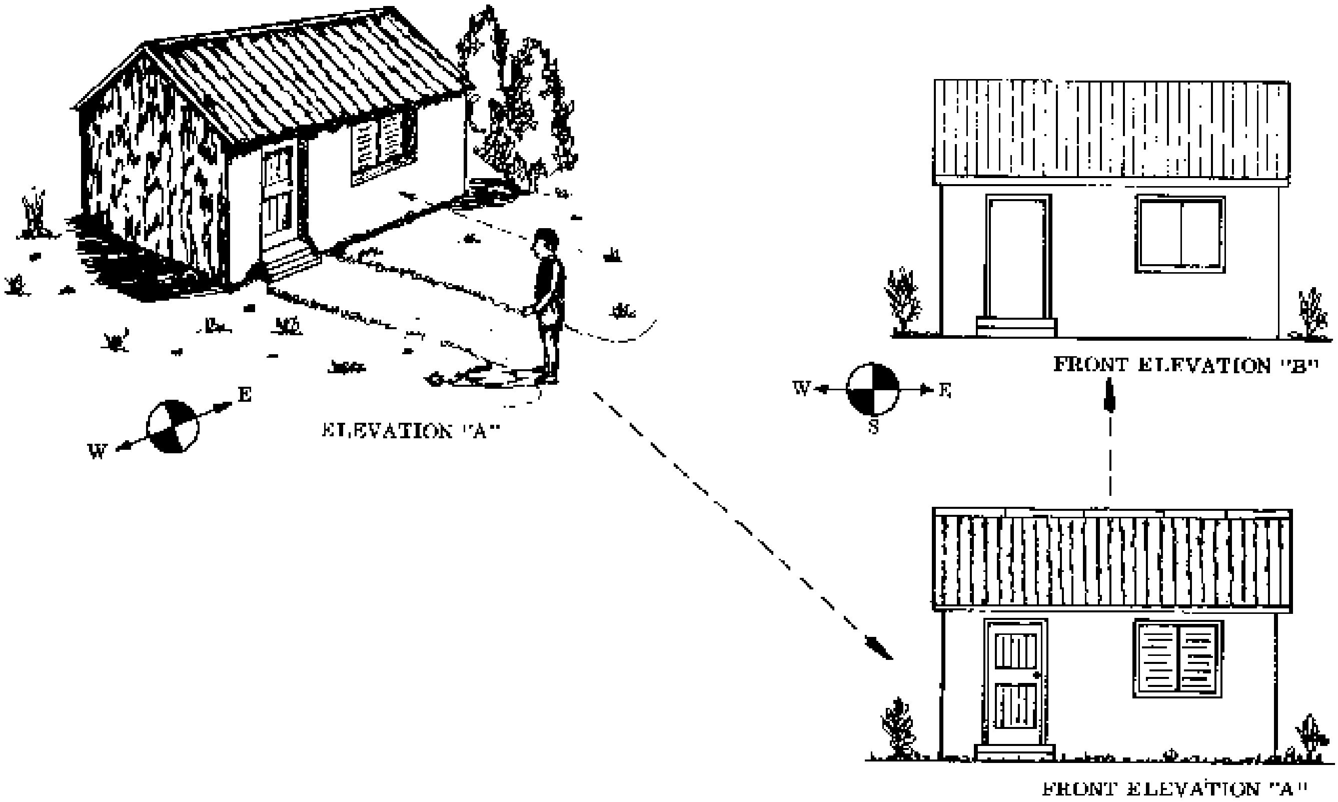
A special type of drawing is used to show what a building will look like from the outside. These drawings are called "elevations" and they show what you would see if you looked straight on at the side of the house. Of course a. house has more than one side, and so there are always a number of elevations. There are as many elevations as there are sides of the house. Houses usually have four sides and so there are usually four elevations.

It is not always necessary to draw all the possible elevations of a building, especially if some of the sides look very similar to each other.

The drawing here shows the front elevation of a small house. You should notice that the sides of the house are not drawn. This is because if you stand directly in front of the house you cannot see the sides. The front elevation shows the sizes and positions of the doors and windows as well as the height and length of the house itself.

The building shown on the next page faces south. The front elevation is therefore called the "south elevation". The other three elevations are the east elevation, the north elevation, and the west elevation.

In general only main features are shown on the elevations. Small details of the doors, windows, etc. are given in the detail drawings.



ELEVATIONS

IF YOU LOOKED STRAIGHT AT ONE SIDE OF A BUILDING IT WOULD LOOK LIKE "A".

<u>YOU SHOULD DRAW IT LIKE "B".</u>

Sections and cross sections

<u>SECTIONS</u>

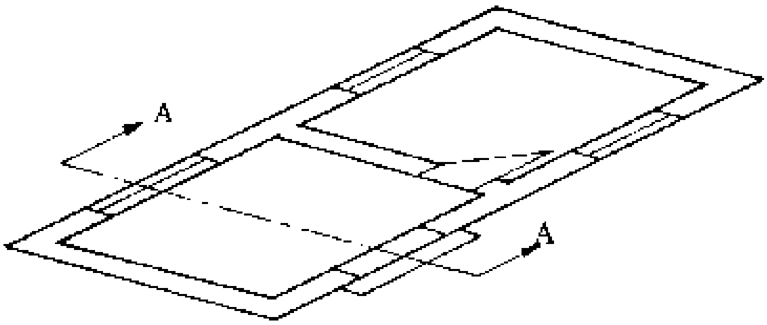
Suppose you were able to cut right through a building and then take away one part. What you would see would look something like the diagram on the next page (1). If you now look at the building straight on, you will see a "cross section" of the building (2). The cross section shows the insides of the roof and the room as well as the footings and foundations.

Sections are useful because they give a lot of information about the building which is not found in the elevations and the plans. For example, on a section you can see the height of a room inside the building, the thickness of the ceiling, and the floor and roof construction. You can also see the thickness and width of the foundation, which is not given in the plans and elevations.

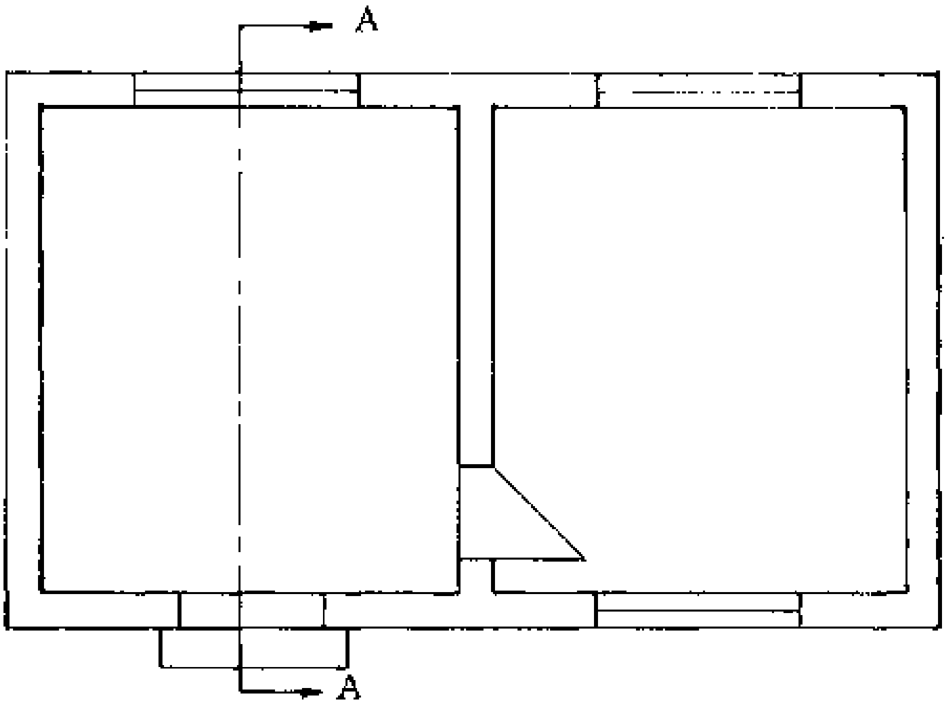
> − CHOOSING SECTIONS: You will usually find it necessary to take at least two sections through the building. You can take any section through any part of the building, but of course the best sections are the ones which are the hardest to draw! When you take a section through a building, you have to mark on the plan exactly where you have "cut" and the direction from which you look at the section.

On the right page you can see the conventional way of doing this. The place where the building is cut is marked by a broken line which has arrows at its ends to show which way the section faces. All sections should be marked on the plan, and you should label each end of the line with a letter. On the plan here, the section has the letter "A" at each end. When this cross section is drawn, it is labelled as "cross section A−A". The next section would be "cross section B−B" etc.

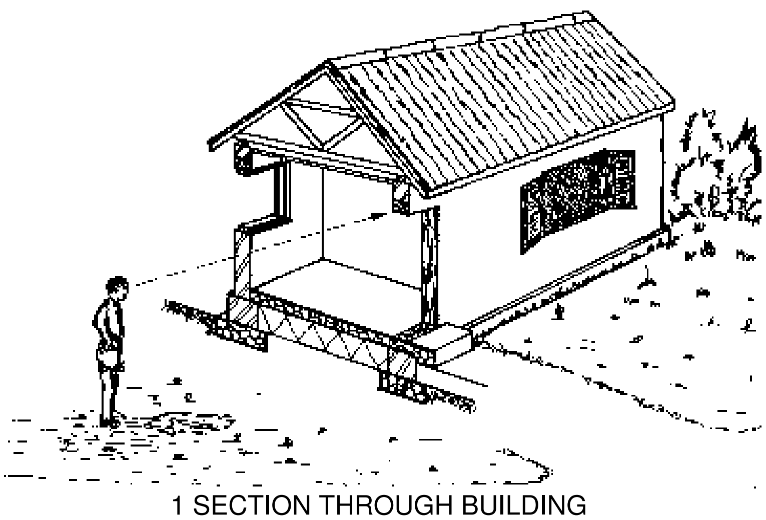
CROSS SECTIONS

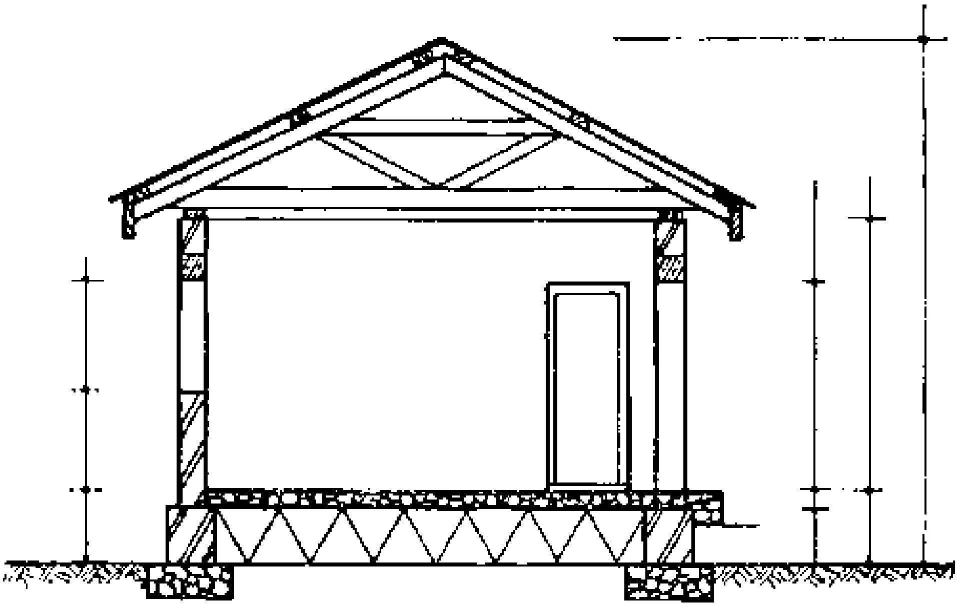


3 SKETCH PLAN



3 FLOOR PLAN


1 SECTION THROUGH BUILDING



2 CROSS SECTION A–A

Plans – elevations – cross sections

PLANS – ELEVATIONS – CROSS SECTIONS – 4 HOURS

IMPORTANT

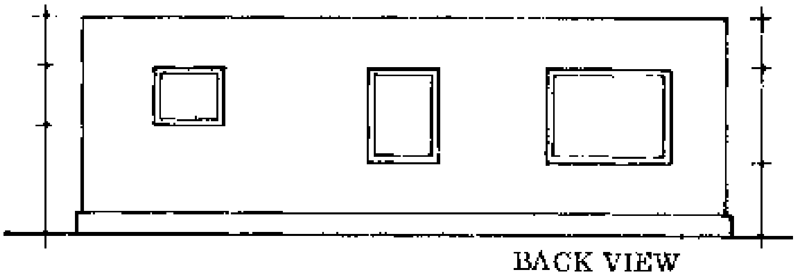
- INDICATE ALL DIMENSIONS AT LEAST ONCE.
- MAKE CROSS SECTIONS OF THE MOST DIFFICULT PARTS OF THE BUILDING.
- ALL ELEVATIONS SHOULD BE IN LINE WITH EACH OTHER.
- IF THERE IS NOT ENOUGH SPACE MARK DIMENSIONS LIKE AT "D"

NOTICE

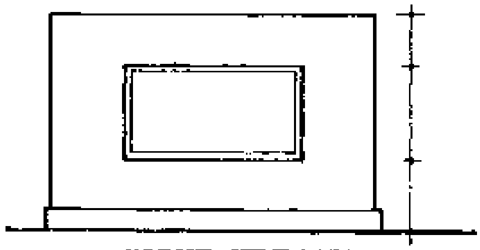
- THE FLOOR GOES THROUGH AT "A".
- THE FLOOR IS STOPPED AT "B".
- FLOOR THICKNESS AT "C"

EXERCISE

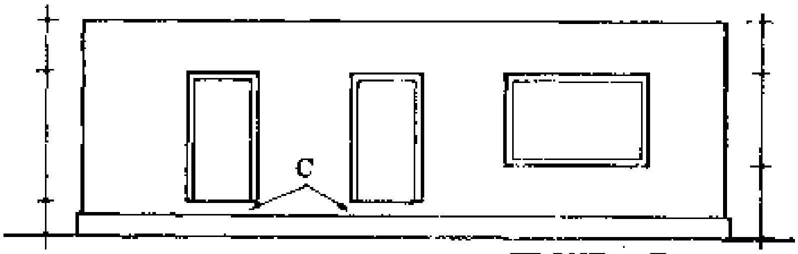
MAKE A SIMILAR DRAWING WITH DIFFERENT DIMENSIONS AND DIFFERENT DESIGN.



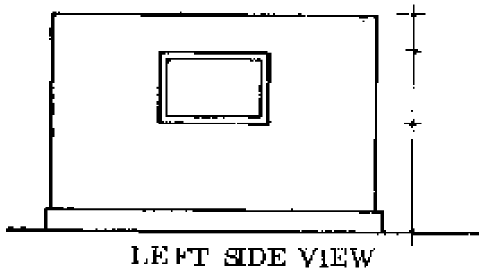
BACK VIEW



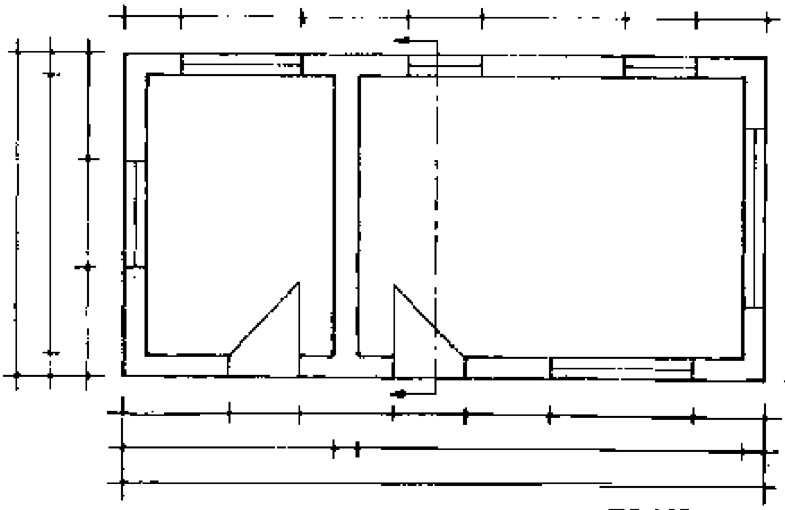
RIGHT SIDE VIEW



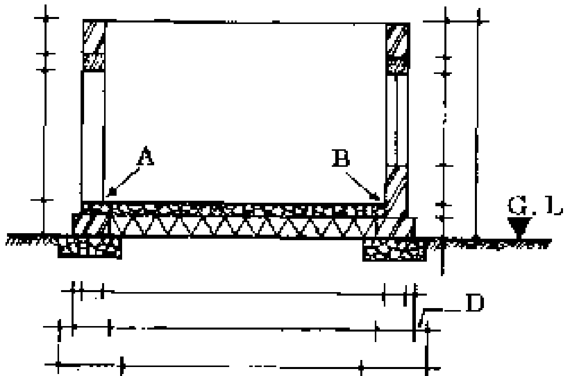
FRONT VIEW



LEFT SIDE VIEW



PLAN



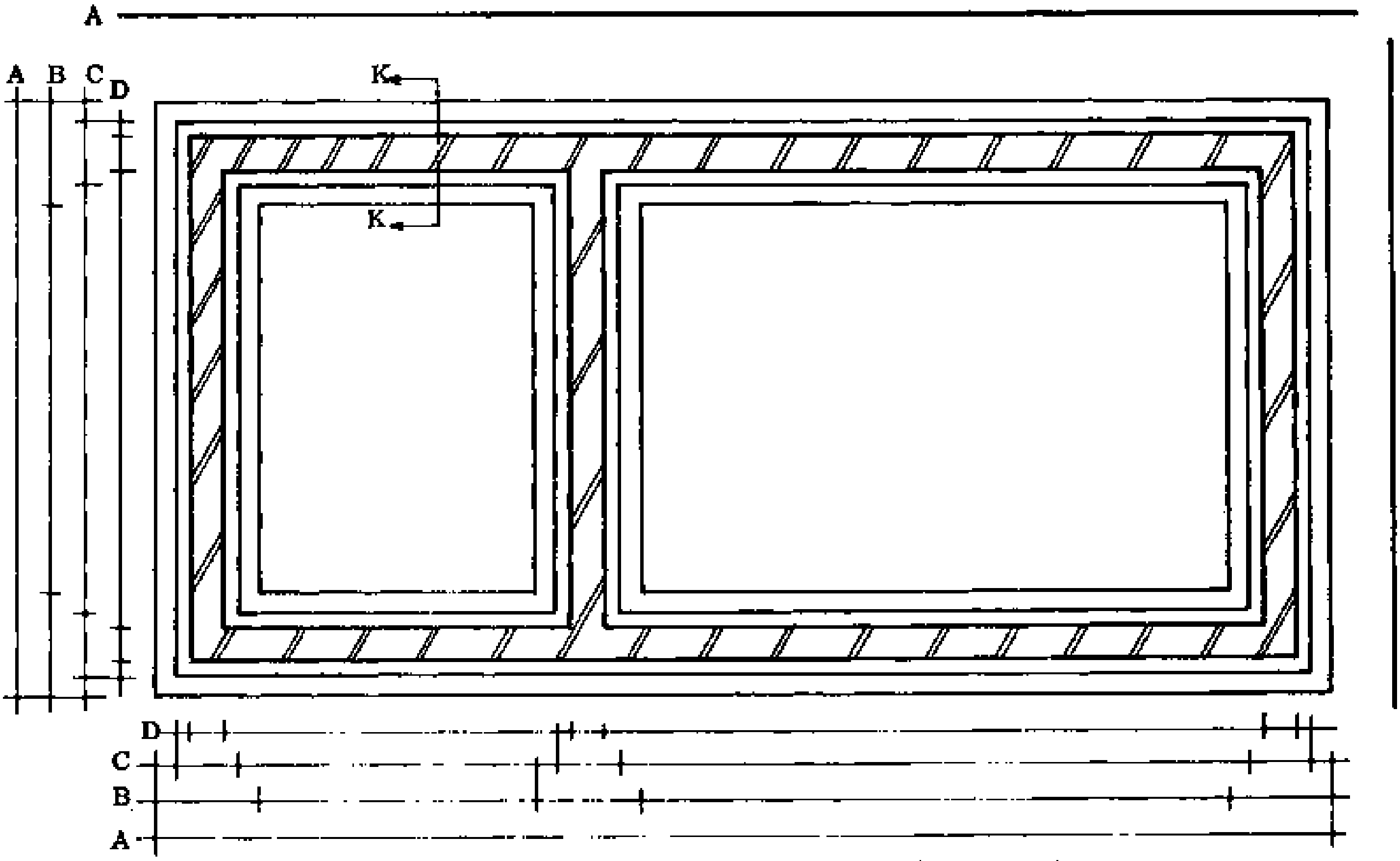
CROSS SECTION A-A

Foundation plans

FOUNDATION PLAN – 1 HOUR

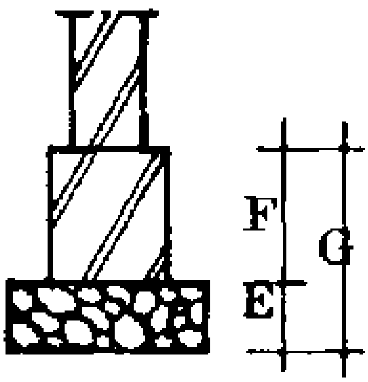
<u>EXERCISE</u> DRAW FOUNDATION PLANS FOR THE FOUR FLOOR PLANS ON PAGE 58. USE A SCALE OF 1: 20 (cm).

MAKE THE PLANNING LINES FIRST!



FOUNDATION PLAN

A = TOTAL WIDTH
B = FOUNDATION WIDTH
C = FOOTING WIDTH
D = RISING WALLS



CROSS SECTION K–K

E = FOUNDATION THICKNESS
F = FOOTING HEIGHT
G = TOTAL HEIGHT

BUILDING WITH VERANDAH – 4 HOURS

<u>TECHNICAL DATA</u>

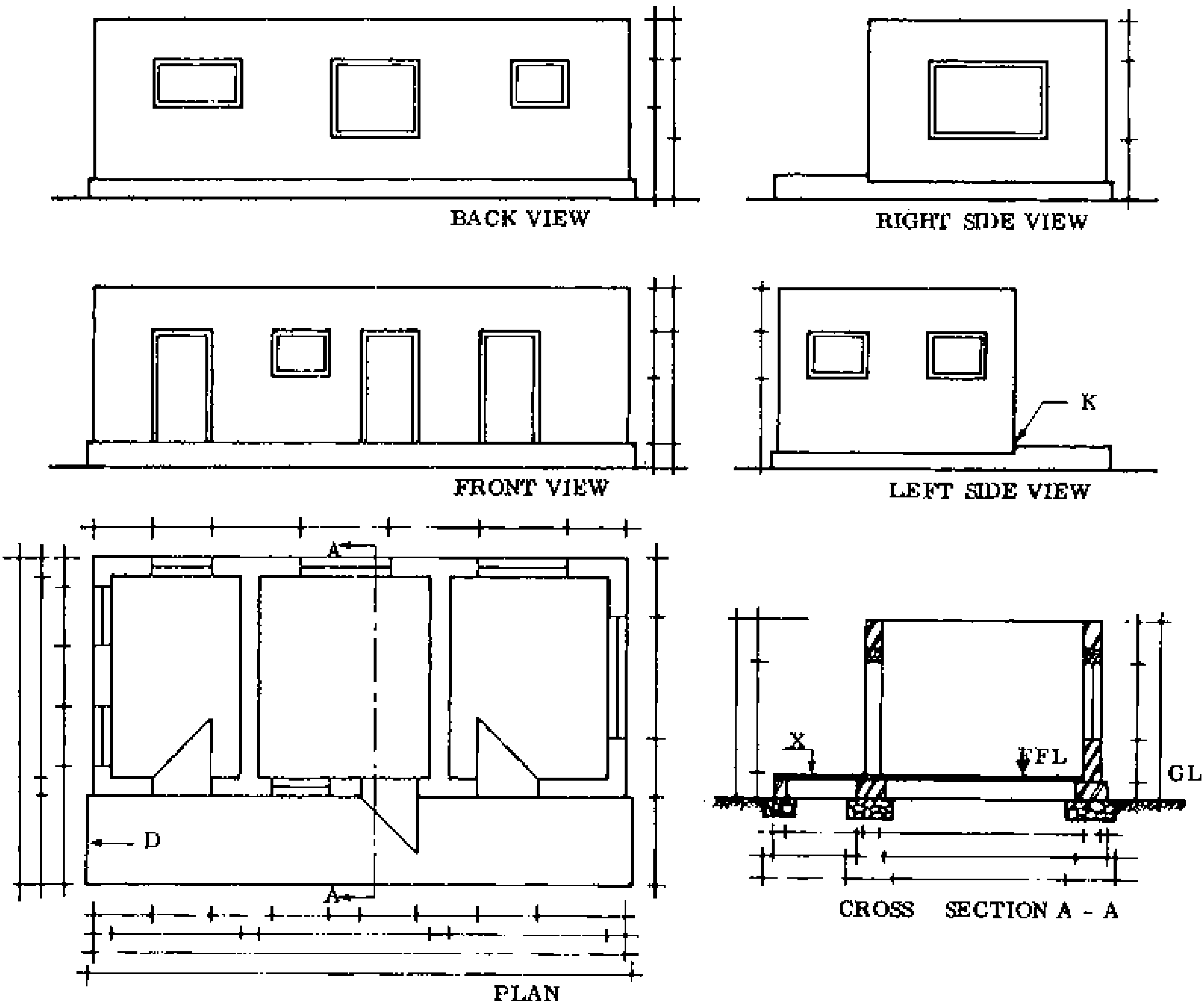
FOOTING FOR THE VERANDAH IS SMALLER.
FOUNDATION FOR THE VERANDAH IS SMALLER.
VERANDAH FLOOR IS AT THE SAME LEVEL AS THE INSIDE FLOOR (X).

VERANDAH FLOOR IS PROJECTING ON THE PLAN (D).
NOTICE THE DIFFERENCE IN THE VERANDAH FLOOR AND THE FOOTINGS HEIGHT (K).

<u>EXERCISE</u>

MAKE A DRAWING OF A BUILDING WITH VERANDAH.
USE SCALE 1 : 50 (cm)

PLANS - ELEVATIONS - CROSS SECTION



FOUNDATION PLAN FOR BUILDING WITH VERANDAH – 1 ½ HOURS

<u>NOTICE</u>

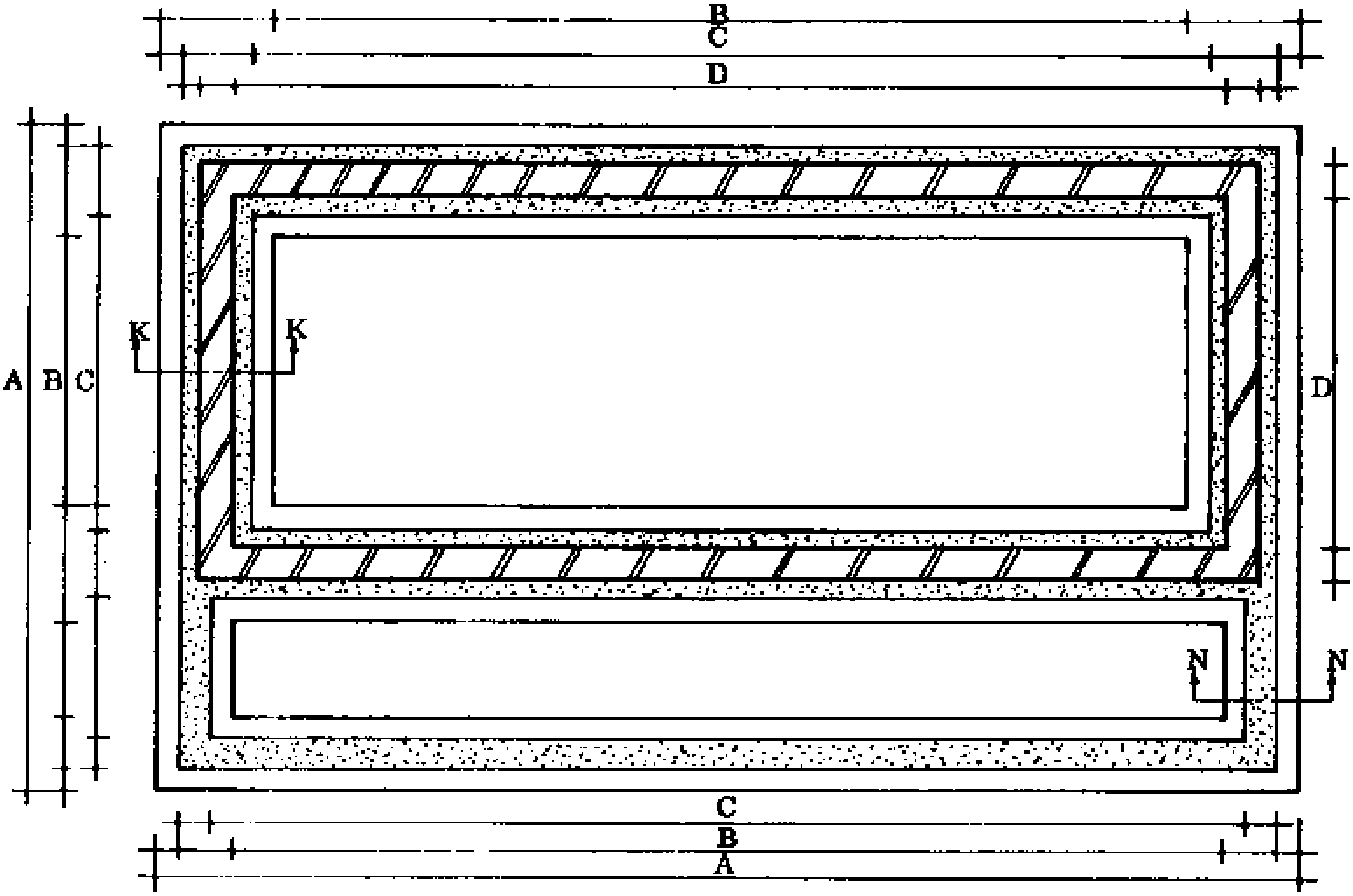
K – K & N – N ARE CROSS SECTIONS.

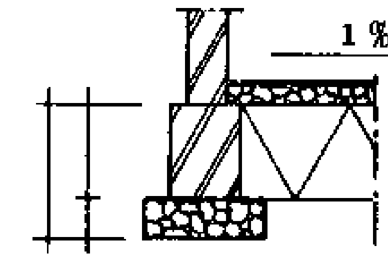
DIMENSION LINES:

A = TOTAL LENGTH
B = FOUNDATIONS
C = FOOTINGS
D = WALLS

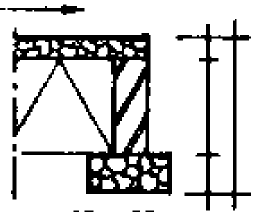
EXERCISE

MAKE FOUNDATION PLANS FOR THE PLANS ON PAGE 65.





CROSS SECTION K – K


N – N

SURFACE OF FOOTING --


Door frames

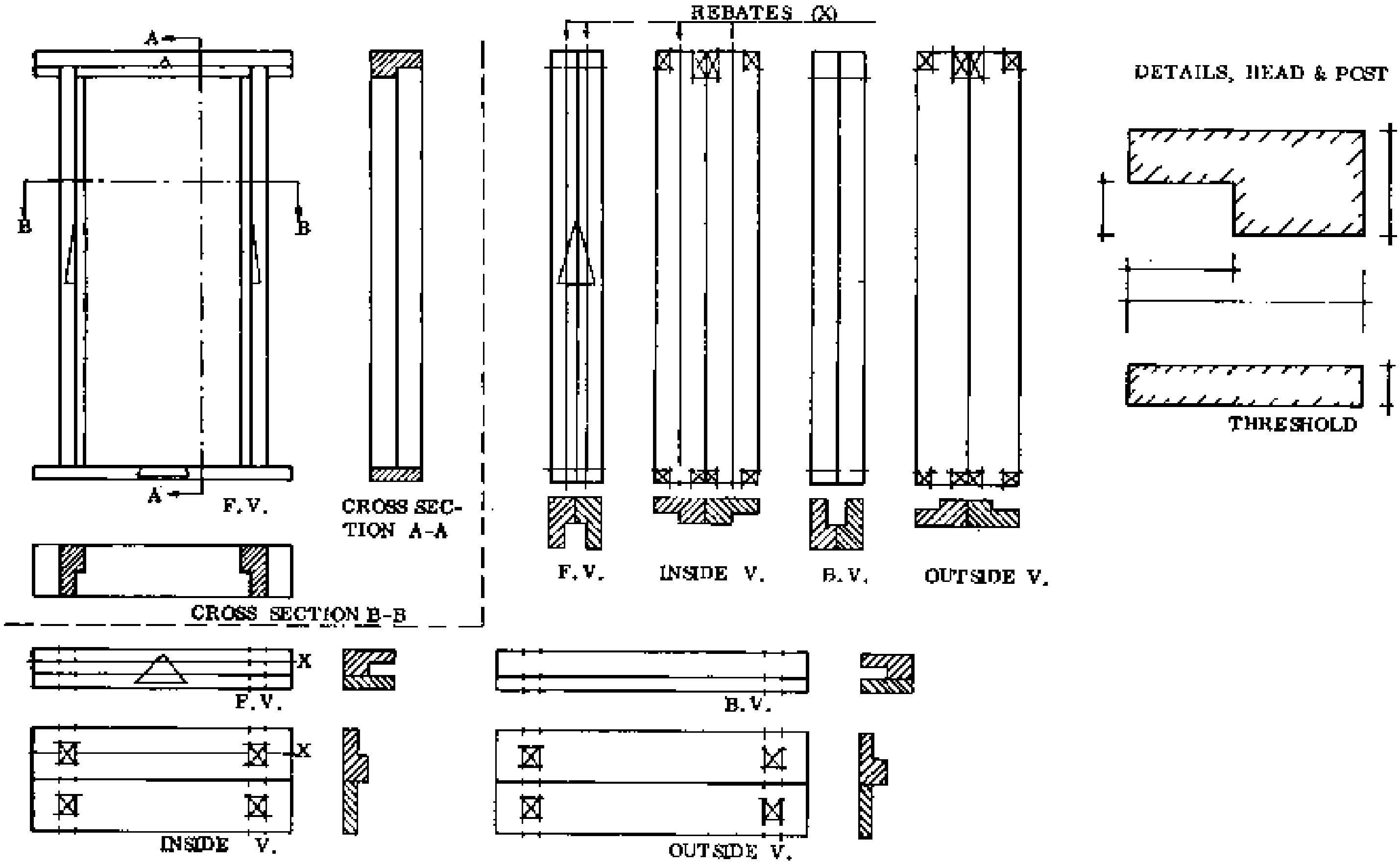
FRAME WITH REBATE – 2 ¾ HOURS

NOTICE

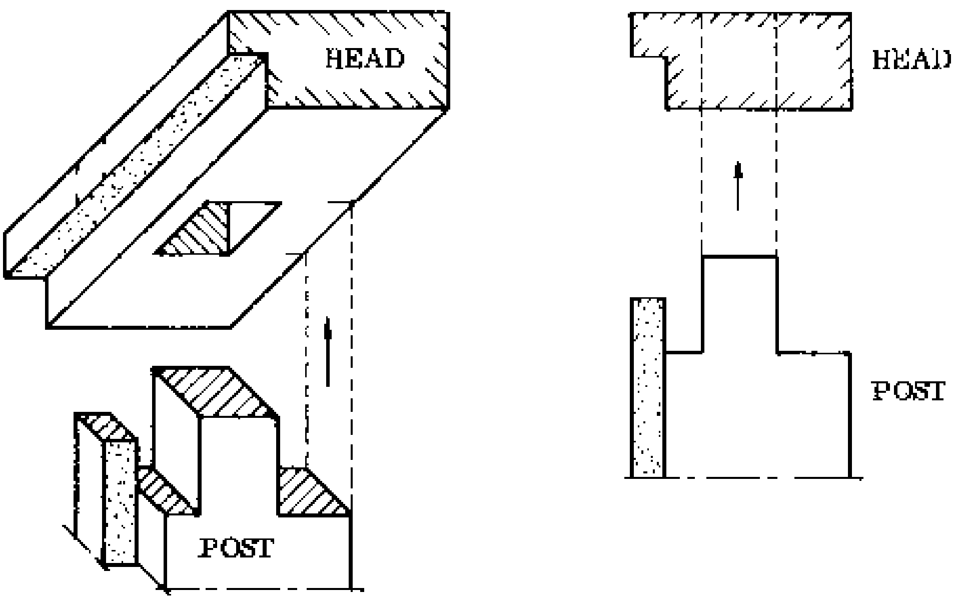
– CROSS SECTION A–A and B–B THERE IS NO T. V. or SIDE V.
– MARKING LINES FOR THE REBATES(X)
– STUDY THE CROSS SECTIONS OF THE MEMBERS(FOR MARKING OUT)
– SHOULDERS ARE DIFFERENT

EXERCISE

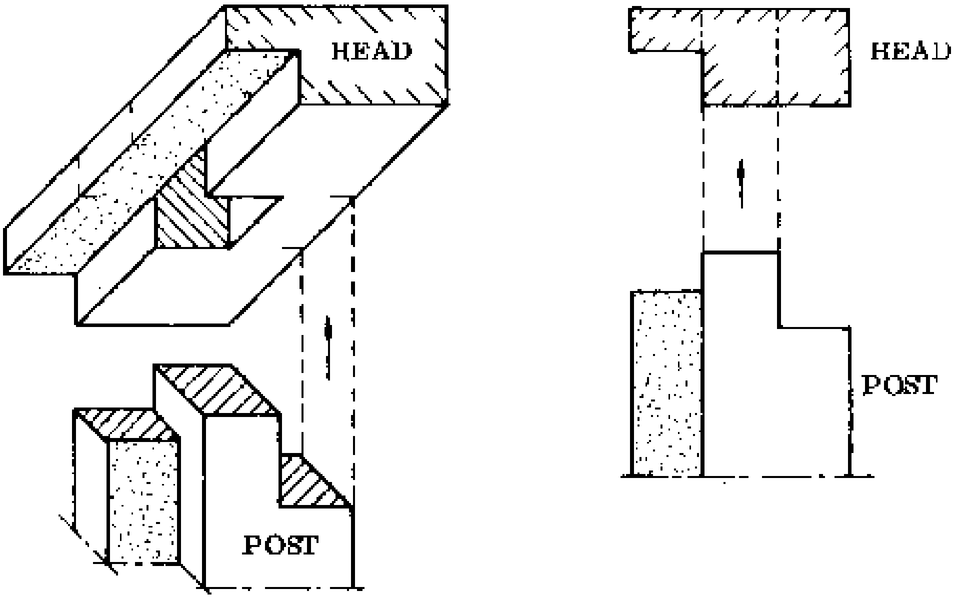
DRAW A DOORFRAME WITH THRESHOLD. USE SCALE 1 : 10 (cm).
DRAW ALL MEMBERS AND MARK THEM OUT FOR JOINTS.



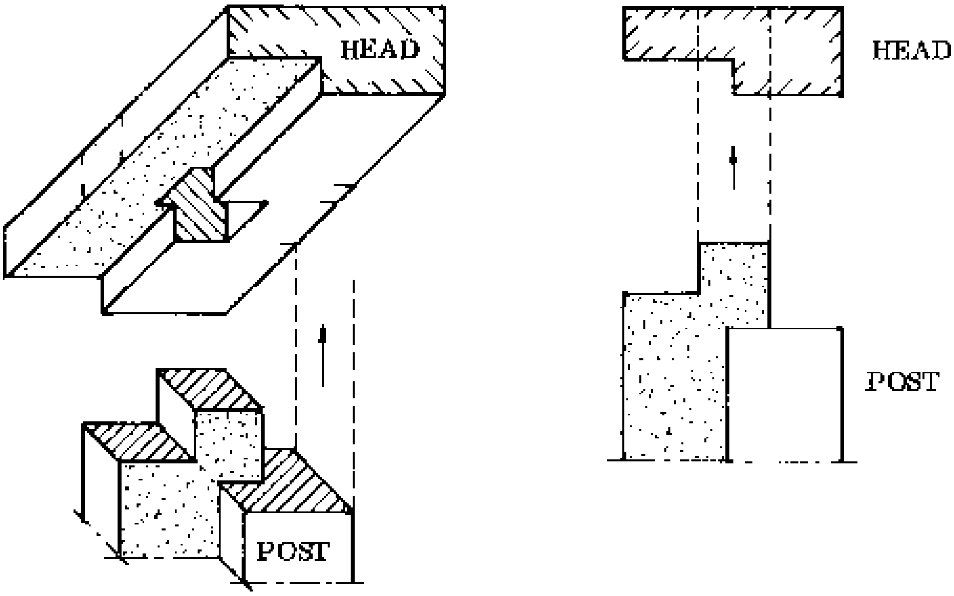
WHEN TO REDUCE MORTICE AND TENON (use teaching aids)



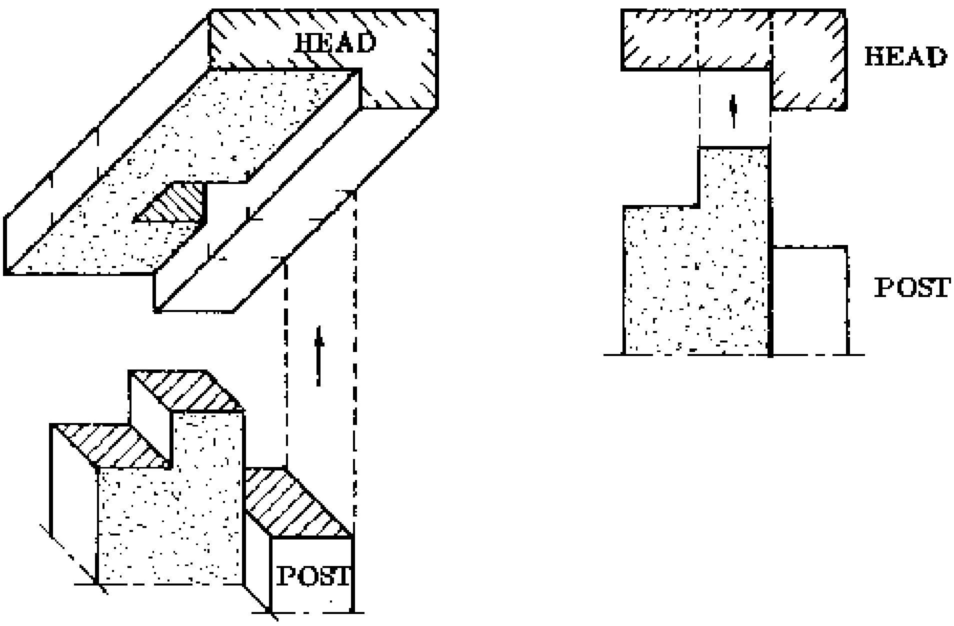
REBATE DOES NOT DISTURB THE TENON.



REBATE DOES NOT DISTURB THE TENON.



REBATE DOES DISTURB THE TENON.



REBATE DOES DISTURB THE TENON.

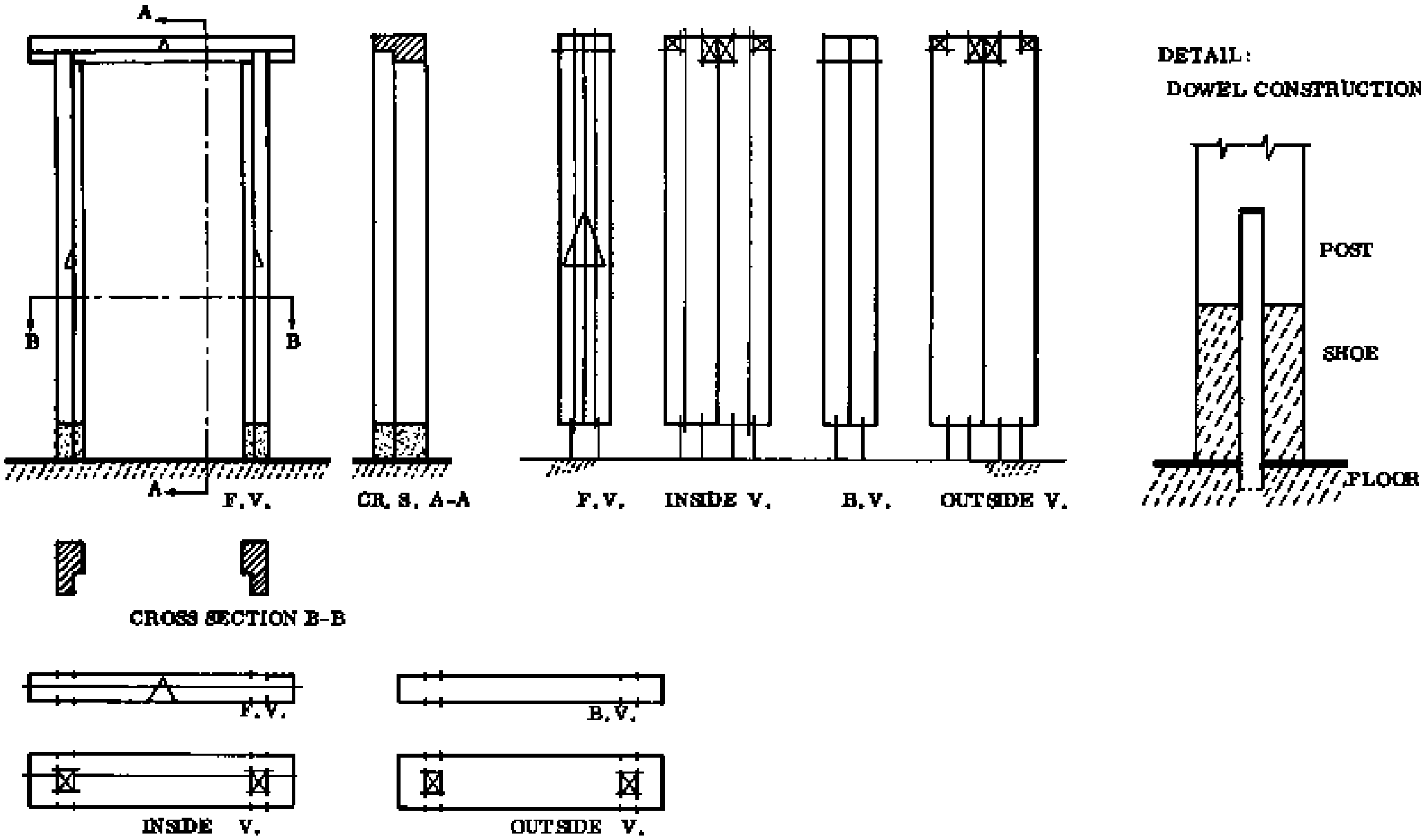
FRAME WITH CONCRETE SHOE – 2 ½ HOURS

NOTICE

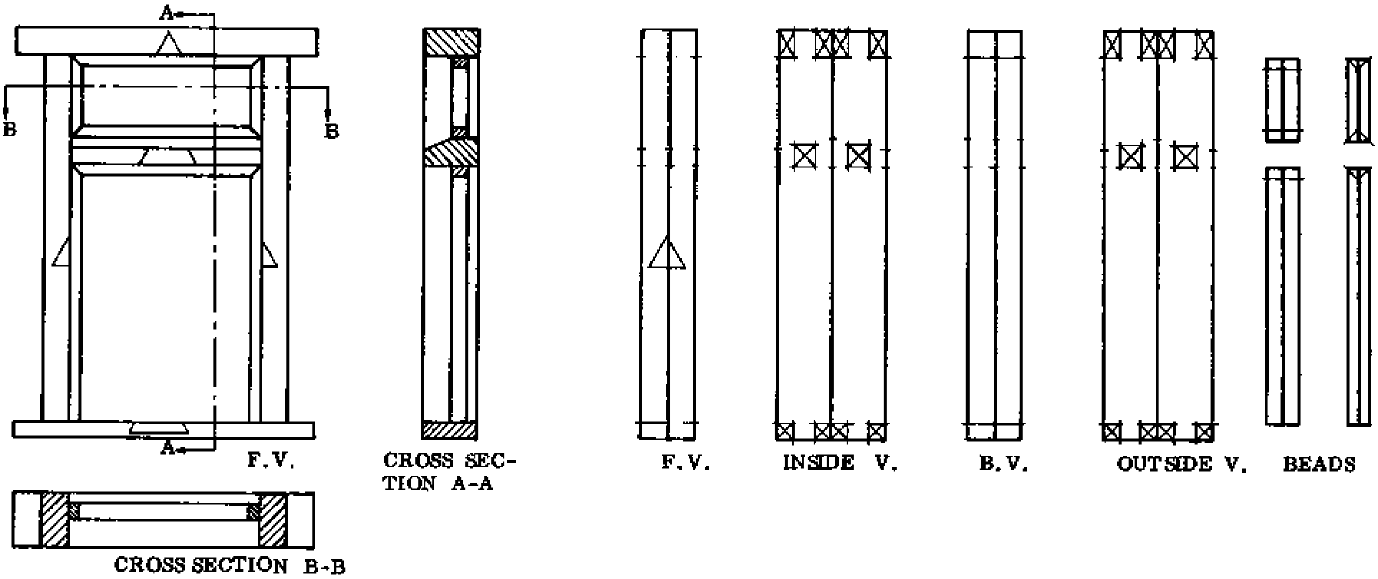
– HEIGHT OF FRAME WITH CONCRETE SHOE
– PLACING OF THE STEEL DOWELS
– CROSS SECTION B–B

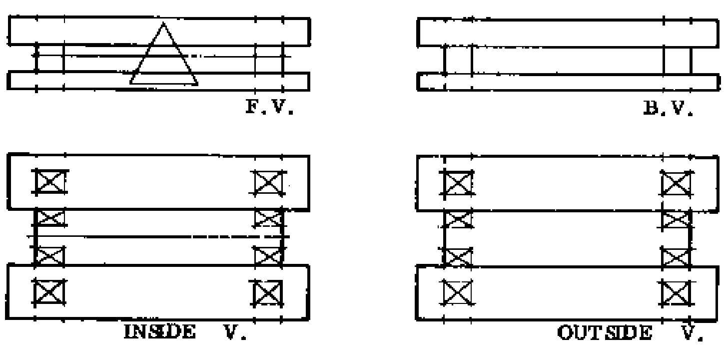
EXERCISE

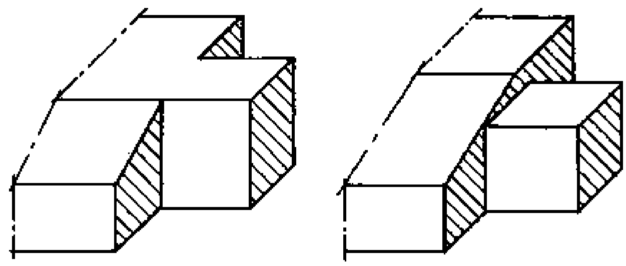
– MARK IN ALL DIMENSIONS.
– MAKE A DRAWING OF A DOOR FRAME WITH CONCRETE SHOE. USE SCALE 1 :20(cm).



FRAME WITH TRANSOM AND THRESHOLD – 3 HOURS

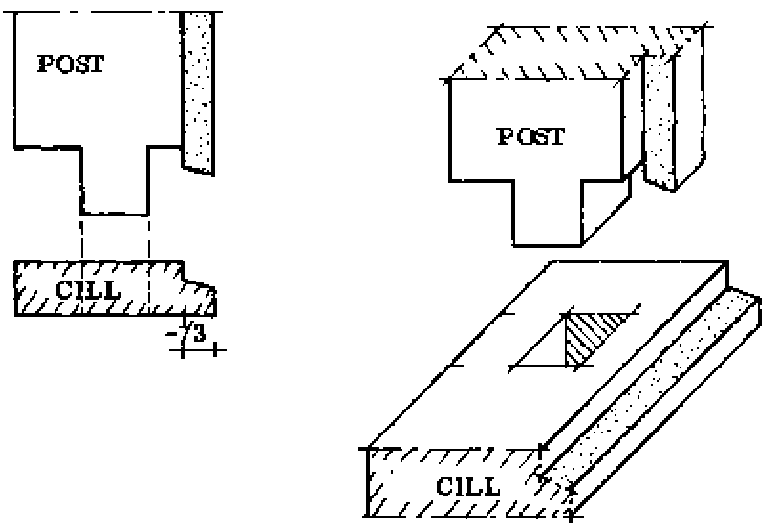




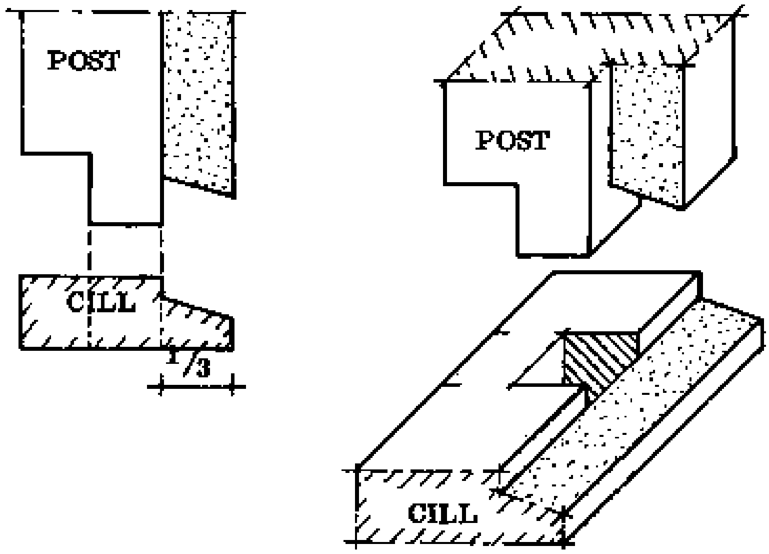


NOTICE THE DIFFERENT TENONS !

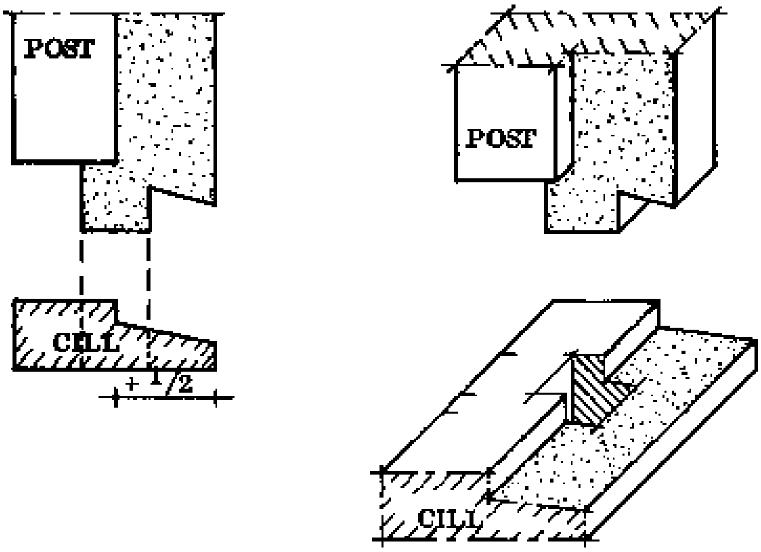
WHEN TO REDUCE MORTICE AND TENON



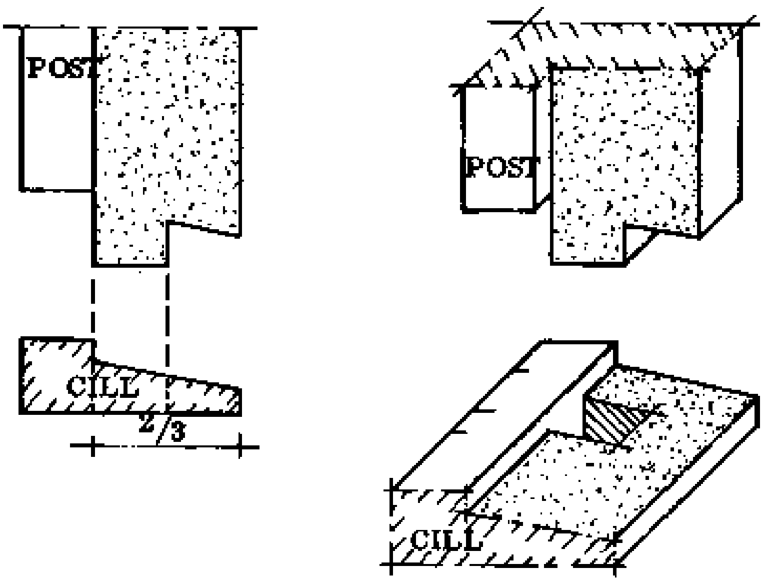
1 REBATE DOES NOT DISTURB THE TENON.



2 REBATE DOES NOT DISTURB THE TENON.



3 REBATE DOES DISTURB THE TENON.



4 REBATE DOES DISTURB THE TENON.

Window frames

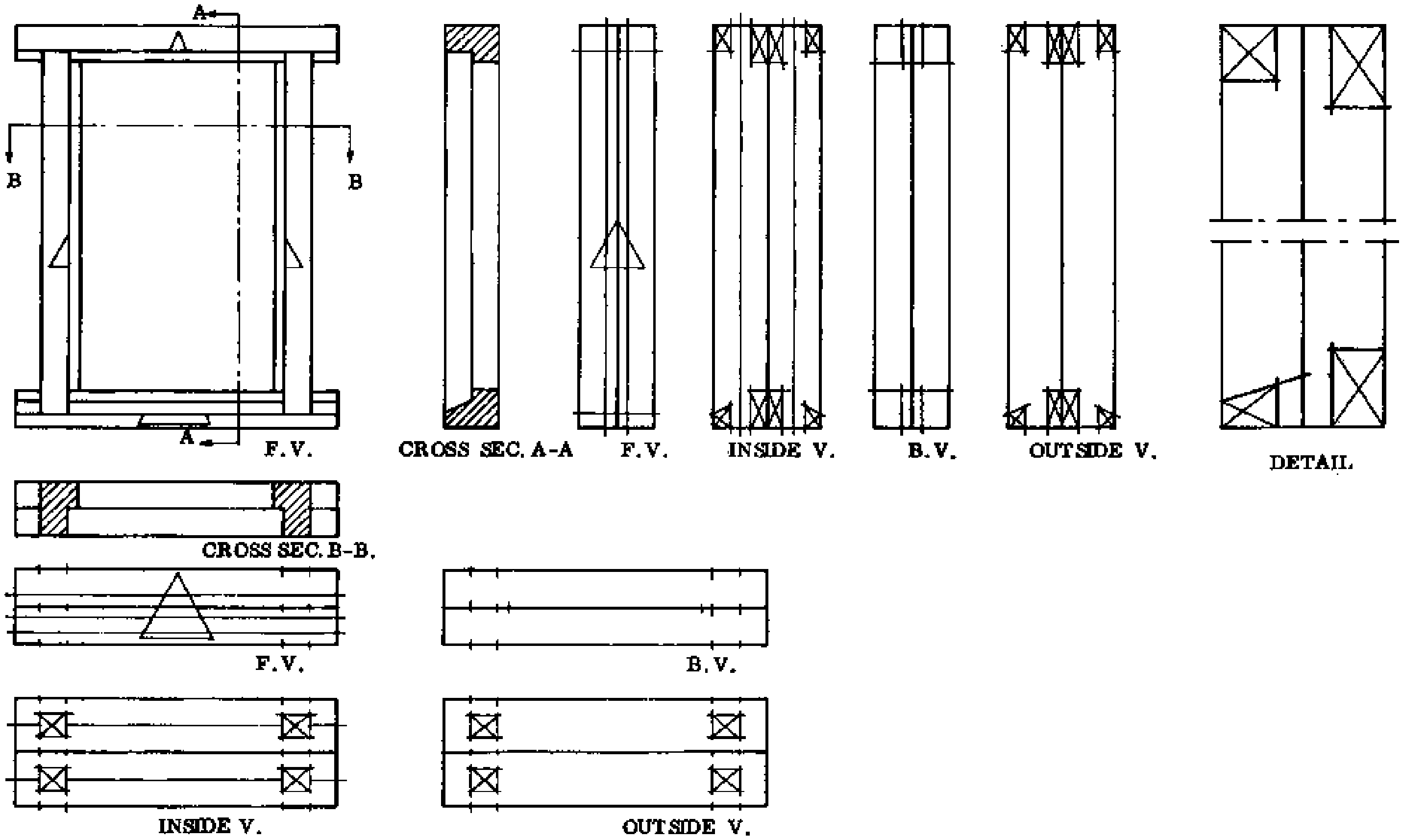
WINDOW FRAME WITH REBATE – 2 ½ HOURS

NOTICE

– FOR HEAD AND POST CONSTRUCTION SEE 68.
– FOR CILL–POST CONSTRUCTION SEE PAGE 71.

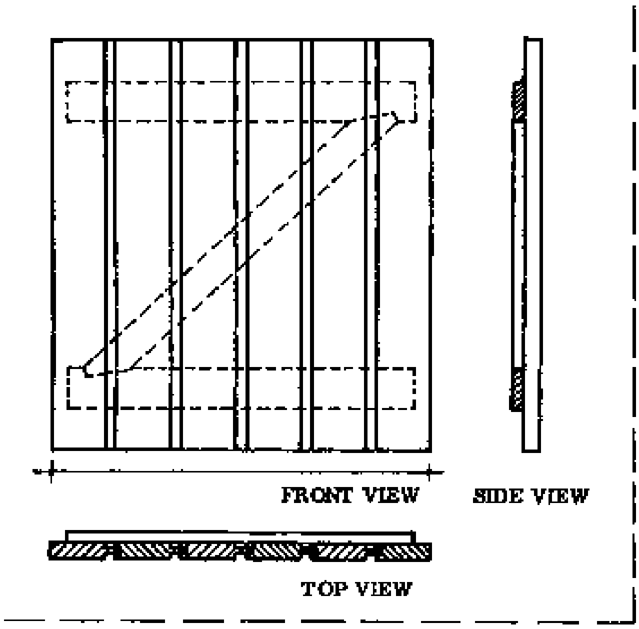
EXERCISE

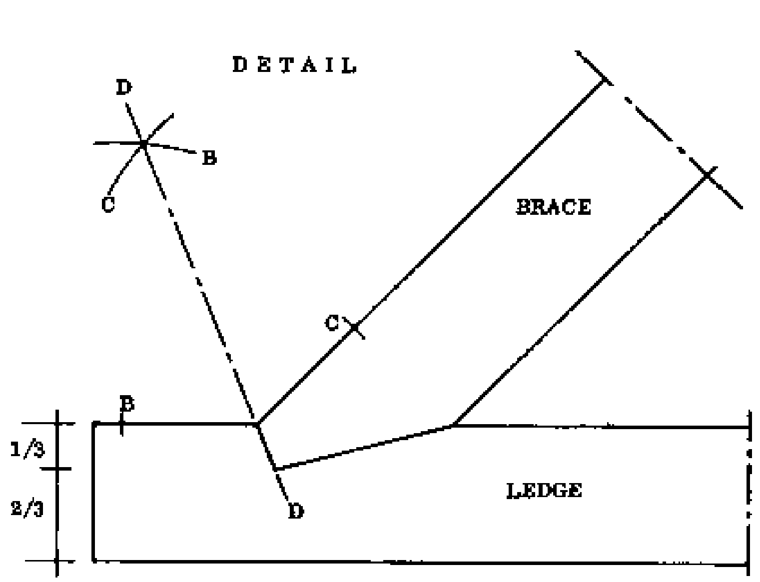
– DRAW ALL DIMENSION LINES AND MARK THEM.
– MAKE A DRAWING OF A WINDOW FRAME WITH TRANSOM AND REBATE.

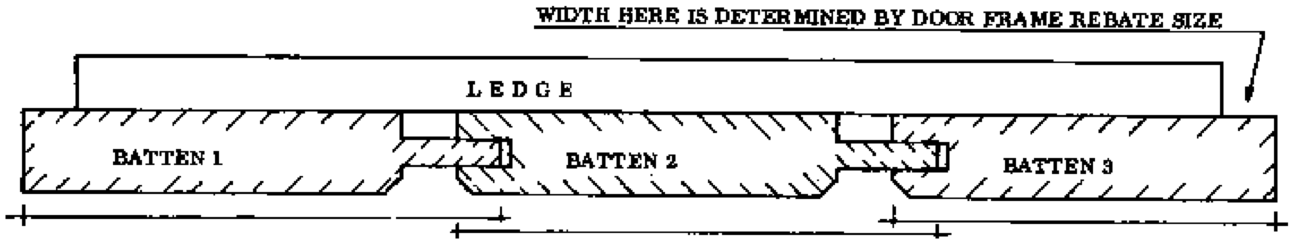


Casements and doors

LEDGED, BRACED AND BATTENED CASEMENT – 2 HOURS







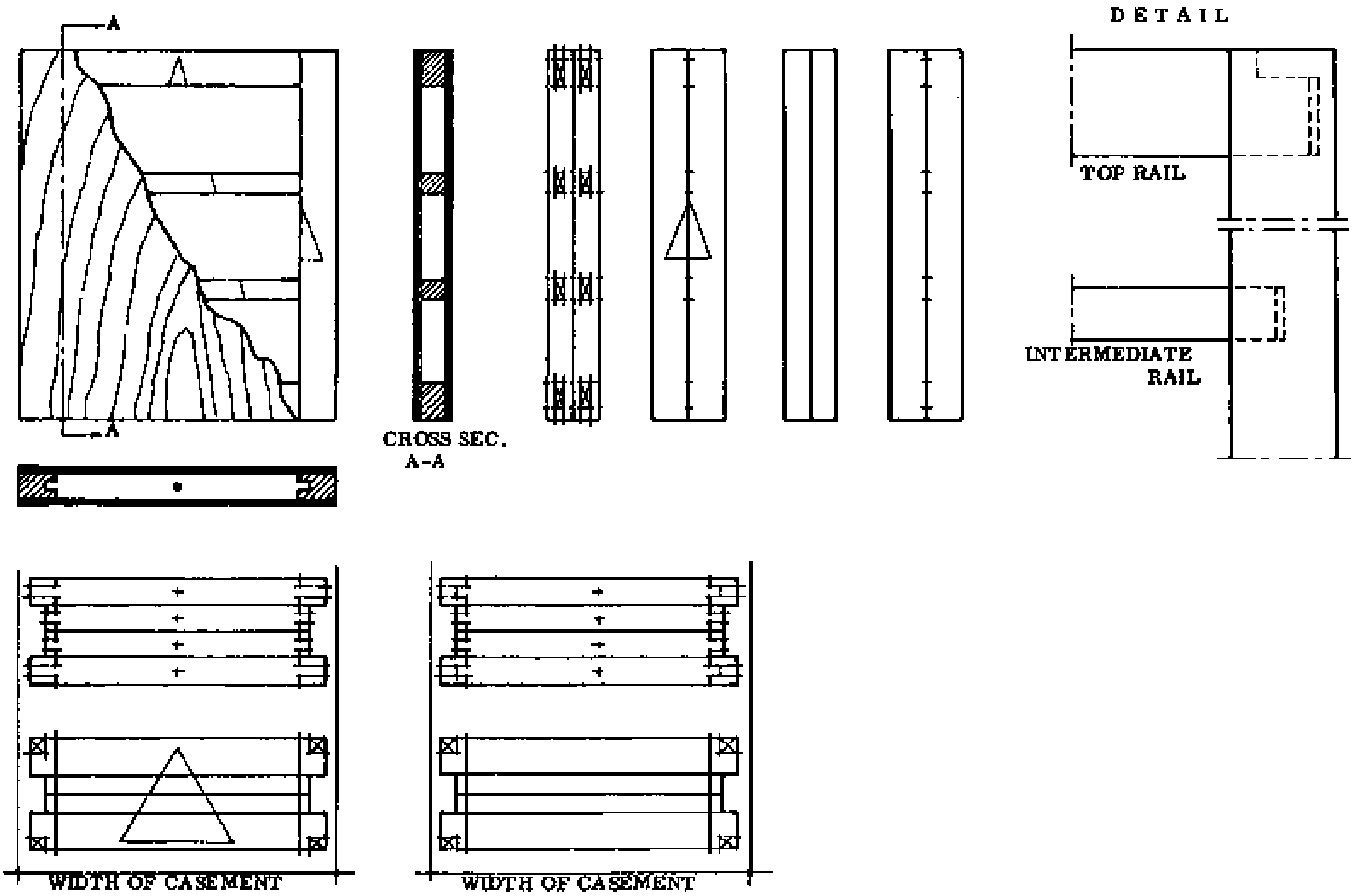
<u>FLUSH CASEMENT</u> – 2 ¾ HOURS

<u>NOTICE</u>

– HAUNCHED TENON ON TOP AND BOTTOM RAILS
– SHORT TENON ON INTERMEDIATE RAILS
– HOLES FOR VENTILATION
– FOR DOORS: ADD LOCK BLOCK

<u>EXERCISE</u>

– DRAW ALL DIMENSION LINES.
– MARK IN ALL DIMENSIONS.
– MAKE A DRAWING OF A FLUSH DOOR.



PANELLED CASEMENT – 2 ½ HOURS

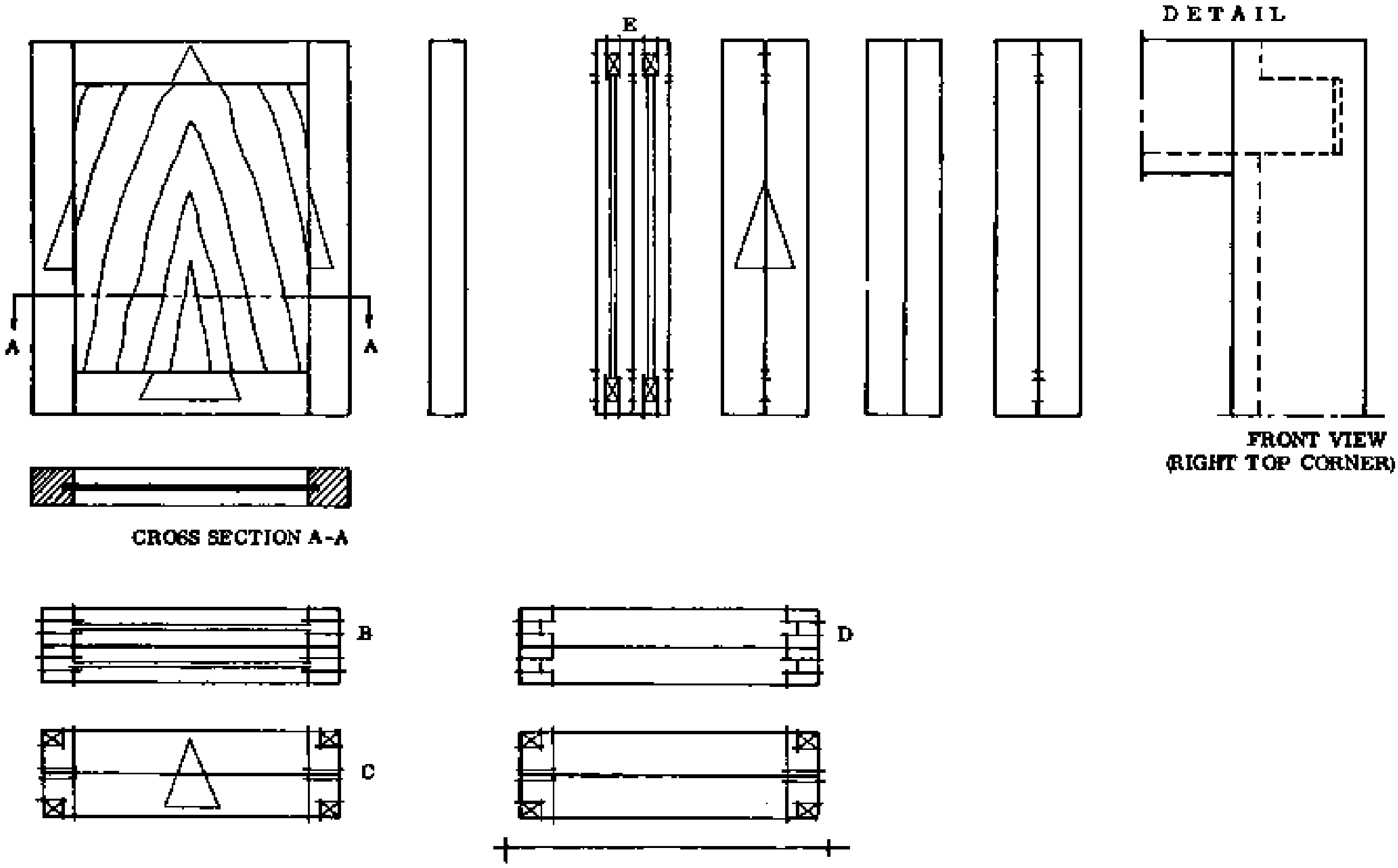
<u>NOTICE</u>

– COMPARE TO PAGE 76.
– THEN COMPARE "B" "C" "D" "E"

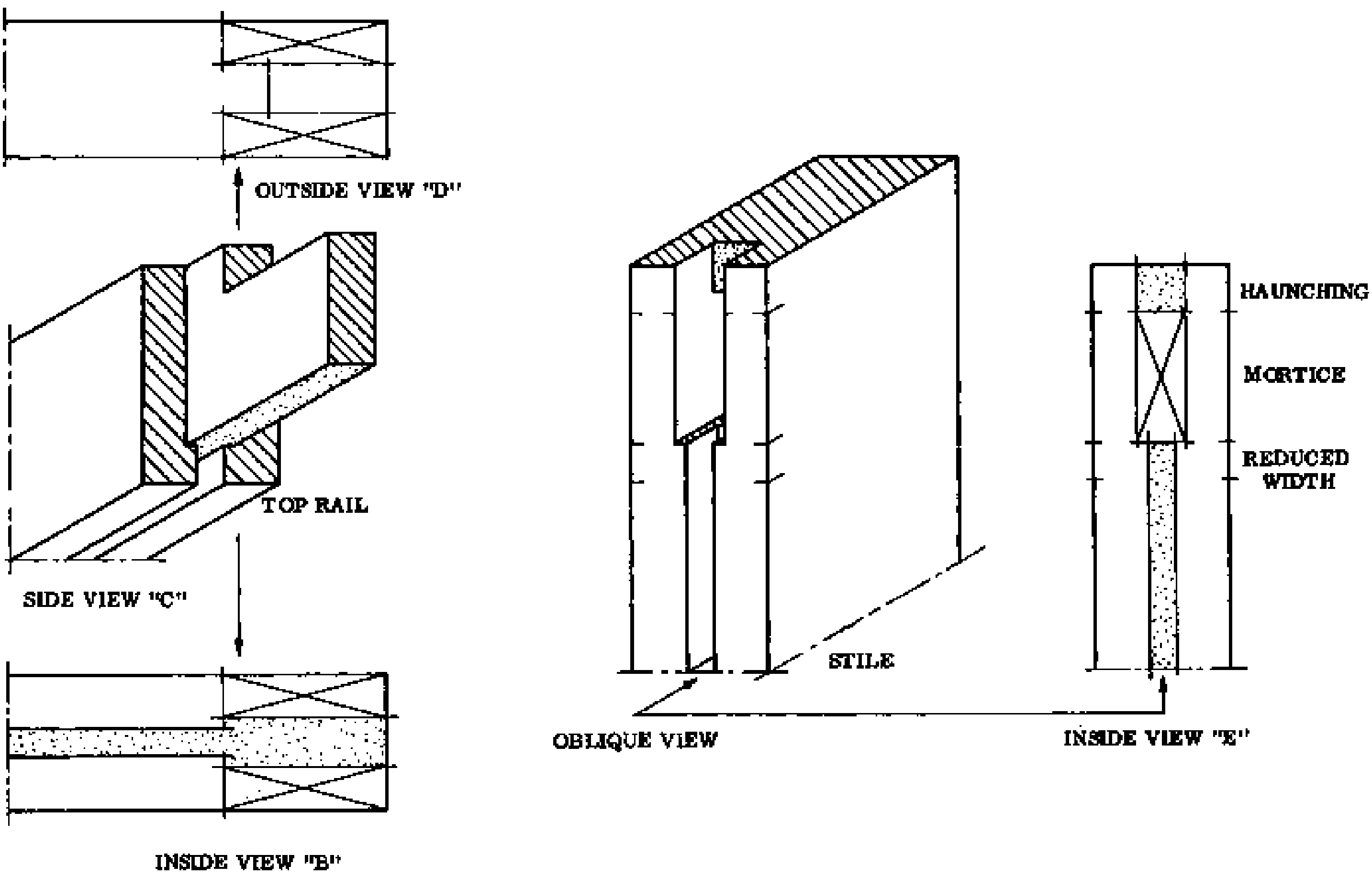
<u>EXERCISE</u>

– DRAW ALL DIMENSION LINES.
– MARK IN ALL DIMENSIONS.
– NAME ALL THE VIEWS.
– MAKE A DRAWING OF A PANELLED DOOR.

REMEMBER THAT THE TOP AND BOTTOM RAILS ARE SHORTER BECAUSE OF THE STOPPED MORTICE AND TENON!



GROOVED STILE AND TOPRAIL MARKING OUT



<u>NOTICE DOTTED AREAS</u>

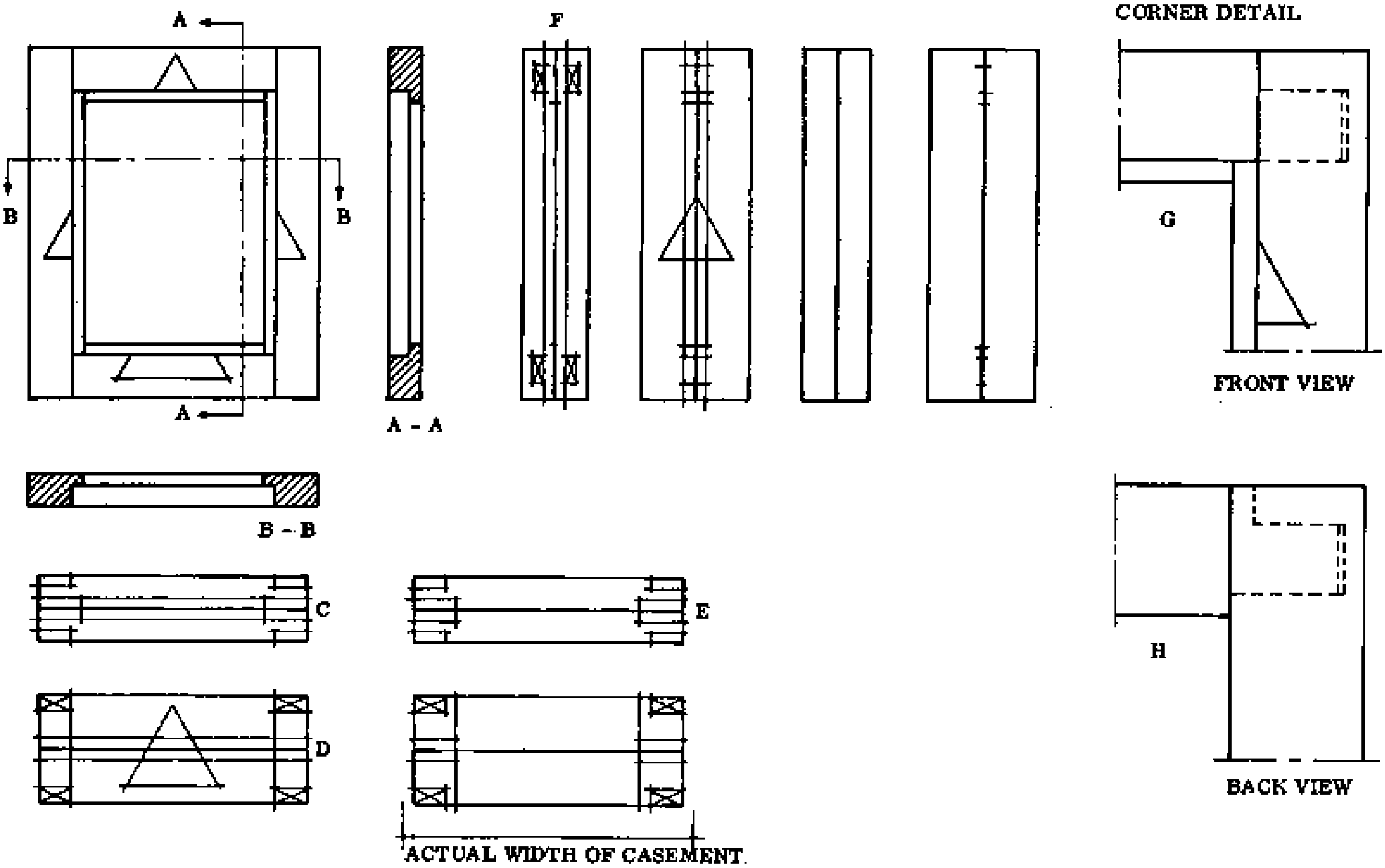
REBATED CASEMENT – 2 ¾ HOURS

NOTICE

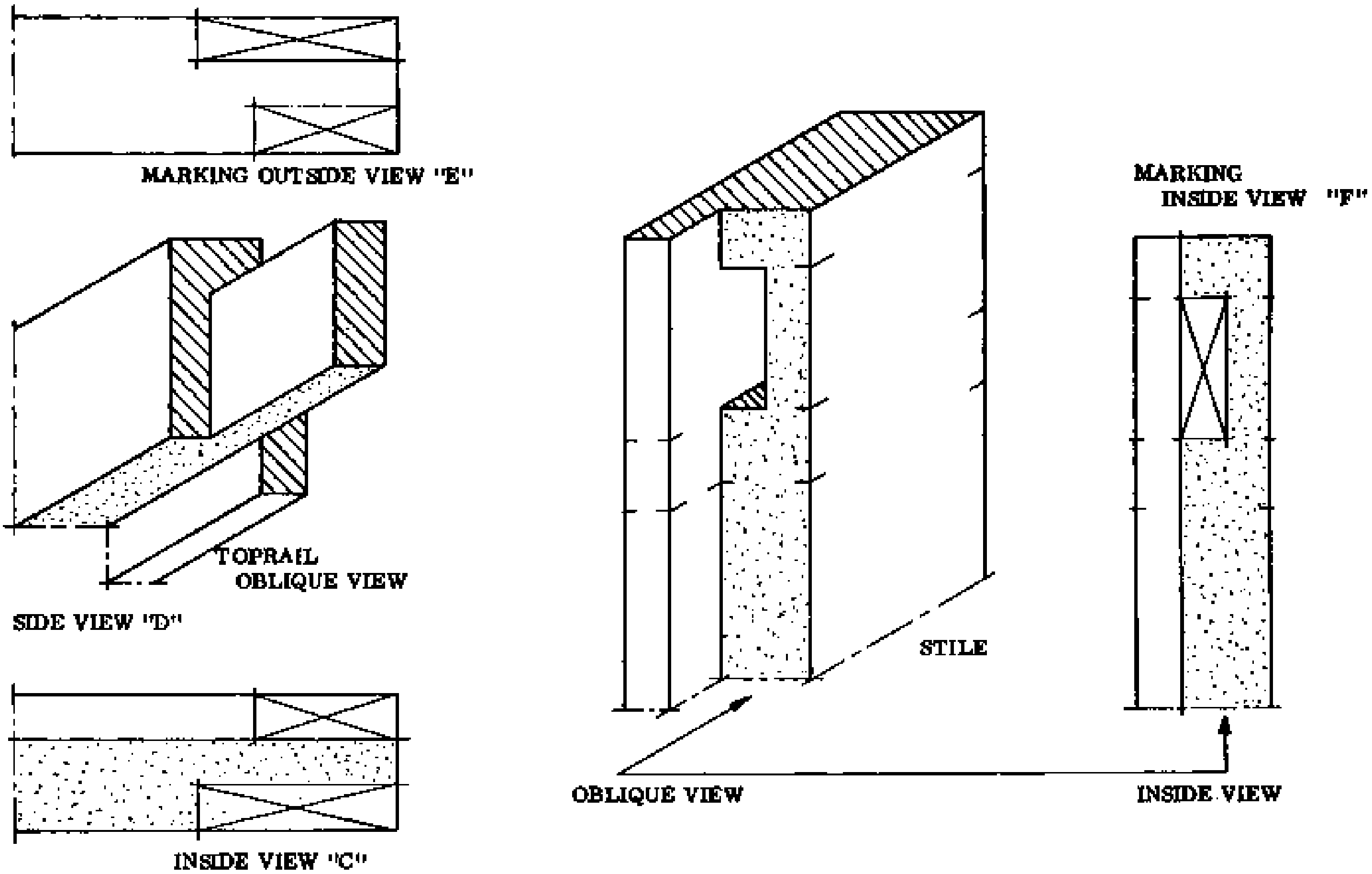
- – COMPARE WITH PAGE 78.
- – THEN COMPARE "C" "D" "E" "F".
- –NOTICE SHOULDERS AT "G" "H".

EXERCISE

- – NAME ALL VIEWS.
- – DRAW ALL DIMENSION LINES.
- – MARK IN ALL DIMENSIONS.
- – MAKE A DRAWING OF A REBATED DOOR.



REBATED STILE AND TOPRAIL CONSTRUCTION



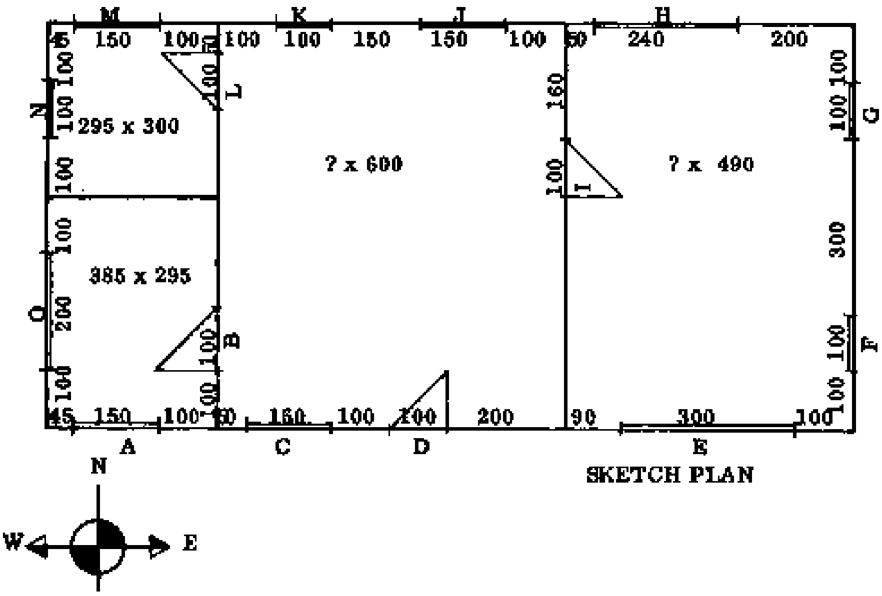
NOTICE DOTTED AREAS

FORM III

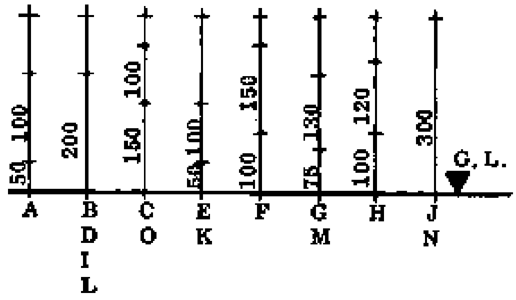
Working drawings

TO BE ABLE TO MAKE A WORKING DRAWING FOR A BUILDING YOU NEED A SKETCHPLAN WITH THE NECESSARY DETAILS SUCH AS INSIDE DIMENSIONS OF THE ROOMS,: THE POSITIONS OF THE WINDOWS AND DOORS. ETC.

ON THE NEXT PAGE YOU WILL FIND A LAY–OUT OF HOW TO WRITE DOWN ALL THE TECHNICAL DATA REGARDING MATERIALS AND SOME DIMENSIONS.



SKETCH PLAN



WALL THICKNESS = 15 cm

SKETCH PLAN

TECHNICAL DATA

ROOF CONSTRUCTION, MAIN BUILDING

KIND OF ROOF			ODUM WOOD
RISE OF ROOF		cm	
RISE OF TRUSS		cm	
KIND OF COVERING	x	cm	ALUMINIUM
SPAN OF TRUSS		cm	
ROOF OVERHANG, LONG SIDES		cm	
ROOF PROJECTION AT GABLE		cm	
CEILING THICKNESS		cm	PLYWOOD
FASCIA BOARDS	x	cm	WAWA
RAFTERS	x	cm	ODUM WOOD
PURLINS	x	cm	ODUM WOOD
TIE BEAM	x	cm	ODUM WOOD
BRACES	x	cm	ODUM WOOD
WALL PLATE	x	cm	ODUM WOOD

VERANDAH, ROOF CONSTRUCTION

VERANDAH, ROOF CONSTRUCTION		ODUM WOOD
KIND OF ROOF		ODUM WOOD
RISE OF ROOF	cm	
SPAN OF TRUSS	cm	
OVERHANG ON LONG SIDES	cm	
PROJECTION AT GABLE ENDS	cm	

CEILING THICKNESS		cm	PLYWOOD
FASCIA BOARDS	x	cm	WAWA
RAFTERS	x	cm	ODUM WOOD
PURLINS	x	cm	ODUM WOOD
TIE BEAM	x	cm	ODUM WOOD
BRACES	x	cm	ODUM WOOD

MAIN BUILDING

FOUNDATION	x	cm	CONCRETE
FOOTING HEIGHT ABOVE G.L.		cm	
FOOTING WIDTH		cm	SANDCRETE
WALL THICKNESS		cm	LANDCRETE
PLASTER THICKNESS(inside)		cm	CEMENT PLASTER
PLASTER THICKNESS(outside)		cm	CEMENT PLASTER
FLOOR THICKNESS		cm	ONE COURSE WORK

VERANDAH MAIN BUILDING

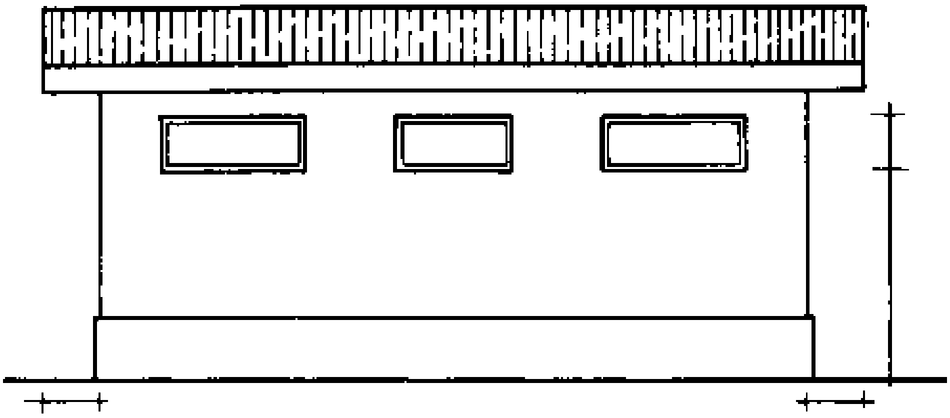
COLUMNS	x	cm	REINFORCED CONCRETE
EAVE BEAM	x	cm	REINFORCED CONCRETE
EAVE PLATE	x	cm	ODUM WOOD
FLOOR SLOPE		%	PER METER
FOOTING HEIGHT ABOVE G.L.		cm	
FOOTING WIDTH		cm	SANDCRETE
FOUNDATION	x	cm	CONCRETE
FLOOR THICKNESS		cm	ONE COURSE WORK

DIRECTION OF BUILDING EAST / WEST NORTH – SOUTH

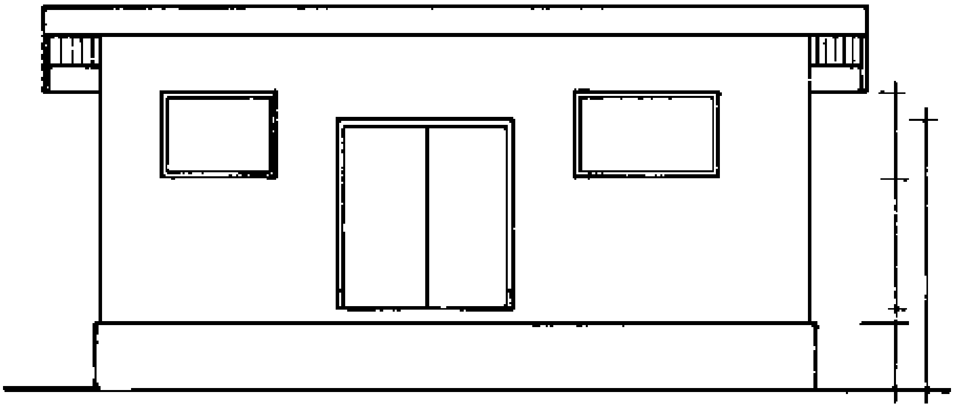
SPECIAL REQUIREMENTS

Building with pentroof

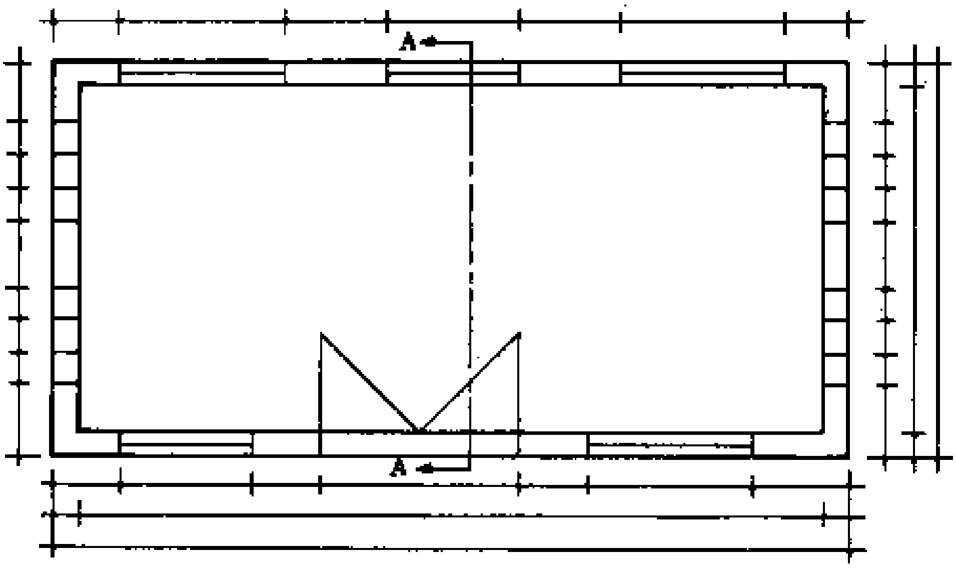
EXERCISE: MAKE AN ORTHOGRAPHIC DRAWING WITH CROSS SECTION OF A BUILDING WITH PENTROOF. USE SCALE 1 : 100 (cm). – 5 HOURS



BACK VIEW

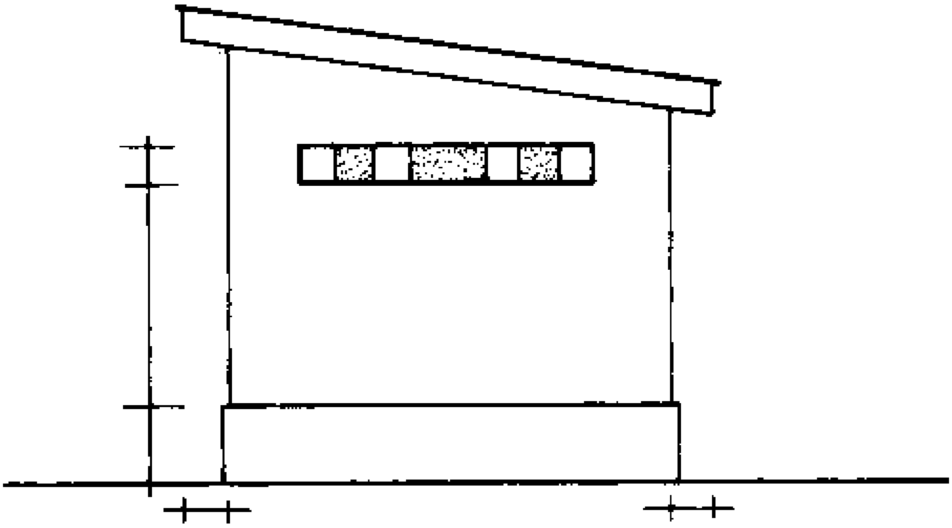


FRONT VIEW

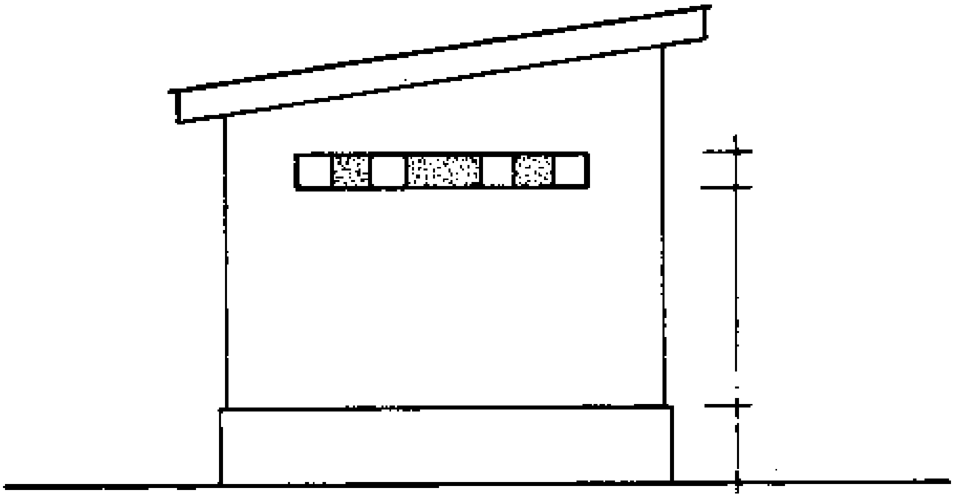


PLAN

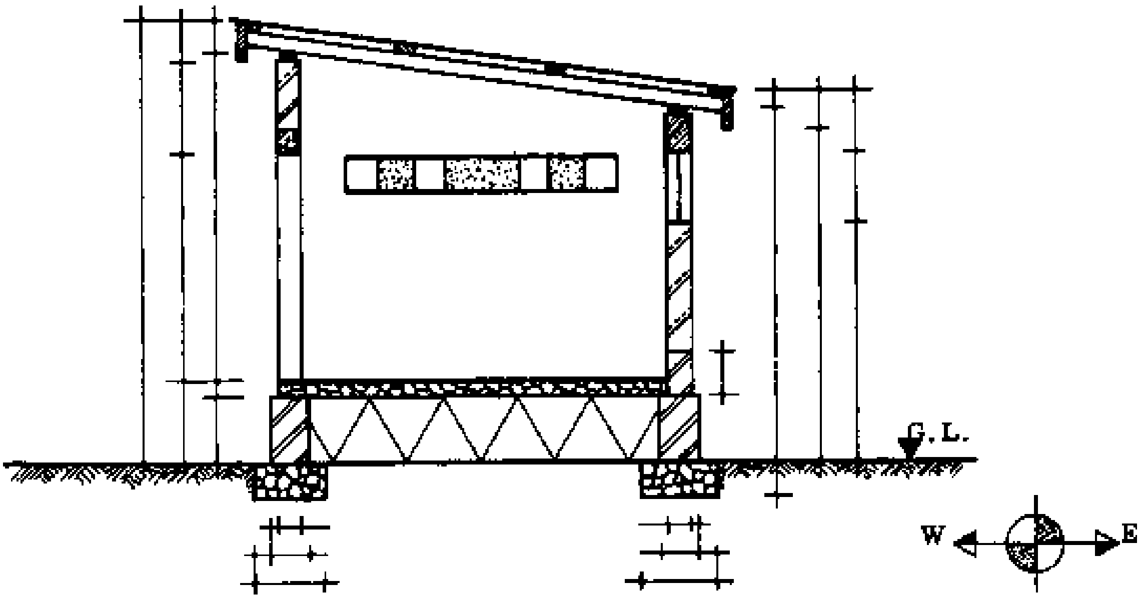
BUILDING WITH PENTROOF



RIGHT SIDE VIEW



LEFT SIDE VIEW



CROSS SECTION A–A

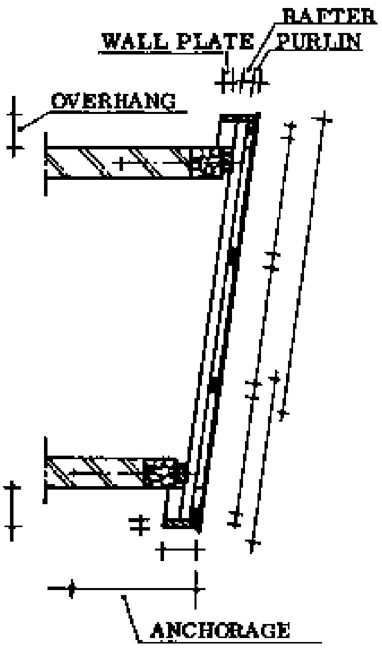
Pentroof plan

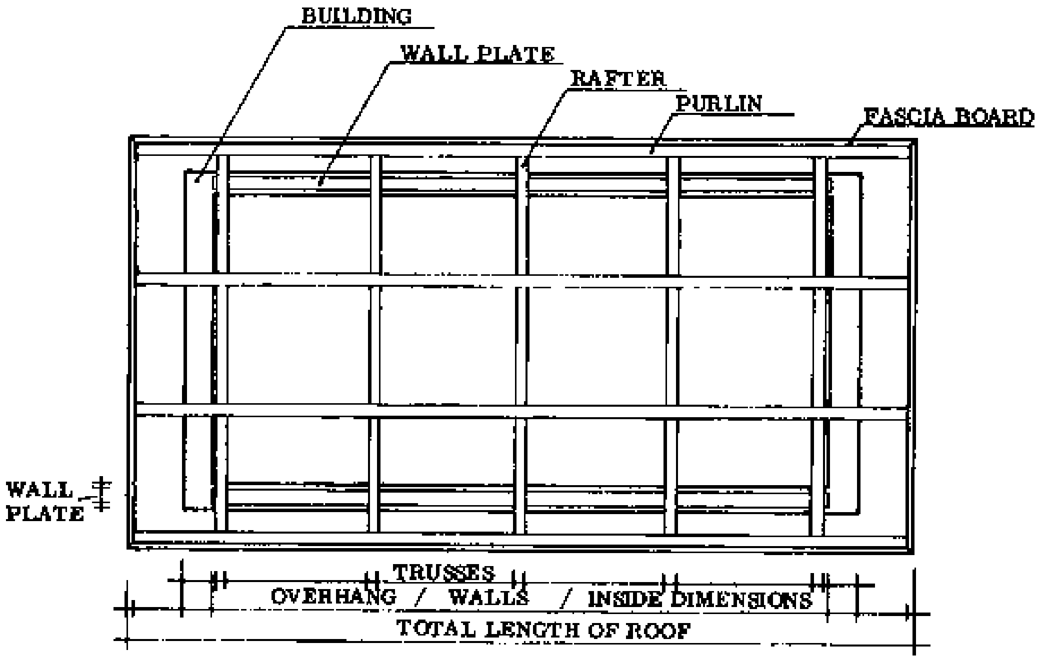
PENTROOF PLAN – 2 ½ HOURS

REMEMBER:

- LENGTH OF THE ROOF IS MEASURED ON THE PLAN.
- WIDTH OF THE ROOF IS MEASURED ON THE CROSS SECTION.
- THE OVERHANG OF THE ROOF IS MEASURED SQUARE TO THE WALL.
- FIRST DRAW THE CROSS SECTION, THEN THE PLAN.

EXERCISE : MAKE A ROOF PLAN FOR A STORE WITH A PENT ROOF. USE A SCALE OF 1 : 50 (cm).





Parapetted pent roof

<u>PARAPETTED PENT ROOF</u> – 4 HOURS

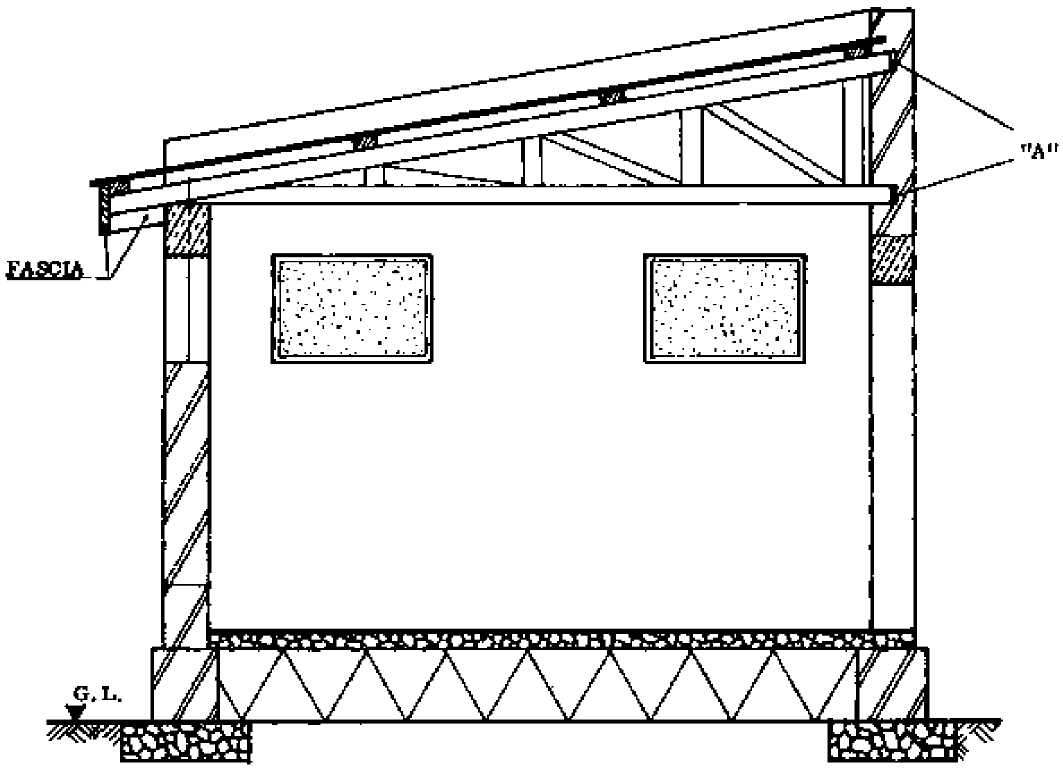
STUDY CAREFULLY THE BACK VIEW OF THE BUILDING ON PAGE 86.

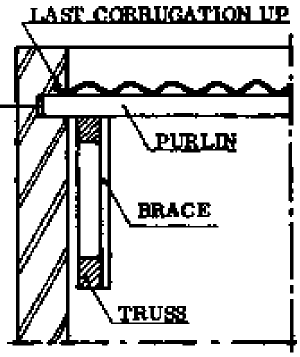
<u>NOTICE</u>

- EXPANSION GAPS AT "A"
- FASCIA OVERHANG
- PARAPET PROJECTION
- CONCRETE BELT INSTEAD OF A WOODEN WALL PLATE
- FOR BACK VIEW SEE PAGE 86

<u>EXERCISE</u>

MAKE AN ORTHOGRAPHIC DRAWING
WITH CROSS SECTION OF A STORE
WITH A PARA PETTED ROOF.

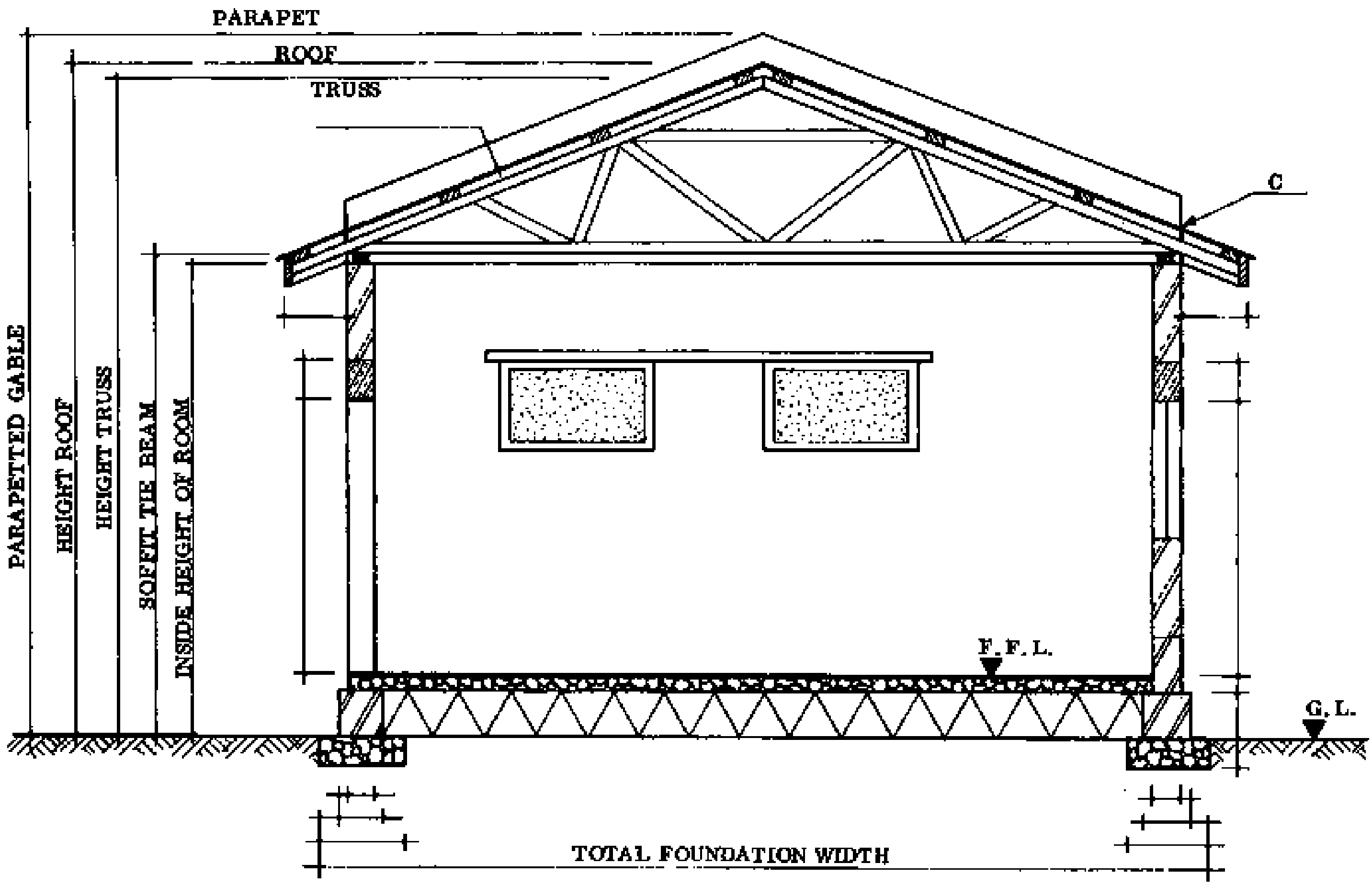




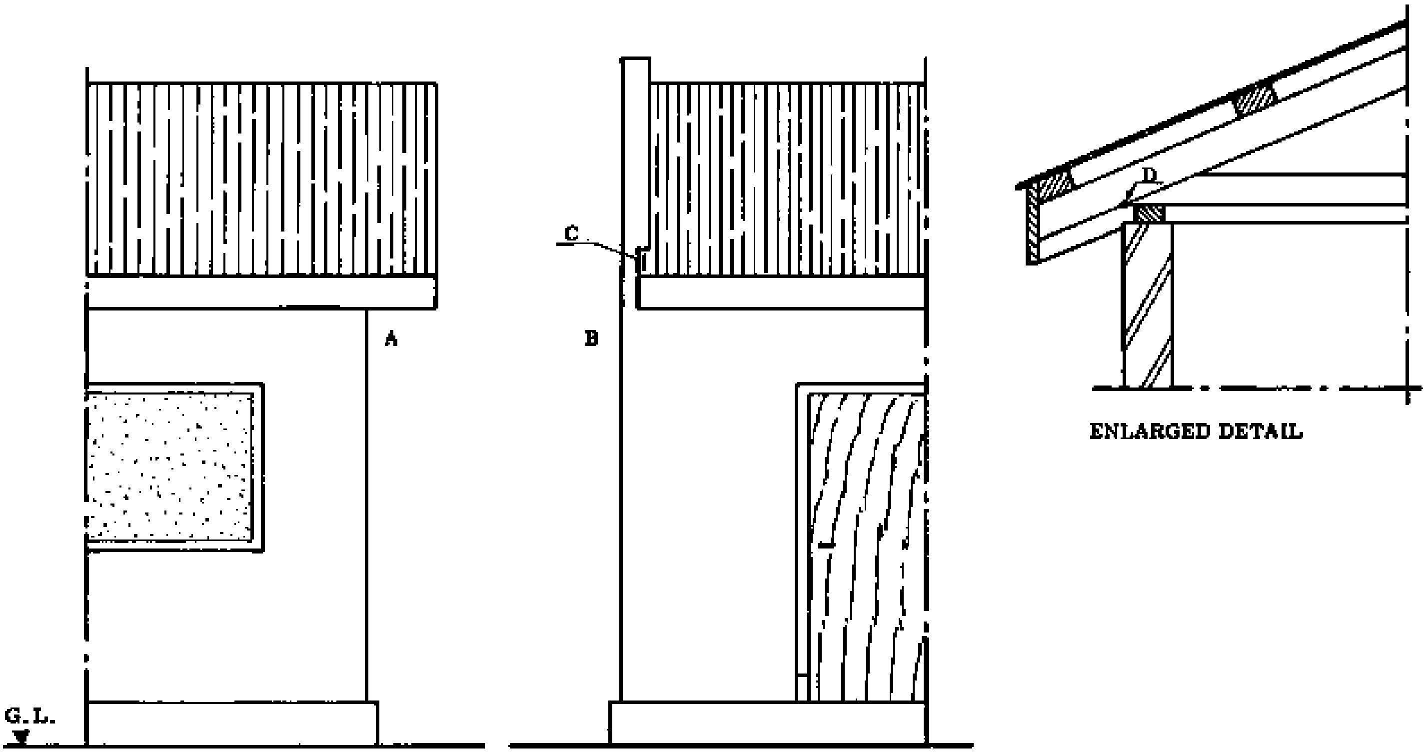
DETAIL

CROSS SECTION K - K

Parapetted gable roof



PARAPETTED GABLE ROOF



BACK VIEW
GABLE PROJECTION

BACK VIEW
PARAPETTED GABLE

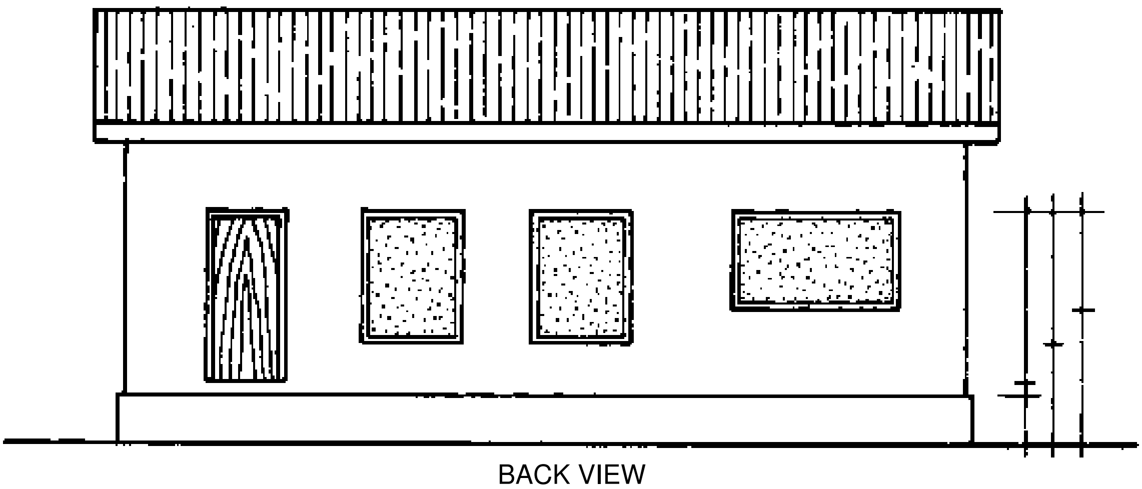
<u>BACK VIEW OF A BUILDING WITH GABLE ROOF</u>

<u>NOTICE</u>

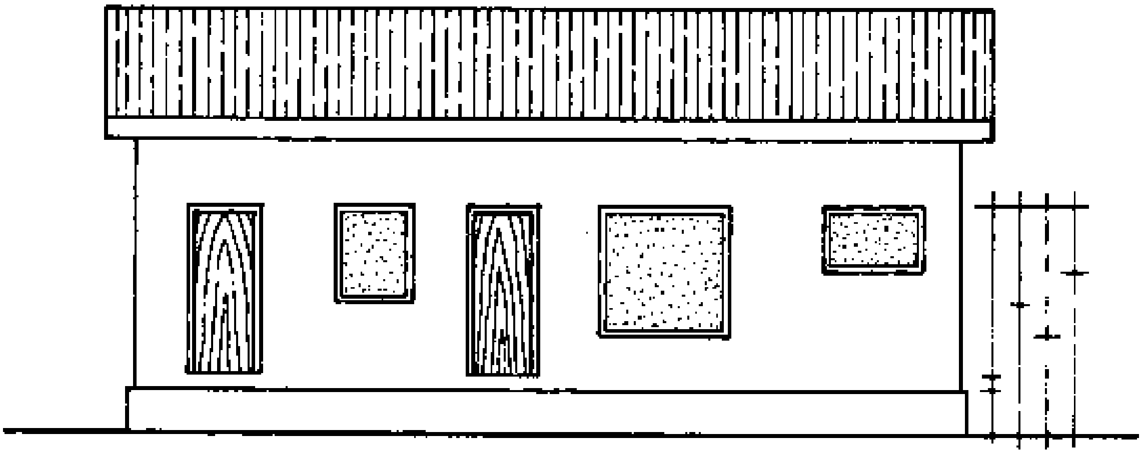
– PROJECTION AT GABLE A
– PARAPETTED GABLE AT B
– THE SHEETS ARE SET INTO THE WALL AT C.
– THE SPAN OF THE TRUSS IS MEASURED FROM POINT D.

Building with gable roof

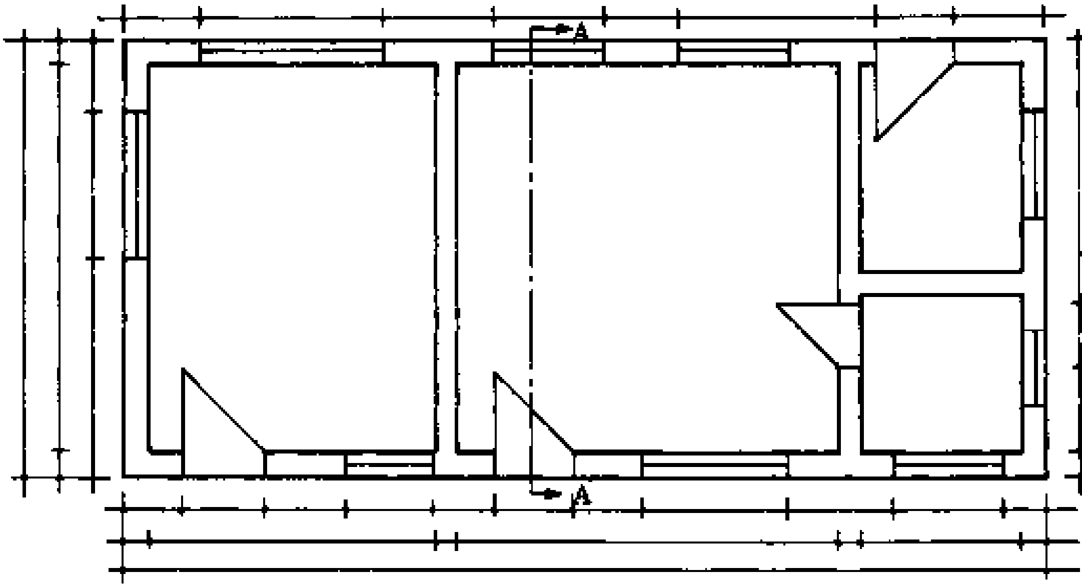
EXERCISE: MAKE AN ORTHOGRAPHIC DRAWING WITH CROSS SECTION OF A BUILDING WITH A GABLE ROOF; USE SCALE 1 : 100 (cm). – 4 ½ HOURS



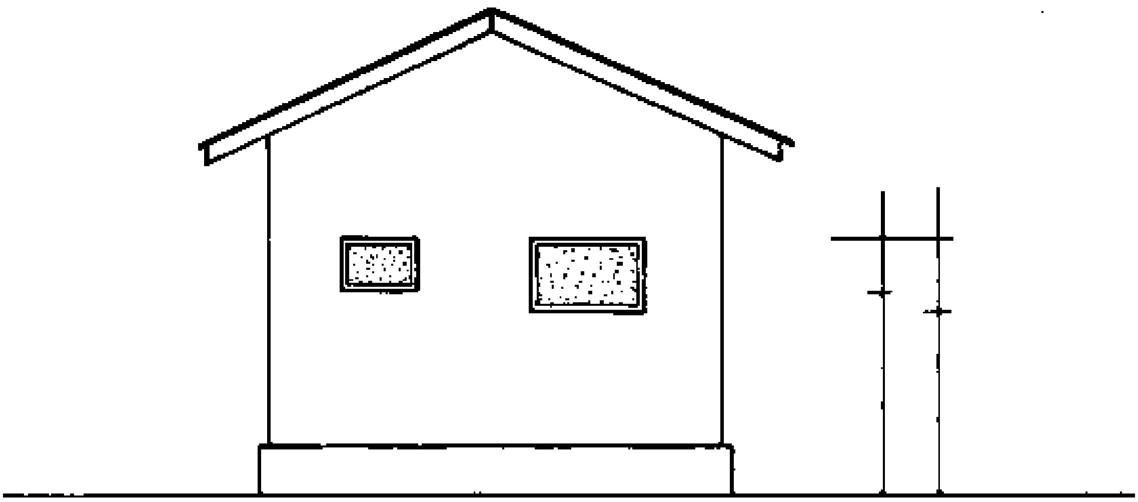
BACK VIEW



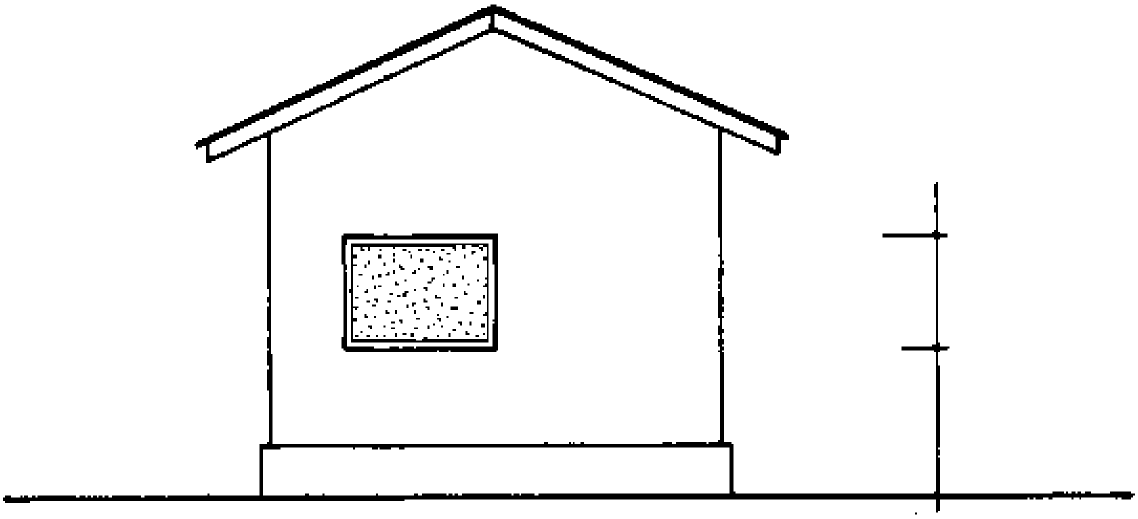
FRONT VIEW



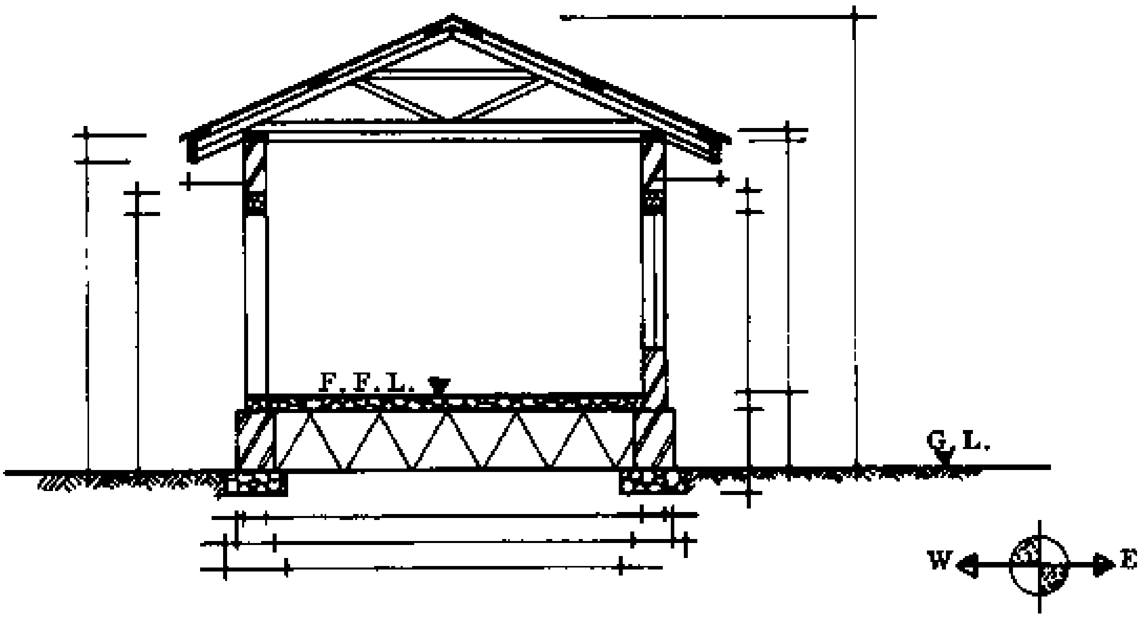
PLAN



RIGHT SIDE VIEW



LEFT SIDE VIEW

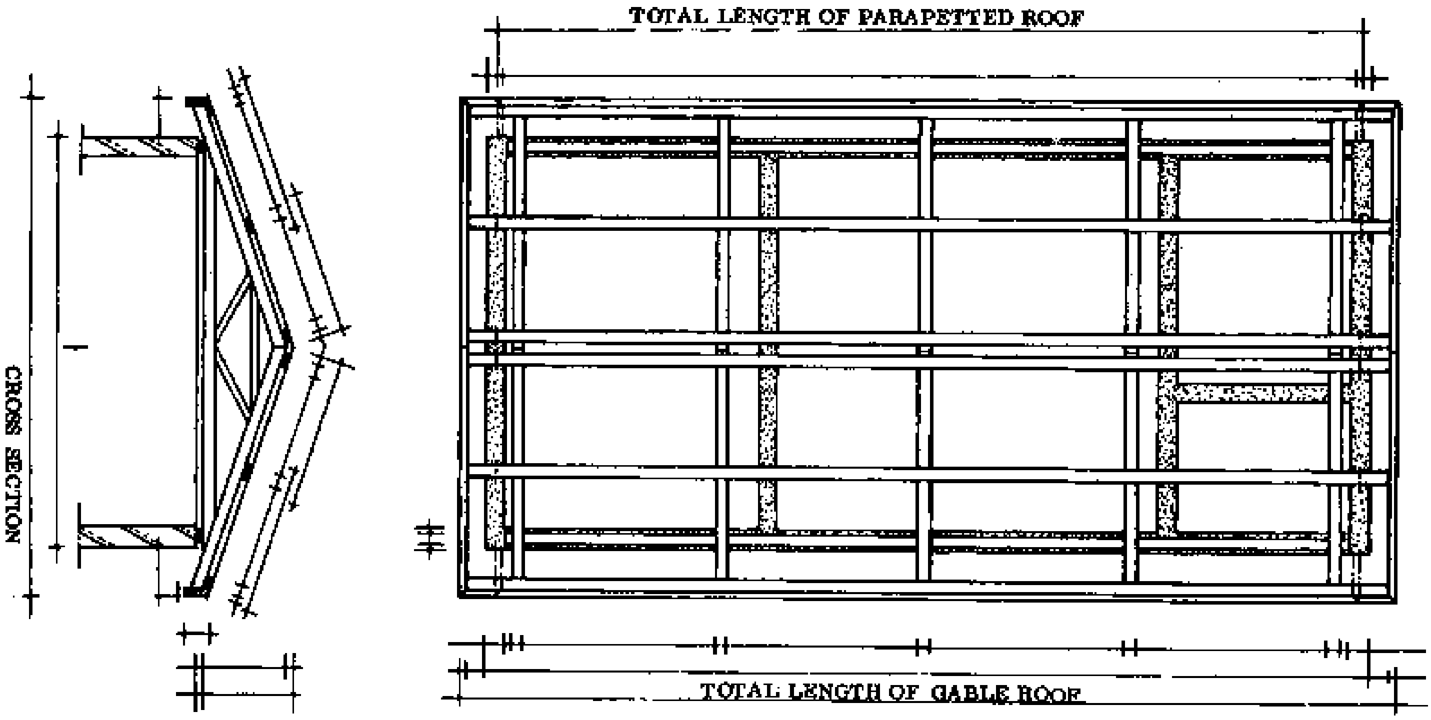


CROSS SECTION A–A

Gable roof plan

<u>GABLE ROOF AND PARAPETTED GABLE ROOF</u> – 3 ½ HOURS

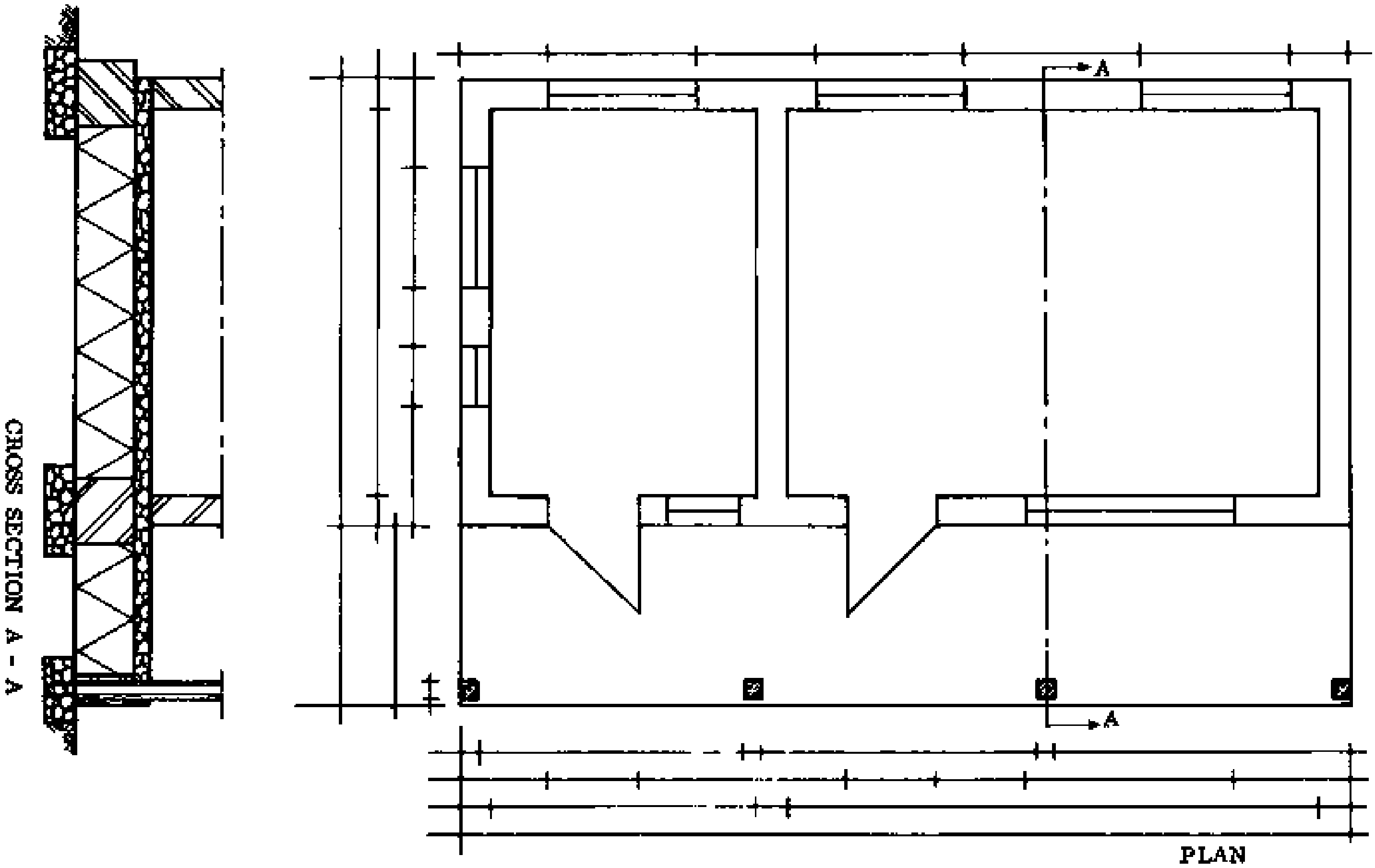
EXERCISE: NAME ALL DIMENSION LINES.
MAKE A DRAWING OF THE ABOVE ROOF DESIGNS.



Building with verandah

<u>PLAN FOR HOUSE WITH VERANDAH</u> – 1 ½ HOURS

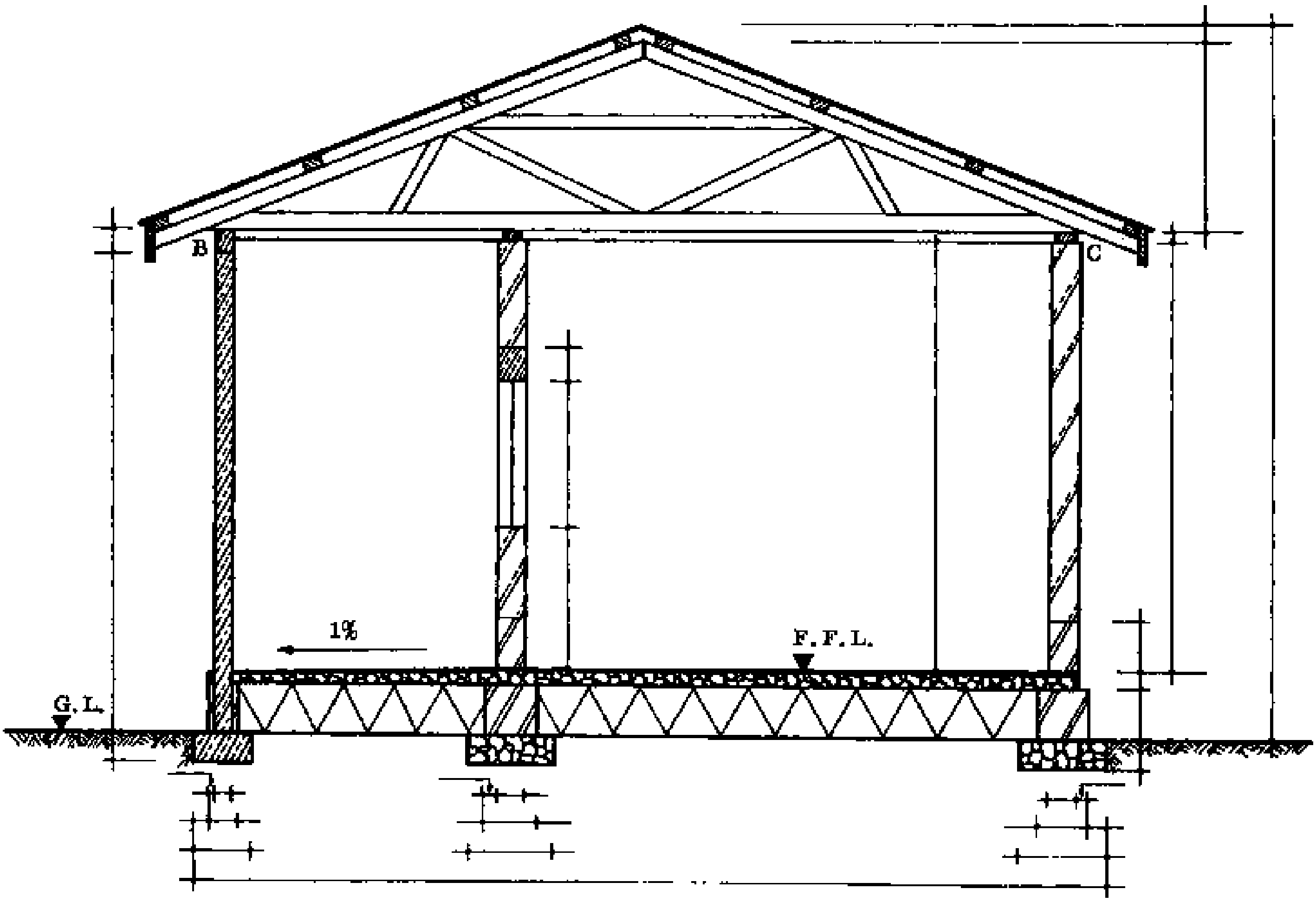
EXERCISE: MARK IN ALL DIMENSIONS.
MAKE AN ORTHOGRAPHIC DRAWING OF A BUILDING WITH A VERANDAH;
DRAW PLAN, VIEWS AND CROSS SECTION.
USE SCALE 1 : 100 (cm). BEFORE DRAWING SEE ALSO PAGE 91 and 92.



BUILDING WITH VERANDAH

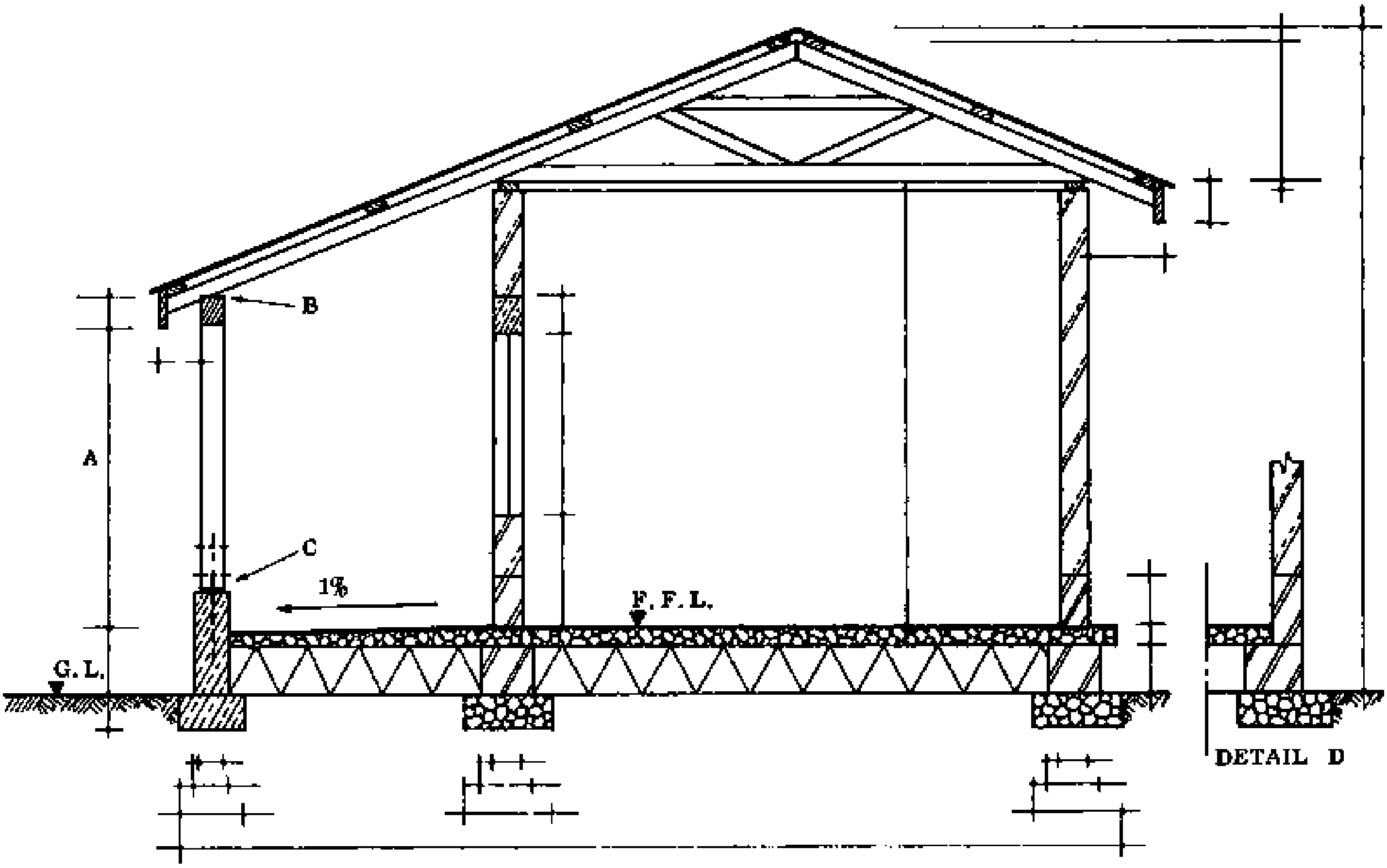
GABLE ROOF DESIGN

NOTICE: SPAN OF TRUSS GOES FROM OUTSIDE FOOTING TO OUTSIDE WALL (B & C). SEE ALSO PAGE 90. COMPARE THIS CROSS SECTION WITH PAGE 92.



BUILDING WITH VERANDAH

GABLE ROOF AND OVERHANG DESIGN

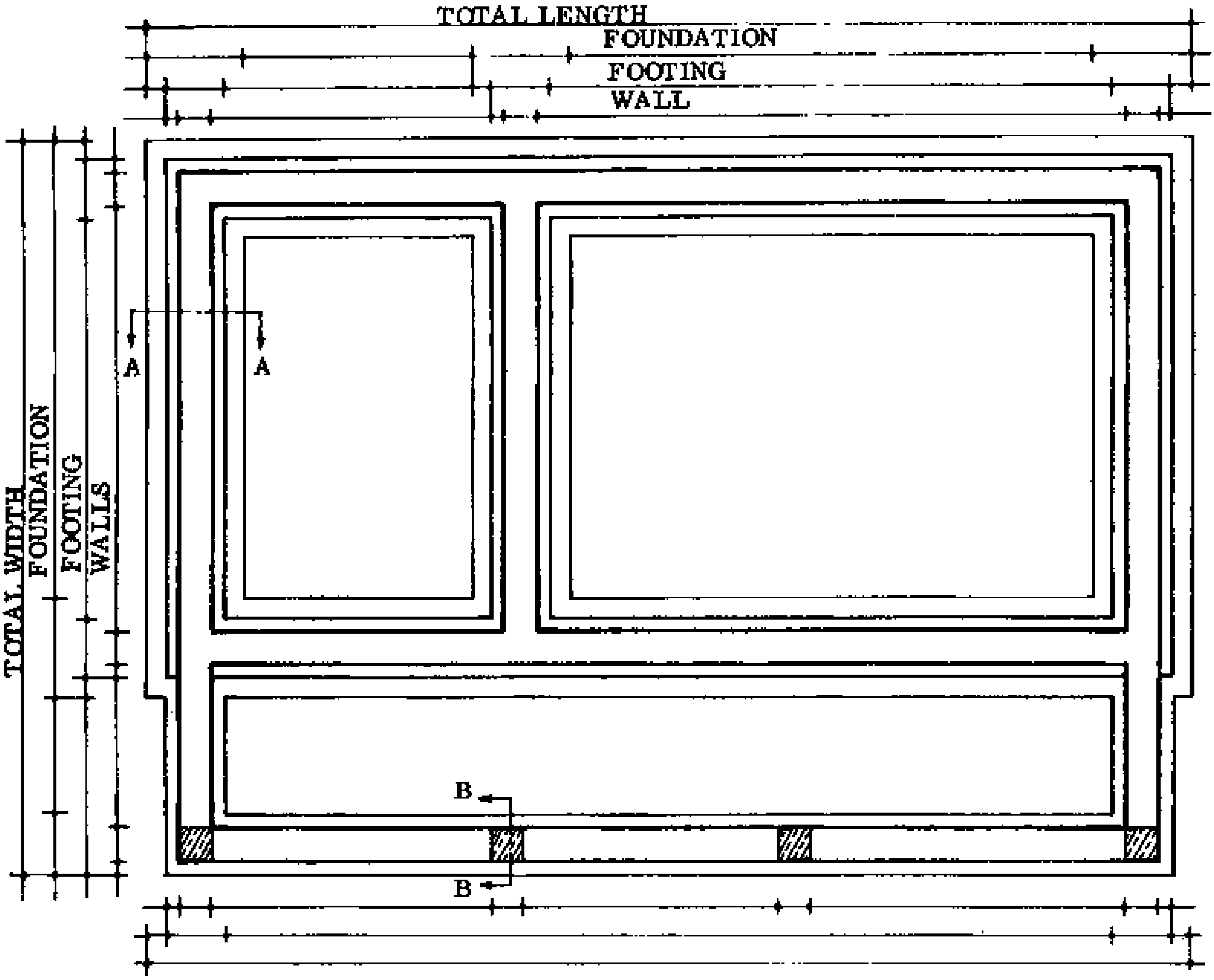


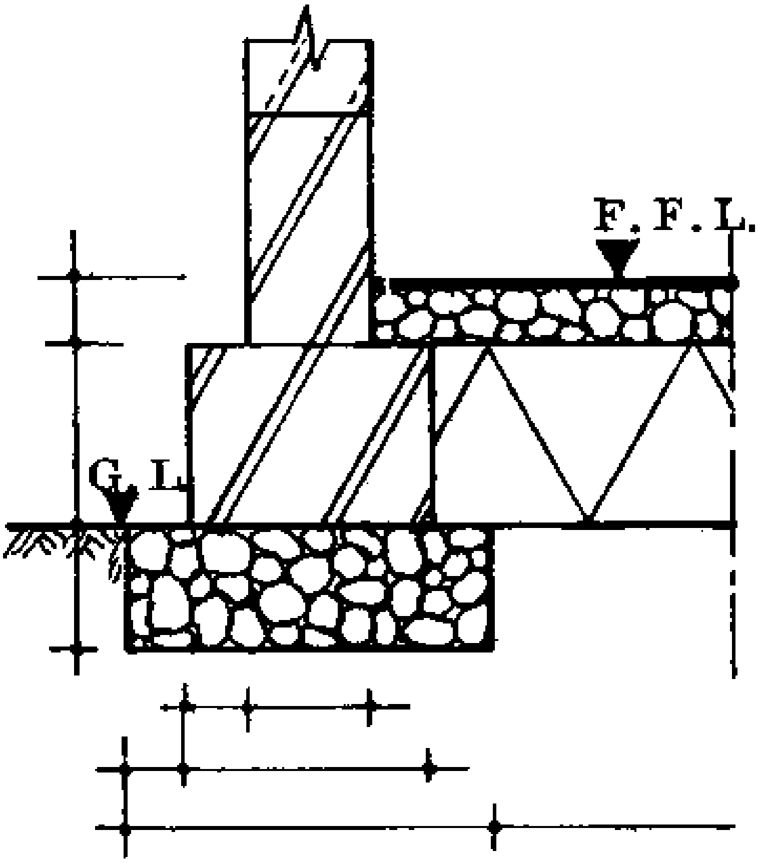
A = HEIGHT IS VERY IMPORTANT
B = NOTICE THE BIRD 'S MOUTH
C = WOODEN POST CONSTRUCTION
D = ALTERNATIVE FLOOR CONSTRUCTION

Foundation plan

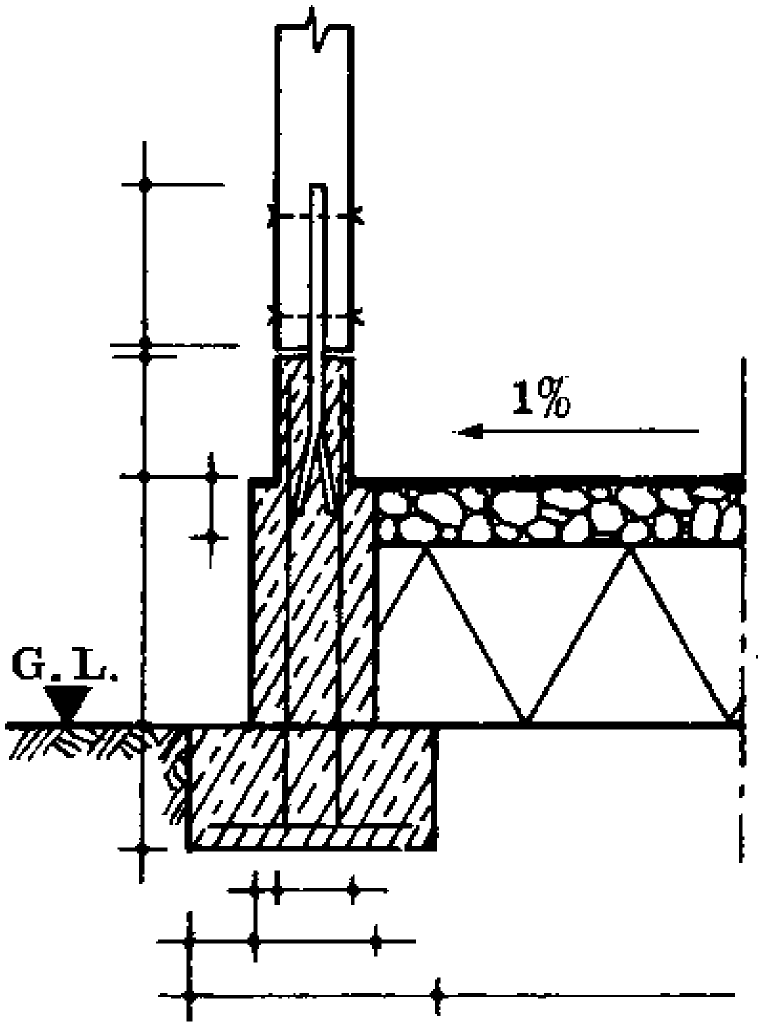
<u>FOUNDATION PLAN</u> – 2 HOURS

BUILDING WITH VERANDAH
SEE ALSO **BUILDING WITH VERANDAH:** GABLE ROOF AND OVERHANG DESIGN


TOTAL LENGTH
FOUNDATION
FOOTING
WALL
TOTAL WIDTH
FOUNDATION
FOOTING
WALLS
A
A
B
B



CROSS SECTION A–A

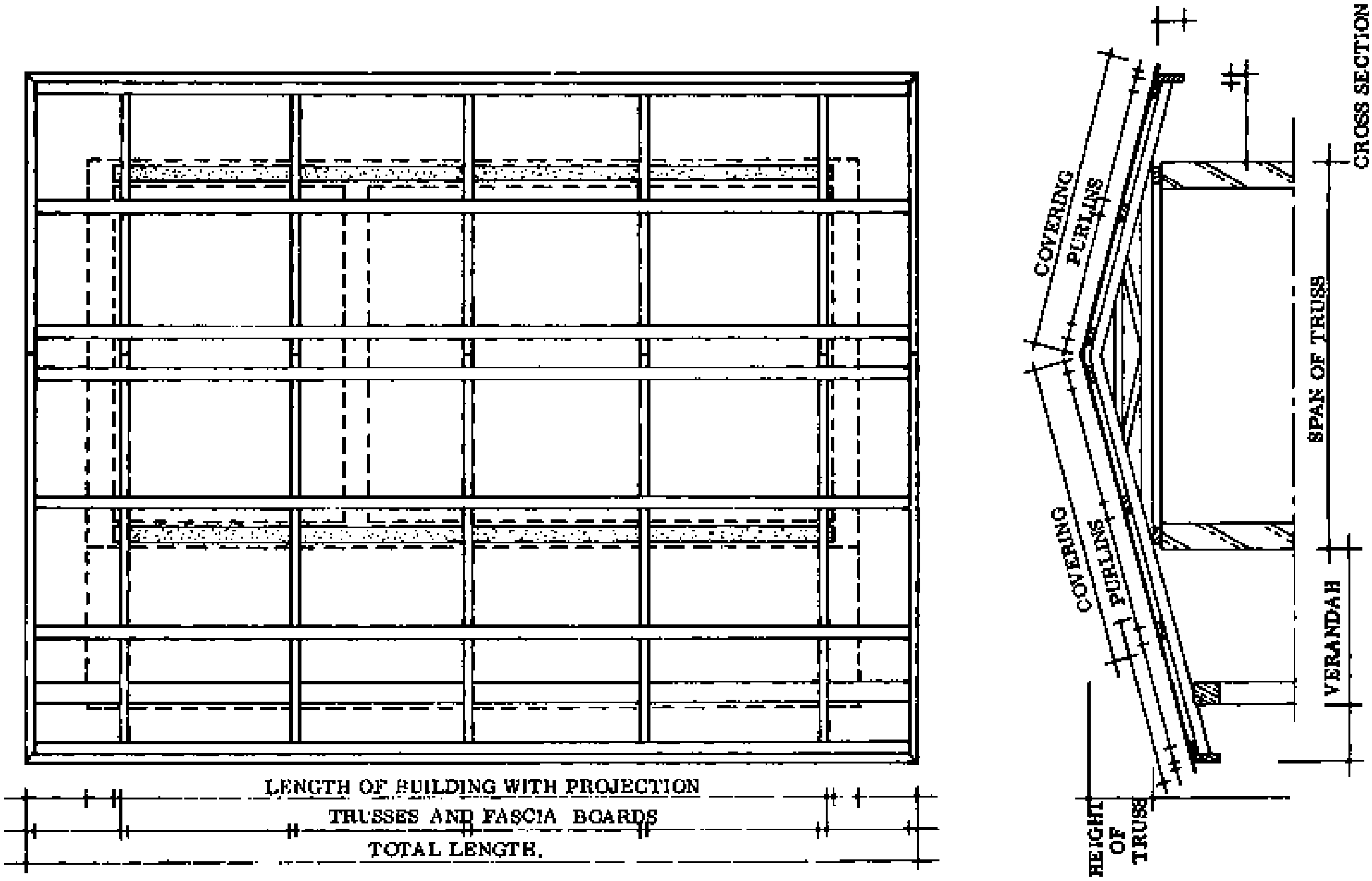


CROSS SECTION B–B

Gable roof with overhang design

<u>GABLE ROOF WITH OVERHANG</u> – 3 ½ HOURS

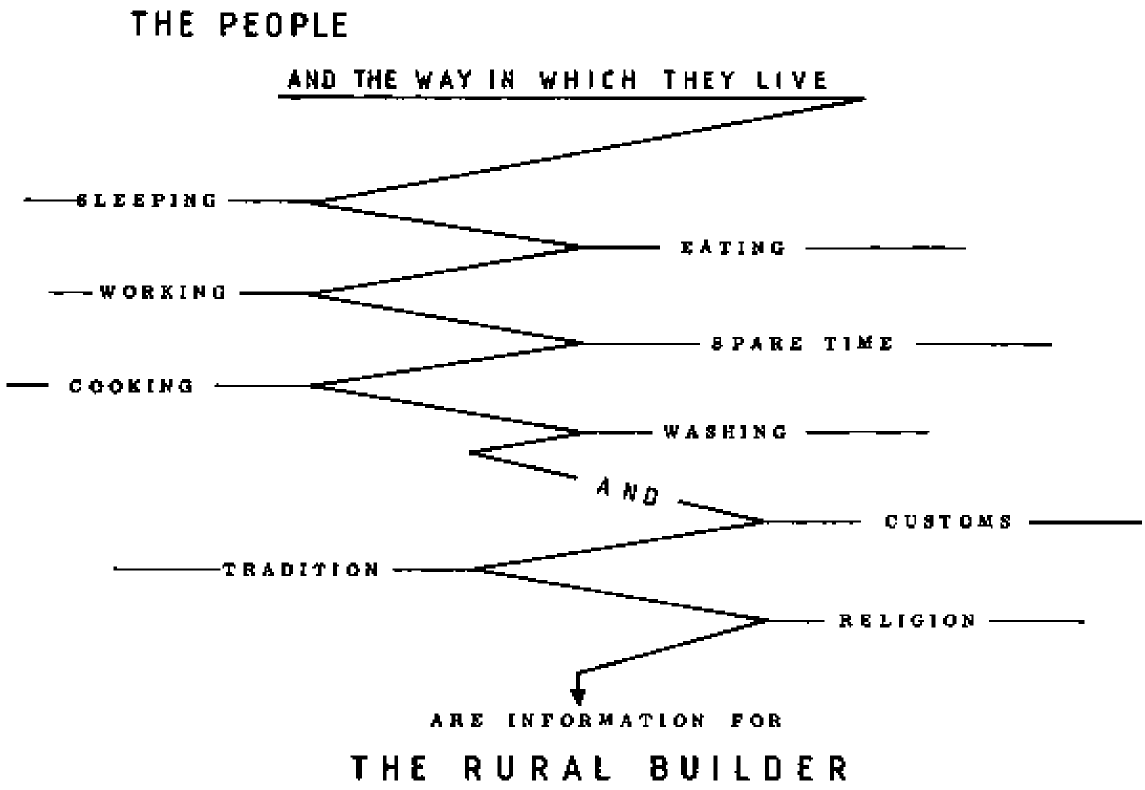
WALL PLATE = DOTTED AREAS.
SEE ALSO **<u>BUILDING WITH VERANDAH</u>:** GABLE ROOF AND OVERHANG DESIGN



NOTES:

FORM IV

The Rural Builder



Building design

BUILDING DESIGN

You have some general technical information about building. Now you can try to make your own designs, with the aid of the basic outlines on the next pages. Keep in mind all that you know about building, and follow a policy of design:

GENERAL POLICY

Plan for the future in your design. Perhaps it may not be possible to build the entire building at once; it may be completed section by section as funds become available. The building can be planned as a whole, properly constructed piece, and then built up over the years. It is better to design what is actually needed than to design something which is not adequate and have to change it, or even abandon it when it cannot be changed into the desired structure.

Remember that a building is a lasting structure. Try to think ahead and lay out the site and the building with the future requirements in mind. Also keep in mind the points listed on page 96. Think about how people do these daily things and design around their needs.

NOTES:

DESIGN POLICY

– EFFICIENCY: This is so that the whole structure will function as it is meant to do. There should be sufficient room for all the activities and for furniture and whatever equipment is needed. Provide ventilation, privacy, protection against in sects, and pay attention to water and sewage problems.

– DURABILITY: The building should withstand the stresses of its own weight, and the outside forces such as wind. It should be as protected as possible against attack from weather, dampness, insects, and the normal wear and tear of use. Keep in mind the climate and its influences, and choose your materials with some thought to their durability.

– ECONOMY: Design and erect buildings economically. Plan ahead and have the materials ready to go through with what ever section has been planned. Knowledge about materials, their quality and durability prevents much waste.

– FINISH: Finish the whole as attractively as possible. Finishes not only improve appearance, but they are usually preservatives as well. Appropriate colours make the building pleasant as well as cooler.

NOTES:

Location plan

LOCATION PLAN

The illustration on the right page shows a piece of land as it looks from the ground, and how it would look if you were above it in an aeroplane looking down. The view you would see from the plane resembles the plan.

A plan tells you all the things which are on the site such as buildings, trees, roads, streams, bridges; and where all of these are located. The plan also shows the orientation of all these features with respect to directions: north, south, east and west; and how the surface of the ground slopes.

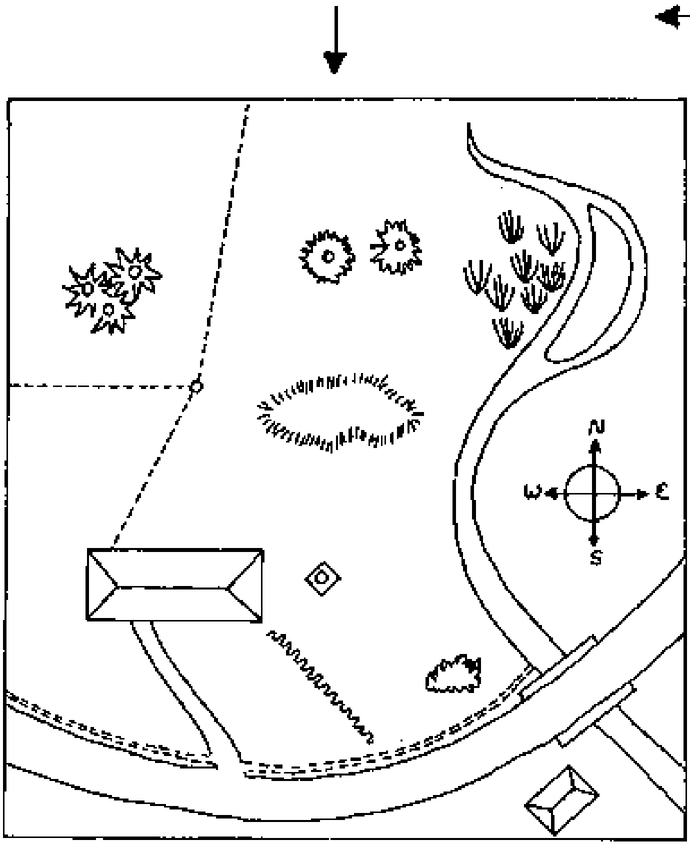
It is impossible to properly plan a building without a great deal of knowledge about the land on which it is to be built. The plan is essential to help the builder to design a building which will fit into the surroundings in the most economical and convenient way.

If a building is planned without taking into account the basic information contained in the location plan, it may turn out to be the wrong shape to fit the site. It may be more costly to build because it is not placed correctly along the "contours " of the land. It may be uncomfortable to live in if it is facing into the hot afternoon sun. It may be hard to reach if there is not a good entrance way from the road.

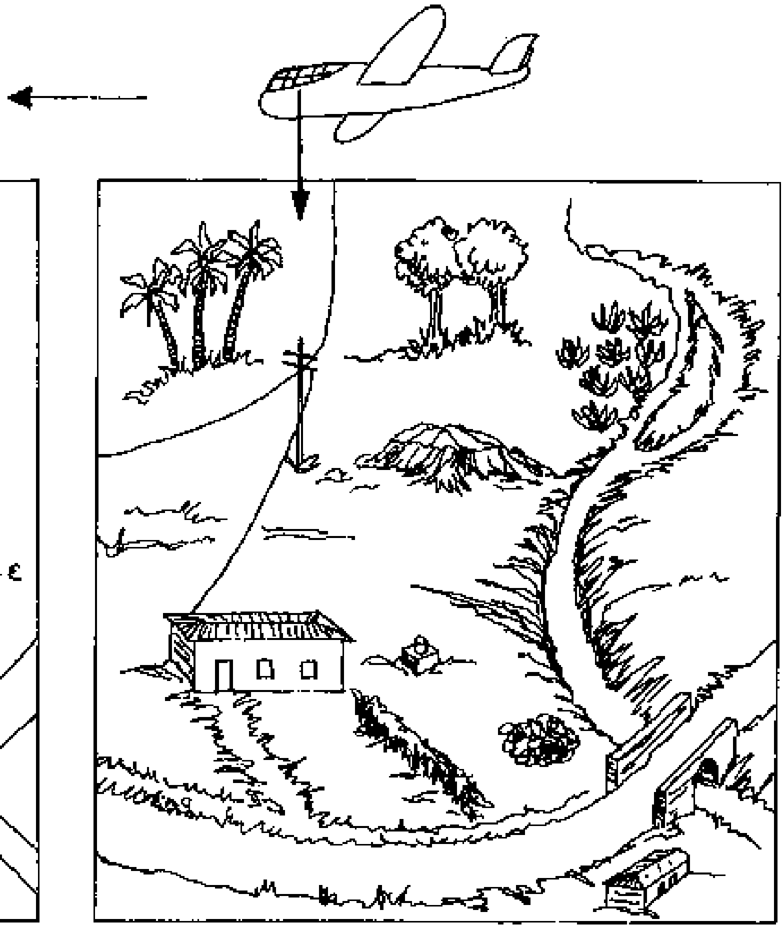
The following pages contain some information about the factors which need to be considered about the site when you are planning a building. These include the measurements of the site and plot, the building regulations and restrictions, the direction of the breeze and of storms, the slope of the site, the direction of the sun's rays at different times of day: all of these need to be considered when planning so that the building will be comfortable to live in and economical to build.

YOU WOULD SEE ONLY THE ROOFS OF THE BUILDINGS AND THE TOPS OF THE TREES, SO THE VIEW YOU WOULD SEE IS LIKE THIS:

IF YOU LOOK DOWN FROM AN AEROPLANE:



THIS VIEW IS A PLAN OF THE LAND AND MAY BE CALLED A MAP OR SURVEY PLAN.

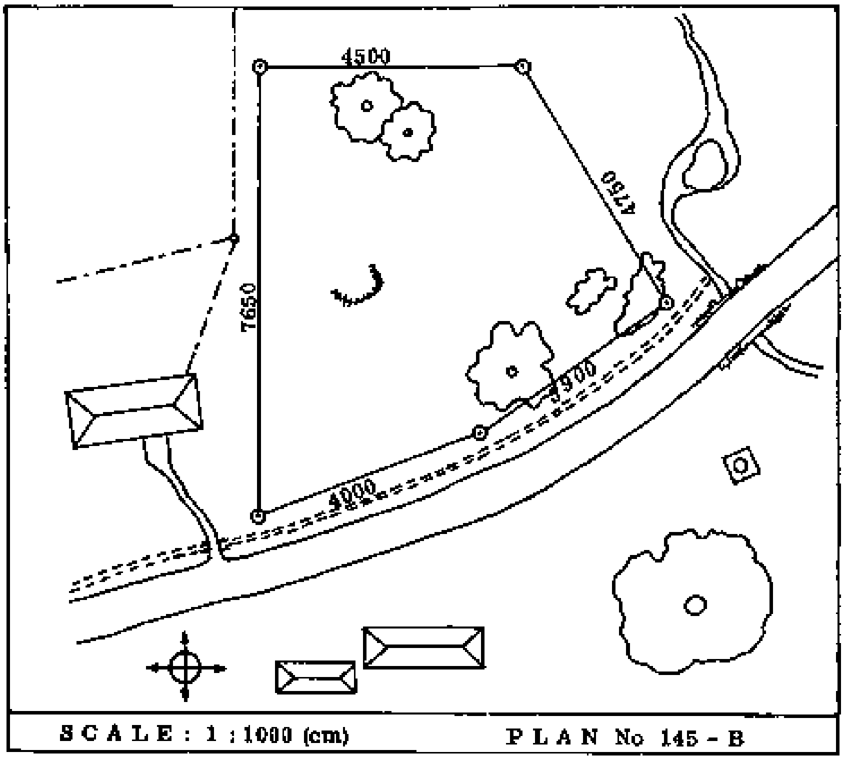


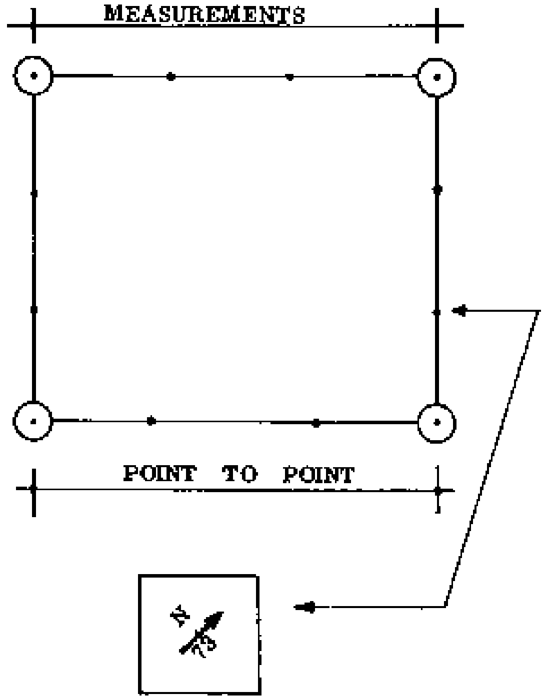
PICTORIAL VIEW

Boundary line

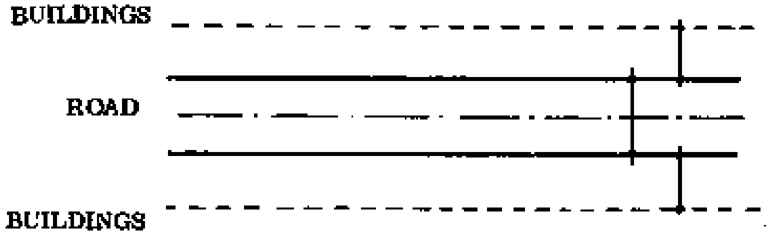
<u>BOUNDARY LINE</u>

SITE PLANS HAVE THE LENGTHS WRITTEN ALONG THE BOUNDARIES SO THAT THE EXACT LOCATION OF THE PLOT IS KNOWN.



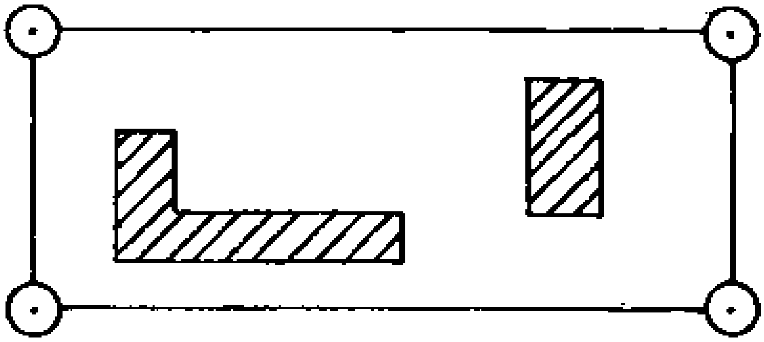


"BOUNDARY STONE". THE ARROW IS FACING THE NORTH. THE NEXT STONE IS 73 METRES AWAY.



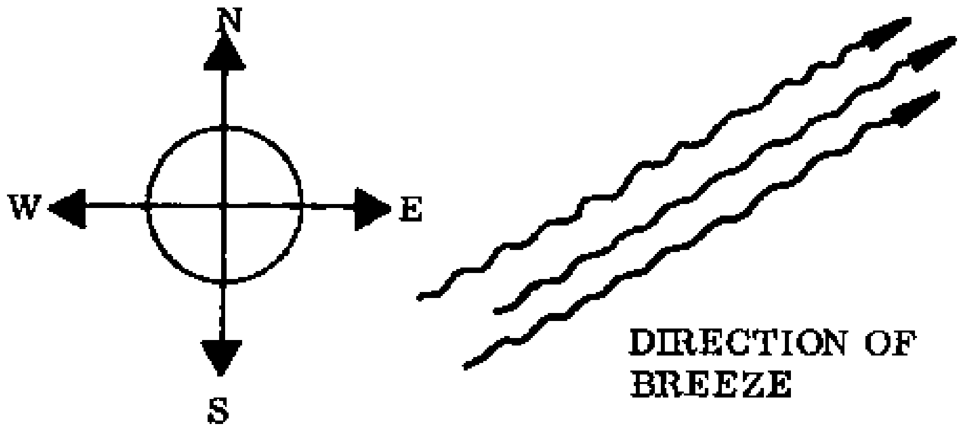
BUILDING LINE

IN PLANNED TOWNS NO BUILDING IS ALLOWED TO REACH TO THE EDGE OF THE ROAD: A BUILDING HAS TO BE A CERTAIN DISTANCE AWAY FROM THE ROAD TO ALLOW FOR FUTURE ROAD WIDENING AND SO THAT THERE IS ENOUGH SPACE BETWEEN BUILDINGS.



SITE COVERAGE

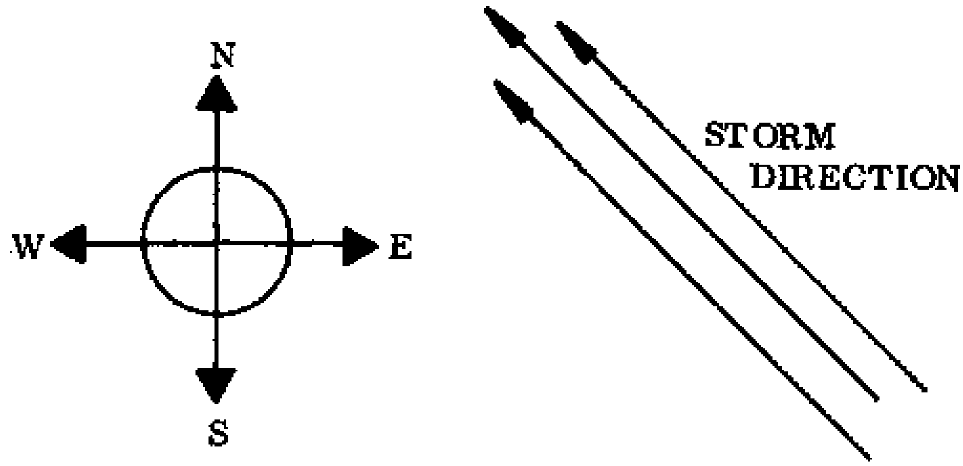
IN SOME TOWNS THERE ARE RULES ABOUT HOW MUCH LAND CAN BE BUILT OVER: FOR SO MANY SQUARE METRES OF LAND, THE BUILDINGS CAN TAKE UP ONLY A CERTAIN AMOUNT OF THE SPACE. IN ADDITION, THE BUILDINGS USUALLY HAVE TO BE A CERTAIN DISTANCE AWAY FROM THE PLOT BOUNDARIES. THIS IS TO MAKE SURE THAT THE BUILDINGS WILL HAVE PLENTY OF LIGHT AND AIR SO THEY ARE HEALTHY TO LIVE IN.



BREEZE

IN HOT WET CLIMATES, IT IS IMPORTANT TO HAVE A BREEZE BLOWING THROUGH THE BUILDING SO THAT THE PEOPLE INSIDE ARE COOLER.

THE DIRECTION OF THE PREVAILING BREEZE (THE USUAL DIRECTION THE BREEZE COMES FROM) IS MARKED ON THE PLANS.

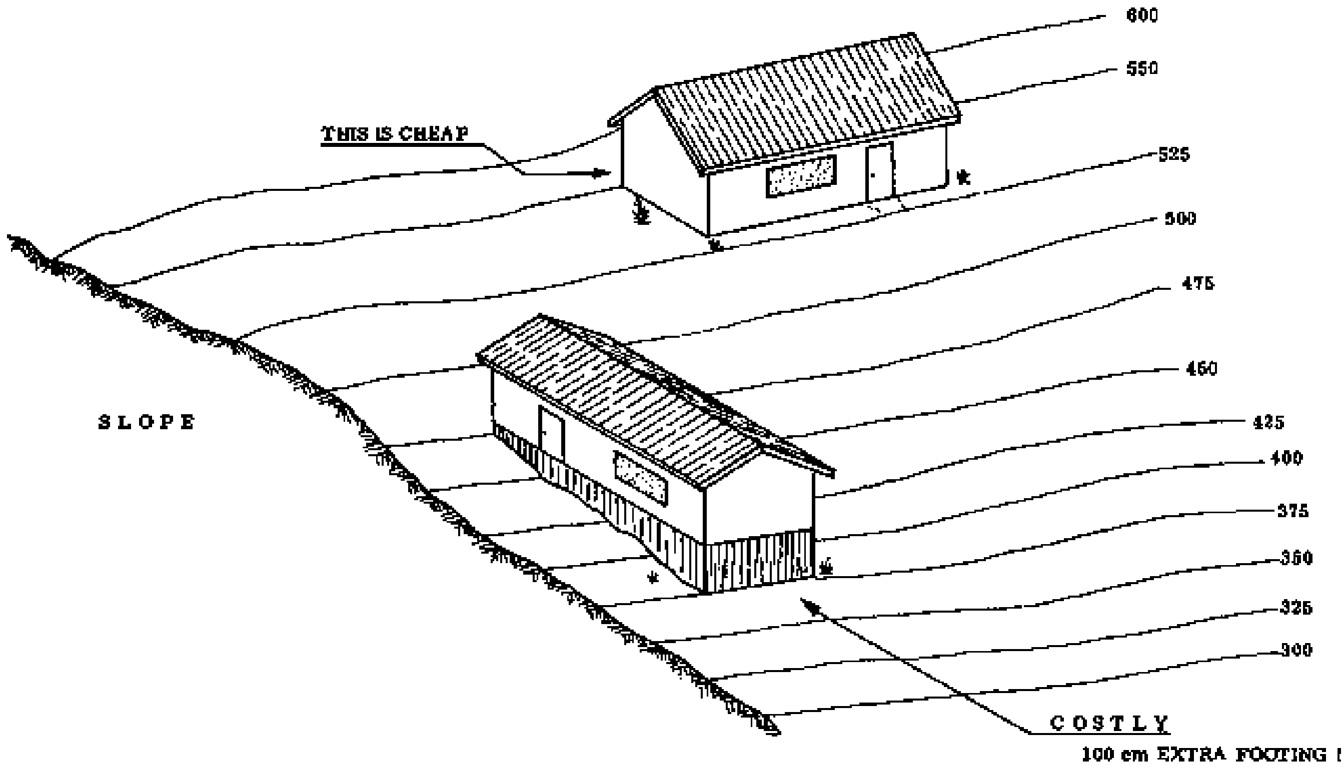


STORMS

IN AREAS WHICH GET BAD STORMS, THE RURAL BUILDER WILL PLAN THE BUILDING SO THAT THE OPENINGS WHICH FACE THE STORM ARE PROTECTED.

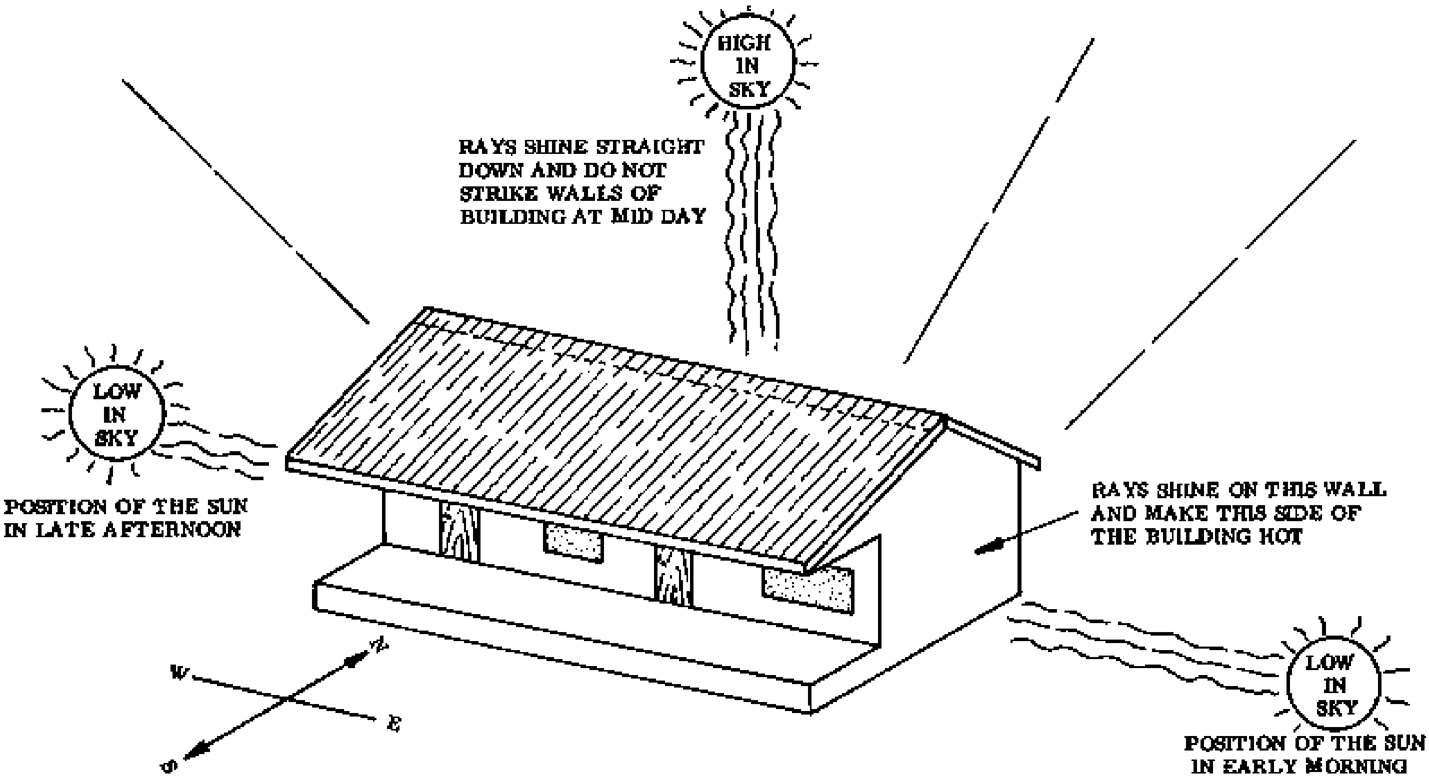
BUILDING ALONG THE CONTOURS

WHERE THE GROUND SLOPES STEEPLY THE RURAL BUILDER NEEDS TO SHOW THE CONTOUR LINES ON THE PLAN. THESE ARE DRAWN AT EVERY 50 cm OF HEIGHT DIFFERENCE, OR LESS IF NECESSARY.



Building information

BUILDINGS WHICH HAVE THE LONG SIDES FACING NORTH AND SOUTH AND HAVE A VERANDAH ARE COOLEST AND MOST COMFORTABLE IN HOT COUNTRIES BECAUSE THE SUN SHINES ON THE SHORT SIDES ONLY.



<u>DESIGNING BUILDINGS TO WITHSTAND STRONG W</u>INDS

Many buildings are not strong enough to resist the forces of very strong winds. They may be destroyed and the people inside can be injured or even killed. The guidelines here aim to help the Rural Builder to design and construct buildings so that such occurrences are reduced in the future. The point of these guidelines is to reduce the force of the wind against the building, and to make the building more resistant to wind forces. The following points are illustrated on the right.

A – Take advantage of natural windbreaks such as trees or hedges when deciding on the site for the building. Such a location can reduce the force of the wind.

B – Sites on hills and near hilltops can have much higher windspeeds.

C – Valleys can funnel winds and create higher windspeeds.

D – The pitch of the roof is very important. This should be between 15 and 20 degrees.

E – A hip roof resists wind forces better than a gable roof.

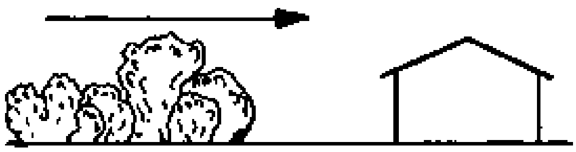
F – Avoid making large overhangs, even if they are supported by columns. Locate verandahs away from the direction of the strongest winds.

G – A parapet around the roof helps to reduce the wind force along the roof edges.

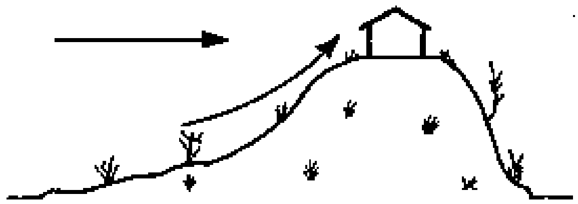
H – Avoid making large openings such as doors or windows near the roof line or near the corners of walls. These tend to weaken the structure if they are located where the loads are greatest.

I – Make sure that every part of the building is secured: the roof parts to each other, the roof itself to the walls, the walls to the other walls, the walls to the floors, the floor to the foundations. The foundations should rest on firm soil if possible.

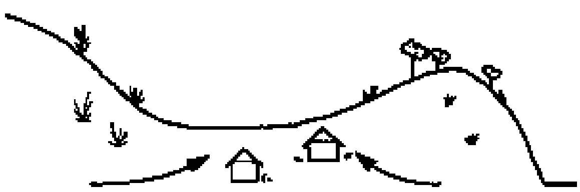
– REMEMBER: Whatever the form of roof construction, the parts of the roof must be securely tied together. Anchor the whole structure to the building. Ignoring this precaution means that the roof will almost certainly be damaged in any strong wind.



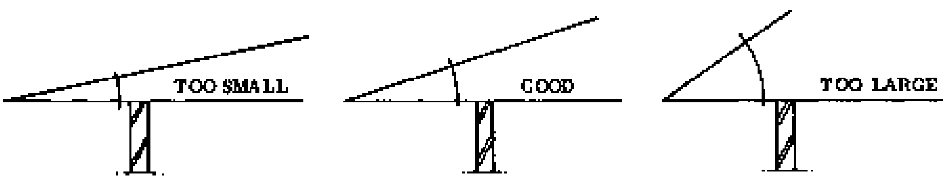
A



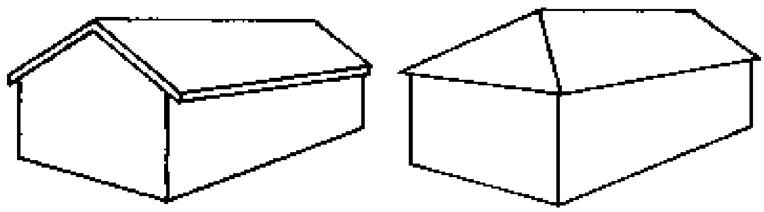
B



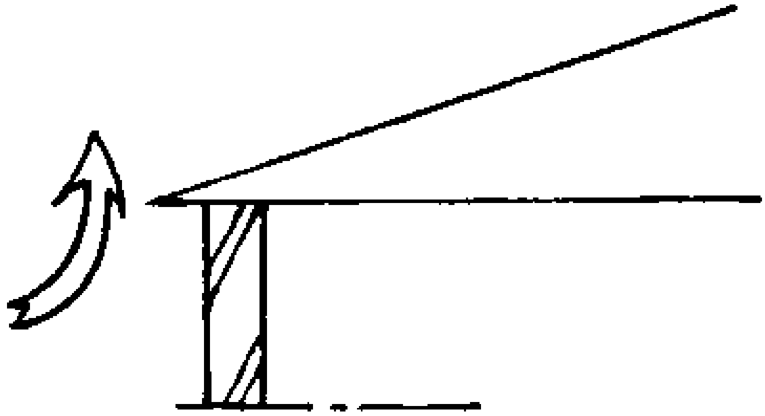
C



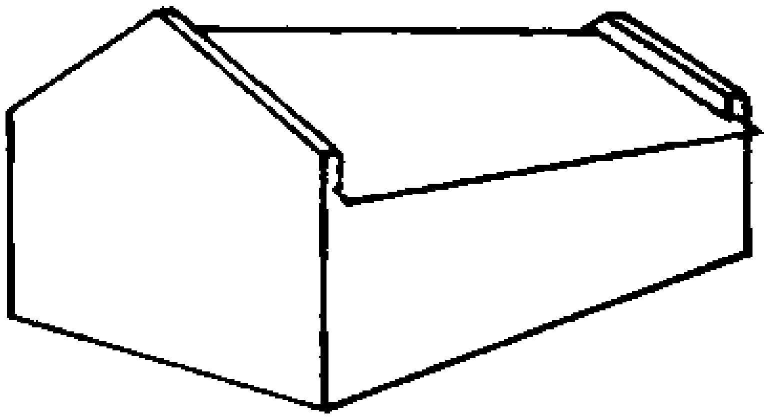
D



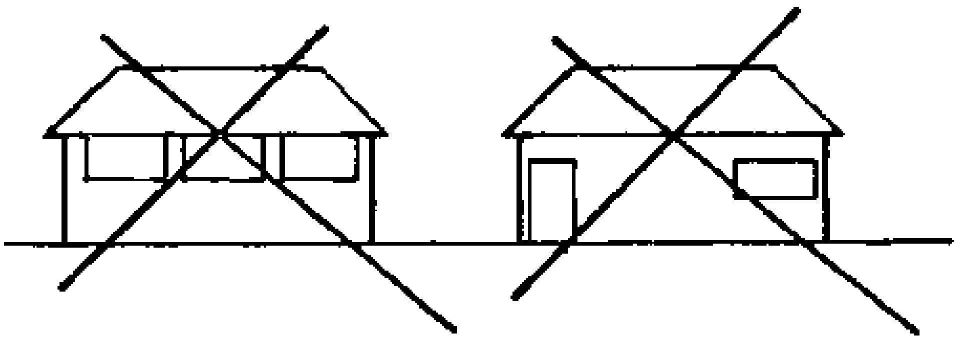
E



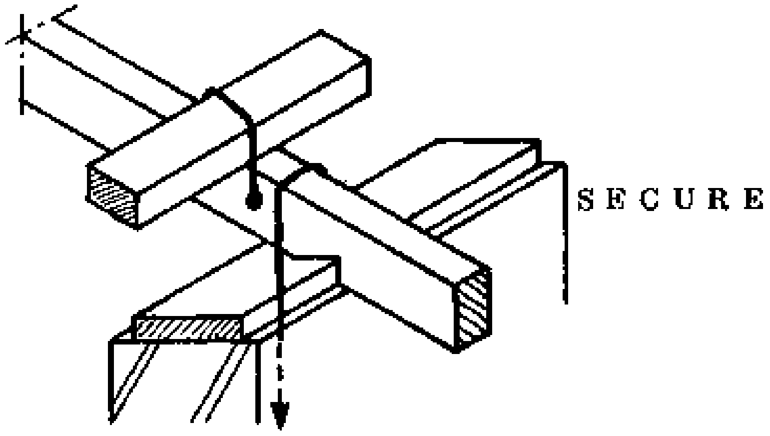
F



G

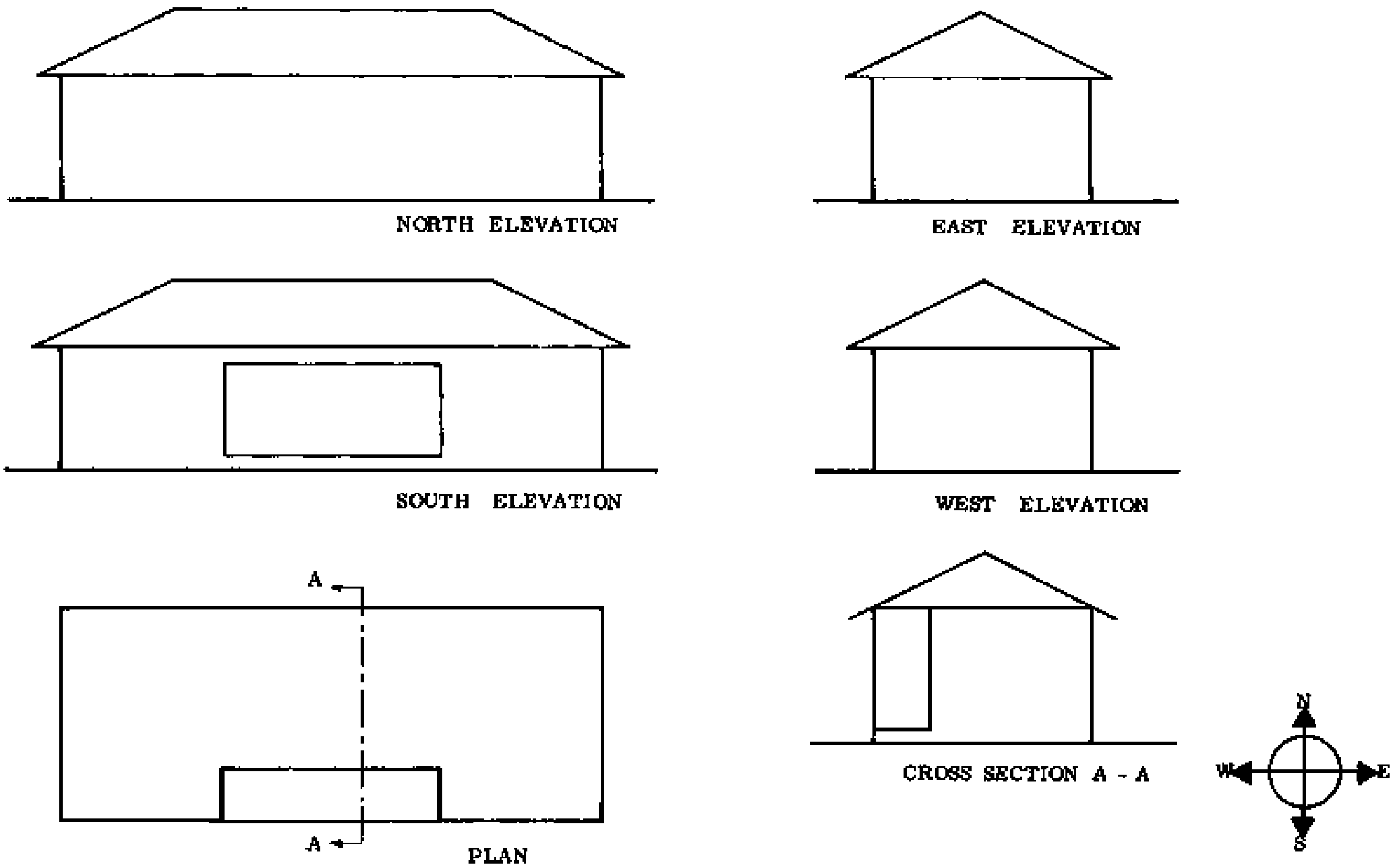


THIS IS WRONG
H

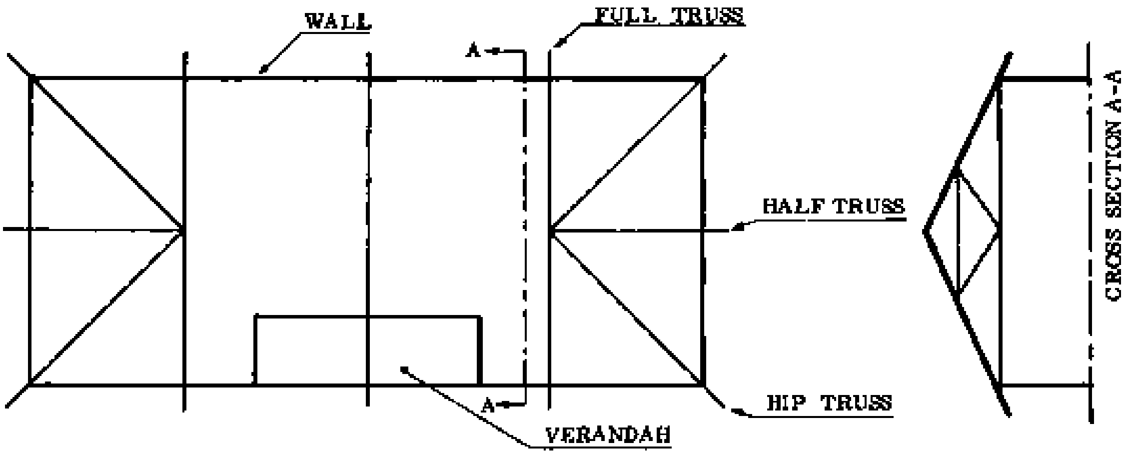


Basic outline of different buildings and roofs

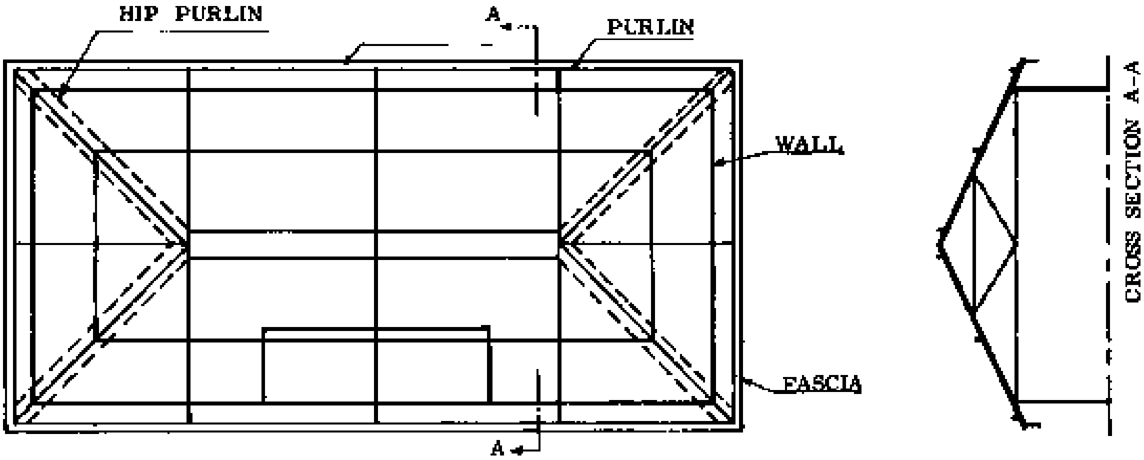
BASIC OUTLINE OF BUILDING UNIT WITH ENCLOSED VERANDAH



BASIC OUTLINE FOR HIP ROOF CONSTRUCTION

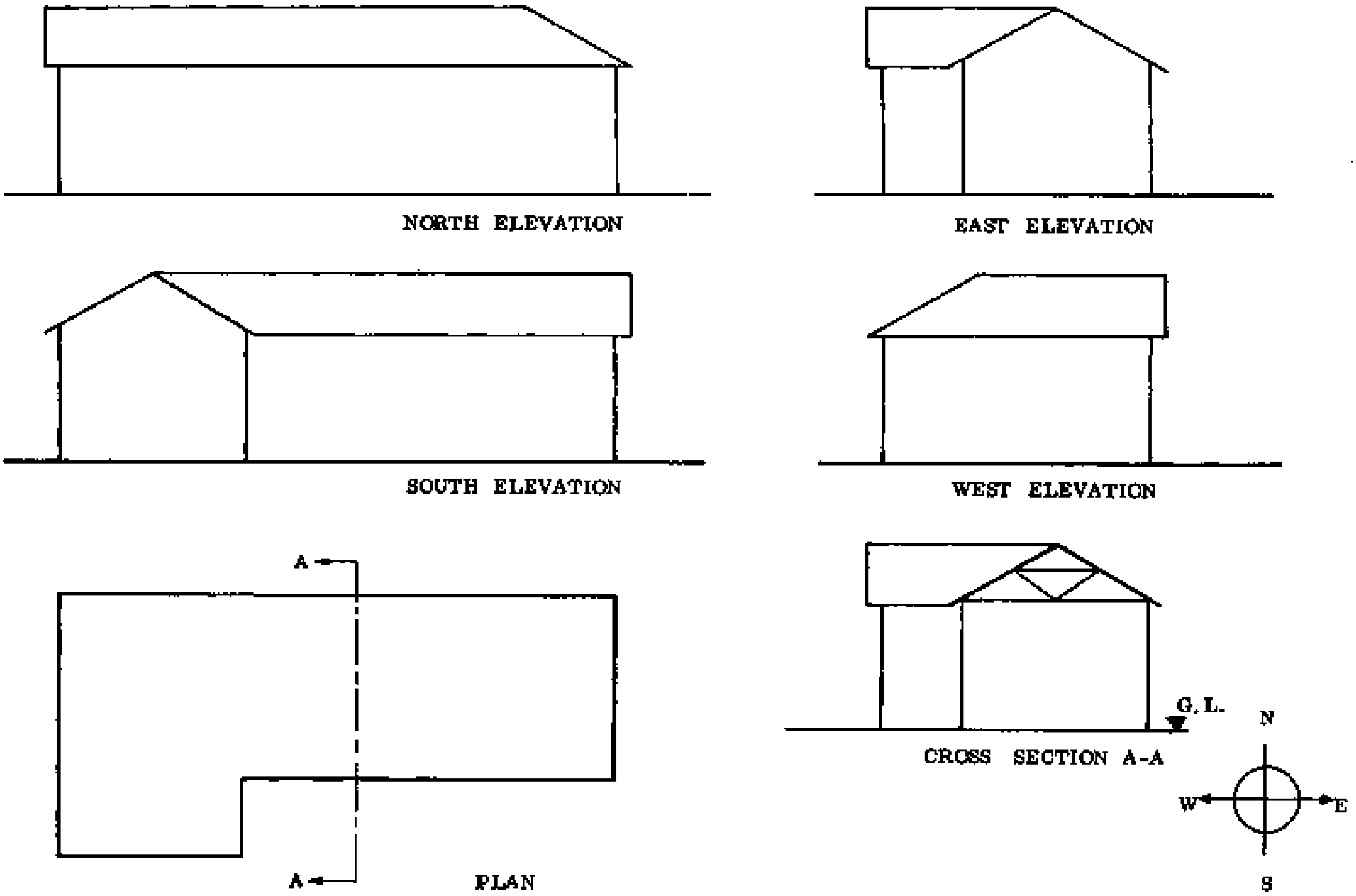


1st STAGE

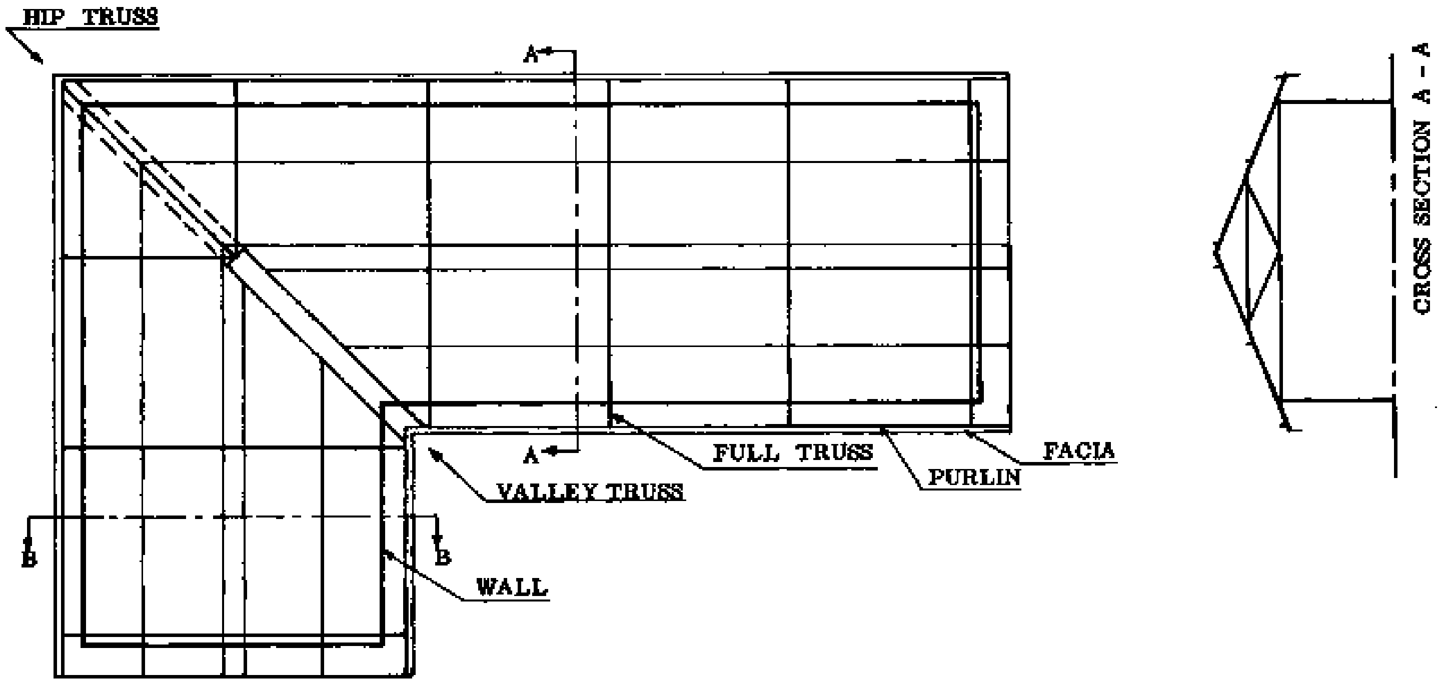


2nd STAGE

BASIC OUTLINE "L" SHAPED BUILDING UNIT

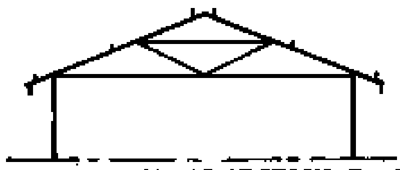


BASIC OUTLINE " L " SHAPED ROOF CONSTRUCTION



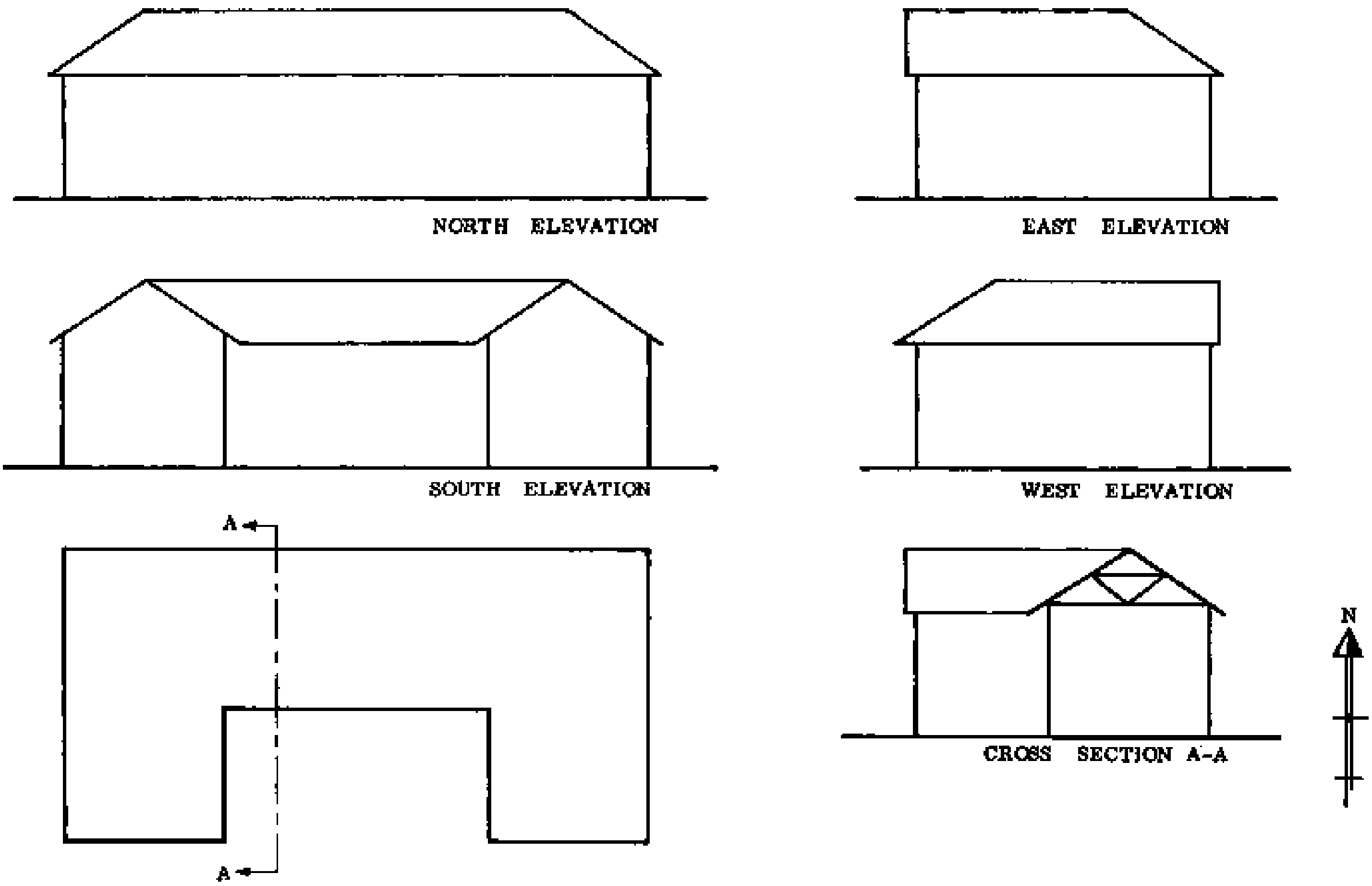
PLAN

HIP & VALLEY ROOF CONSTRUCTION

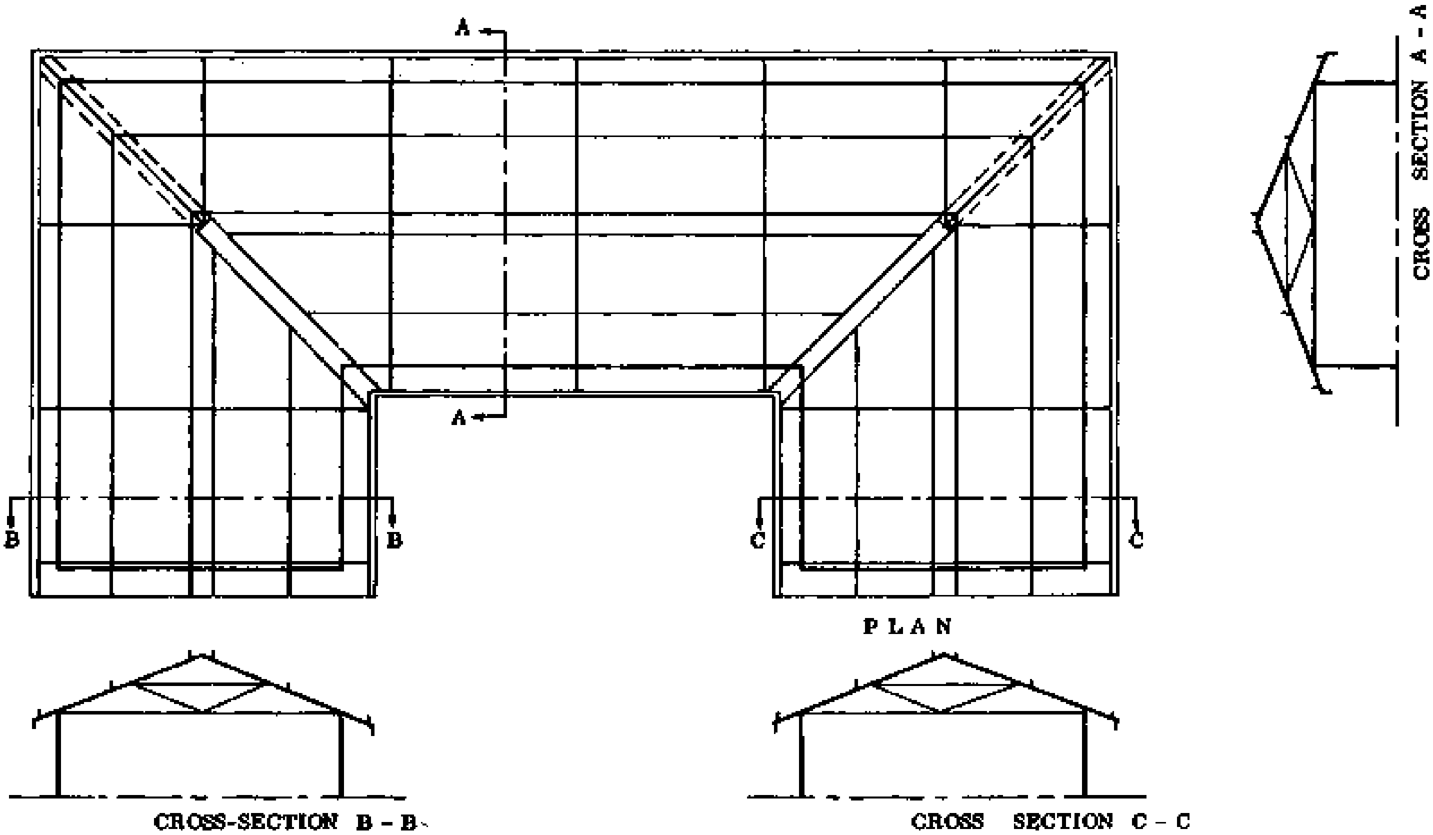


CROSS SECTION B - B

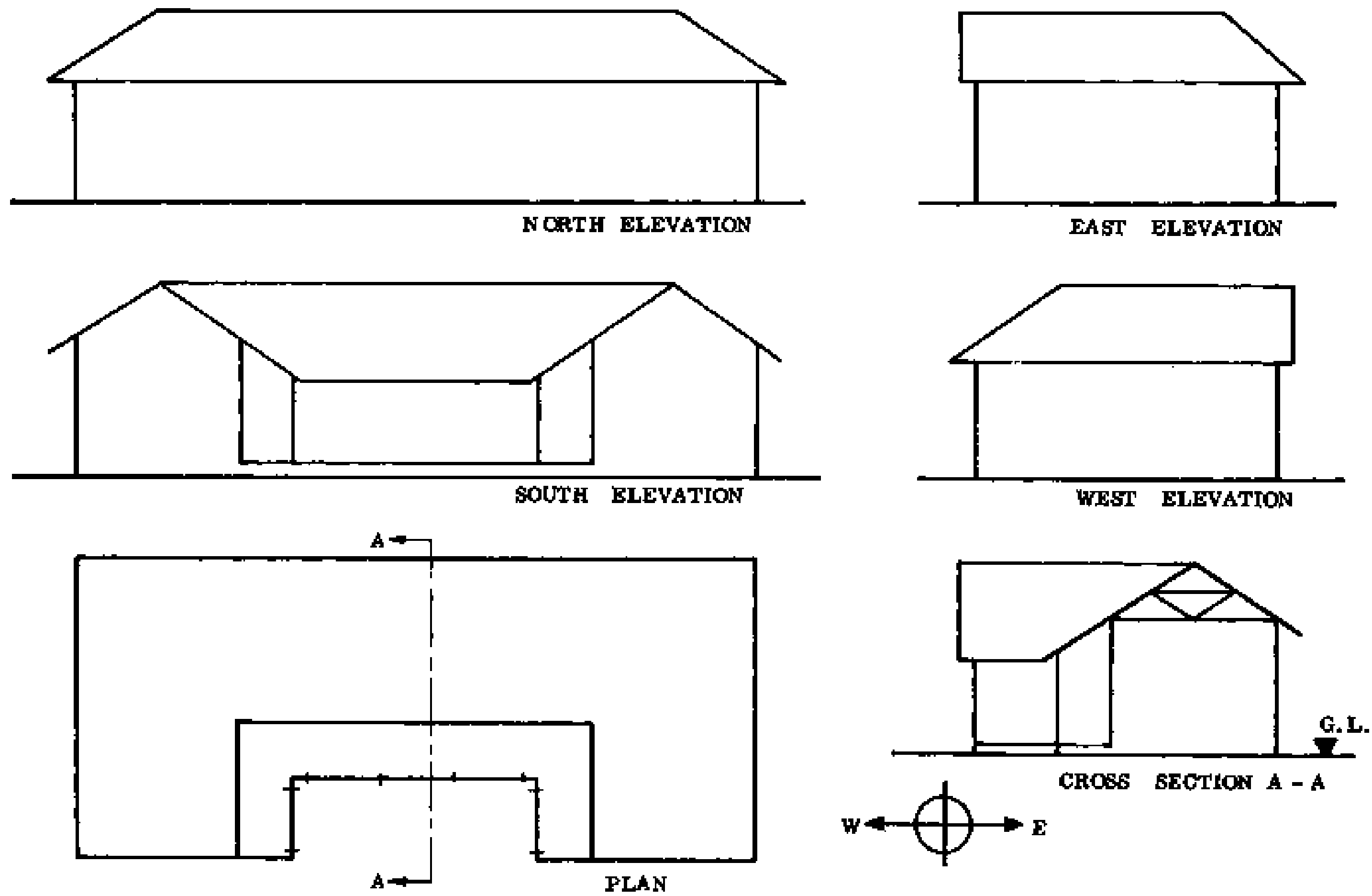
BASIC OUTLINE "U" SHAPED BUILDING UNIT



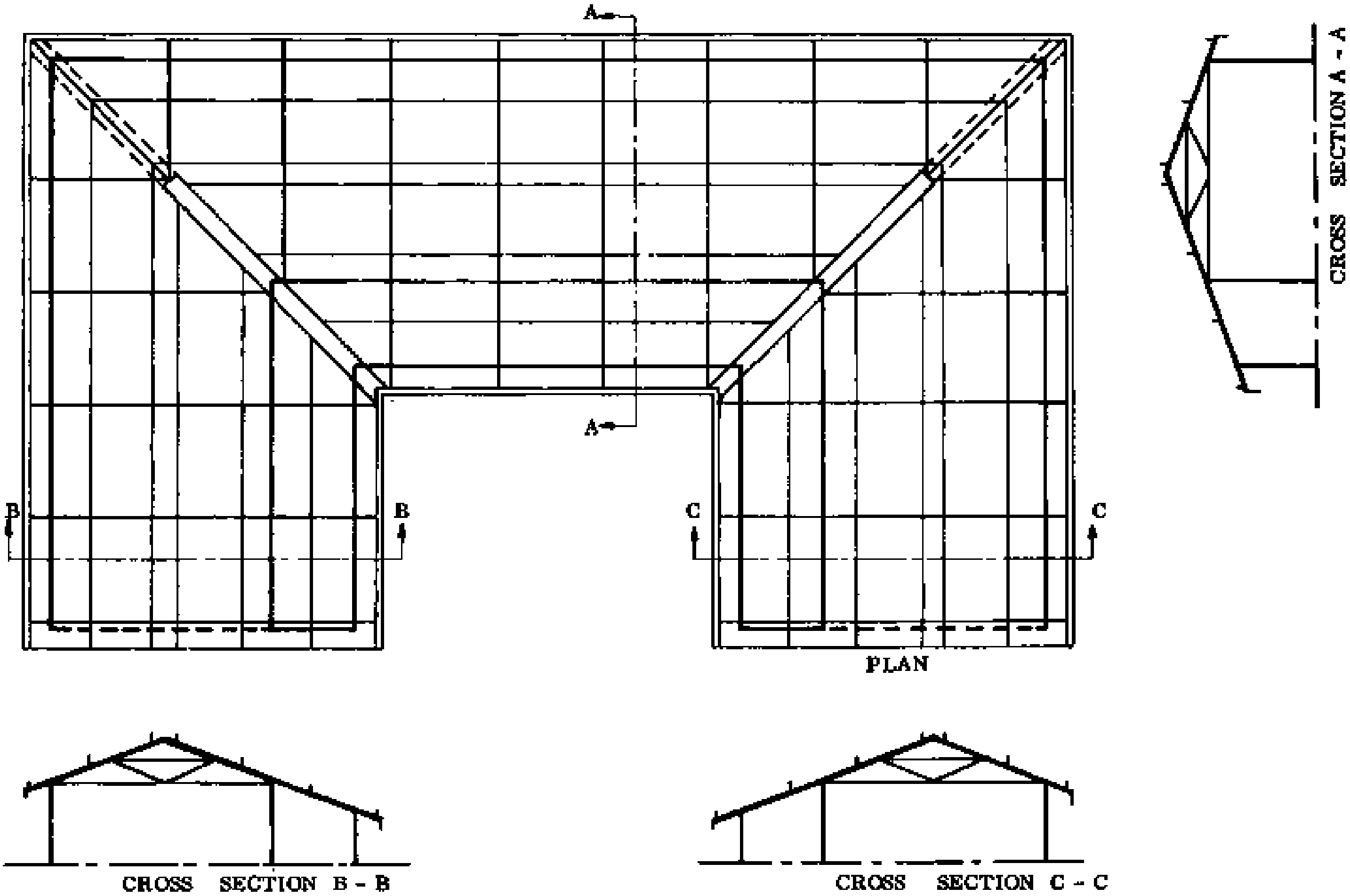
BASIC OUTLINE "U" SHAPED ROOF CONSTRUCTION



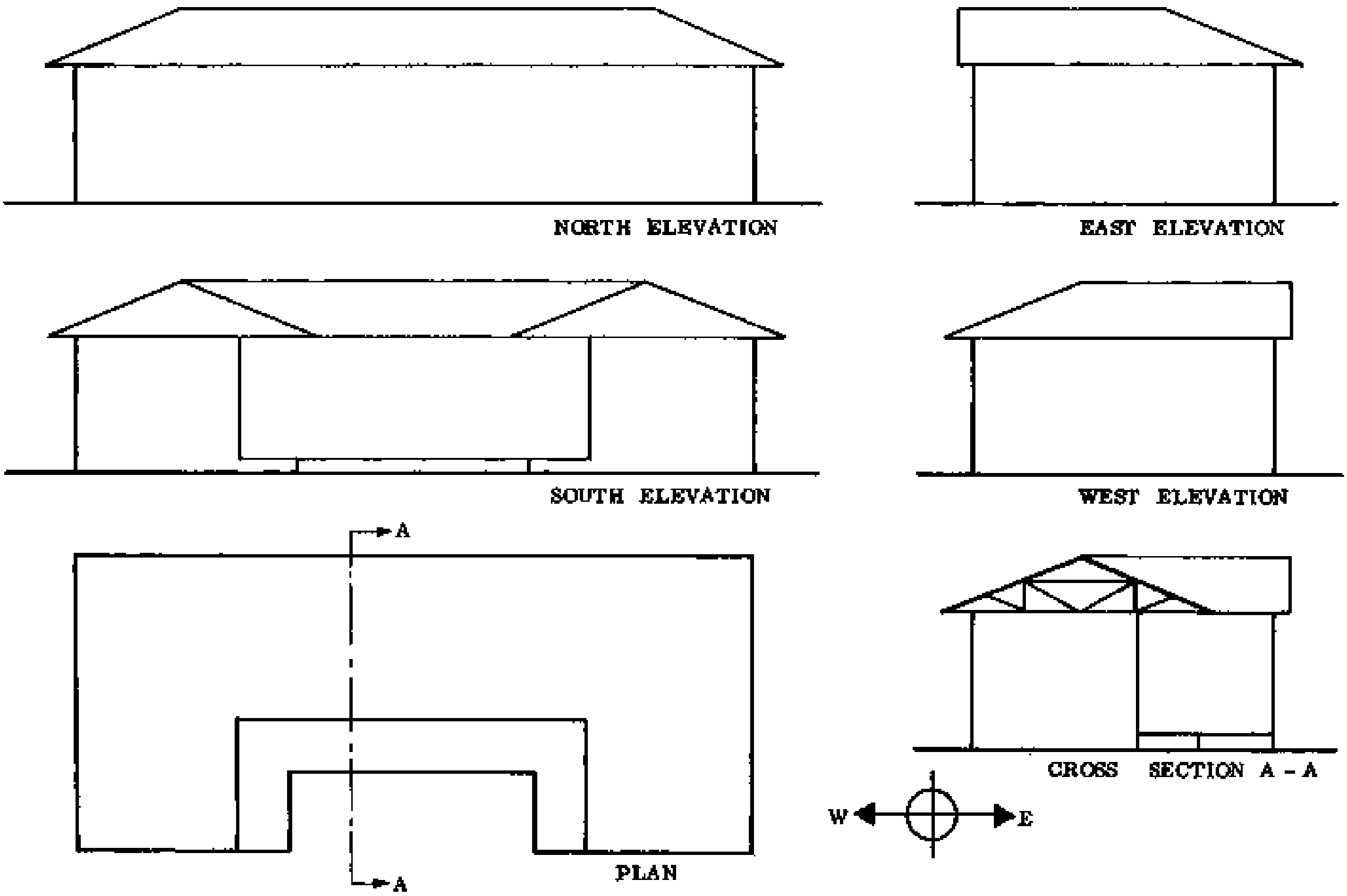
BASIC OUTLINE "U" SHAPED BUILDING UNIT WITH RAFTER EXTENDING OVER VERANDAH



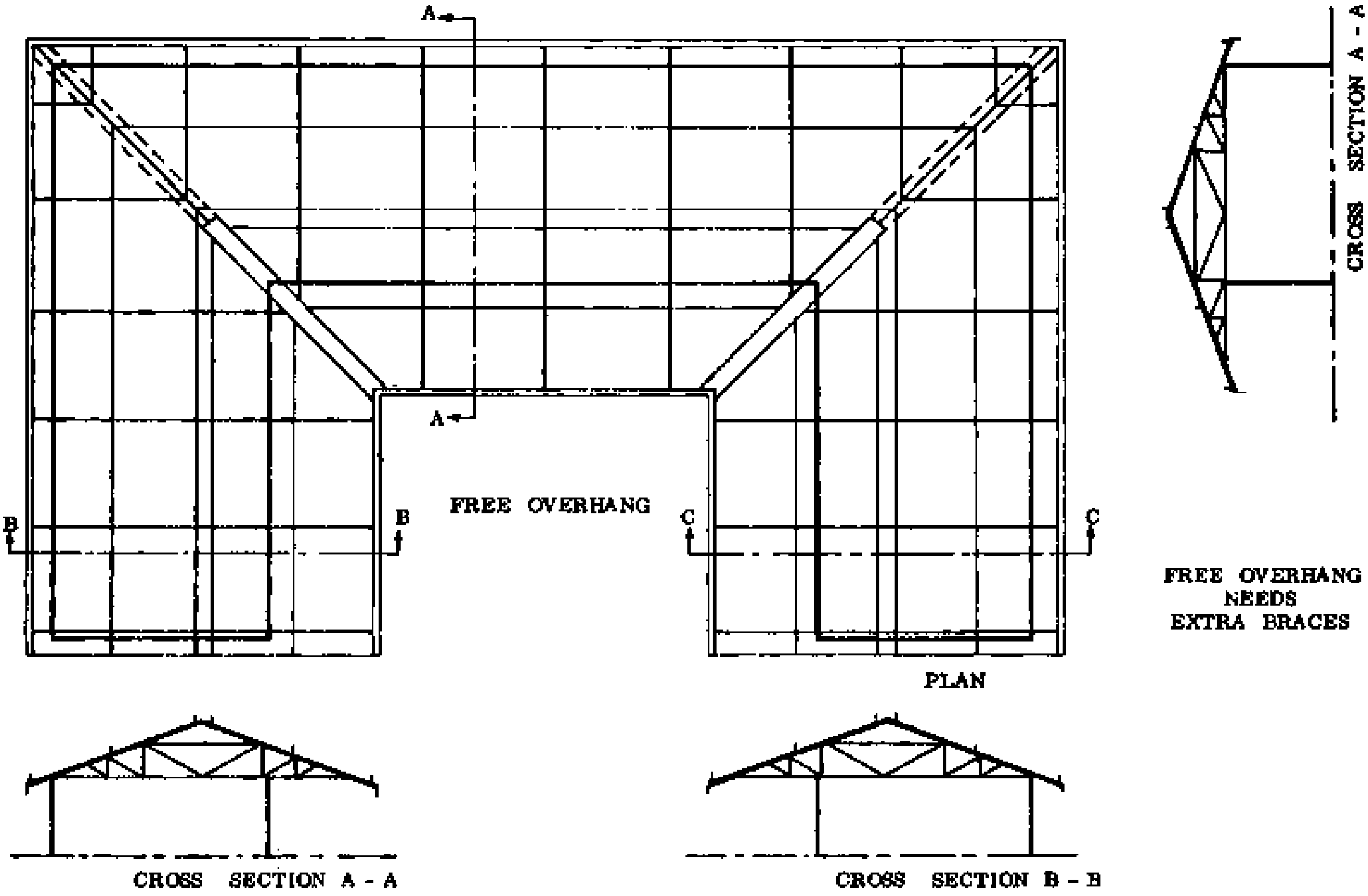
BASIC OUTLINE "U" SHAPED ROOF WITH RAFTER EXTENDING OVER VERANDAH



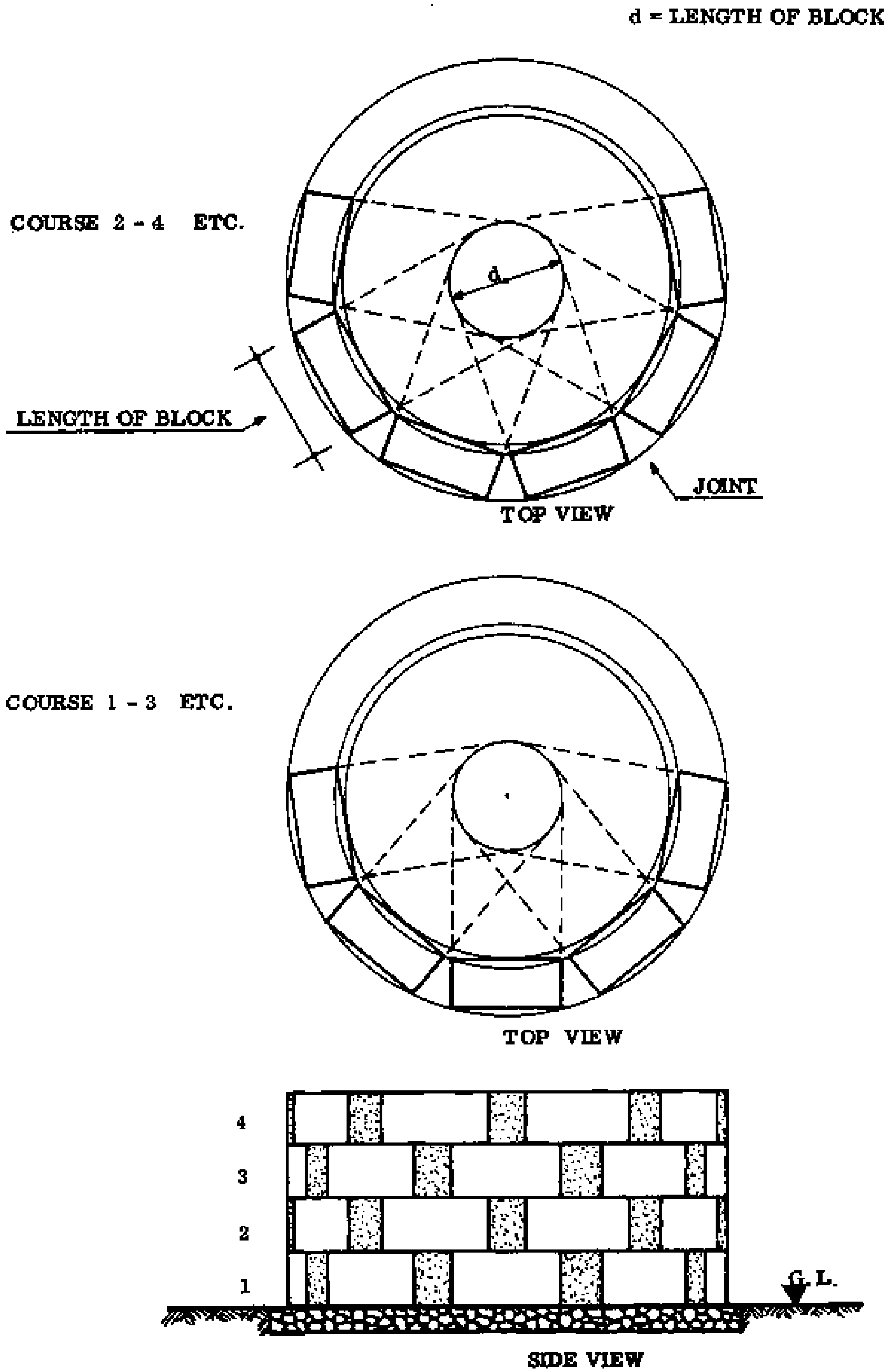
BASIC OUTLINE "U" SHAPED. BUILDING UNIT WITH TIE BEAM EXTENDING OVER VERANDAH



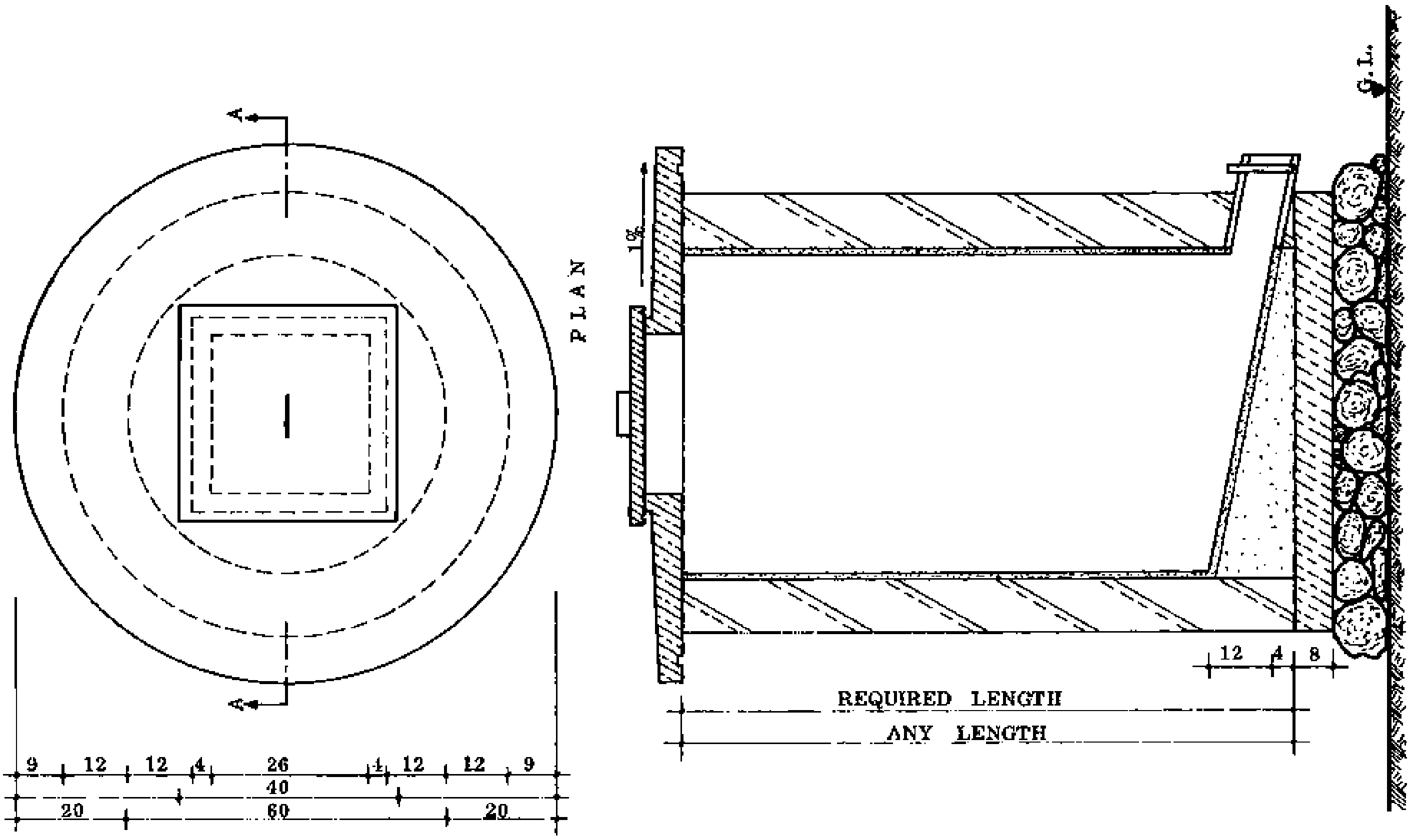
BASIC OUTLINE "U" SHAPED ROOF WITH TIE BEAM EXTENDING OVER VERANDAH



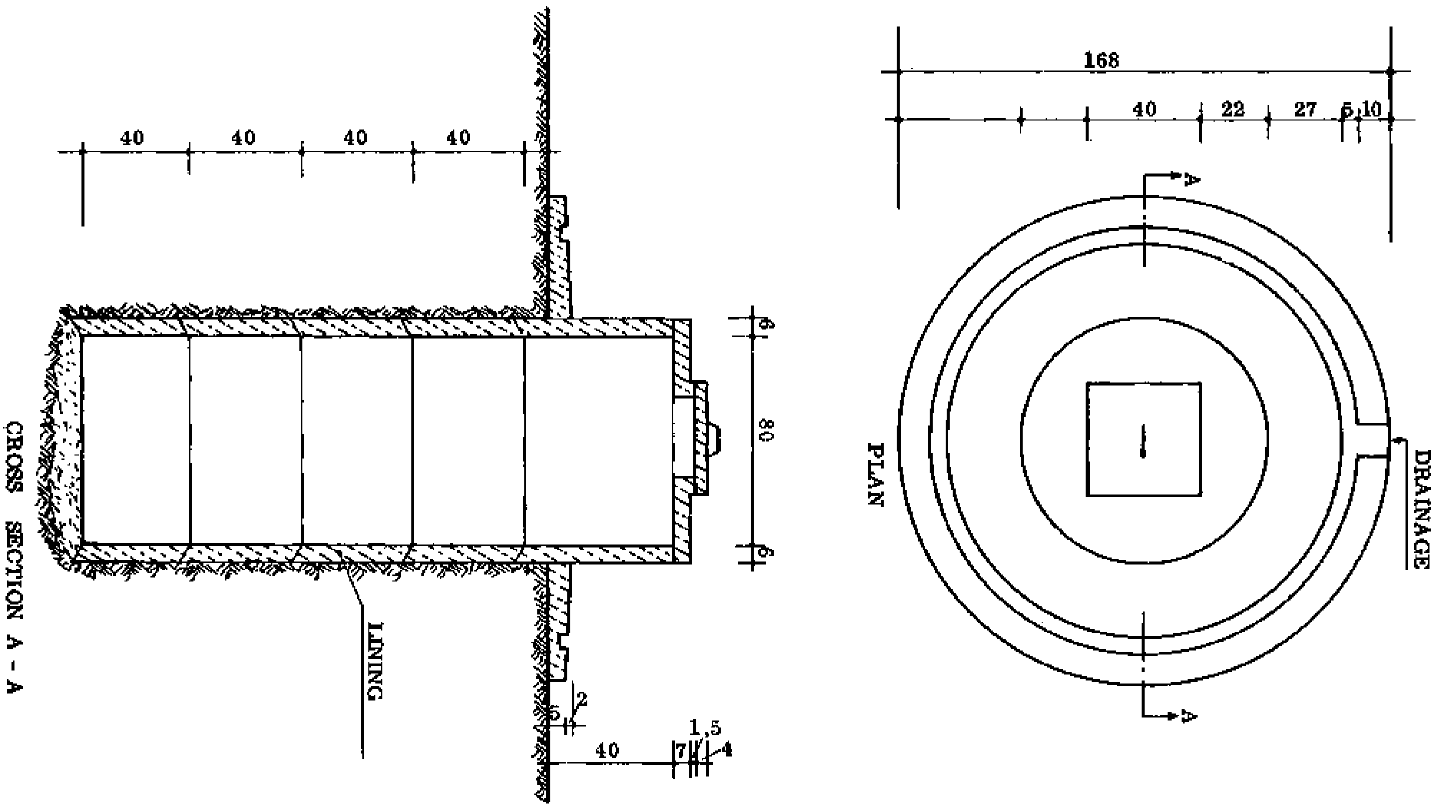
Circular work


d = LENGTH OF BLOCK
COURSE 2 - 4 ETC.
d
LENGTH OF BLOCK
JOINT
TOP VIEW
COURSE 1 - 3 ETC.
TOP VIEW
4
3
2
1
G. L.
SIDE VIEW

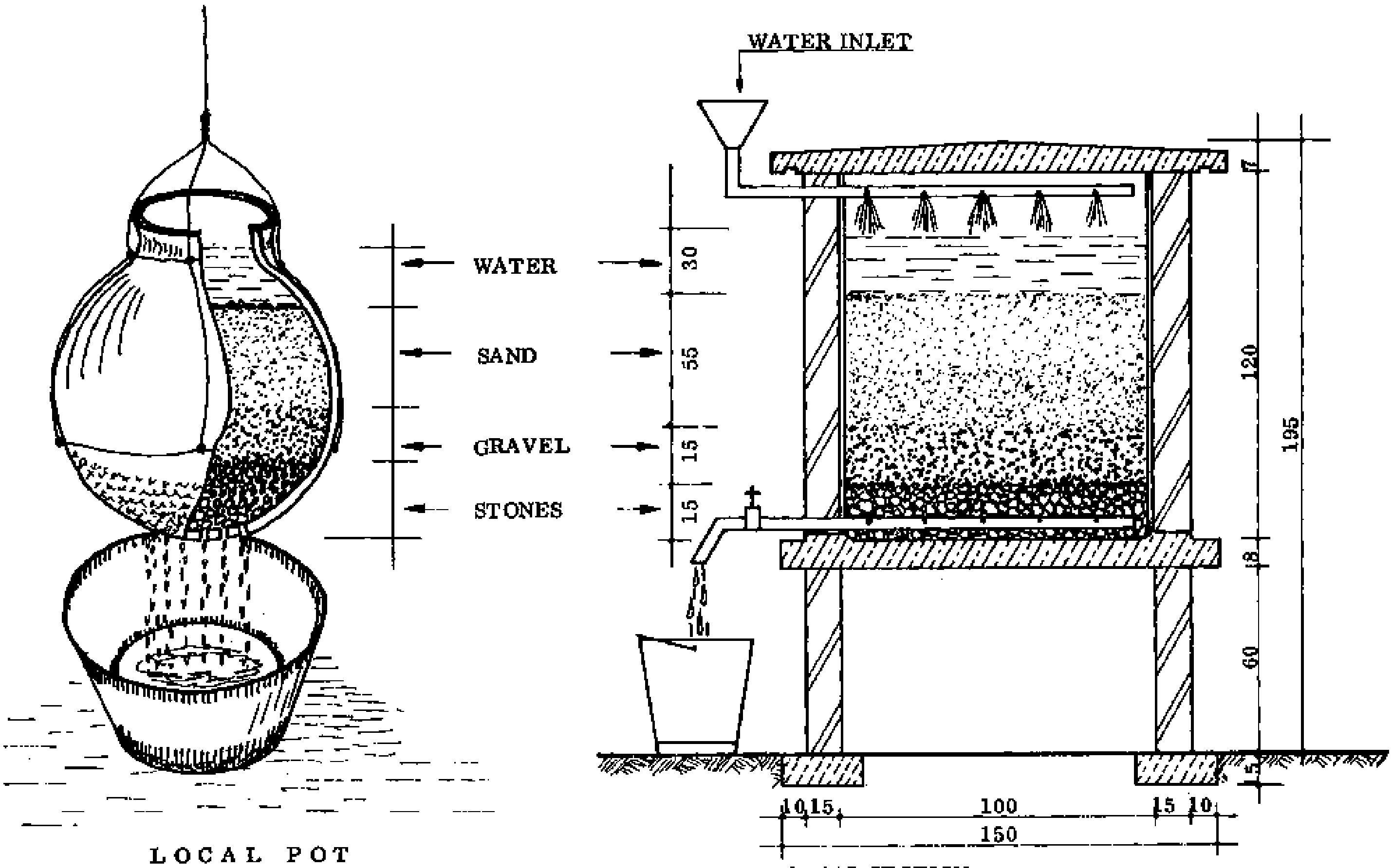
Grain silo


PLAN
CROSS SECTION A - A
G.L.
1%
REQUIRED LENGTH
ANY LENGTH
12 4 8
9 12 12 4 26 4 12 12 9
40
20 60 20

Water well


CROSS SECTION A - A
LINING
40 40 40 40
6 80 6
6 2
40 7 1,5 4
PLAN
DRAINAGE
168
40 22 27 5 10

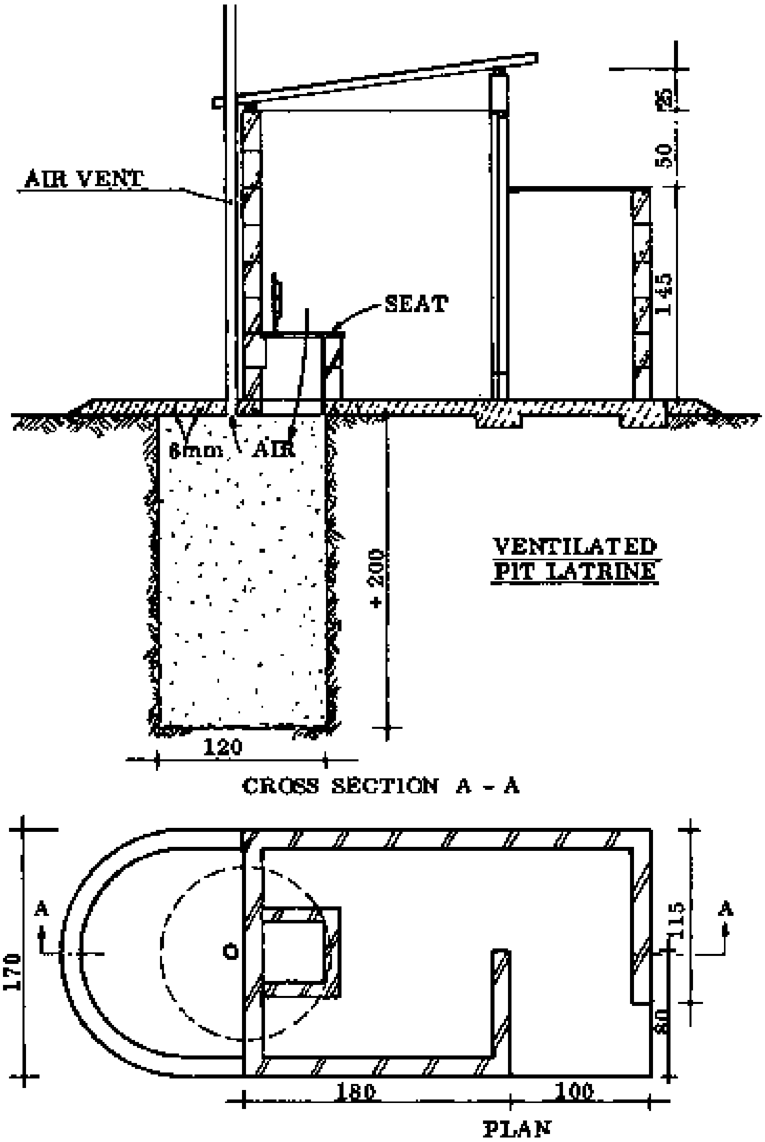
Water filter



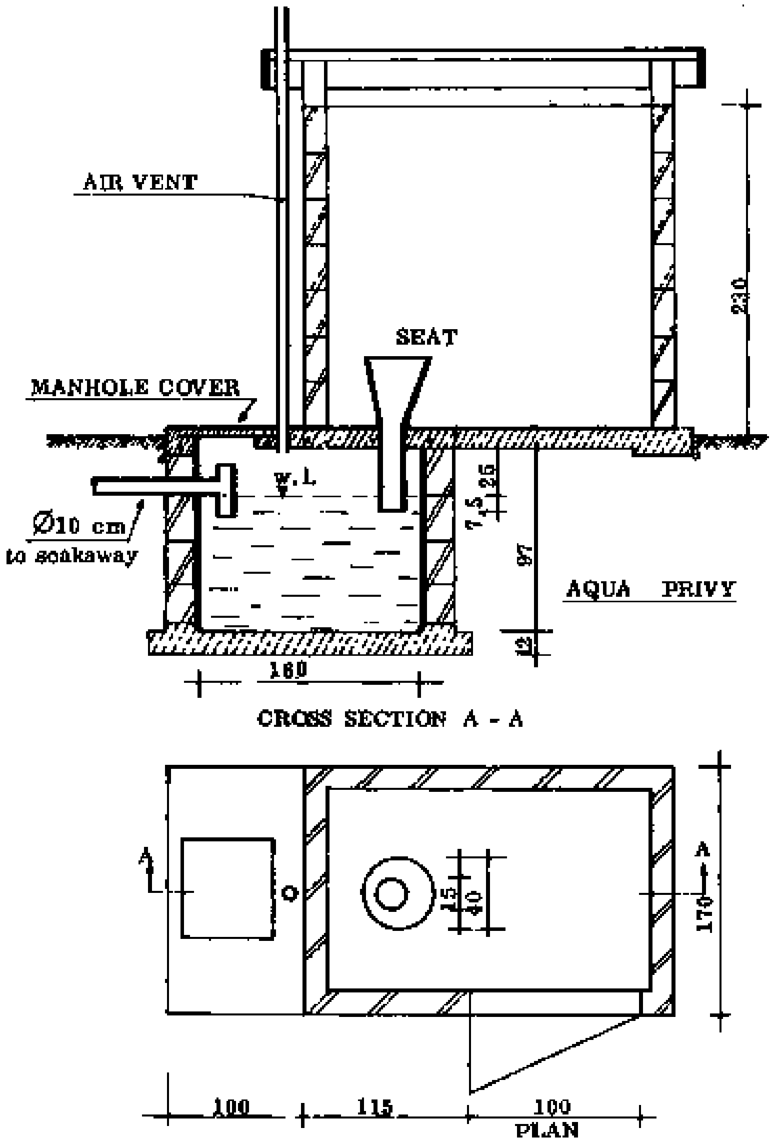
LOCAL POT

CROSS SECTION

Pit latrine and aqua privy

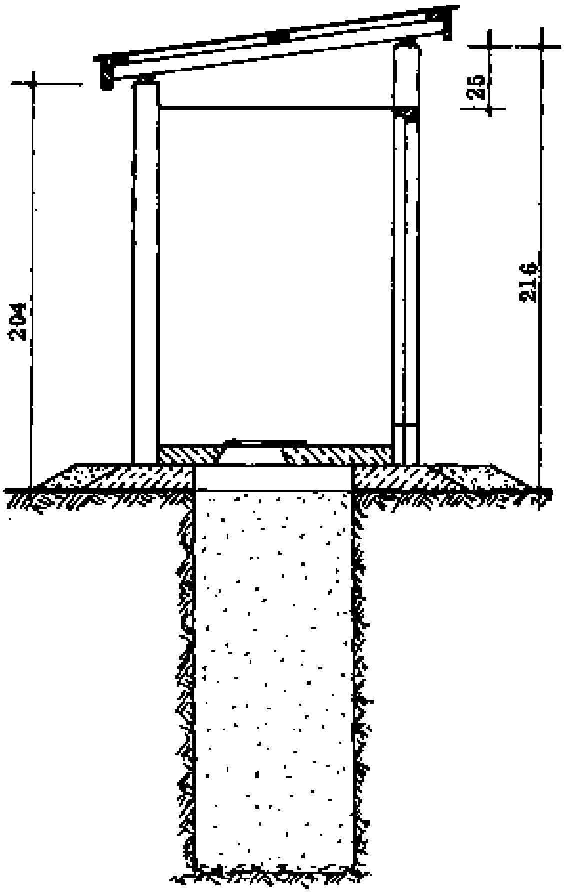


VENTILATED PIT LATRINE



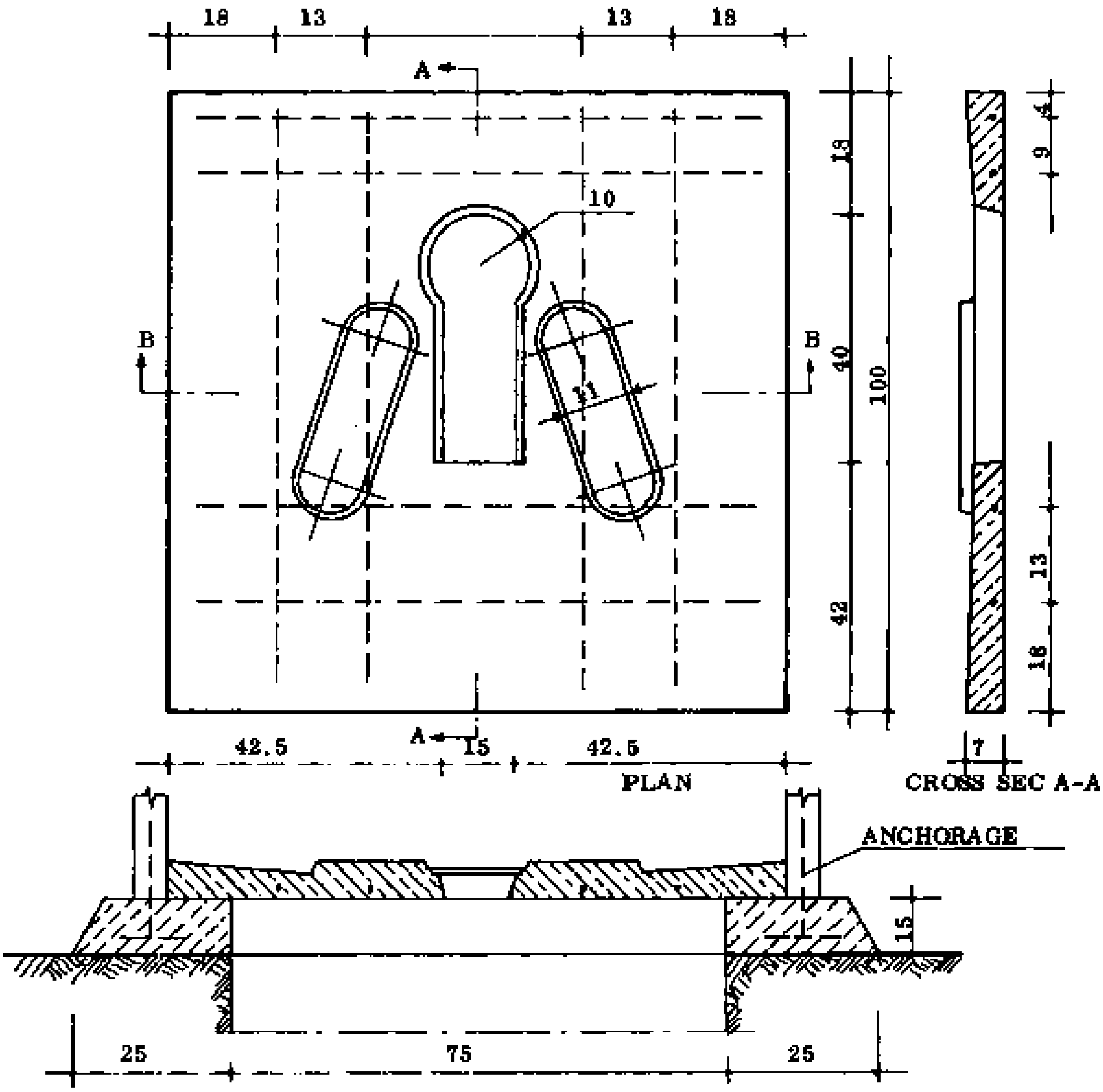
AQUA PRIVY

Pit latrine and squatting slab



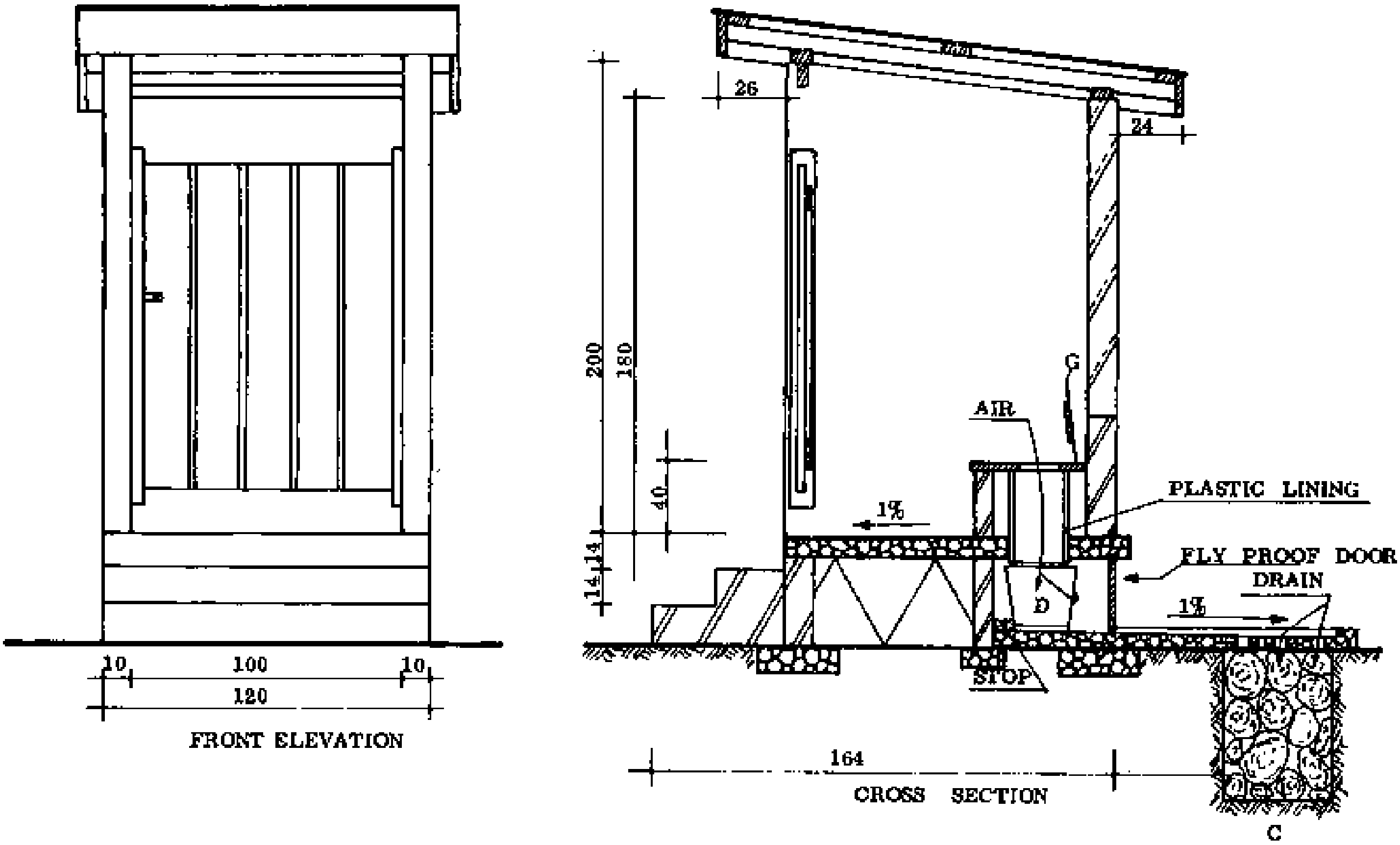
REMOVABLE LIGHT-WEIGHT CONSTRUCTION AND SLAB CAN BE REUSED.

PIT LATRINE



BUCKET LATRINE

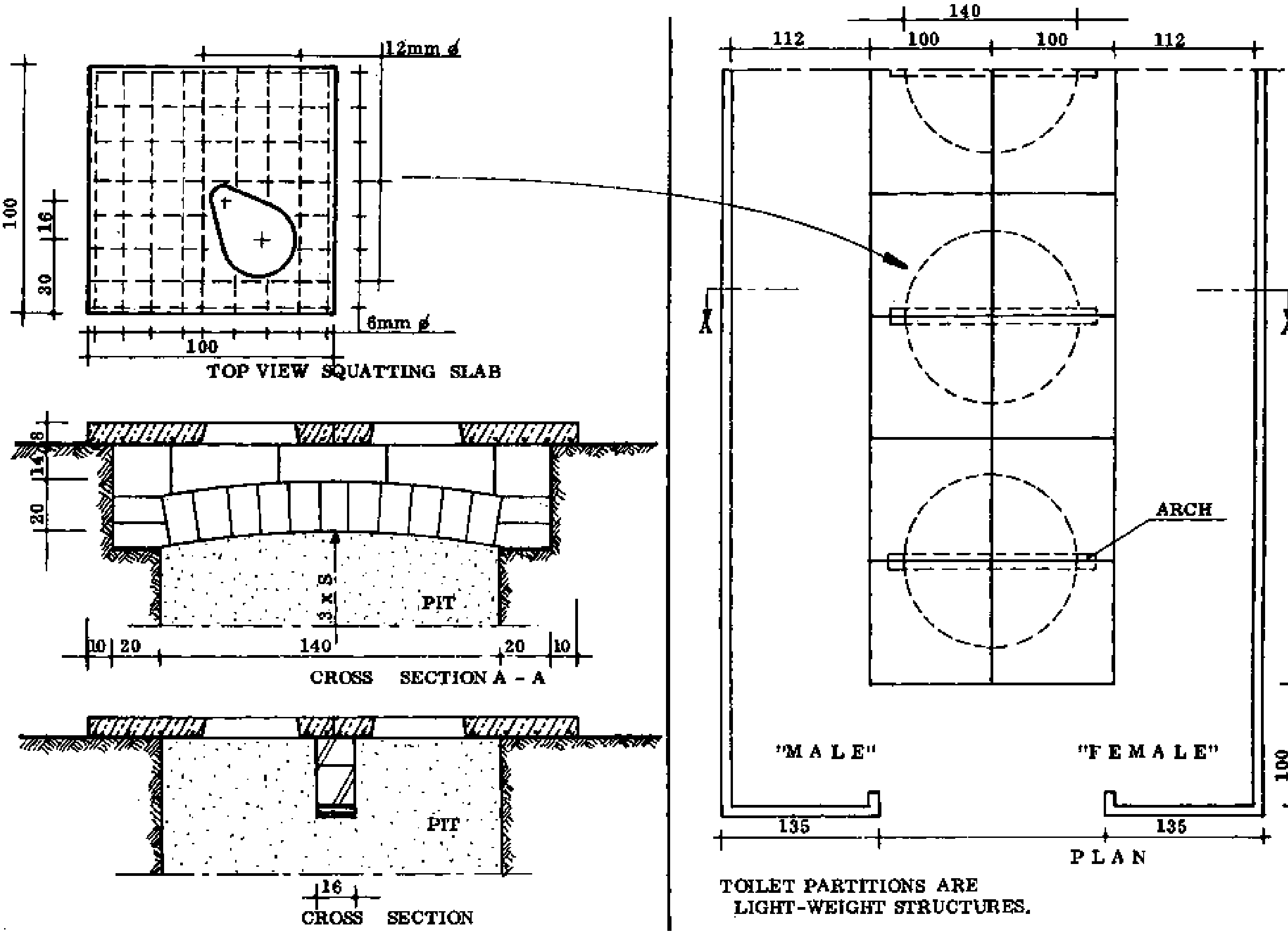
Bucket latrine



BUCKET LATRINE

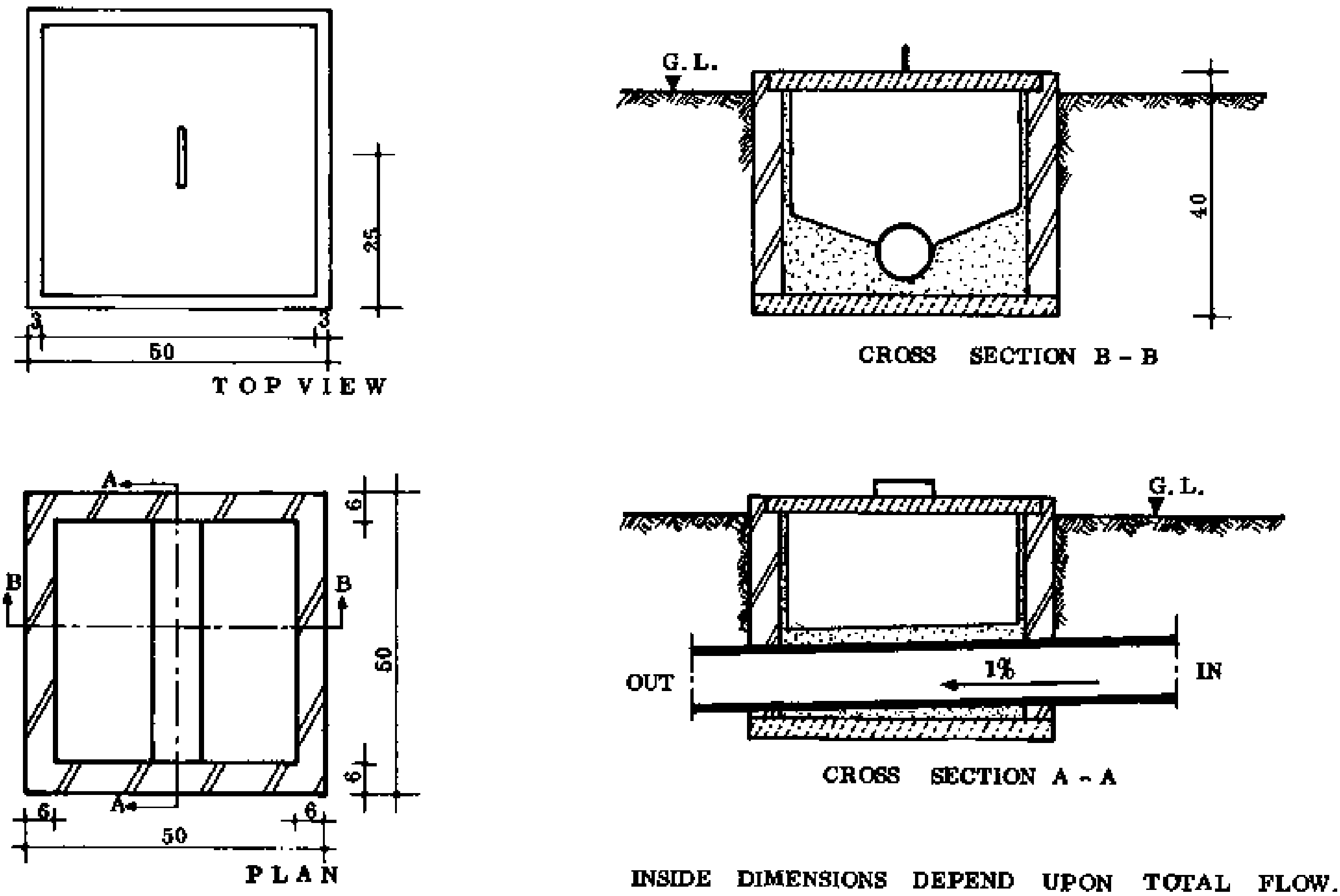
STOP = STOP FOR BUCKET
C = SOAKAGE PIT
D = BUCKET
G = COVER

Community pit latrine



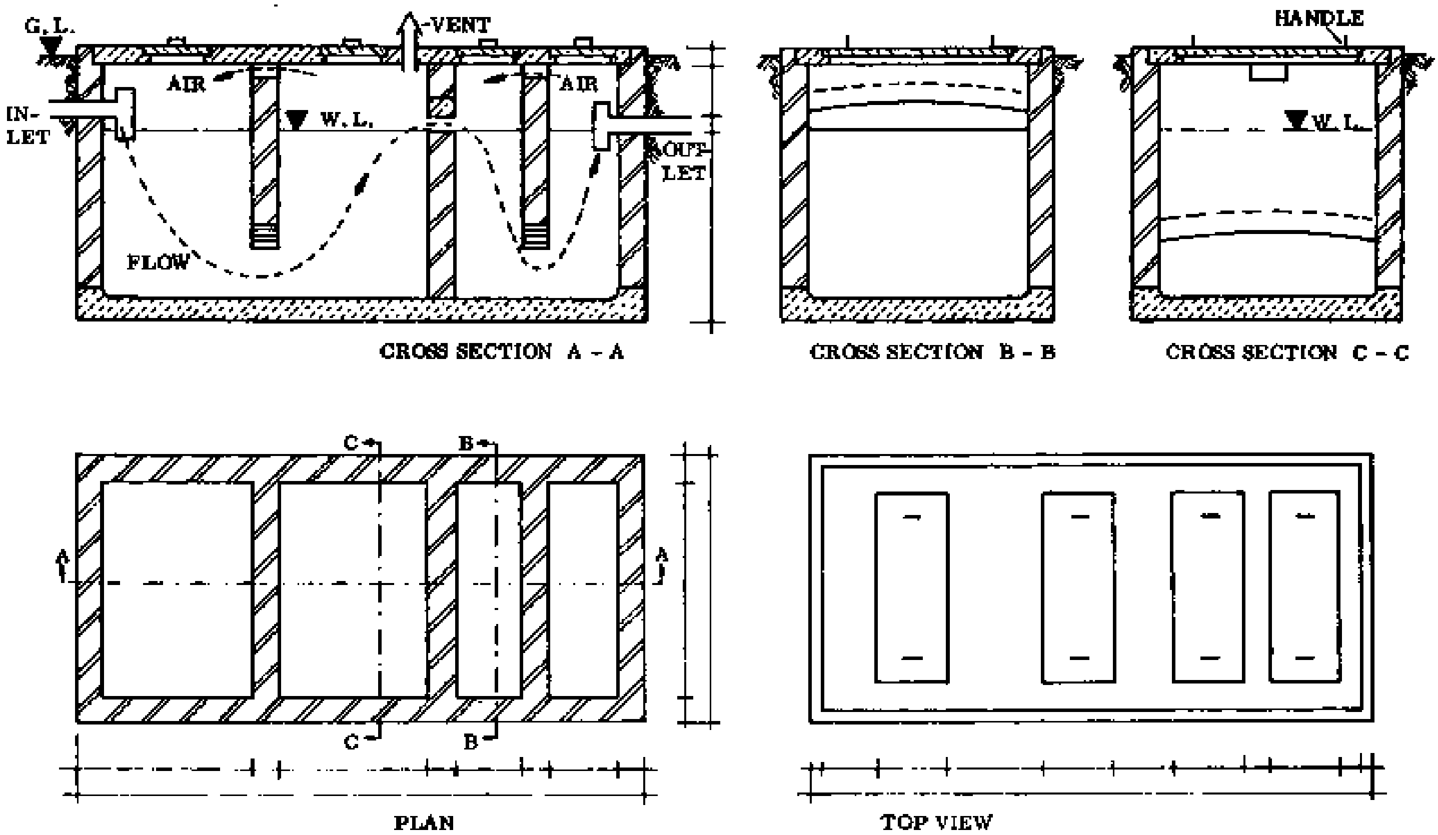
PIT LATRINE

Manhole



<u>MANHOLE</u>

Septic tank



<u>SEPTIC TANK</u>

DIMENSIONS DEPEND ON THE TOTAL SEWAGE INPUT

NPVC

Table of Contents

Table of Contents

Rural Building – Reference Book

PREFACE

This official text book is designed purposely to meet the needs of trainees who are pursuing rural building courses in various training centres administered by the National Vocational Training Institute.

The main aim of this book is to provide much needed trade information in simple language and with illustrations suited to the understanding of the average trainee.

It is the outcome of many years of experiment conducted by the Catholic F. I. C. brothers of the Netherlands, and the German Volunteer Service instructors, in simple building techniques required for a rural community.

The National Vocational Training Centre is very grateful to Brothers John v. Winden and Marcel de Keijzer of F.I.C. and Messrs. Fritz Hohnerlein and Wolfram Pforte for their devoted service in preparing the necessary materials for the book; we are also grateful to the German Volunteer Service and the German Foundation For International Development (DSE) – AUT, who sponsored the publication of this book.

We are confident that the book will be of immense value to the instructors and trainees in our training centres.

DIRECTOR: National Vocational Training
Institute, Accra

INTRODUCTION TO A RURAL BUILDING COURSE

Vocational training in Rural Building started in the Nandom Practical Vocational Centre in 1970. Since then this training has developed into an official four year course with a programme emphasis on realistic vocational training.

At the end of 1972 the Rural Building Course was officially recognised by the National Vocational Training Institute. This institute guides and controls all the vocational training in Ghana, supervises the development of crafts, and sets the examinations that are taken at the end of the training periods.

The Rural Building programme combines carpentry and masonry, especially the techniques required for constructing housing and building sanitary and washing facilities, and storage facilities. The course is adapted to suit conditions in the rural areas and will be useful to those interested in rural development, and to farmers and agricultural workers.

While following this course, the instructor should try to foster in the trainee a sense of pride in his traditional way of building and design which is influenced by customs, climate and belief. The trainee should also be aware of the requirements of modern society, the links between the old and new techniques, between traditional and modern designs – and how best to strike a happy medium between the two with regard to considerations like health protection, storage space, sewage and the water supply. The trainee should be encouraged to judge situations in the light of his own knowledge gained from the course, and to find his own solutions to problems; that is why this course does not provide fixed solutions but rather gives basic technical information. The instructor can adapt the course to the particular situation with which he and the trainee are faced.

This course is the result of many years of work and experimentation with different techniques. The text has been frequently revised to serve all those interested in Rural Development, and it is hoped that this course will be used in many vocational centres and communities. It is also the sincere wish of the founders of this course that the trainees should feel at the completion of their training that they are able to contribute personally to the development of the rural areas, which is of such vital importance to any other general development.

We are grateful to the Brothers F.I.C., the National Vocational Training Institute and the German Volunteer Service for their assistance and support during the preparation of this course.

Bro. John v. Winden (F.I.C.)
Wolfram Pforte (G. V. S.)
Fritz Hohnerlein (G.V.S.)

LAY–OUT OF THE RURAL BUILDING COURSE

The Rural Building Course is a block–release–system course, which means that the trainee will be trained in turn at the vocational centre and at the building site. The period of training at the centre is called "off–the–job" training, and the period on the building site is called "on–the–job" training. Each will last for two years, so that the whole course will take four years and will end with the final test for the National Craftsmanship Certificate.

BLOCK RELEASE SYSTEM

YEAR	TERM 1	TERM 2	TERM 3
1	X	X	X
2	O	O	O
3	O	X	O
4	X	O	X

X = OFF–THE–JOB TRAINING
O = ON–THE–JOB TRAINING

The total "off–the–job" training period is approximately 76 weeks, each week 35 hours. During this training about 80% of the time is spent on practical training in the workshop. The remaining 20% of the time is devoted to theoretical instruction.

The total "on–the–job" training period is approximately 95 weeks, each week 40 hours. During this period the trainee does full–time practical work related to his course work. In addition some "homework" is assigned by the centre and checked by the instructors.

A set of books has been prepared as an aid to the theoretical training:

A – Rural Building, Basic Knowledge (Form 1)
B – Rural Building, Construction (Forms 2, 3, 4)
C – Rural Building, Drawing Book (Forms 1, 2, 3, 4)
D – Rural Building, Reference Book

All these books are related to each other and should be used together. The whole set covers the syllabus for Rural Building and will be used in the preparation for the Grade EL, Grade I, and the National Craftsmanship Certificate in Rural Building.

BOOK INTRODUCTION

Rural Building Tools, Maintenance of Tools, Materials and Products is a reference book. This means that you should not read it through at once like a textbook, but use it when you need to look up information about certain tools, about the maintenance of a tool, or about a kind of building material or building product.

This book is divided into 4 parts:

PART 1: RURAL BUILDING TOOLS

> This part of the book covers the basic tools needed in Rural Building and how to use them. It also treats a variety of site tools, site equipment and some optional tools.

PART 2: MAINTENANCE OF TOOLS

> This section is about how to maintain the tools, so that they work better and last longer,

PART 3: RURAL BUILDING MATERIALS

> This part deals with building materials; both the traditional ones and modern ones, that are used in Rural Building.

PART 4: RURAL BUILDING PRODUCTS

> This part of the book covers the products such as reinforcement steel, blocks, paint, sheet materials, roofing sheets etc. used in Rural Building.

It is very important that you know all the technical terms, so if you come across a word or term that you don't understand you should look it up in the glossary at the end of this book, where most of the technical terms are explained. If you can't find the word in the glossary, write it down and ask your instructor to explain it.

The Tables of Figures in Appendix I are intended to help you to figure out the amounts of building materials that will be required for the planned building.

GENERAL RULES FOR SAFETY

1. Give all your attention to the job and don't distract others.

2. Be sensible in your behavior, don't play with tools or run about the building site or workshed.

3. Be alert, watch out for any dangerous situations, warn your colleagues, and report it to the person in charge.

4. If you are not sure of the correct way to use a tool, ask your instructor.

5. Make sure that your workpiece is safe and securely fastened in place before you start cutting or any work.

6. When cutting wood, guide the cutting tool in the correct way and keep your hands away from the cutting edge. Always cut away from yourself.

7. Wear safety goggles when cutting blocks, breaking concrete or grinding tools.

8. Carry tools with the pointed ends down.

9. When you finish working with a tool, clean it and return it to the toolbox.

10. Never throw or drop tools.

11. Keep the place tidy. A workplace scattered with tools is dangerous.

12. Maintain your tools, work only with clean and sharp tools.

13. A good quality, well maintained tool can do half the work for you.......

NOTES:

PART 1: RURAL BUILDING TOOLS

During thousands of years of development, people became aware that making certain things and doing certain jobs requires the use of special tools. Technical tasks could not be done with bare hands alone.

To make the things that they wanted, people were forced to design and make different tools for different jobs. For example, without tools like the plough, the farmer would not be able to feed his family. The plough was invented to make his work easier and to make sure that he could harvest a surplus of food for the benefit of the whole society. The plough was invented step by step and adapted to serve under different conditions.

In the same way, tools are very important in building. They enable people to shape all kinds of materials into useful articles and to make improved shelters to protect them from the weather and from enemies.

Early tools were the axe and the cutlass, which allowed men to cut wood for building instead of breaking it, and to make things like ladders, wheels and stools.

Now the Rural Builder uses more advanced tools and it is necessary for him to learn how to use and treat these tools well, because they are valuable. Even the most skilled craftsman can do little or nothing without the proper tools.

Since the Rural Building trade combines the crafts of carpentry and masonry, the Rural Builder's set of tools must also be a combination of masonry and carpentry tools.

This combined set of tools is limited and adapted for building in rural areas. It will enable the Rural Builder to construct perfectly well the kind of living quarters that are needed in the Northern and Upper regions of Ghana, starting from the foundation to the last nail of the roof construction.

Due to the structure of this course it is convenient to introduce the masonry tools first.

NOTES:

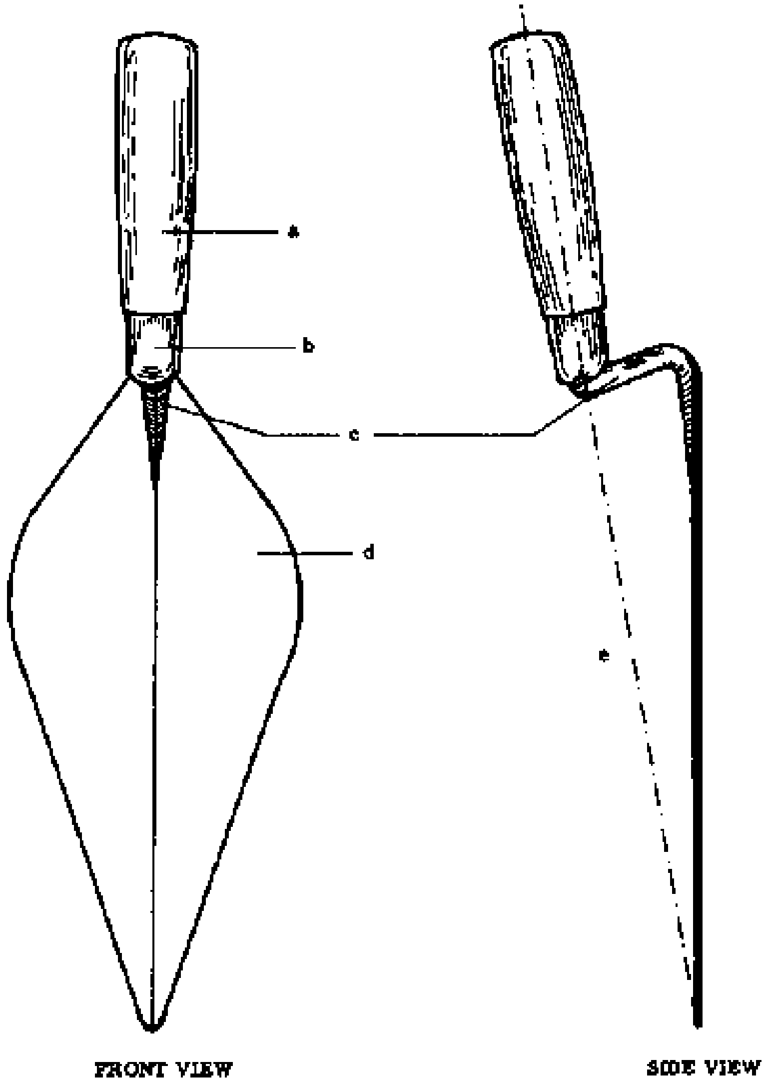


Fig. 1

NEVER CUT SANDCRETE BLOCKS WITH A TROWEL, AS THIS WILL DENT THE EDGE OF THE BLADE.

LAYING TOOLS

THE TROWEL

Of all the tools that a blocklayer uses, the brick trowel is by far the most important one, for it is almost continuously needed during the building construction.

Its main function is to pick up the mortar and to spread it to an even thickness in preparation for laying the blocks. Apart from its use in the trimming of landcrete blocks, the trowel is needed for any work where mortar or concrete is worked up.

NOTE: Never cut sandcrete blocks with a trowel, as this will dent the edge of the blade.

The long narrow−bladed trowel shown in Fig. 1 is very popular in this country and it is most frequently used for laying blocks and trowelling floorscreeds.

This trowel consists of a wooden handle (a) connected by a ferrule (b) to the shank (c) which joins the steel blade (d). The size of the blade ranges from 23 to 36 cm in length; this dimension being measured from the back of the shank to the tip of the blade, while the width varies from 9 to 13 cm.

The extended axle line of the handle (e) should line up with the tip of the blade in order to provide the best handling. This applies to all types of brick trowels.

When you buy a trowel, make sure that the blade is of a good quality steel. You can judge this quality by knocking your fingernail on the blade. The higher the sound the harder the steel.

The blade should also be able to bend slightly and return to its original position. If not, the blade is too soft.

NOTES:

Fig. 1

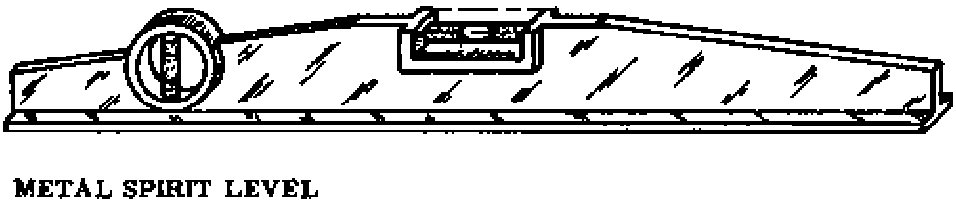


Fig. 2

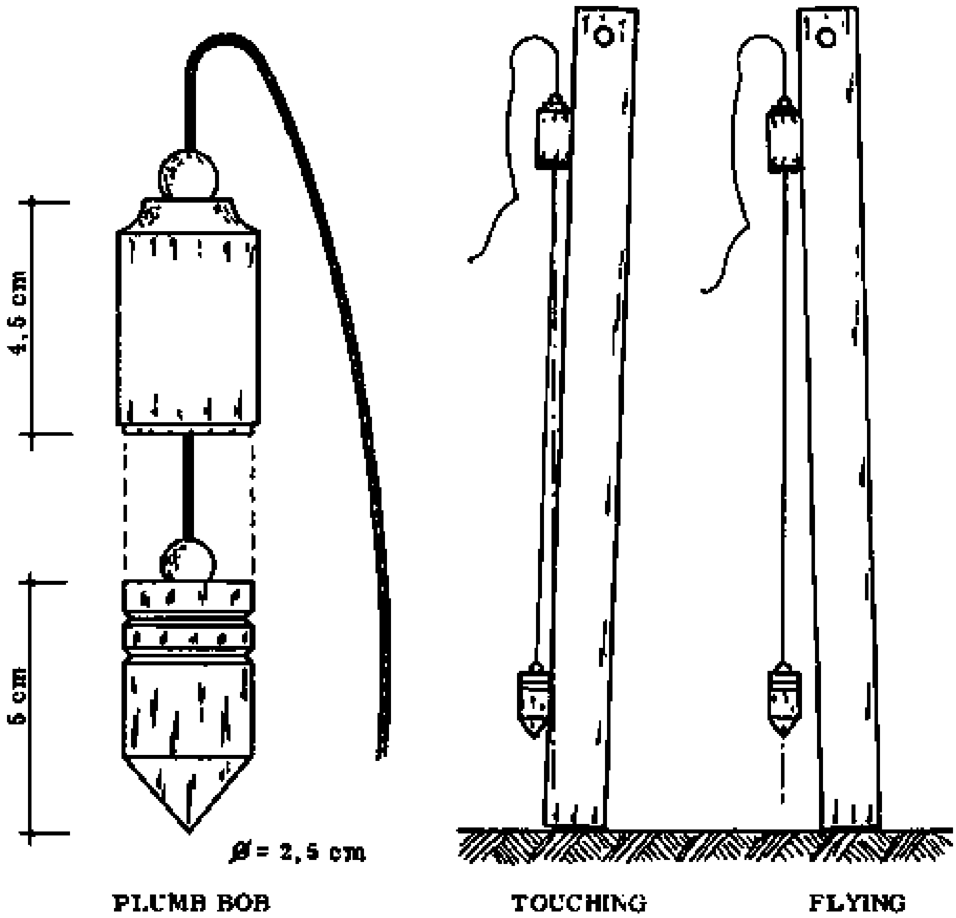


Fig. 2

STRAIGHTENING TOOLS

There are four main straightening tools.

SPIRIT LEVEL

These are wooden or metal straight edges specially fitted with plastic tubes containing spirit and a bubble of air.

These tubes are set into the straight edge so that when it is placed across two points which are level to each other, the air bubble will be exactly in the centre of the tube. This position is clearly marked with lines inside the tube (Figs. 1 & 2).

In a similar way, a tube is set in the straight edge to read with the level held vertically, which enables you to plumb members over short distances. If the level is used in conjunction with a straight edge you can plumb or level over a longer distance.

To level a longer horizontal distance you cannot use a straight edge with a level. Instead you have to use a water level which will be explained later. To level a vertical distance which is longer than your straight edge you can use your plumb bob.

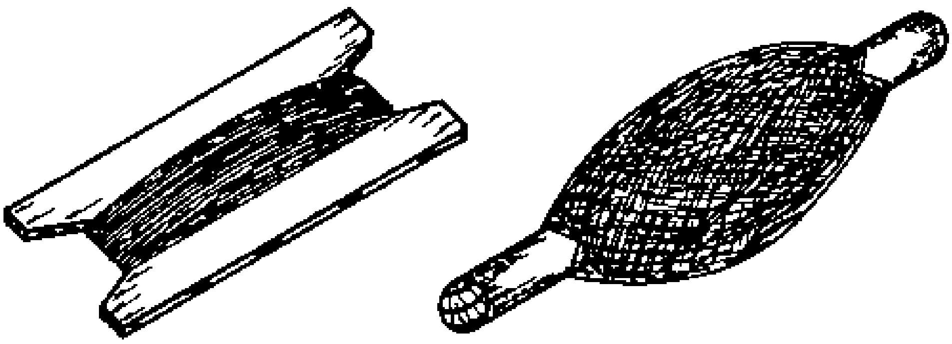
PLUMB BOB

This tool consists of a solid brass or metal cylinder with a pointed end, which is attached to a suspending line so that its tip is always pointing vertically down. Its upper part is a small wooden block with a hole drilled in its centre so that the line with the cylinder on it can be pulled up or lowered down through the hole.

The diameter of the wooden block is slightly greater than the diameter of the cylinder, so that the cylinder can move freely up and down without touching the workpiece. The dimensions of the plumb bob are shown in Fig. 3.

The main use of the plumb bob is as a more accurate replacement for the vertical spirit level and also to transfer points down vertically in marking. Both methods will be described later.

NOTES:



MASON LINE

Fig. 1

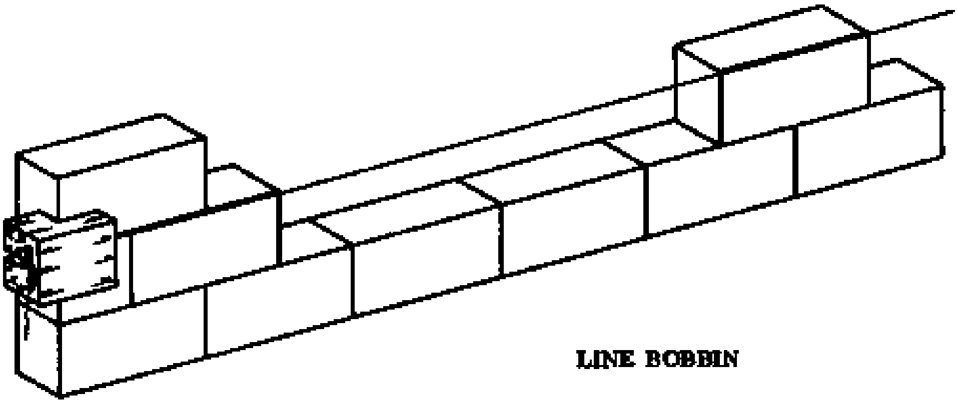


Fig. 2

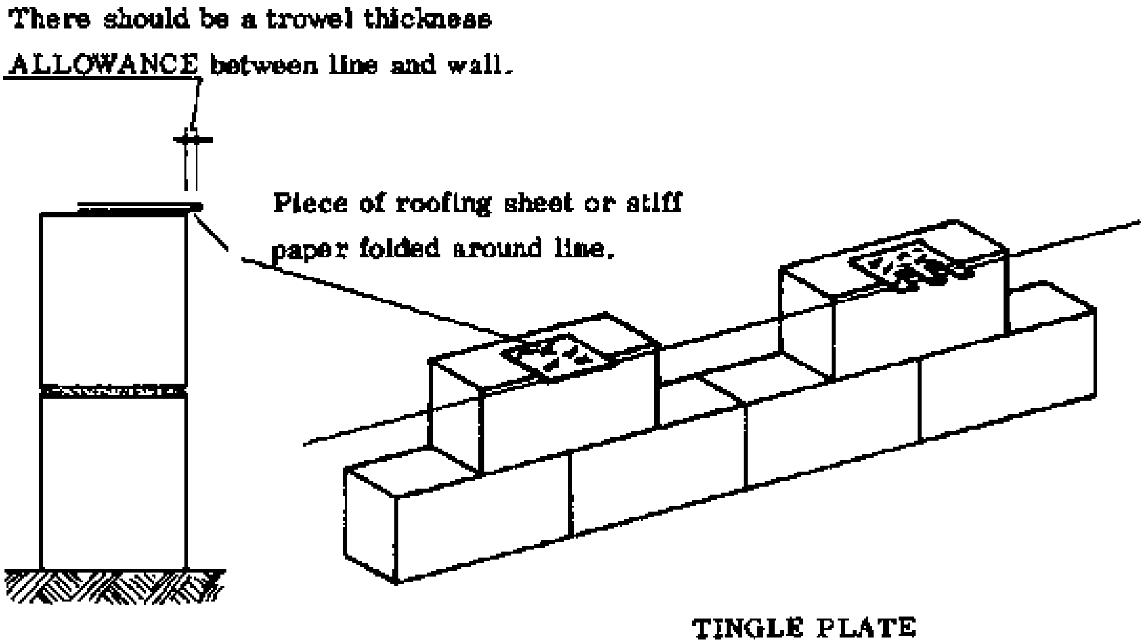


Fig. 3

MASON LINE

When building up walls between two quoins we employ the mason line, which is approximately 30 metres long, to ensure that the courses are straight and at the correct height (Fig. 1).

The line is tightened between two nails driven into the bed joints.

Mason lines are also used for setting out buildings, lining out frames for doors and windows and many other purposes where a straight line is needed for a guide over longer distances.

Instead of nails, so−called line bobbins may be used. These are hard wood blocks made to the size and shape indicated in Fig. 2. The line is stretched between opposite quoins, passed through the sawcut of each bobbin and wrapped around the projecting screws. Their uses will be explained later.

Line bobbins are preferred to nails, as they are easily adjusted to the required level and no holes need to be made in the bed joints.

In addition to the mason line, a tingle plate must be used if the distance between the quoins becomes too great and the line starts to sag. A tingle plate is made from <u>thin</u> metal and it is used to support the line in the middle to prevent sagging. The tingle plate must of course be set at the correct height (Fig. 3).

A tingle plate can easily be made from a piece of roofing sheet or any other sheet metal. Sometimes a piece of stiff paper is used for the purpose.

If the line breaks, it should be spliced and not tied with a knot, because a line full of knots will not be straight.

NOTES:

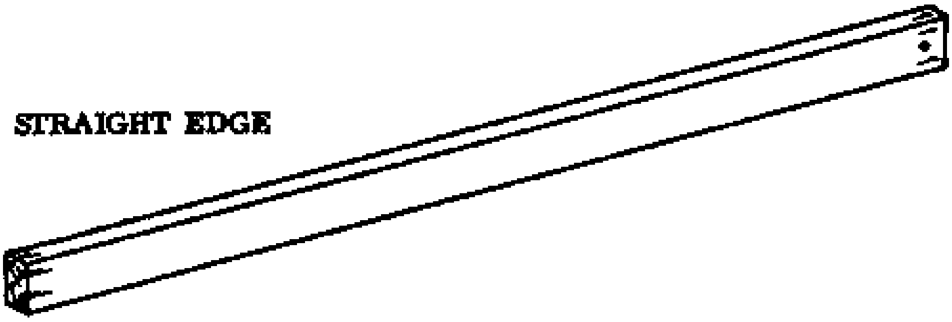


Fig. 1

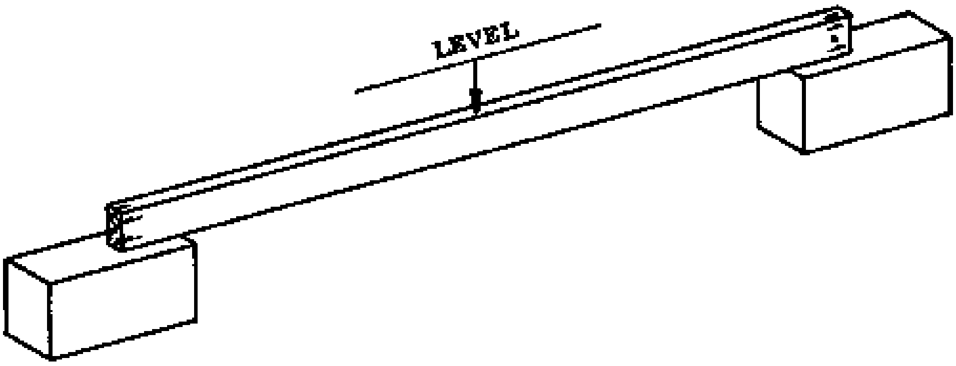


Fig. 2

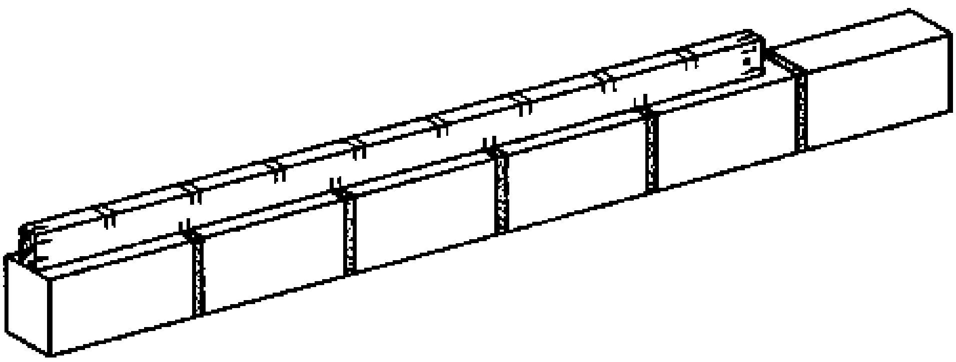
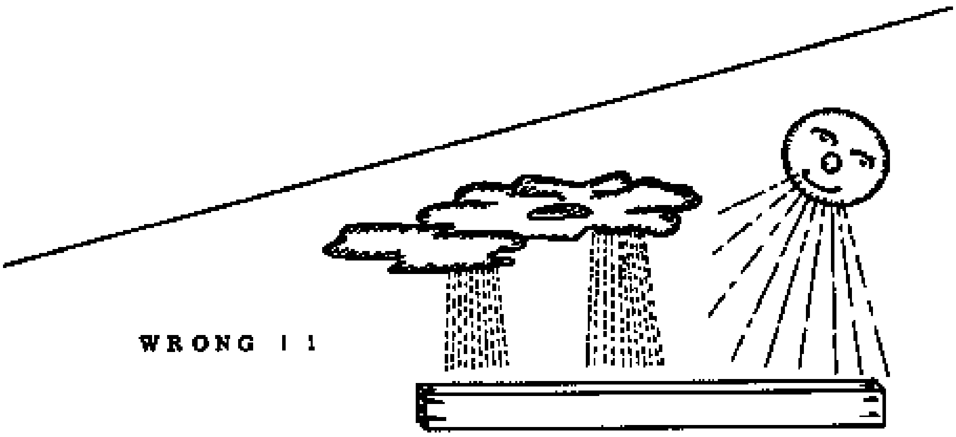


Fig. 3



STRAIGHT EDGE

This is a planed piece of wood which should be well seasoned and dry to prevent it from bending and twisting. The dimensions of a straight edge are usually 2 to 2,50 m long, 7,5 cm wide and 2,5 cm thick; both edges must be perfectly straight and parallel (Fig. 1).

The straight edge is employed for testing masonry work either alone or in conjunction with the spirit level (Fig. 2).

Some straight edges are marked off with saw cuts to the required gauge; that is, one division is equal to the height of a block plus the joint; and, on the other edge, the length of a block plus the joint (Fig. 3).

Its wide range of further applications will be described as it is needed for certain constructions.

Do not allow a straight edge to dry out in the sun or to be soaked in water as this may cause it to bend or twist (Fig. 4). When you are finished using it, hang the straight edge in a protected place to keep it straight.

NOTES:

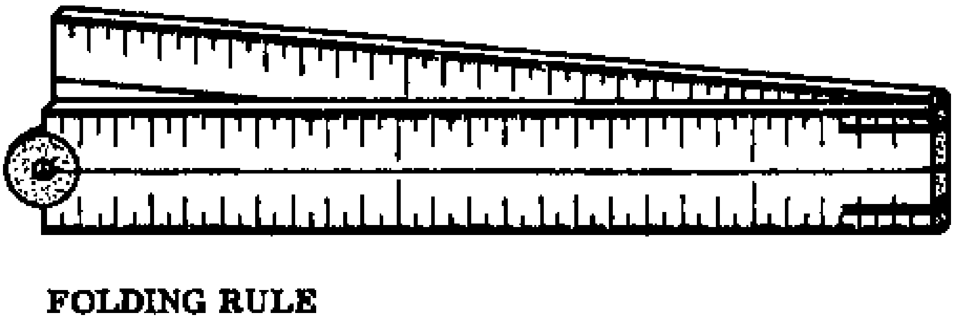


Fig. 1

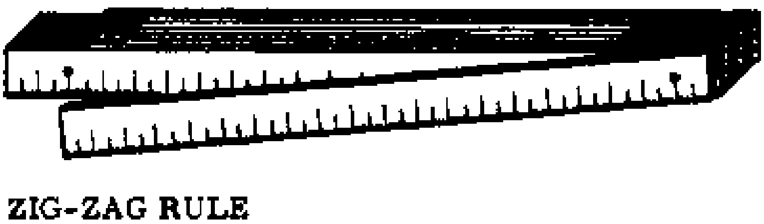


Fig. 2

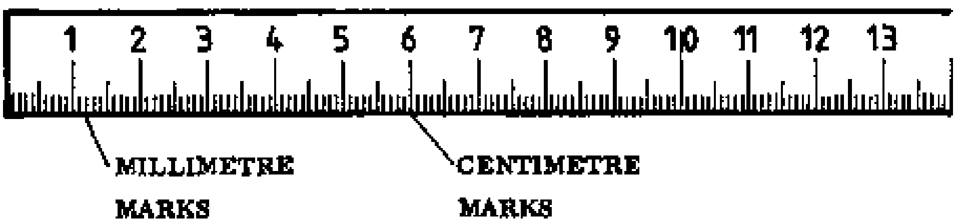
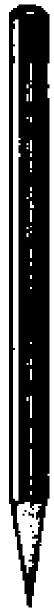


Fig. 3



PENCIL

Fig. 4

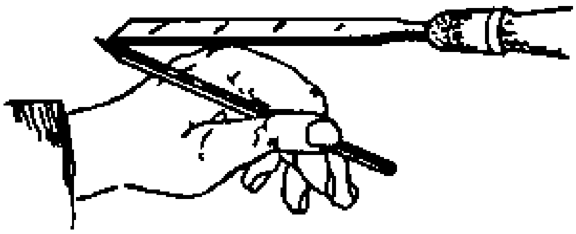


Fig. 5

MEASURING AND MARKING TOOLS

FOLDING RULE

The four–fold rule shown in Fig. 1 is made of four wooden, plastic or metal pieces which are held together by special hinges. It is one metre long and divided on both sides into millimetres and centimetres. It is used to find and check measurements as well as to mark out the work.

To make the rule operate more smoothly and last longer, put a drop of machine oil in the joints.

ZIG–ZAG RULE

A zig–zag rule is similar to a folding rule (Fig. 2). It is made out of the same materials but from pieces which are 20 cm long. As the hinges are different from those of the folding rule, be careful not to break it when opening and closing it. They come in lengths of 100 and 200 cm.

HOW TO READ RULES

The marks on a rule are of different lengths to make it easier to read accurately (look at the rule you use in class). The marks at each centimetre are the longest, the marks for 5 mm (1/2 cm) are medium long, while the millimetre marks are shortest (Fig. 3).

When measuring with the folding rule or the zig-zag rule, one must make sure that the rule is completely opened and straight. It is then held parallel to an edge, or at right angles to a face. If this is not done, the measurements you get will always be a little different from the correct ones.

PENCILS

For marking on wood, a hard lead pencil (H or 2H) is best (Fig. 4). The point should always be kept sharp, because using a blunt pencil can result in an inaccuracy of up to 2 mm.

Fig. 5 shows how to hold a pencil while sharpening it.

NOTES:

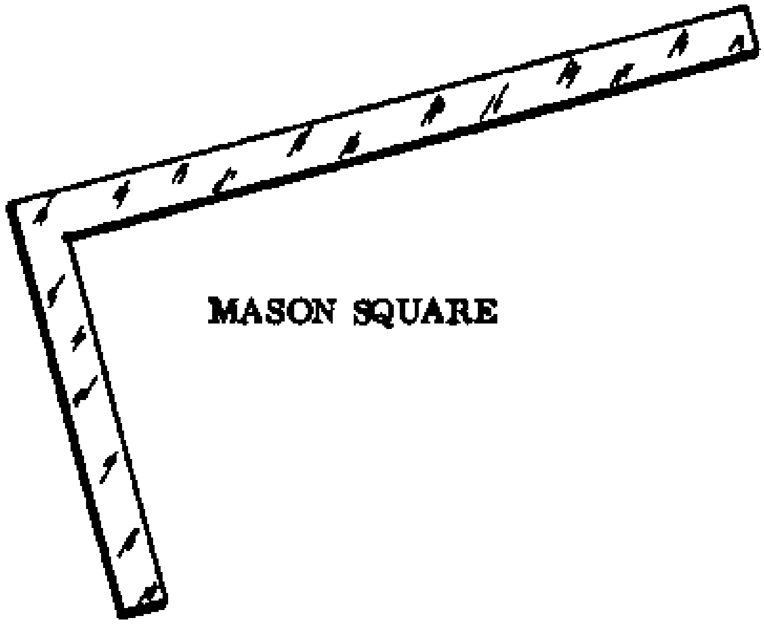
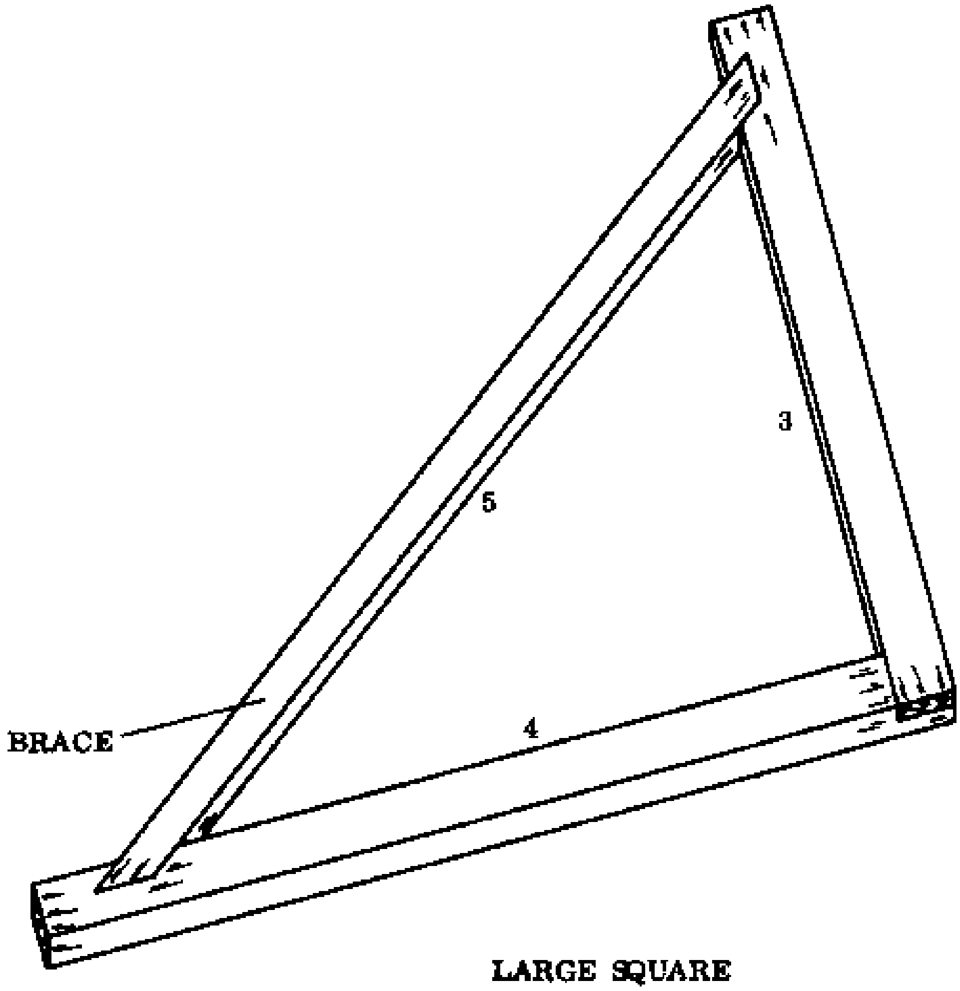
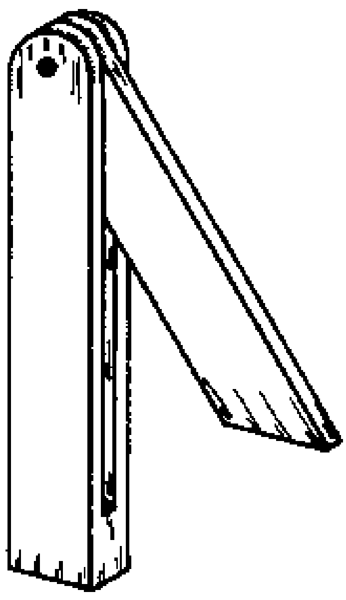


Fig. 1



LARGE SQUARE
Fig. 2



SLIDING BEVEL
Fig. 3

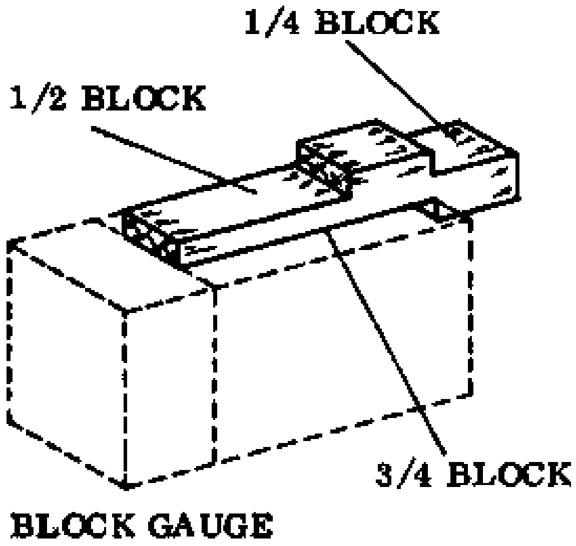


Fig. 4

THE MASON SQUARE

The mason square is made from steel (Fig. 1). Measured along the outer edge, the short blade is 33 cm long and the long blade is 60 cm long. The blades are sometimes marked with millimetres, centimetres, and decimetres.

The mason square is used for setting out right angles as at quoins, and for testing corners during plastering.

When using the square, hold it either horizontally or vertically (not at an angle) to be sure of getting the correct angles.

THE LARGE SQUARE

This square is made entirely from wood (Fig. 2). To construct this large square which is made at the building site, use the 3–4–5 method and nail the boards together securely. A brace over the two legs ensures that the square remains at the correct angle. The square is used to test larger right angles.

THE SLIDING BEVEL

A sliding bevel (Fig. 3) can be made out of wood by the Rural Builder. The two legs are adjustable and held together by a small bolt with a wingnut to make it easy to adjust the bevel. It is used when you have to mark many blocks at a certain angle (also see page 78).

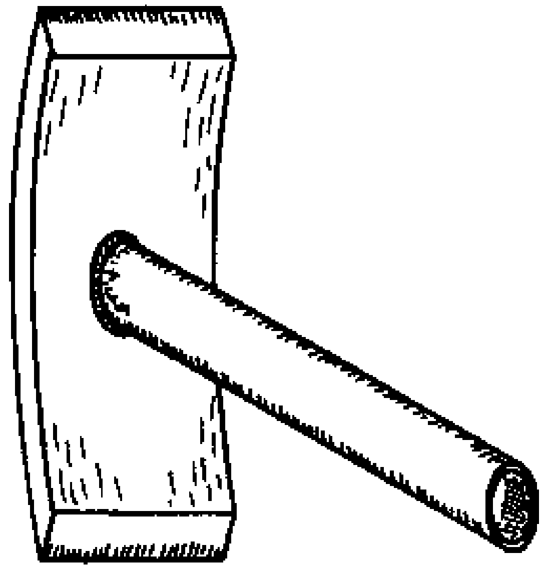
BLOCK GAUGES

These are pieces of wood cut to the size and shape indicated in Fig. 4. Block gauges may be used to mark off the sizes of 1/4, 1/2, or 3/4 blocks. Since the dimensions of landcrete blocks are different from sandcrete blocks, the trainee will make two different block gauges.

The gauges help the Rural Builder to work more efficiently when he is measuring blocks for cutting.

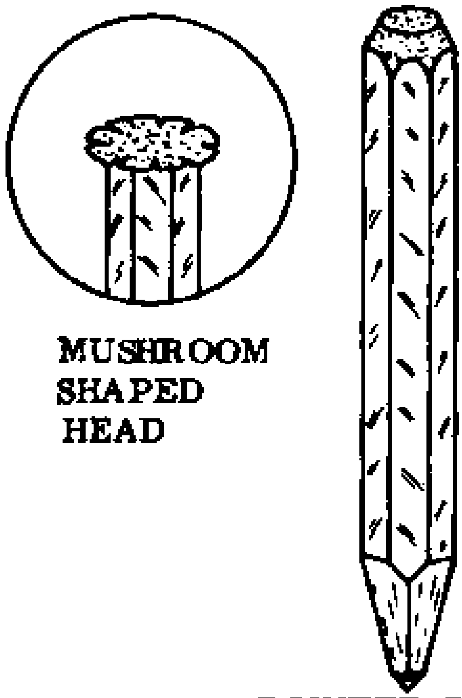
– NOTE: More tools for measuring and marking are included in the following sections with the carpentry tools.

NOTES:



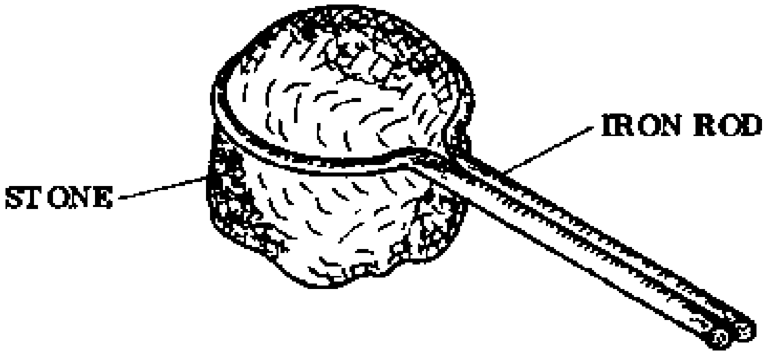
BLOCK SCUTCH OR SCUTCHER

Fig. 1



POINTED CHISEL

Fig. 2



STONE BREAKING TOOL

Fig. 3

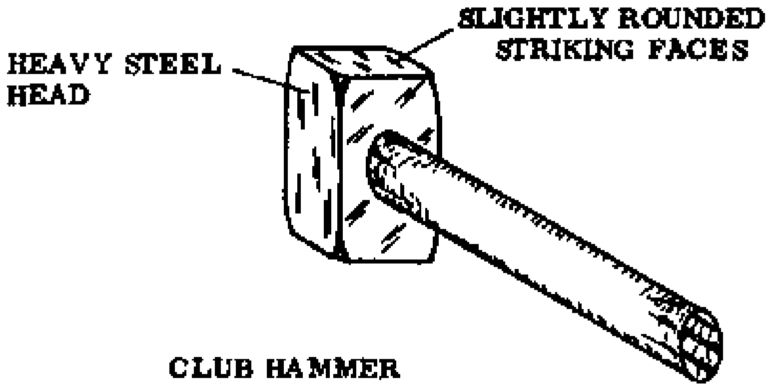


Fig. 4

CUTTING TOOLS

THE BLOCK SCUTCH

This tool consists of a hard steel blade with two cutting edges, welded to the handle which is made of iron pipe (Fig. 1). It is used for cutting all sorts of blocks and dressing cut surfaces. The angle between the blade and handle should be 75 to 80 degrees, which increases the effectiveness of the blow. The handle is oval shaped to provide a better grip.

THE POINTED CHISEL (COLD CHISEL)

This is a forged steel rod with a hardened cutting tip and striking end. It is octagonally shaped to provide a better grip for the hand (Fig. 2). Cold chisels are available in different sizes and are used together with a club hammer.

The head of the cold chisel should never be allowed to become mushroom shaped, as this may result in badly cut hands or in a piece of steel breaking off and piercing someone's eye. Always wear your safety goggles when you use the chisel.

THE STONE BREAKING TOOL

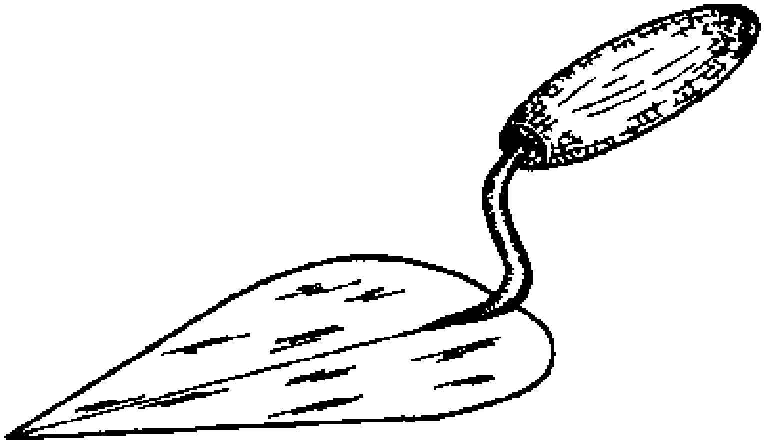
A device like the one in Fig. 3 is a useful tool on the building site. It can be made locally and is used to break stones into smaller pieces needed for concrete work. Place the device on top of the piece of stone and press it down during the hammer blow.

THE CLUB HAMMER

This hammer has a heavy steel head with slightly rounded striking faces and it can weigh from 1 to 2 kg.

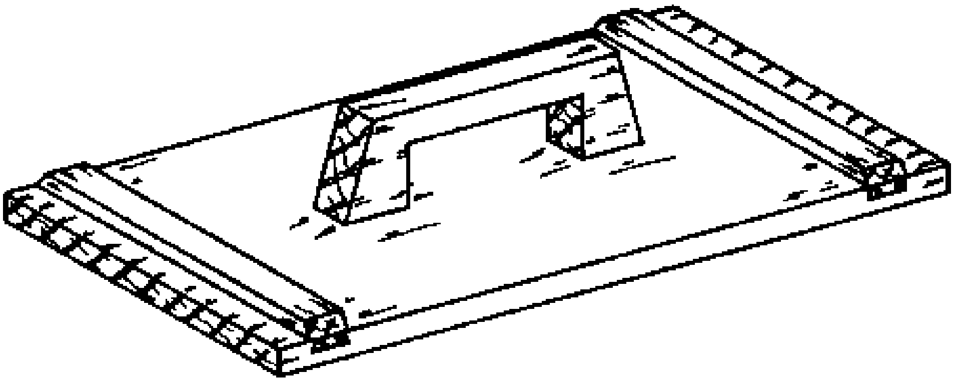
The head is fixed on a wooden handle which is 15 to 20 cm in length. The hammer is used to strike cold chisels and to break stones into smaller sizes. When using the hammer, make sure that the wedge that holds the handle in the head is firmly in position (Fig. 4).

NOTES:



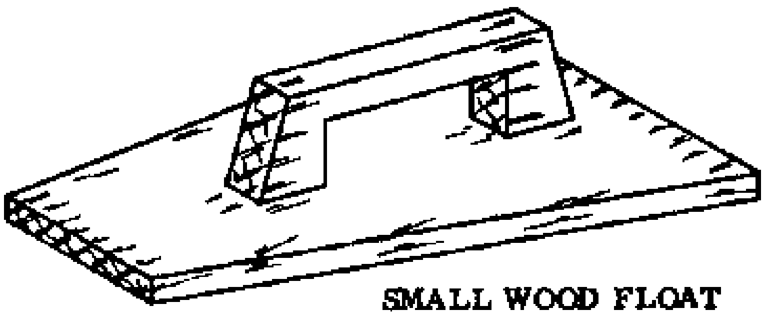
POINTING TROWEL

Fig. 1



BIG WOOD FLOAT

Fig. 2



SMALL WOOD FLOAT

Fig. 3

FINISHING TOOLS

THE POINTING TROWEL

Fig. 1 shows a trowel of almost the same shape as the brick trowel mentioned earlier, but smaller in its dimensions.

This pointing trowel is chiefly used for precision work such as finishing in general and the dressing of corners and edges in particular.

THE BIG WOOD FLOAT

This tool has a blade made of a soft wood like Wawa. It measures approximately 40 cm long and 25 cm wide. A handle made from hard wood is fixed to it with screws so that the blade can be replaced when necessary (Fig. 2).

Its main uses are to distribute an even thickness of mortar during plastering and to flatten concrete surfaces during floor construction.

THE SMALL WOOD FLOAT

The small wood float is constructed in the same way as the big one but with smaller dimensions, being approximately 25 cm in length and 15 cm in width.

As it is used mainly to give the plaster and floor surfaces a smoother finish, its blade may be made from hard wood (Fig. 3).

Because the wood float is made from wood it absorbs water from the wet mortar or cement during use, and it tends to warp. To prevent it from warping, keep the float under water when it is not in use so that all the sides are wet and the wood swells evenly.

NOTES:

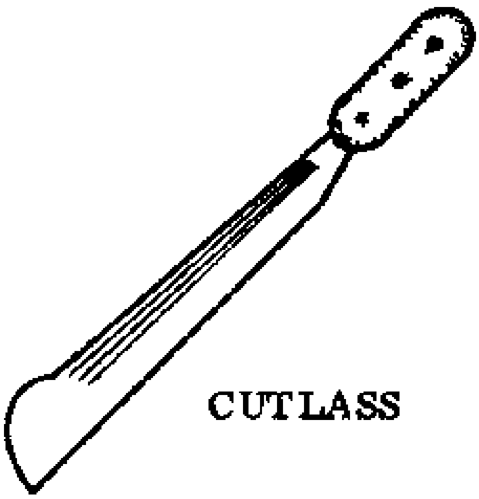


Fig. 1

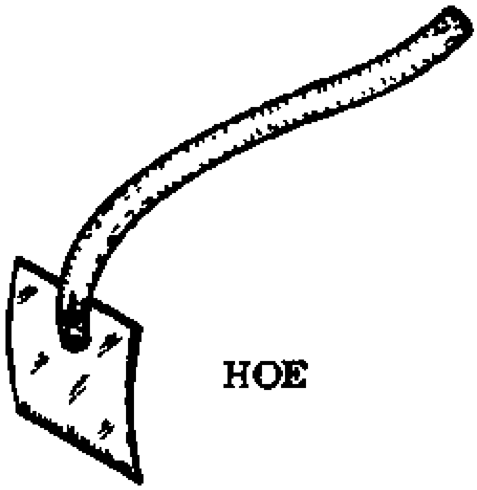


Fig. 2

Fig. 3

Fig. 4

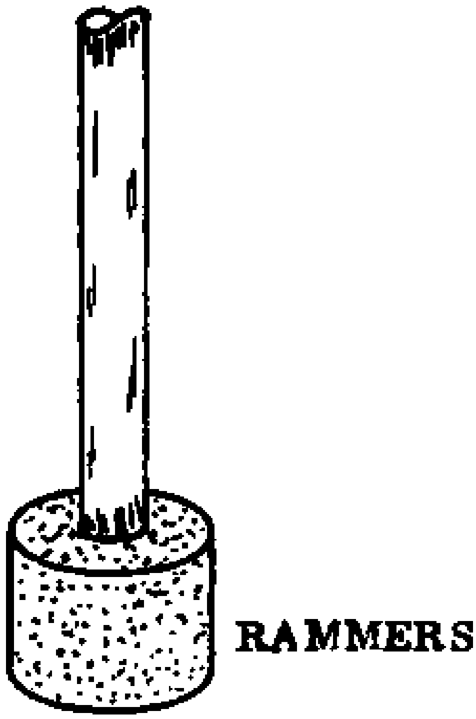


Fig. 5

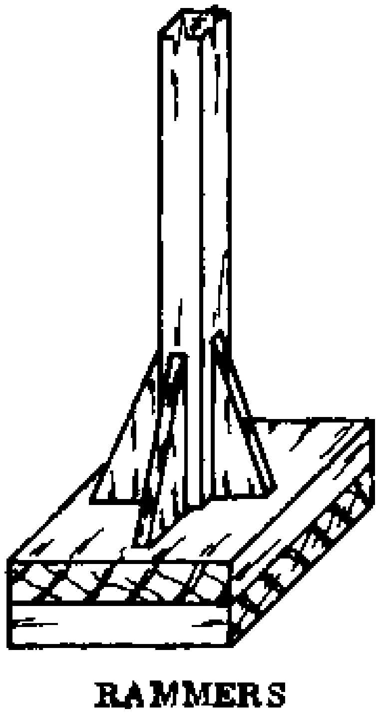


Fig. 6

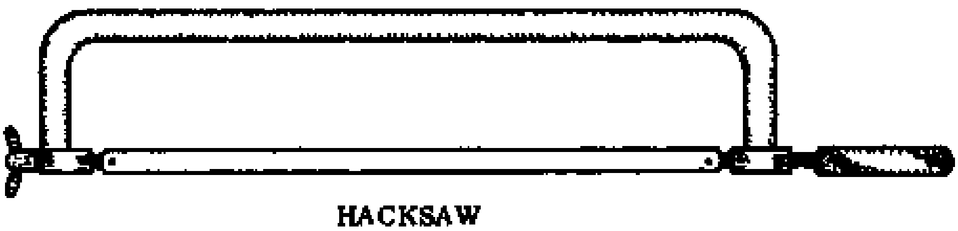


Fig. 7

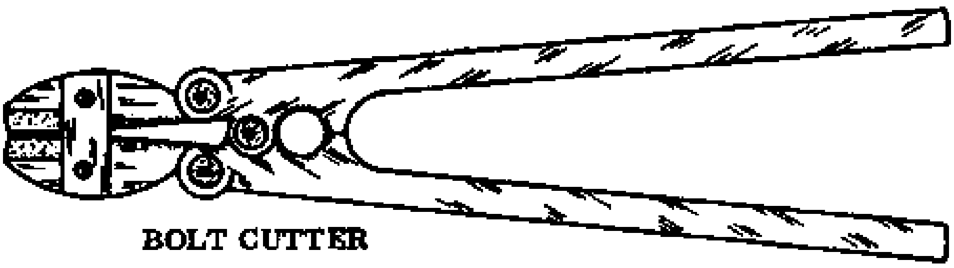


Fig. 8

SITE TOOLS

CUTLASS

The cutlass (Fig. 1) is used for clearing the site and other general cutting work.

HOE

This farming tool is often used in Rural Building to excavate top soil (Fig. 2).

SHOVEL

There are various types of shovel−like tools. The most common type is the one with a round−nosed steel blade of about 25 by 30 cm, connected to a short wooden shaft that has a "D" or "Y" shaped handle at the end (Fig. 3).

Whether the shovel has a short or a long handle is a matter of personal preference or local custom. It has been observed that the short−handled one is more suitable for filling purposes and for moving light soil, while the long−handled shovel with a square steel blade is better for loading sand and for mixing.

PICK−AXE

This digging tool consists of a heavy steel head with one pointed end and one end with a chisel edge. The head is connected to a wooden shaft (Fig. 4). The pickaxe is used during excavation to break up hard rocky soils or loosen laterite etc.

RAMMER

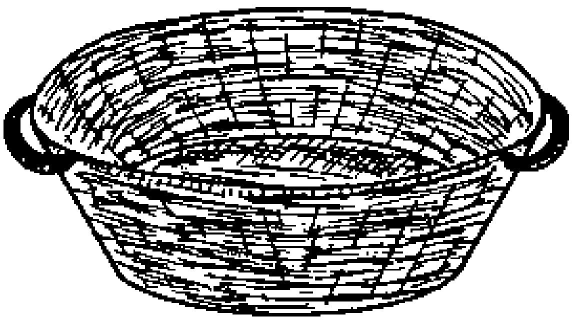
Rammers are either made entirely out of wood or they have a wooden handle attached to a metal or concrete head (Figs. 5 & 6). They are used to compact soil or concrete.

HACKSAW

A hacksaw is a handsaw used for cutting metal. It consists of a steel blade tightly stretched in a metal frame. The blade is removable and other blades can be fixed in the frame for cutting asbestos−cement or other materials (Fig. 7).

BOLT CUTTER

The bolt cutter is a tool which is used to cut steel reinforcing rods up to 19 mm in diameter (Fig. 8).



METAL HEADPAN

Fig. 1

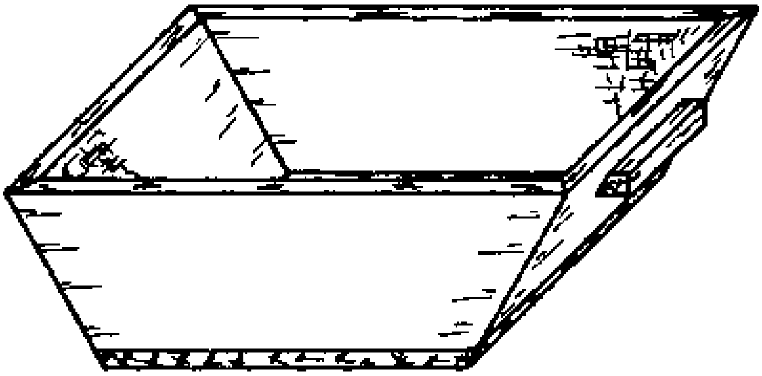


Fig. 2

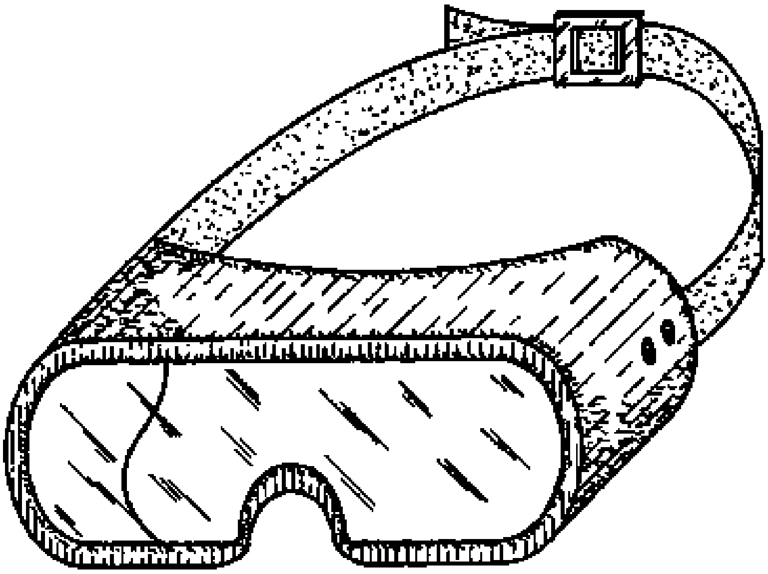


Fig. 3

HEADPAN

Smaller quantities of mortar and concrete are kept and transported in headpans. These are round containers shaped like bowls and made from mild steel or sheet metal (Fig. 1).

If made locally from wood, the headpan will be square with slanting sides (Fig. 2).

The common headpan has a holding capacity of about 15 litres for liquids, or half a bag of cement (slightly heaped up). These figures indicate that the headpan can also be used as a measure.

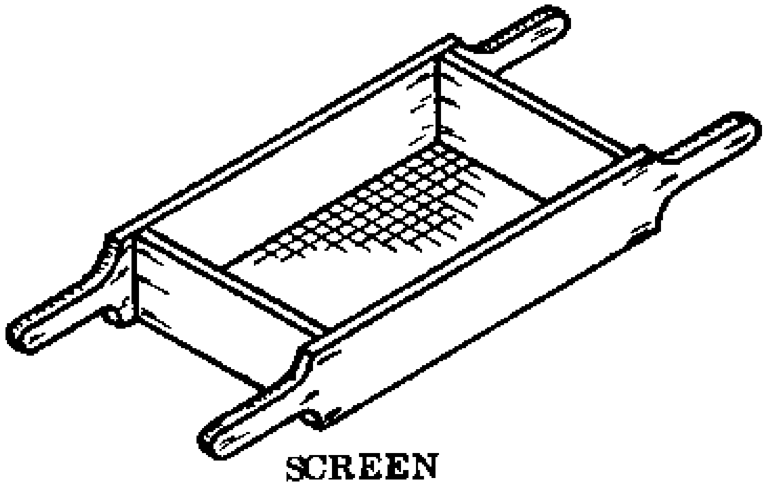
If you make your own headpan from wood or metal, be sure that it has the same capacity as other headpans so that you can measure accurately with it.

SAFETY GEAR

SAFETY GOGGLES

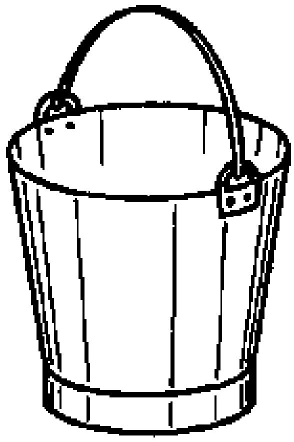
These are made from plastic and are designed to protect the eyes during all kinds of cutting or grinding operations and where there is a lot of dust in the air (Fig. 3).

NOTES:



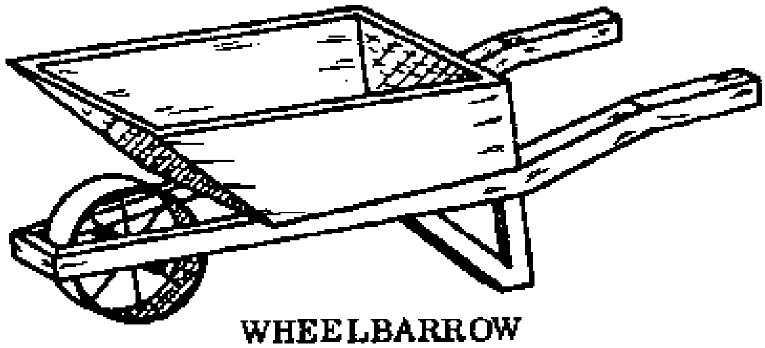
SCREEN

Fig. 1



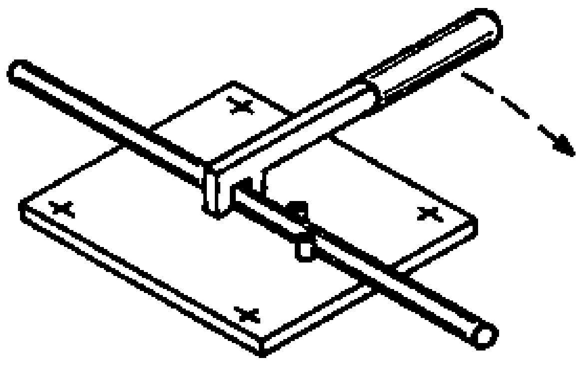
BUCKET

Fig. 2



WHEELBARROW

Fig. 3



BENDING PLATE

Fig. 4

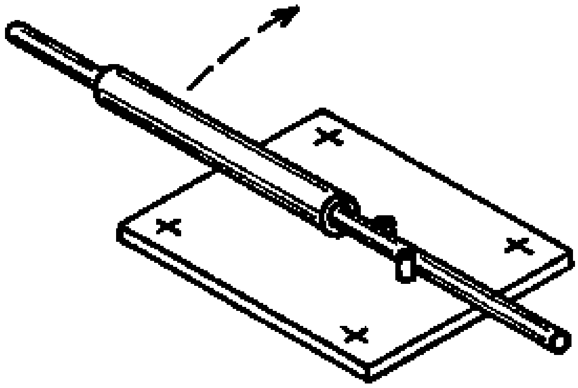


Fig. 5

SITE EQUIPMENT

SCREEN

A screen is a rectangular frame with a wire mesh built into it for separating impurities or stones from sand (Fig. 1). A well−equipped building site will have two different screens: a larger mesh to separate out stones of a convenient size; and a smaller one to sieve sand that will be used for plastering.

BUCKET

Buckets are open containers that can be made from different materials like rubber, plastic, or galvanized iron (Fig. 2). The average bucket (size no. 28) has a volume of 10 litres and is used mainly for carrying water.

ROPE

Ropes used on the building site are usually made from hemp or nylon. Nylon ropes have a tendency to stretch when they are under strain, and this must be taken into consideration when you use this kind of rope during construction work.

WHEELBARROW

The wheelbarrow is a steel or wooden container with a single steel or rubber−tyred wheel in front. It is lifted and pushed forward by means of two hand−holds attached to the frame (Fig. 3).

BENDING PLATE

Our Rural Building equipment for bending iron rods simply consists of a base−plate with two steel pegs which are spaced according to the diameter of the rod to be bent, and a bending bar (Fig. 4). The bending bar is used to do the actual bending. This is a key−shaped tool with a slot in one side into which the rod fits. Each different diameter of rod needs its own bending bar. If a suitable bending bar is not available, a pipe can be used to do the job (Fig. 5).

WATERING CAN

The watering can (not illustrated here) is a container with a pouring spout, used for watering plants. On the building site it is often used to wet down newly poured concrete or freshly made sandcrete blocks.

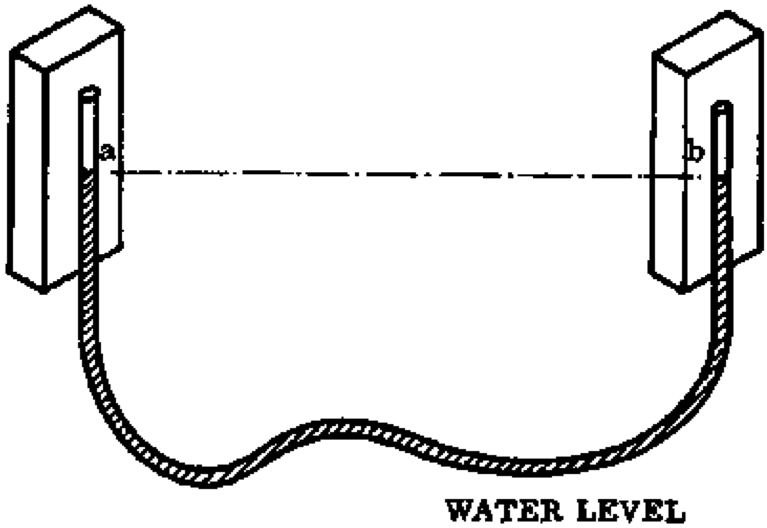


Fig. 1

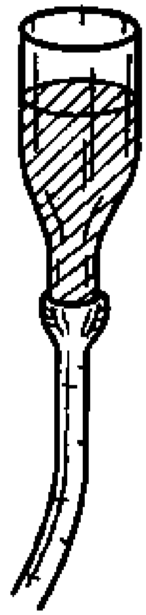


Fig. 2

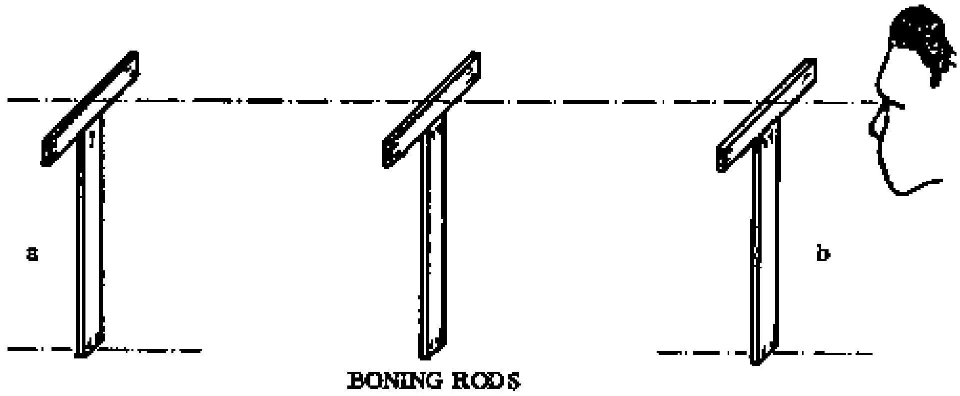


Fig. 3

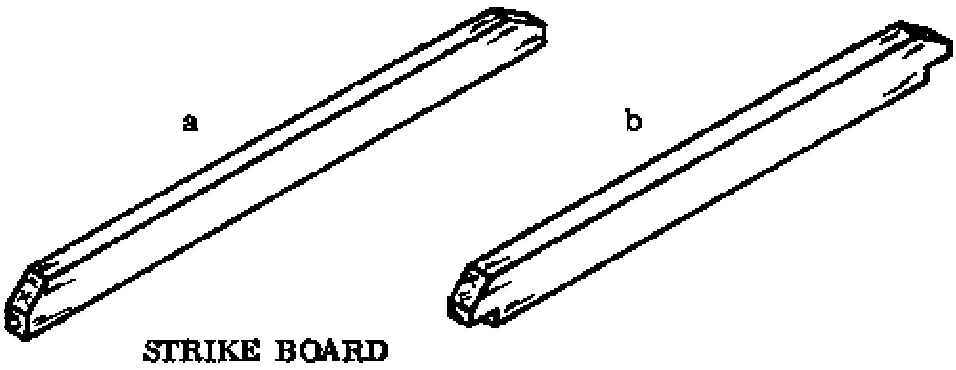


Fig. 4

WATER LEVEL

This instrument is used for setting out levels on the site as well as to transfer and control levels over large distances. It consists of a transparent plastic tube filled with water (Fig. 1). The level of the water at one end of the tube (a) will be at exactly the same height as the level at the other end (b), provided that there is no air bubble in the tube and it is not buckled.

The water level enables us to level over large distances with a high degree of accuracy.

If there is no transparent plastic tube available and some rubber hose can be found, the Rural Builder can take two glass bottles, knock out the bottoms and fit the bottle necks to each end of the hose. This apparatus is then filled with water until the water is seen in the bottles. Levels can be read as easily with this device as with any other water level (Fig. 2).

BONING RODS

Boning rods are T−shaped wooden tools, usually 120 cm high and 20 cm wide at the top. They are used in sets of three to help the Rural Builder to level between two given points (Fig. 3).

Points a and b are marked with the water level and any point in between them can be obtained by using the third boning rod and sighting along the rods (Fig. 3).

STRIKE BOARD

Strike boards are made from well seasoned wood. They are similar to straight edges except that they are usually longer (Fig. 4).

Strike boards (a) are used to level off the screed on floors, or in the case of notched strike boards (b) to level off concrete before the screed is layed.

NOTES:

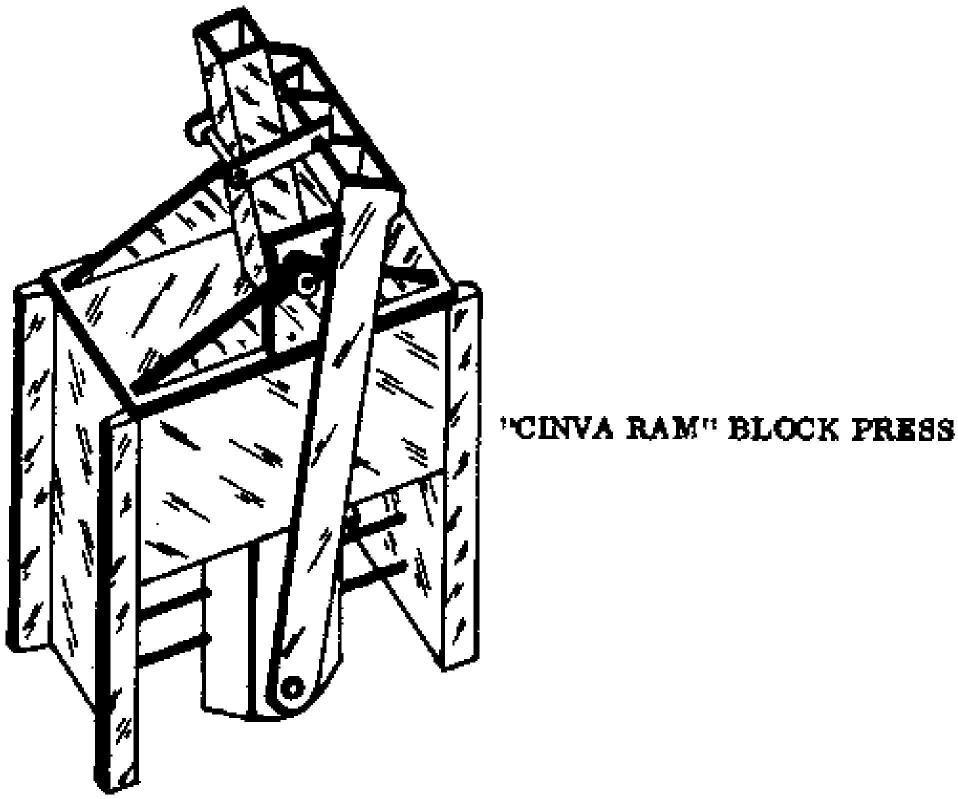


Fig. 1

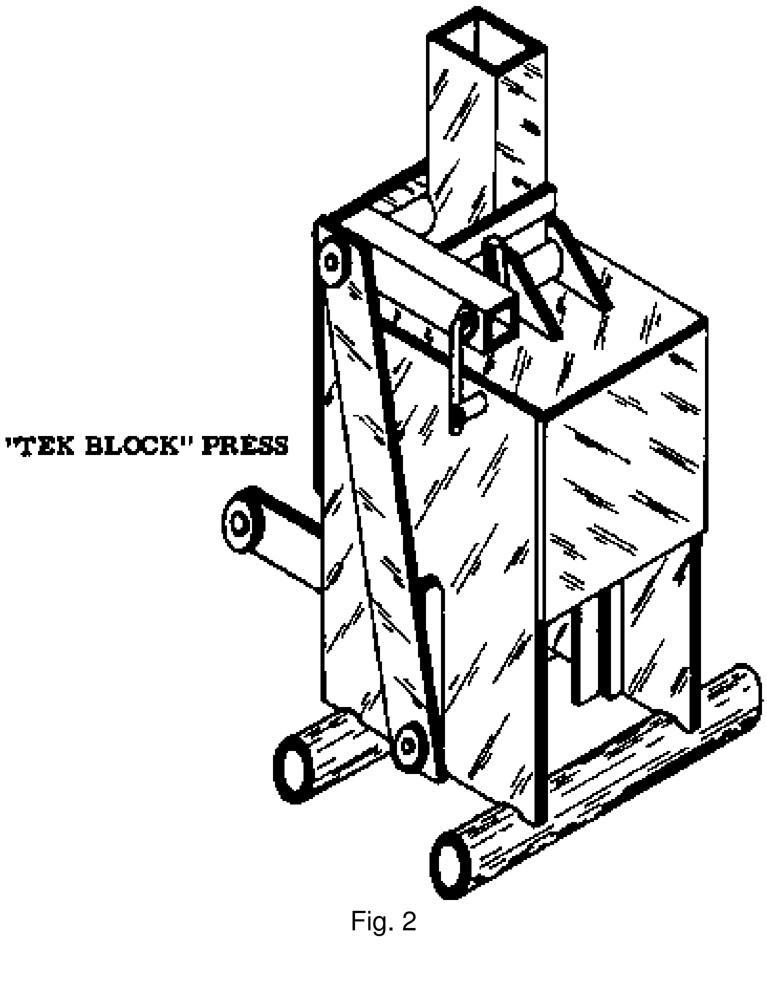


Fig. 2

"CINVA RAM" BLOCK PRESS

The Cinva Ram block press is a simple low−cost machine which produces building blocks from common laterite. It consists of a mould in which a slightly moist soil/cement mixture is compressed (packed down) by a hand operated piston and lever system (Fig. 1).

Unlike sand−cement blocks made with a similar press, these blocks can be removed immediately from the press and stacked for curing without the use of a pallet underneath.

The machine is made from steel and it is tough, durable and will stand up to long and hard use. Little maintenance is needed except for oiling.

− SPECIFICATIONS:	Size of blocks	−−	10 × 15 × 30 cm
	Building unit	−−	12 × 17 × 32 cm (2 cm joints).

"TEK" BLOCK PRESS

The Tek block press is similar to the Cinva Ram, except that this press produces blocks of larger dimensions (Fig. 2).

The Tek block press was designed at U. S.T. Kumasi and has been used successfully in the field for many years. The Tek block press can make blocks in any area where good laterite is available.

A moist soil/cement mixture is put into the steel mould box, pressed into a block and ejected (pushed out).

With the wooden handle, one man can put a lot of pressure on the block, so the blocks are very hard and long−lasting.

− SPECIFICATIONS:	Size of blocks	−−	14 × 22 × 29 cm
	Building unit	−−	16 × 24 × 31 cm (2 cm joints).

− MAINTENANCE: Oiling the machine will make it work better and last longer. Oil or grease the moving parts at least twice a day when the machine is in use.

Wipe the inside of the mould box with oil about every 10 blocks. This will make it easier to remove the blocks.

If more than one man presses on the handle of the machine, the handle should break. If the handle is too big and strong, the machine will break instead of the handle. A broken machine is far more difficult to repair than a broken handle, therefore do not use any handle which is longer than 2,5 m.

When the machine is not in use, paint it with oil to prevent rust.

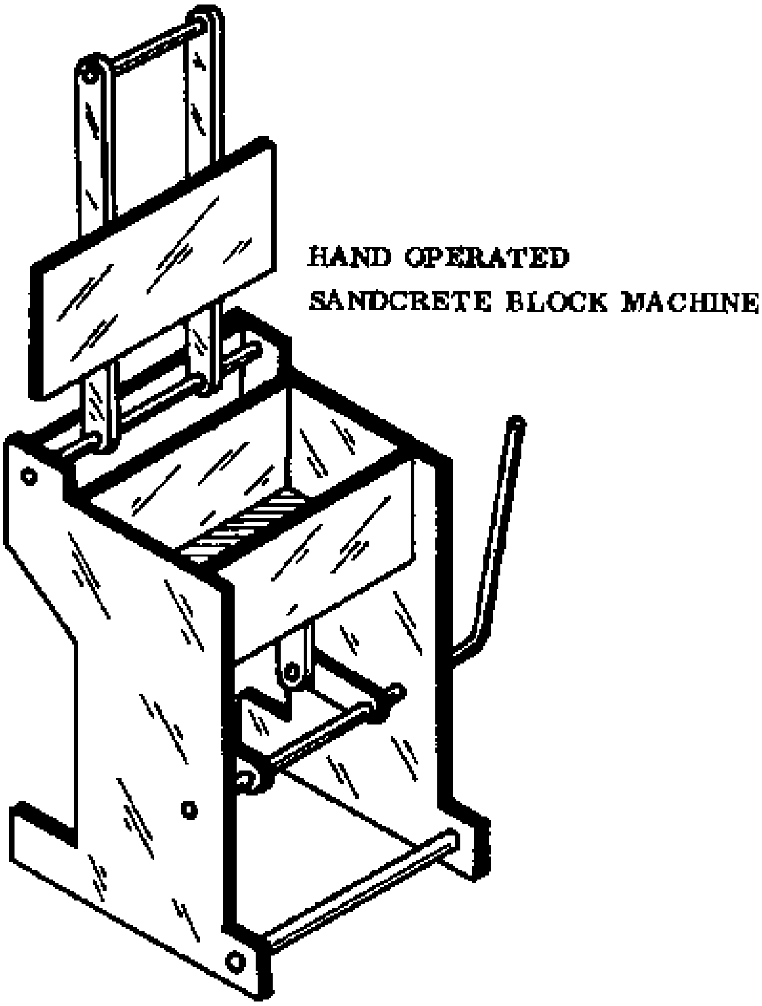
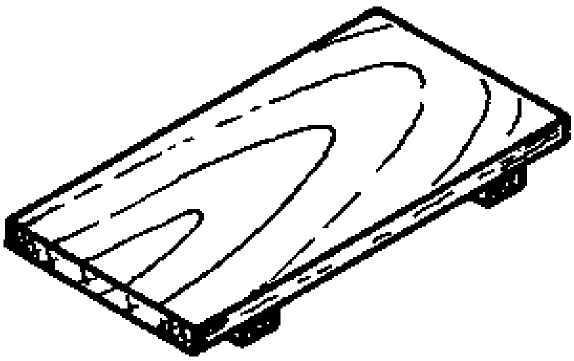
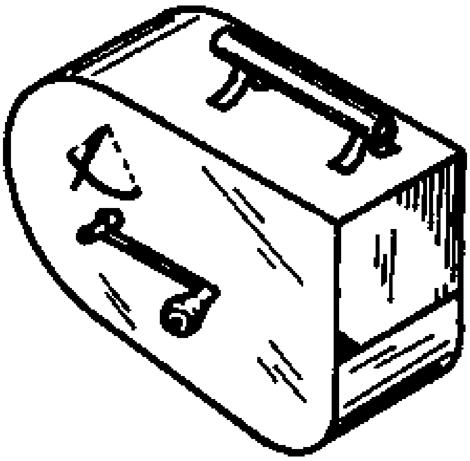


Fig. 1



PALLET
Fig. 2



SPATTERDASH APPARATUS

Fig. 3

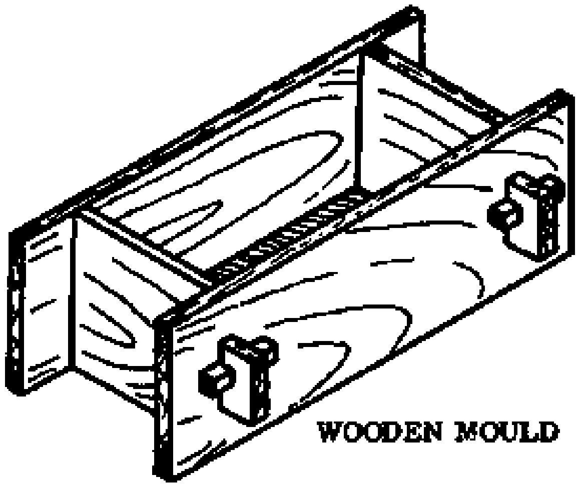


Fig. 4

HAND OPERATED SANDCRETE BLOCK MACHINE

This type of block machine consists mainly of a mould box with a movable bottom plate mounted into a supporting frame. The bottom plate is connected to a handle so that it can be raised (Fig. 1).

The lid is made of heavy material so that it presses down to compact the sandcrete. Sometimes additional weights are attached to the top of the lid to make it press harder.

After it is compacted, the block is pushed out by means of the handle at the side of the machine.

Unlike landcrete blocks, sandcrete blocks must be made on pallets, as they are too soft to be carried when they are freshly made (Fig. 2).

The inside measurements of the mould box are approximately: 46 cm in the length, 23 cm in the width, and 28 cm deep. Blocks of various shapes can be made with this machine by changing the height of the pallet or by using inserts.

SPATTERDASH APPARATUS

The spatterdash apparatus is used to give plaster or concrete an attractive appearance without the use of paint.

A slurry of sand and cement is placed in the apparatus (Fig. 3); when the handle is turned, the mixture is thrown against the wall, giving the surface a textured effect. Another handle adjusts the texture of the spatterdash from rough to fine.

WOODEN MOULD

A specially made wooden mould can be used when unusual blocks such as arch−blocks are needed or when there is no block−making machine available.

To make work easier and more accurate, the wooden mould should be made so that the sides of the mould can be removed easily and fixed back together by using wedges through tenons (Fig. 4).

NOTES:

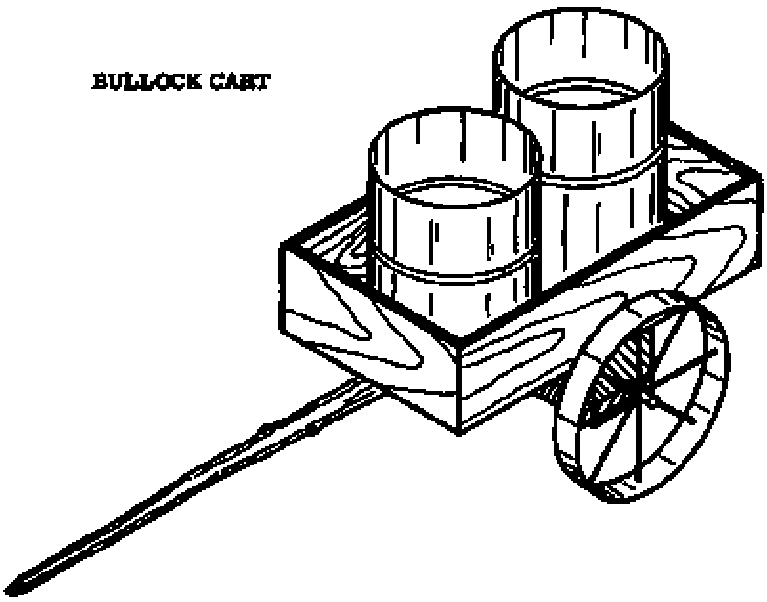


Fig. 1

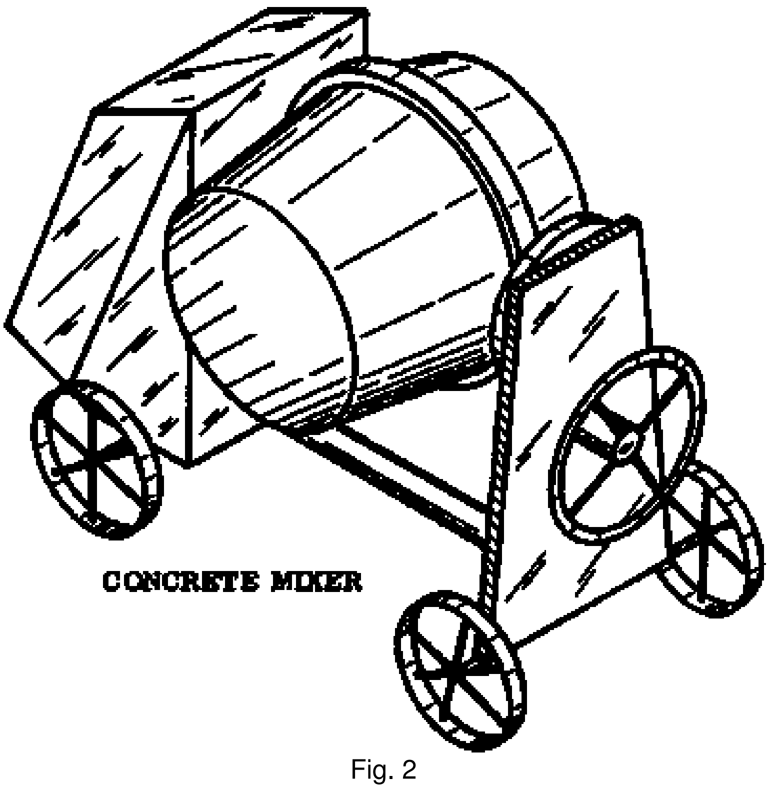


Fig. 2

BULLOCK CART

A bullock cart can transport water and limited quantities of building materials and it is therefore particularly useful at a Rural Building site. Bullock carts are made locally from wood and have steel rimmed wheels. The steel axles turn In wooden bearings which are soaked in oil. These bearings should be inspected and oiled regularly (Fig. 1).

CONCRETE MIXER

If there are few labourers and it is necessary to mix large amounts of concrete, a concrete mixer can be hired to do some of the work (Fig. 2).

The Rural Builder should know how to load the machine, in the right sequence and make sure that the concrete is well mixed and has the correct content of water.

After the job is done the machine should be cleaned thoroughly with water and all sand and cement should be washed off from the drum and the frame of the machine.

A maintenance card will tell you how to maintain the machine and how often this needs to be done.

The engine needs special care and the Rural Builder should learn as much as he can about caring for it.

NOTES:

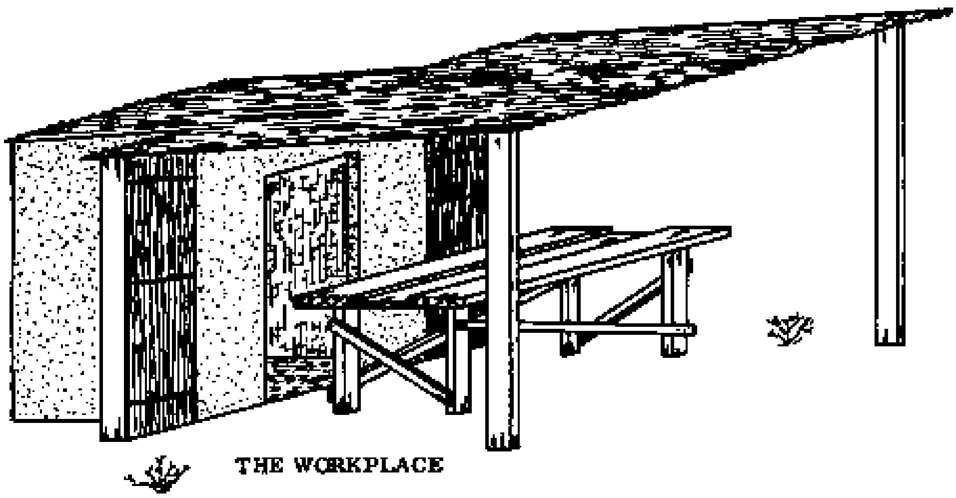


Fig. 1

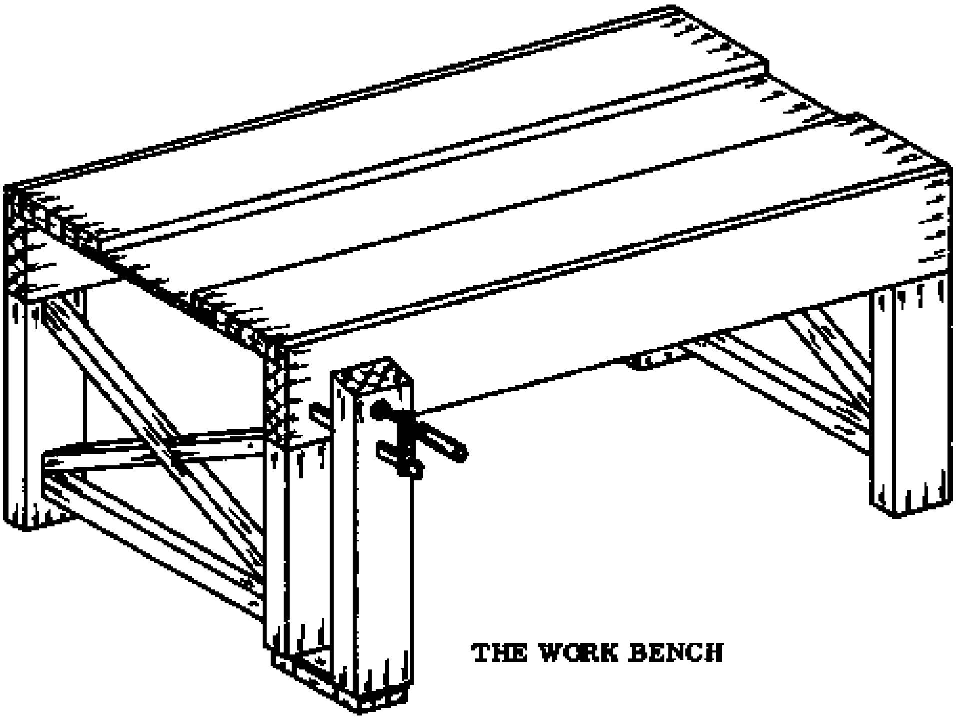


Fig. 2

THE WORKPLACE

The ideal workplace (Fig. 1) will have a waterproof shed which is open on three sides. The fourth side should be arranged for laying out the tools and toolboxes. If possible there should be a lockable store for tools and materials next to the workshed. The workshed should be close to the timber pile.

THE WORK BENCH

The bench is used for supporting the workpiece while it is being marked and during the various operations of its construction. Therefore, the bench must be strong, rigid and made from good wood.

The top must be flat and it is constructed out of planks which are 5 cm thick and 30 cm wide. The length of the bench can be from 2 to 4 metres. The height of the bench can vary between 80 and 90 cm. The legs should be well braced.

There are single and double width work benches. The last type is commonly used at the building site. It must be wide enough to handle door and window frames and long enough (a full board length of 4 metres) to be used for bending concrete iron.

If the bench is built on the building site, it is not necessary to use extra timber. The timber used in the bench can be reused for some other workpiece after the carpentry work is finished.

Permanent work benches (Fig. 2) used in a workshop will be constructed slightly different from the types used at a construction site (Fig. 1). A wooden vice is used to hold the timber, with the help of a G−clamp (Fig. 2).

NOTES:

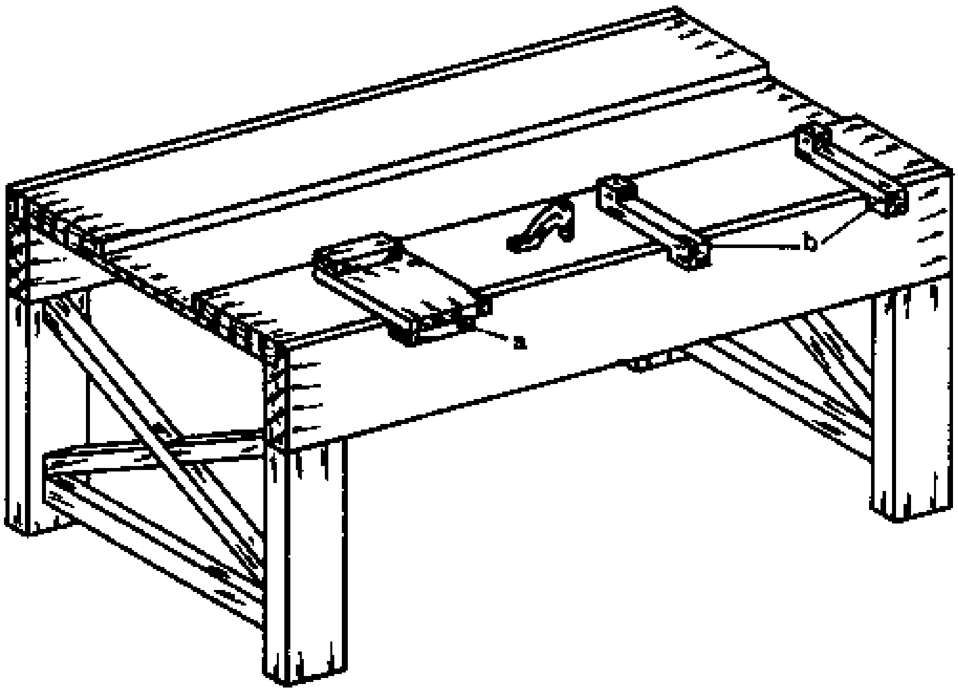


Fig. 1

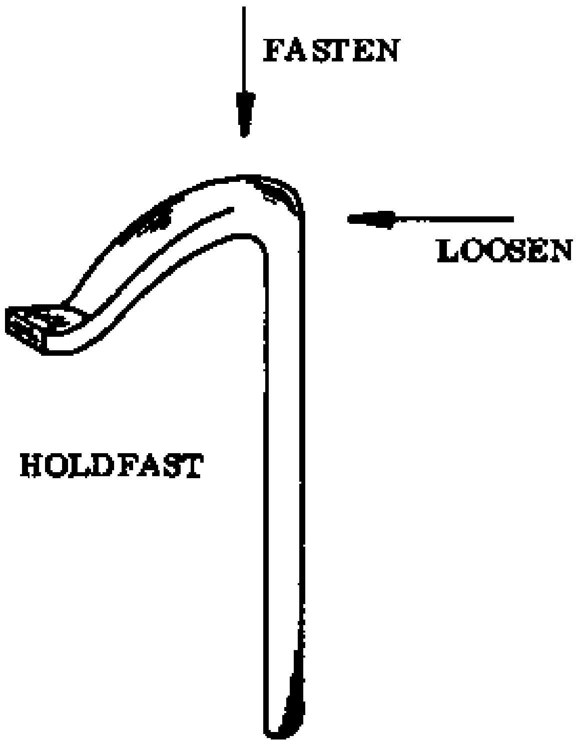
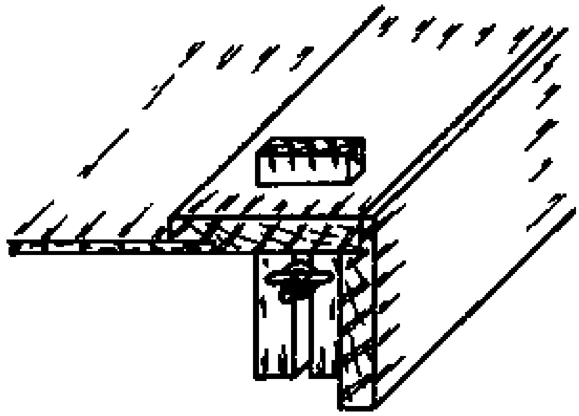


Fig. 2



BENCH STOPS
Fig. 3

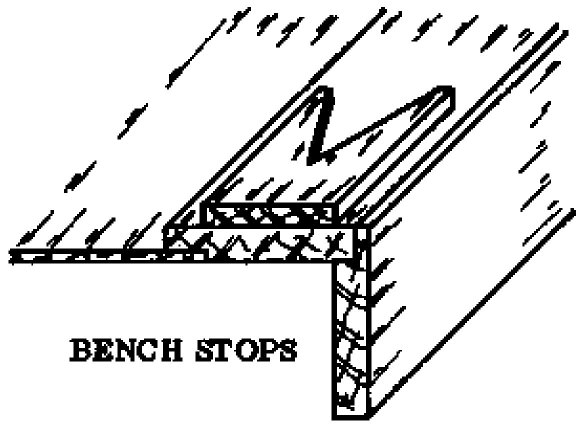


Fig. 4

BENCH HOOKS

When we have to cut a short piece of timber across the grain, we use a wide bench hook to support it. The bottom batten of the hook is held against the side of the bench and the work is pressed against the upper batten (Fig. Ia).

For long pieces of timber, we use small bench hooks for support (Fig. 1b).

Wide bench hooks measure approximately 15 × 25 cm; small ones about 5 × 25 cm.

THE HOLDFAST

A holdfast can be used to fasten wood firmly to the top of the bench. It is made tight or loosened by knocking it with a hammer (Fig. 2).

Holdfasts can be made locally from a piece of concrete iron, 2,5 cm in diameter, with a piece of a car spring welded to the top.

THE BENCH STOP

On the left side of the bench there is a bench stop made from hard wood, to support the timber during planing.

Some bench stops can be moved up or down. These are called adjustable bench stops (Fig. 3). Other bench stops are stationary (Fig. 4).

NOTES:

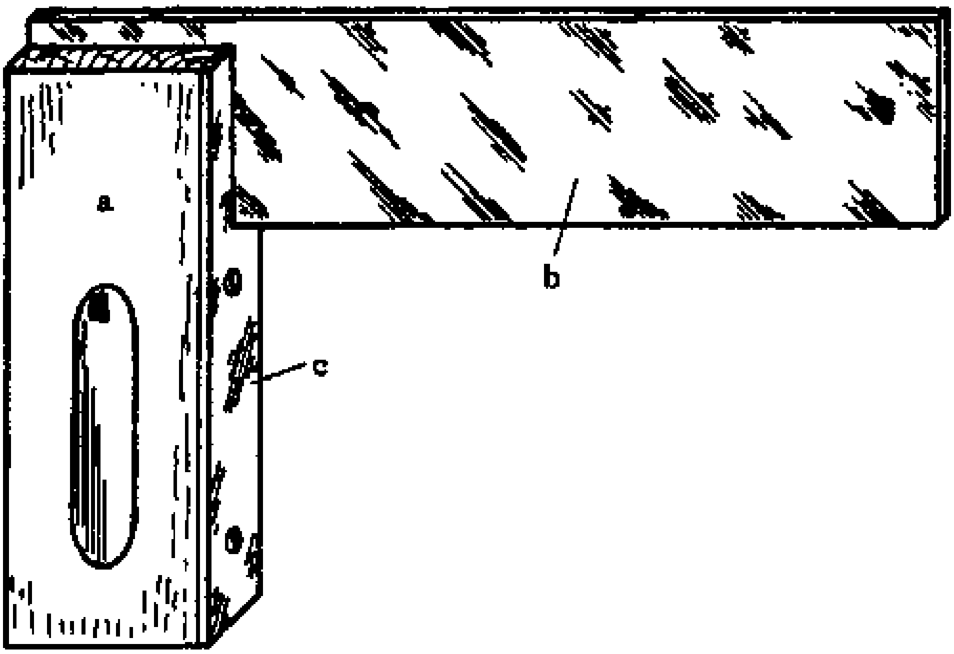


Fig. 1

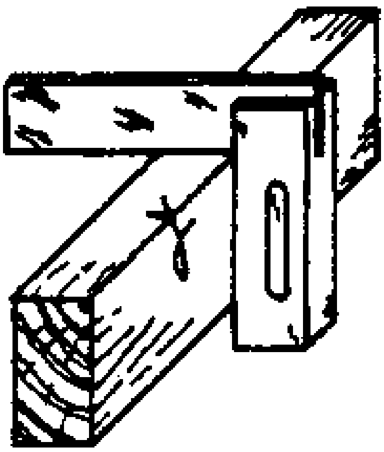


Fig. 2

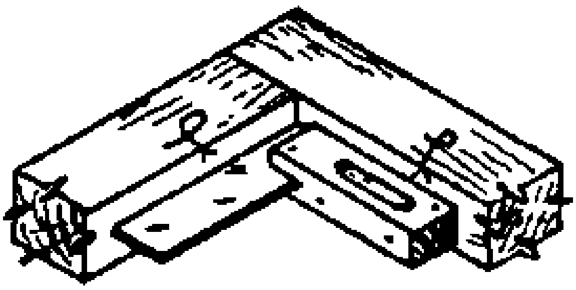


Fig. 3

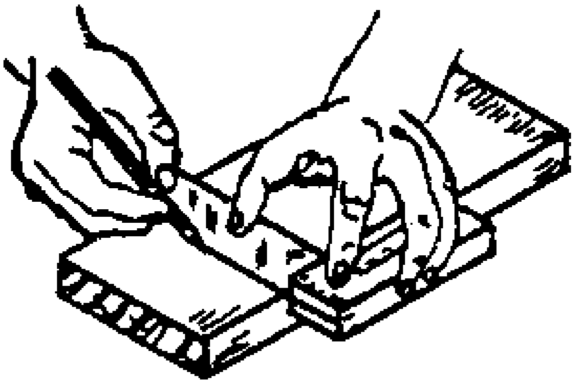


Fig. 4

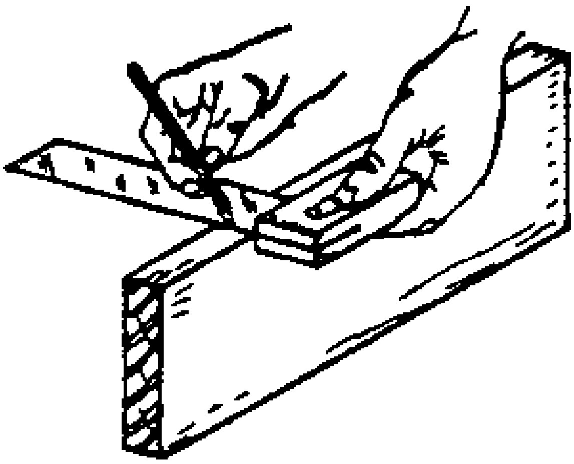


Fig. 5

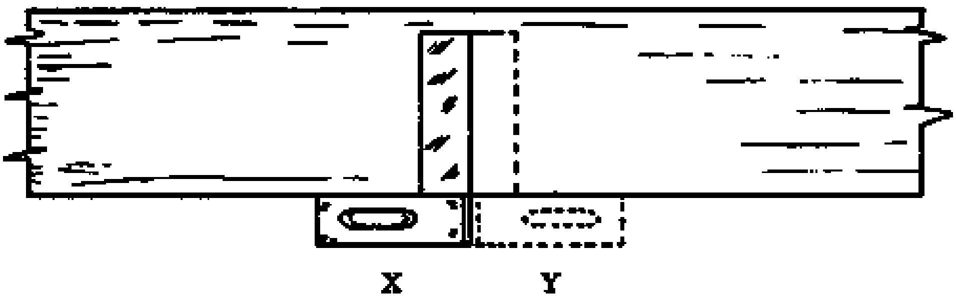


Fig. 6

THE TRY SQUARE

The try square is used for marking timber, and for testing right angles to make sure that they are correct.

Its parts are (Fig. 1): the stock (a), the blade (b) and the stockface (c). The stock can be all metal or it can be made of hard wood with a brass stockface. The blade is made of steel. The angle between the stockface and blade is exactly 90 degrees.

HOW TO USE THE TRY SQUARE

– To test the angles of workpieces and boards, place it as shown in the figures on the left (Figs. 2 & 3). Always use the try square with the stock against the face edge or the face side of the workpiece when you are squaring or testing angles.

– For marking timber, press the stockface against one edge or side of the work–piece and use the blade to guide your pencil (Figs. 4 & 5).

– Keep the pencil pressed to the blade, to avoid making double lines.

– Be careful not to drop the try square or use it carelessly. Any small movement of the blade will make it inaccurate.

HOW TO TEST THE TRY SQUARE

1. Select a board with a true edge.

2. Lay the blade in position "X" and draw a line along the blade (Fig. 6).

3. Turn the square over as shown by the dotted lines (position "Y"). If the line and the blade come together exactly, the angle of 90 degrees is true.

NOTES:

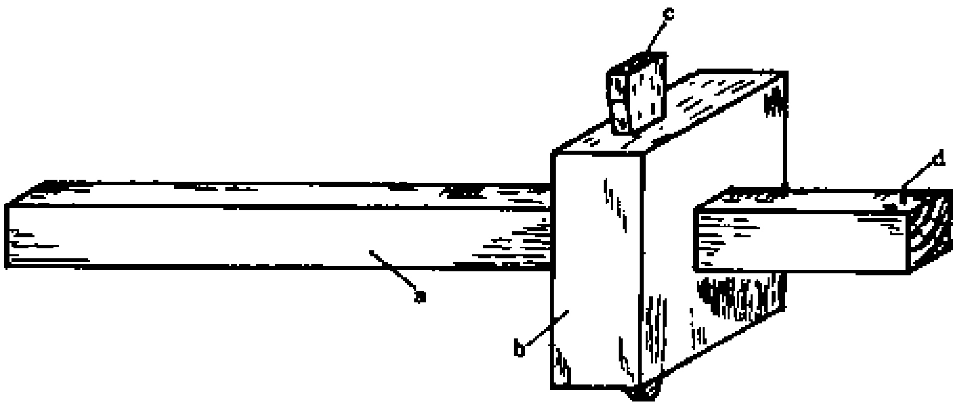


Fig. 1

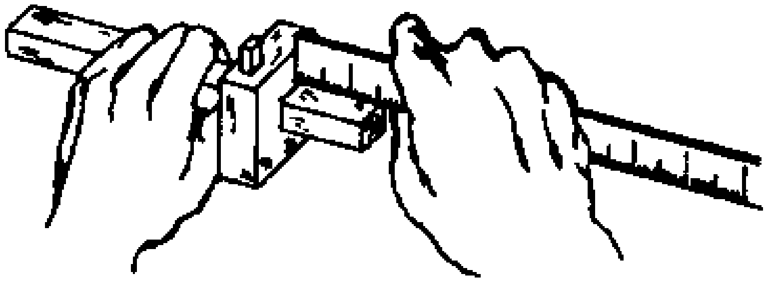


Fig. 2

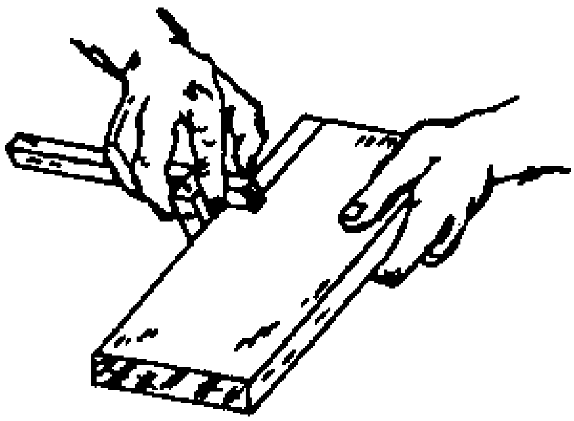


Fig. 3

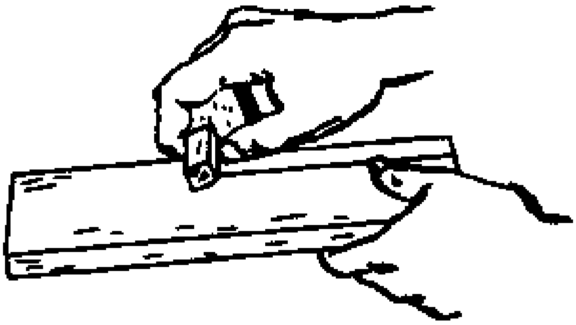


Fig. 4

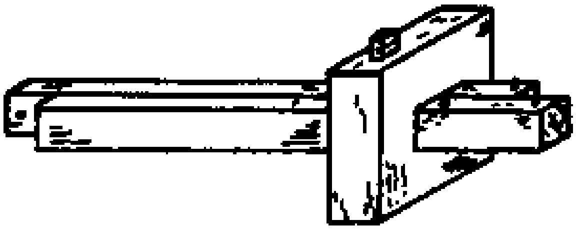


Fig. 5

THE MARKING GAUGE

The marking gauge (Fig. 1) is used to make lines on timber, parallel to the edge of the timber; that is, the lines always continue at the same distance from the edge.

The parts of the marking gauge are: the stem (a), the stock(b), the wedge (c) and the spur or pin (d). Sometimes a screw is used instead of a wedge.

HOW TO SET THE GAUGE

1. Use a rule to measure and slide the stock along the stem until the stockface is at the required distance from the pin (Fig. 2).

2. Slightly tighten the wedge or screw.

3. Check the size once more and make any necessary adjustments by tapping the end of the stem on the work bench.

4. Finally, properly tighten the wedge or screw.

HOW TO USE THE GAUGE

– Hold it in your right hand, with the face side of the stock pressed against the edge of the wood (Fig. 3).

– Keep it tilted slightly forward, so that the pin drags lightly along the wood. Don't try to make a deep mark with the pin (Fig. 4).

– Push it away from you. The pin will trace a line on the wood (Fig. 4) parallel to the edge of the wood. The stock must be held firmly against the timber edge as you move the gauge along.

– The pin may be forced out of line by grooves in the wood structure; if that occurs, mark from the other direction.

– If the gauge is hard to use at first, steady it by holding one end of the wood against the bench stop or hook.

Sometimes, marking gauges with two stems are used for marking out mortices. They are called Mortice gauges (Fig. 5).

NOTES:

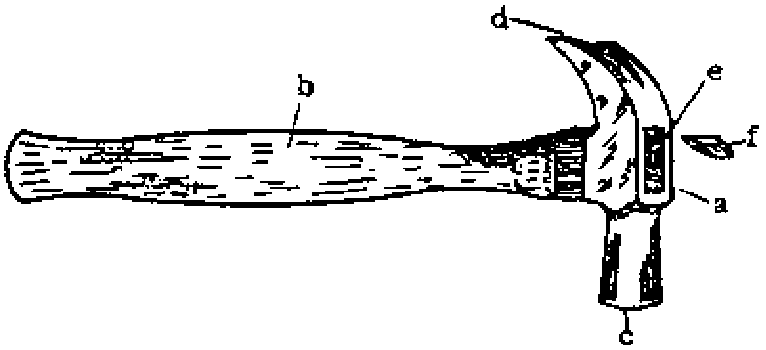


Fig. 1

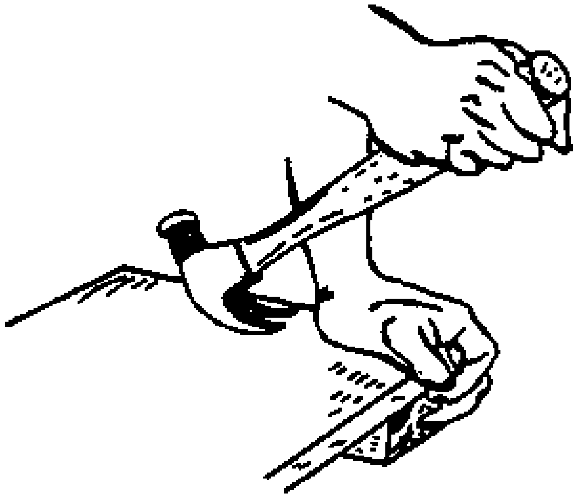


Fig. 2

Fig. 3

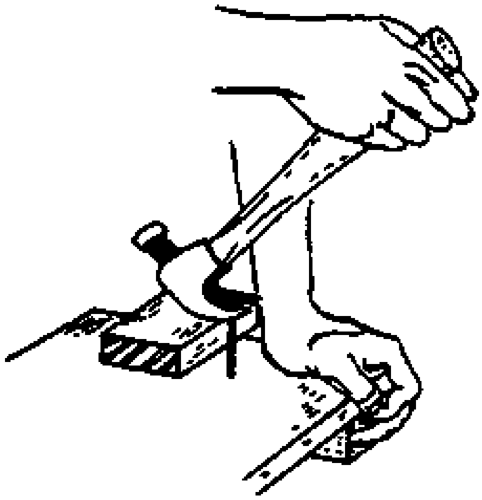


Fig. 4

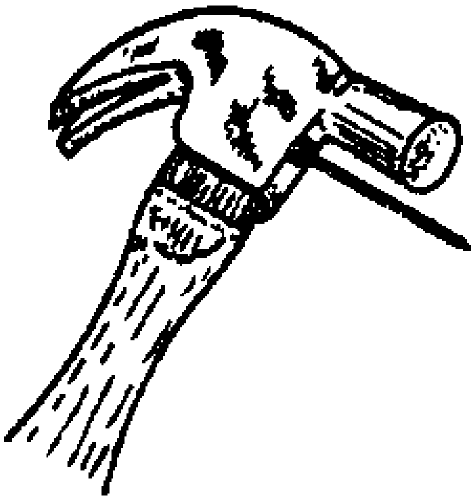


Fig. 5

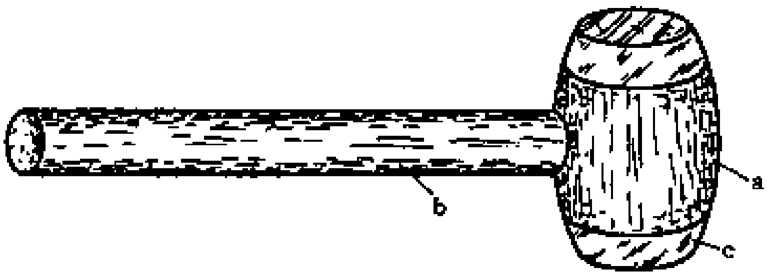


Fig. 6

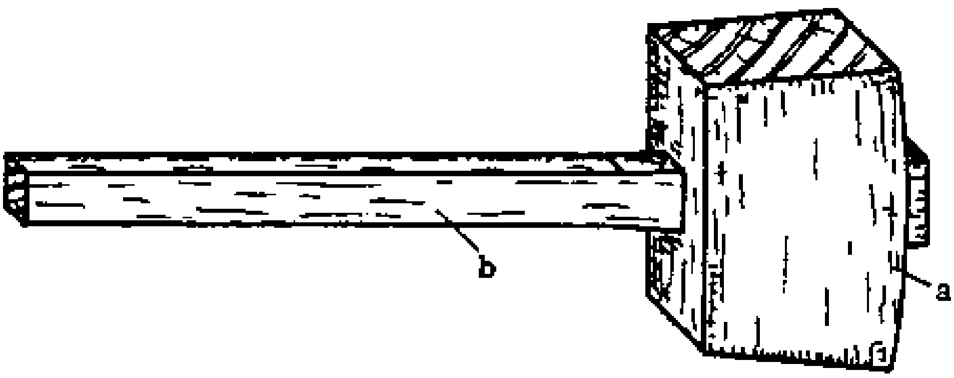


Fig. 7

THE CLAWHAMMER

The clawhammer (Fig. 1) is used in light or heavy carpentry work, for driving and extracting nails. Its size, determined by the weight of the head, can be from 350 to 650 gr.

A hammer has two main parts: the head (a) and the handle (b). The head is made of steel, with a hardened face (c) and a claw (d) for extracting nails. The wooden handle is held in the eye (e) by metal wedges (f). The handle is usually made of hard wood, which absorbs shock better than metal and keeps the arm from getting tired so quickly.

HOW TO PULL NAILS

To pull a nail, slip the claws under the nailhead and pull up and back on the hammer handle (Figs. 2 & 3). When the handle reaches the vertical position and the nail is not yet all the way out, use a block of wood under the hammer (Fig. 4) to help. Pulling the handle back too far may overstrain or possibly break it.

HOW TO DRIVE NAILS

Nailing is covered in detail in the Basic Knowledge book, pages 92 to 94.

– To drive nails when you have only one hand free, hold the nail on the hammer as shown in Fig. 5 and start it in the wood with one sharp blow.

THE MALLET

The mallet is used for driving chisels, assembling joints and knocking together pieces where the hammer would damage the wood or the chisel handle. The mallet (Figs. 6 & 7) has two parts: the head (a) and the handle (b), which passes through a tapered mortice in the head.

The head can be square or round in shape. The round type can be strengthened with a metal collar (c) to prevent it from splitting. This can be made from an old shock absorber mantle.

NOTES:

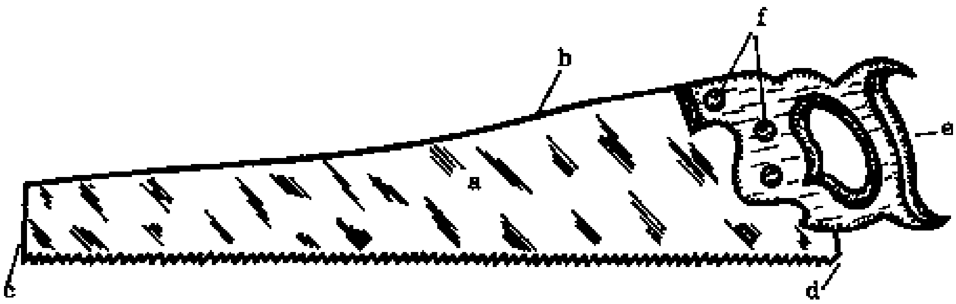


Fig. 1

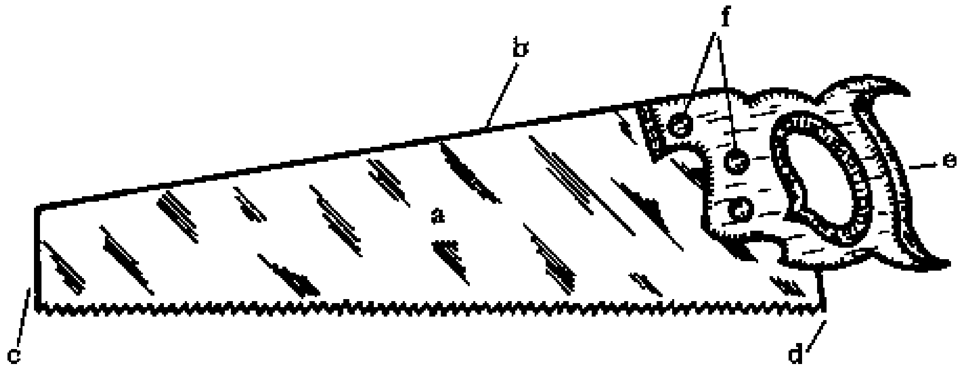


Fig. 2

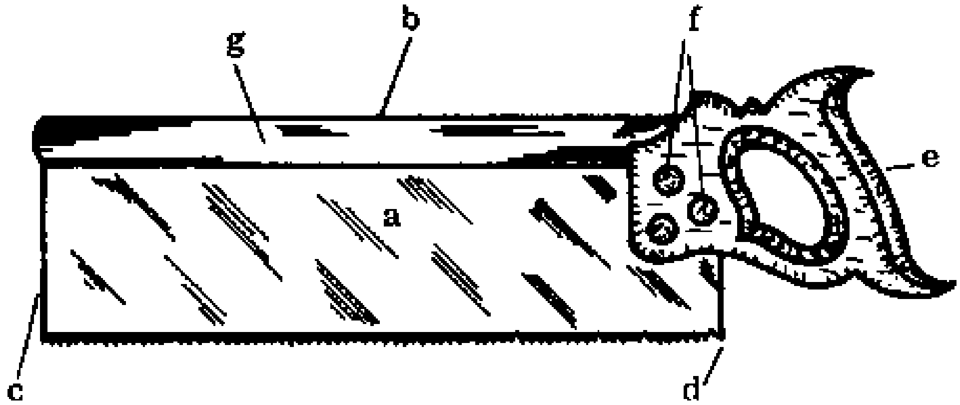


Fig. 3

HANDSAWS

Saws are used for cutting timber to the required size and shape with a minimum of waste in materials and labour. The principal types used in Rural Building are handsaws.

The parts of the saw are (Fig. 1): the blade (a) which has a back (b), toe (c) and heel (d), the handle (e) and the sawscrews (f) which hold the handle to the blade.

Better quality saws are taper ground, that is, they are thinner towards the back of the blade than at the cutting edge. Such saws can run (move) more freely in the kerf (the saw cut).

A good sawblade makes a clear sound when it is slightly bent and struck on the back with a fingernail. The handle should be made of good hard wood and have a comfortable grip.

Manufacturers make saws in various grades, of hard or soft steel, regular or light weight to suit any need. Depending on the kind of work we want to do, we use one of three types of handsaw: a ripsaw, a crosscut saw or a backsaw.

THE RIPSAW

The ripsaw (Fig. 1), because of the special shape of its teeth, is used only to cut with the grain of the wood. The length of the saw can vary from 66 to 71 cm. A long saw can cut faster, but it is harder to control.

THE CROSSCUT SAW

The crosscut saw (Fig. 2) is designed for cutting across the grain. Its length can vary from 51 to 66 cm.

THE BACKSAW

The backsaw (Fig. 3) is used to make fine and finished cuts. In general, the blade of the backsaw is thinner than that of a ripsaw or crosscut saw. The fold of steel that sits on the back of the blade (g) makes it stiff and it can be removed if necessary to make deep cuts.

NOTES:

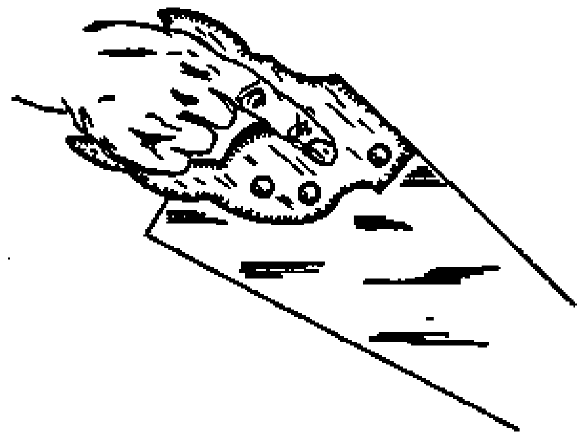


Fig. 1

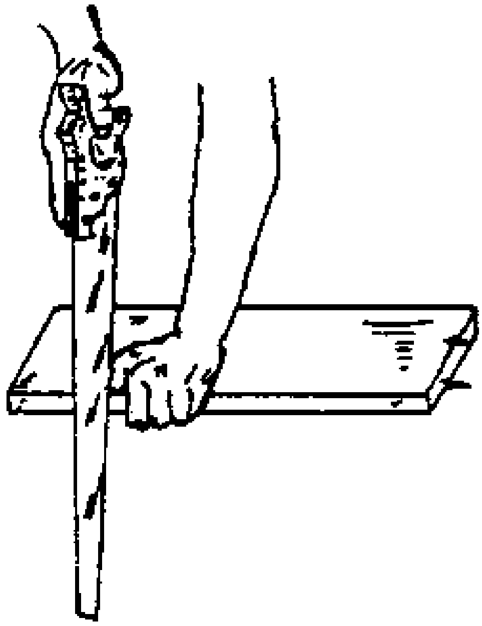


Fig. 2

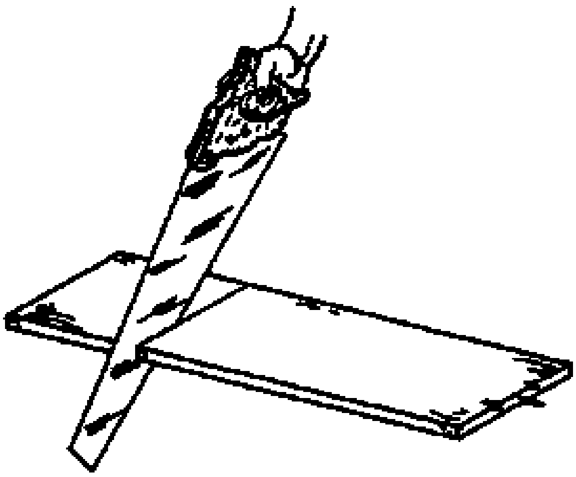


Fig. 3

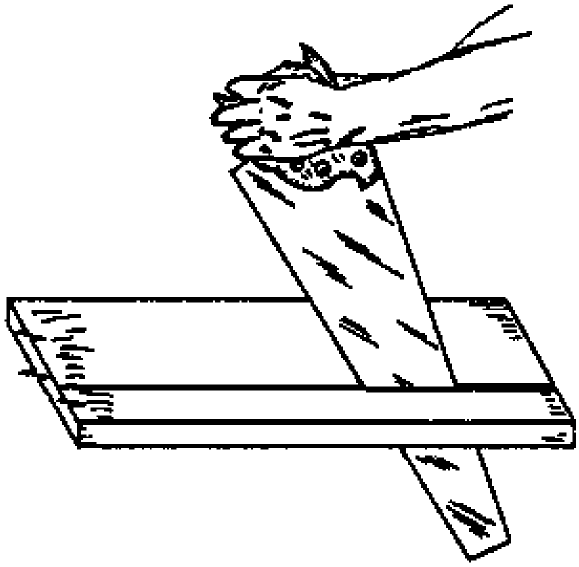


Fig. 4

HOW TO USE A HANDSAW

– Grasp the handle of the saw firmly. Your index finger should point along the blade (Fig. 1). This gives maximum control of the saw and it is the rule for holding all the different kinds of handsaws.

– To start a sawcut, grasp the far edge of the wood with your left hand, using the thumb to guide the saw while starting the cut (Fig. 2). Make two or three backstrokes, lifting the saw on the forward strokes. Draw the saw slowly and carefully, exactly along the cutting line (Fig. 3).

– After the saw is started, push it forward and pull it back, using Long, easy strokes and light pressure.

– Hold the saw at an angle of about 30 degrees to the board for rough work and almost flat to the board for fine cuts.

– If the saw tends to go to one side of the line, twist the handle slightly and gently to make it come back to the line gradually, as the sawing proceeds.

HOW TO RIP BOARDS

For ripping boards (cutting with the grain), you can use different methods. The most common method used in Ghana is known as overhand ripping.

– To do overhand ripping, hold the saw in both hands as shown in Fig. 4.

When cutting timber take care that you always watch the edge of the work bench, to avoid sawing into it.

NOTES:

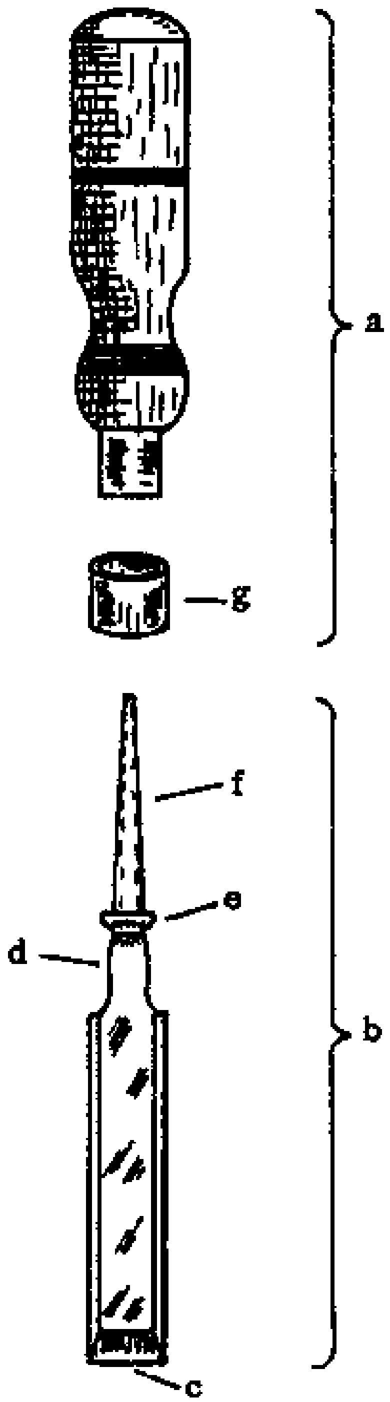


Fig. 1

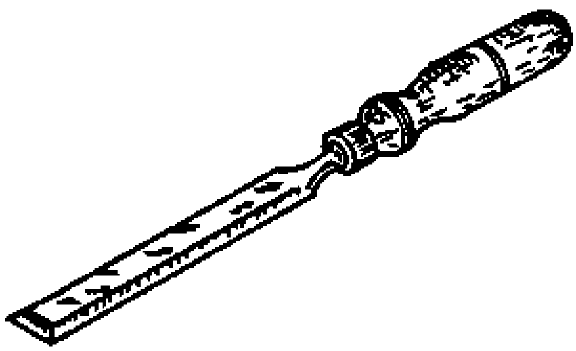


Fig. 2

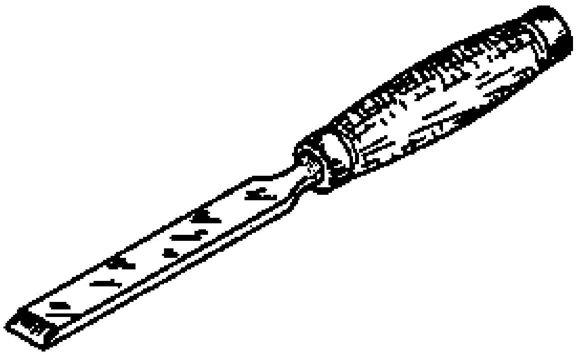


Fig. 3

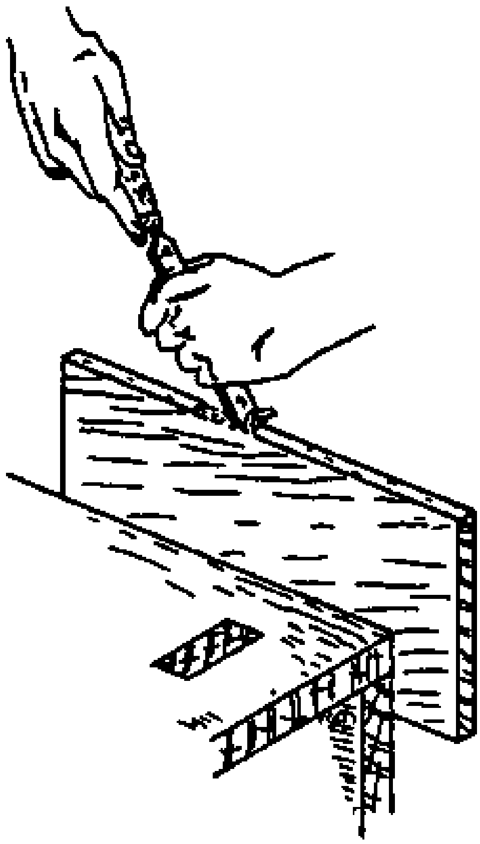


Fig. 4

THE CHISEL

Chisels are used for shaping wood in places where the plane cannot be used.

They have two main parts (Fig. 1): the blade (a) and the handle (b). The blade is made of steel, with a cutting edge (c) which is 3 to 32 mm wide and ground at an angle of 25 degrees. The neck (d) is the narrow part at the top of the blade. The shoulder above the neck (e) is to prevent the blade from being driven too far into the handle and splitting it. The tang (f) is the end of the blade which fits into the. handle and holds the two parts together.

The ferrule (g) at the bottom of the handle keeps the wood from splitting where the blade enters the handle. The handle itself is made from hard wood or plastic and it is slightly rounded on top to prevent splitting.

For the various tasks of carpentry work in Rural Building, there are different kinds of chisels. The two most common ones are the firmer chisel and the mortice chisel.

THE FIRMER CHISEL

Most of the firmer chisels (Fig. 2) are the type with a bevelled edge. The firmer chisel is normally driven into the wood by hand and is used only for light cutting and shaping work.

THE MORTICE CHISEL

The blade of the mortice chisel (Fig. 3) is thicker and stronger than that of the firmer chisel, as it is used for heavy work. This chisel is driven into the wood with a mallet (never with a steel hammer), so it is usually fitted with two ferrules, at the top and bottom of the handle, to prevent splitting.

NOTES:

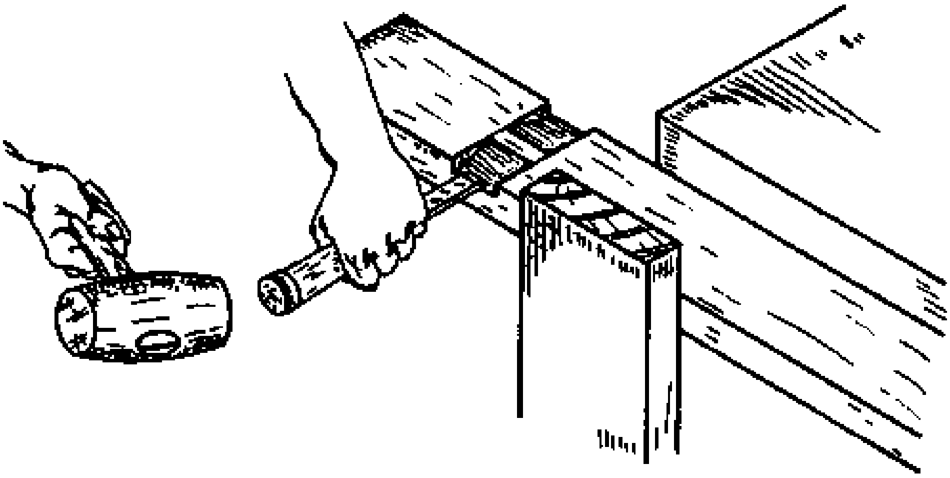


Fig. 1

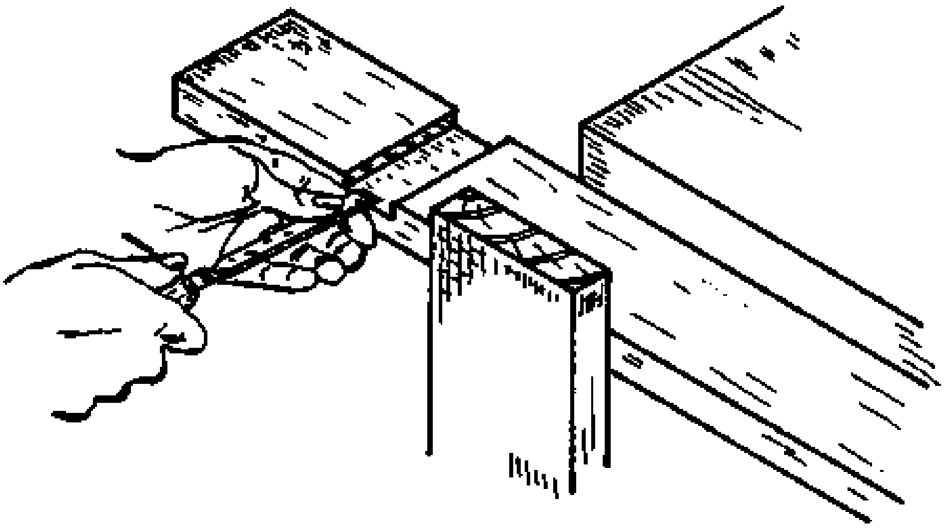


Fig. 2

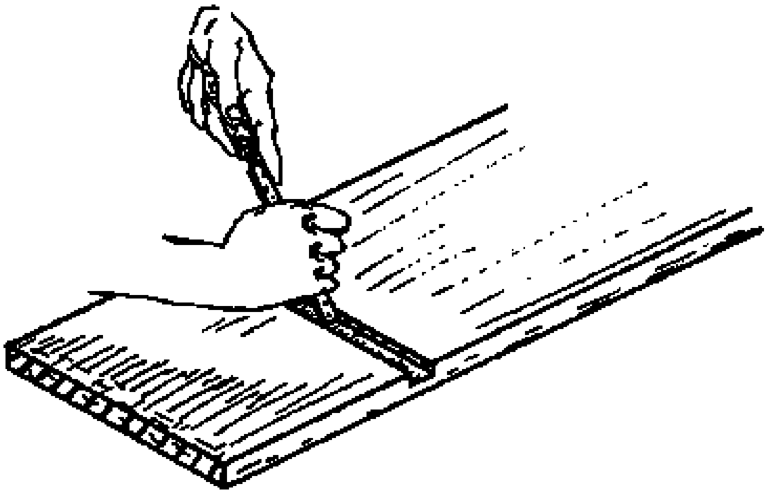


Fig. 3

HOW TO USE THE CHISEL

To do good work, you need a sharp chisel. A dull chisel is hard to force through the wood and it is also hard to guide and control, making the resulting work rough and inaccurate. The time you use to stop and sharpen a dull chisel will soon be regained by better and faster work.

To prevent dulling the chisel, do not allow the cutting edge to touch other tools or the bench top. Always lay the chisel on the bench with the bevel side down.

CHISELLING WITH THE GRAIN

When chiselling with the grain, observe the following points (see Fig. 4 on the previous page):

– Always work with the grain, to avoid splintering or splitting the wood.

– Fasten the work securely so your hands are both free for the chisel.

– Always push the chisel away from yourself, keeping both hands behind the cutting edge.

– Use your left hand to guide the chisel, and your right hand to push on the handle.

CHISELLING ACROSS A BOARD

When chiselling across the grain, observe the following:

– Grasp the blade of the chisel between the thumb and forefinger of your left hand, to guide it and act as a brake, while the pushing is done with your right hand (Fig. 2).

– Cut with the bevel side up, raising the handle just enough to make the chisel cut. For heavier chiselling and for rough cuts, the mallet may be used as is shown in Fig. 1.

– When chiselling across wide boards, where the chisel cannot reach to the center of the board, work with the bevel side down (Fig. 3).

NOTES:

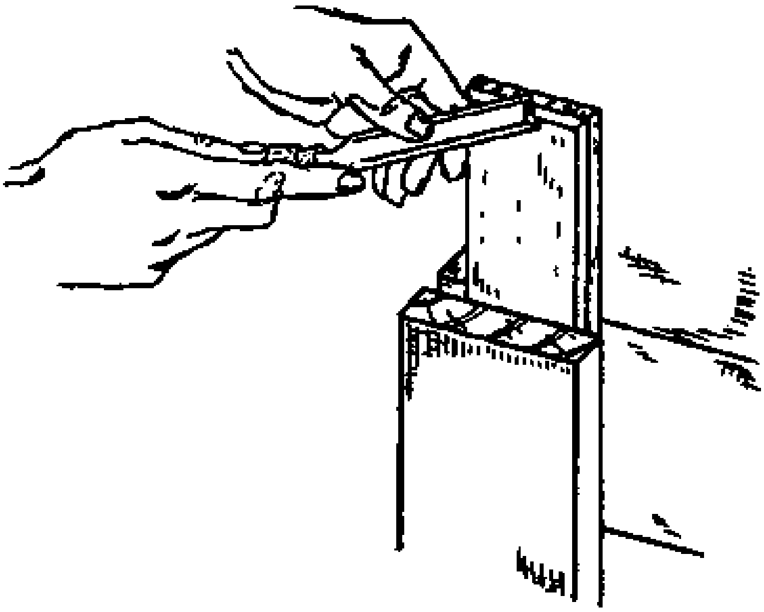


Fig. 1

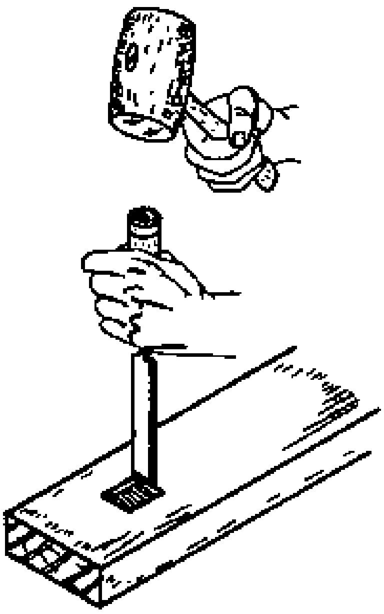


Fig. 2

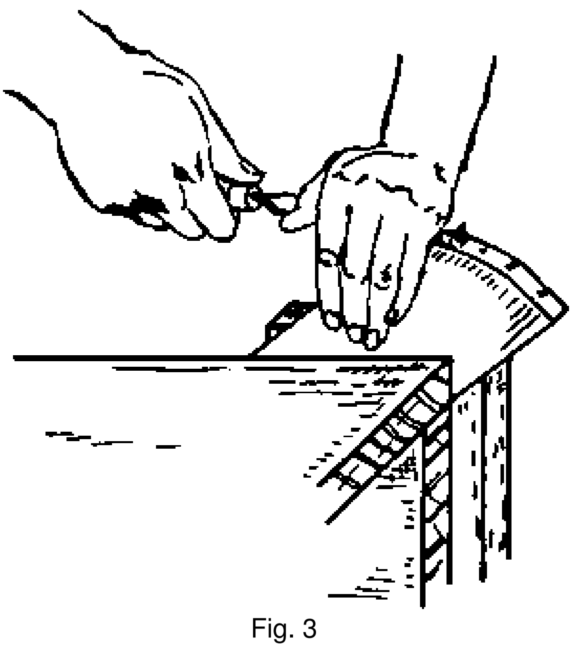


Fig. 3

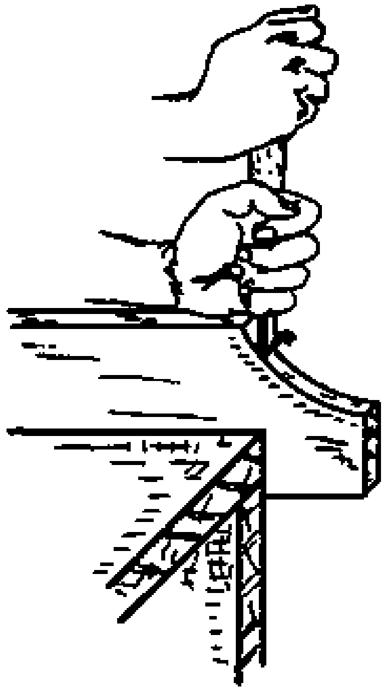


Fig. 4

USING THE MALLET

Use a mallet to drive the chisel when force is required to make deep, rough cuts. Never use a steel hammer, it will soon damage the chisel handle.

– Make a series of light taps with the mallet instead of heavy blows, as light taps will give you better control.

CHAMFERING

The chisel may be used to make chamfers or bevels, with or across the grain.

– Keep the bevel up. As you push the chisel forward, move the handle slightly from side to side, so that the cutting edge works obliquely (at an angle) (Fig. 1).

– Prevent splintering in cutting end chamfers or bevels by working part way from one edge and part way from the other.

MORTICING

Morticing is done as shown in Fig. 2 on the left page.

CUTTING CURVES WITH THE CHISEL

Convex curves can be shaped with the chisel as shown in Fig. 3.

– Use the chisel with the bevel side up. Hold and guide it with your left hand while you push it forward with your right hand.

Concave or inside curves may also be finished with the chisel, as in Fig. 4.

– Use the chisel with the bevel side down.

– Guide it with your left hand, while your right hand pushes down and pulls backward at the same time.

NOTES:

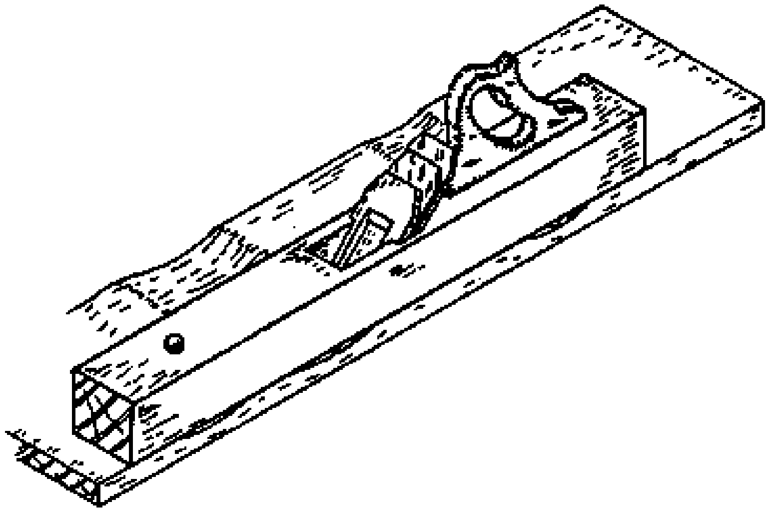


Fig. 1

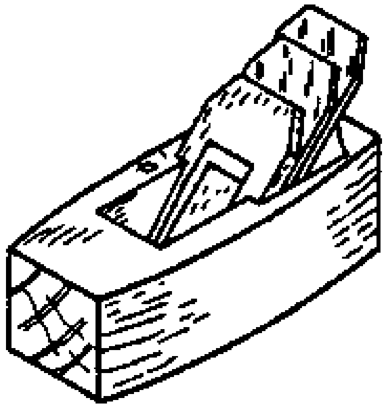


Fig. 2

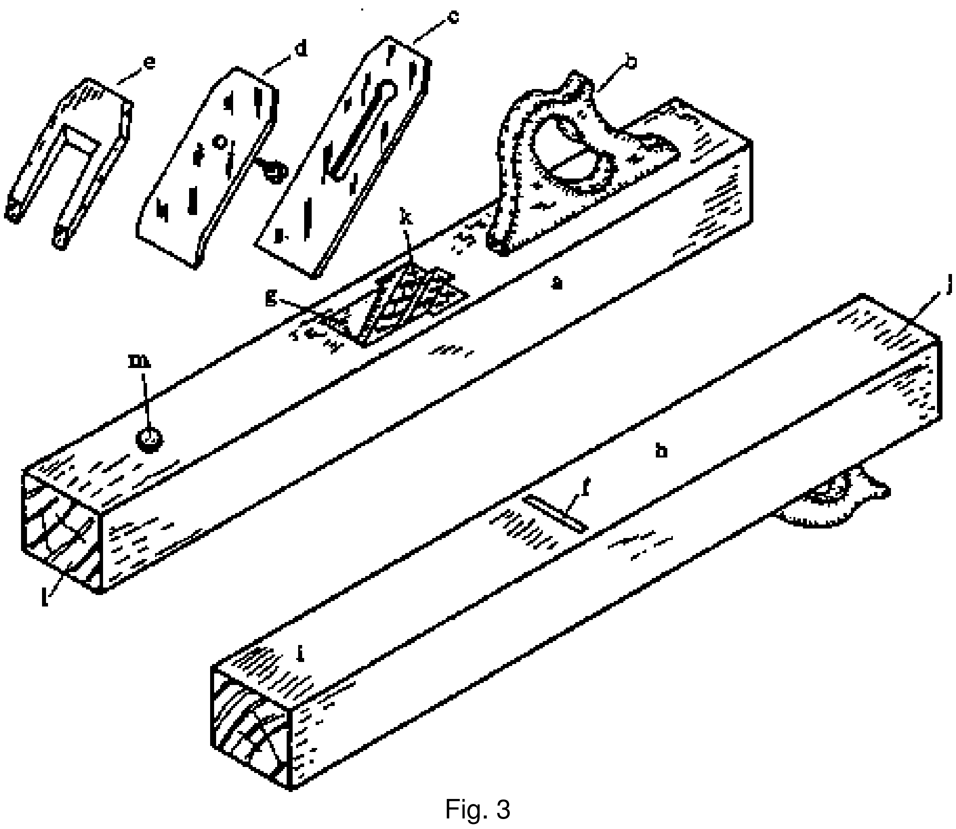


Fig. 3

PLANES

Together with the hammer, saw, try square and chisel, the plane is one of the principal tools used for carpentry work.

When timber comes from the sawmill, it is rough from the saw. Before rough−sawn timber or boards can be used for any finished work, they must be prepared so that all their sides and edges are square, flat and smooth. This preparation is done by planing them first and later smoothing them.

The tool used for the rough part of this work is called a jack plane (Fig. 1). It is used for planing the wood true and to reduce it to the correct size. The jack plane is used for general planing purposes, which is why it is called "jack", meaning generally useful.

After the board has been planed to a true surface, we use the smoothing plane (Fig. 2) to remove the rough marks of the jack plane, making a smooth surface on the board.

Other planes, used for special purposes, are discussed later in this book.

THE JACK PLANE

The jack plane (Fig. 3) consists of five main parts: the stock or body (a), the handle (b), the cutting iron (c), the cap iron (d) and the wedge (e).

The stock of the plane is made of hard wood which wears uniformly (doesn't get more worn out in some areas than in others), is tough, straight grained and keeps its shape. It is about 40 cm long. This long length lets the plane go over the low spots in the wood without cutting (Fig. 1), while it removes the high spots.

The stock holds the cutting iron, which takes off the shavings. The cutting iron sticks out through the mouth (f) on the bottom of the stock and the shavings leave the plane through the escapement (g) on top of the stock.

The bottom of the stock, which rubs along the wood during planing, is called the sole (h). The front part of the sole is called the toe (i) and the back part is the heel (j).

The cutting iron rests on the bed (k), at a 45 degree angle to the sole.

The front end of the stock is called the nose (1). To remove the cutting iron or to reduce the cut, the top of the nose is struck sharply with a hammer. In order to prevent the wood from being bruised, some planes have a small piece of metal let into the nose, to take the blows of the hammer. This is called the striking button (Fig. 3, m, previous page).

The handle is morticed into the stock behind the escapement. It should have a comfortable grip to protect the hand.

The cutting iron is made out of steel. It has a slot in the centre which ends in a screw hole. The cutting edge is ground at an angle of 25 to 30 degrees (see Maintenance of Tools, pages 92 to 99). If there is any imperfection in the cutting edge you will see a mark from it on the wood after planing.

The cap iron is made from mild steel and is secured to the cutting iron by a cheese−head screw (holding screw) which passes through the slot in the cutting iron. The cap iron helps the cutting edge to plane smoothly, by breaking up the shavings before they split ahead and tear up the fibres of the wood.

It is essential that the back of the cap iron should bed perfectly on the face of the cutting iron when they are fitted together, for even the slightest gap between the two will allow a shaving to enter and the mouth of the plane will immediately become blocked (see Maintenance of Tools, page 104).

The wedge is made of hard wood and its function is to hold the irons in place. It fits into special grooves in the sides of the escapement.

It is a good idea to keep the wooden parts of the plane in good condition by occasionally rubbing some vegetable oil, like groundnut oil (not machine oil) on them.

NOTES:

THE SMOOTHING PLANE

The smoothing plane is constructed similarly to the jack plane. It is used to finish the surface of the wood.

The smoothing plane is about 20 cm long, so it is the smallest plane that a builder uses (Fig. 2, page 54).

The smoothing plane is not used to remove large quantities of wood or to plane the wood flat and true. It is set to remove only rather fine shavings, so we use it only to make a smooth surface on the wood.

The smoothing plane has a handguard rather than a handle like the jack plane and it has the striking button on the back end of the plane instead of on the nose.

NOTES:

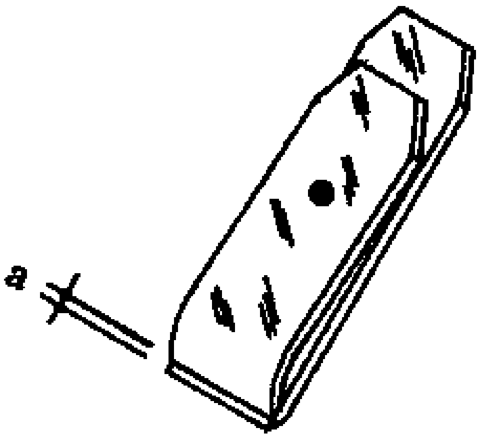


Fig. 1

Fig. 2

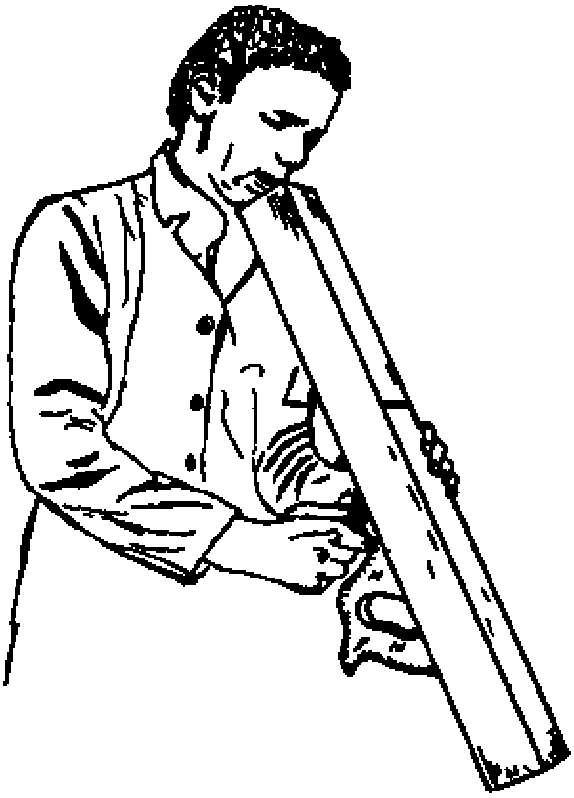


Fig. 3

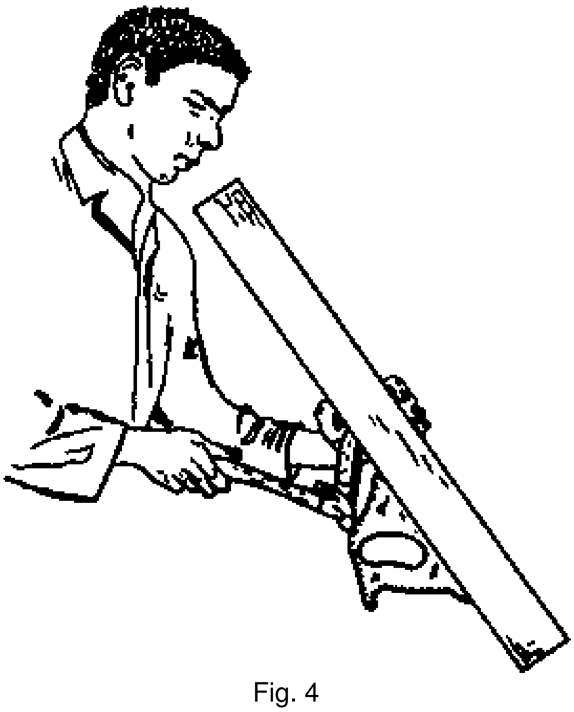


Fig. 4

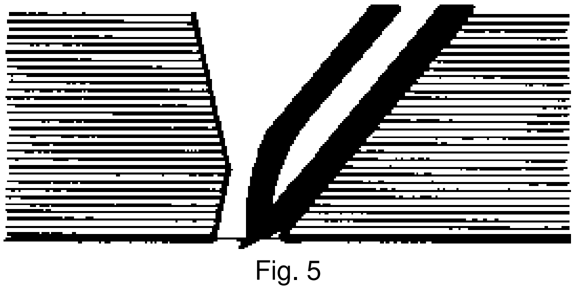


Fig. 5

HOW TO SET THE CAP IRON

The distance from the edge of the cap iron to the cutting edge is called the set (Fig. 1, a).

– The set for the jack plane should be:

2 mm, when planing hard woods;
3 mm, when planing soft woods.

– The set for the smoothing plane should be:

1 mm or less.

In order to set the cap iron, first loosen the cheesehead screw which holds the two irons together; until the cap iron can move. Hold the irons as shown in Fig. 2 and be very careful that the cap iron does not touch the cutting edge as this will make it dull. Adjust the irons to the proper set and tighten the screw.

HOW TO SET THE CUTTING IRON

1. Hold the plane in your left hand and look along the sole while putting the irons in it (Fig. 3). Fix the wedge so that they are held in place lightly. Adjust them to roughly the correct position.

2. Adjust the cutting iron exactly by tapping with the clawhammer either on top of the iron (Fig. 4), so that it comes out more and takes off thicker shavings; or on the striking button to get thinner shavings.

3. After every adjustment, tighten the wedge slightly. Don't hit it too hard or you will damage the wedge.

The cutting iron should project as shown in Fig. 5 on the left page. It is important that the cutting iron projects evenly. For rough work, you will want the cutting iron to project more so as to take off thicker shavings. For fine work, where only a little wood will be planed off, the cutting iron should project less.

– After you finish using the plane, knock the cutting iron back so that it doesn't project out of the sole at all. This is to prevent damage to the cutting edge when the tool is not in use.

NOTES:

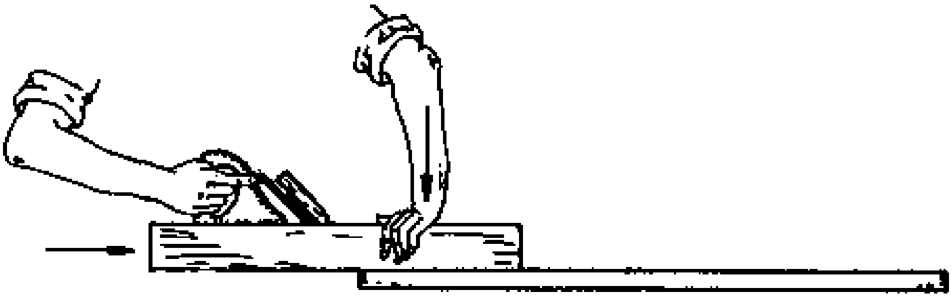


Fig. 1

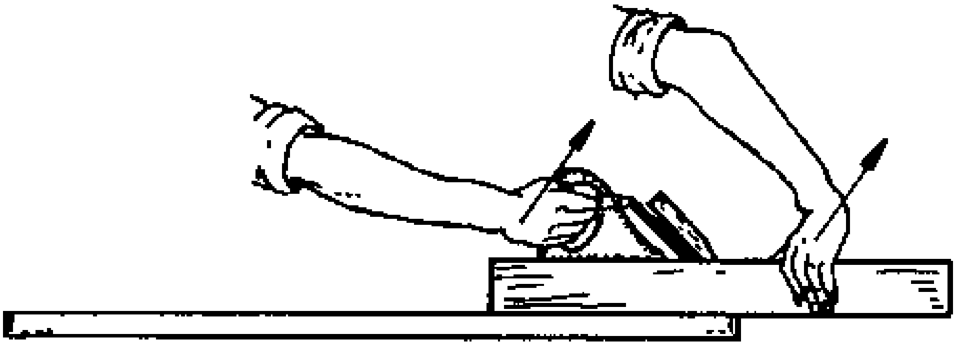


Fig. 2

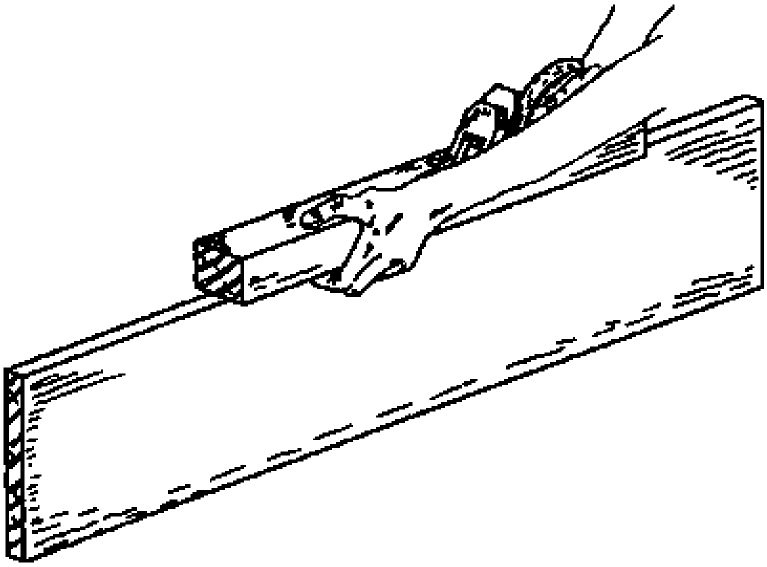


Fig. 3

PLANING

– When you use the plane, try to put pressure on it in such a way that the part of the sole which is in contact with the wood is pressed firmly to the wood surface. At the start of the stroke when the cutting iron does not yet touch the wood, put pressure on the front part of the plane (Fig. 1). When the cutting iron comes to the end of the board, press down more on the heel of the plane (Fig. 2).

– Guide the plane when you plane on edges, by curling your fingers under the plane so that they contact the board (Fig. 3).

– To obtain a good surface, always plane with the grain. If the wood is cross–grained, it is best to hold the plane at an angle to the direction of the stroke.

STUFFING

Sometimes the plane won't take off shavings anymore, but just slips over the wood without cutting it. This happens when shavings have blocked up the plane: the plane is stuffed with shavings.

– The plane may stuff when the cap iron is not fitted well to the cutting iron. Shavings can enter the gap between the irons and block the mouth of the plane (see Maintenance of Tools, page 104).

– Another cause of stuffing may be an incorrectly made plane. If you make your plane by hand, be sure to make the mouth and the escapement large enough. The mouth must not be too big however, because then it will not give a good surface when it is used to plane.

– Make sure that the ends of the wedge are not projecting over the cap iron and blocking the shavings.

NOTES:

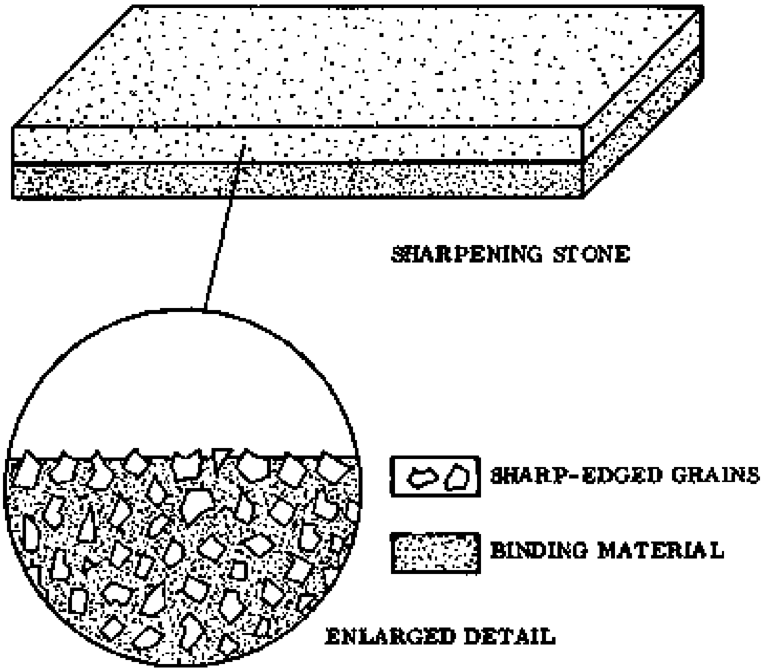


Fig. 1 – Fig. 2

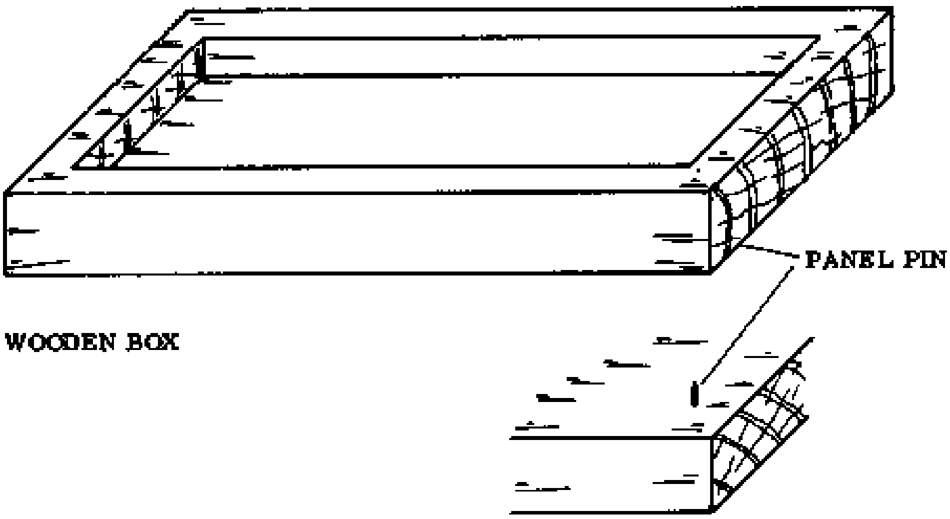


Fig. 3

THE SHARPENING STONE

The sharp edges of plane irons and chisels are made with sharpening stones. The stone acts like a file to wear away the portion of the tool that is rubbed on it.

There are natural and artificial (man–made) stones. Nowadays we use mostly the artificial ones. The grit (rough surface) of the stone consists of hard, sharp–edged grains, embedded in a binding material (Fig. 2). The bigger the grains, the coarser the stone. Stones can be coarse, medium, or fine; in Rural Building we use a combination stone, one side of which is coarse and the other fine (Fig. 1). The coarse side cuts quickly, but does not give a very keen (sharp) edge. The fine grit cuts slowly and gives a keen edge.

Take very good care of your sharpening stone. House it in a solid wooden box. On each corner of the box, drive a panel pin almost home and file the heads to sharp points (Fig. 3). The pins will anchor the box and the stone to the bench when you are sharpening tools.

HOW TO USE THE STONE

– Before using the stone, soak it in water for a few minutes. Use water during the sharpening to wash away the metal particles. After use, clean the stone with water. The water keeps the stone from glazing (becoming clogged with small metal particles between the grains, which makes it smoother and less efficient to use).

– Try to keep the stone worn down evenly and flat by using the entire surface, not rubbing just in the centre.

– The end nearest you is less easy to use, so turn the stone around occasionally to let both ends wear down equally.

– If a stone is worn hollow, it can be made flat again by rubbing it on a flat stone or cement surface, using sand and water to grind it.

NOTES:

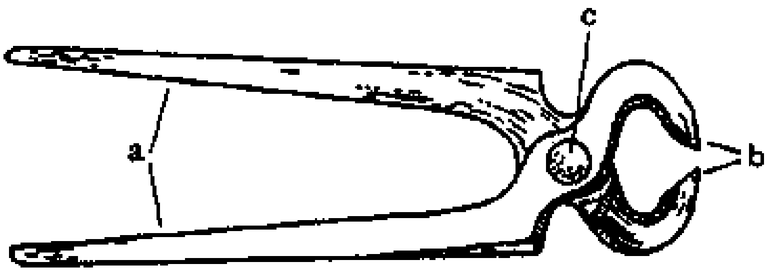


Fig. 1

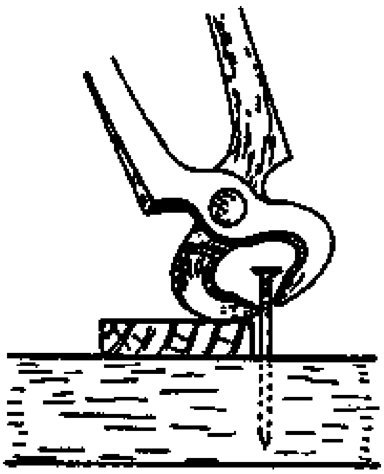


Fig. 2

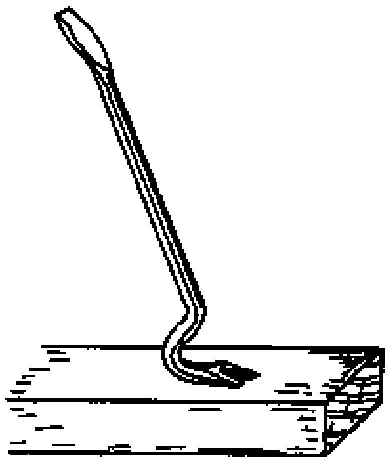


Fig. 3

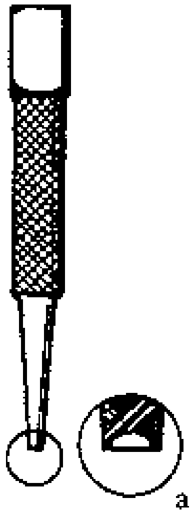


Fig. 4

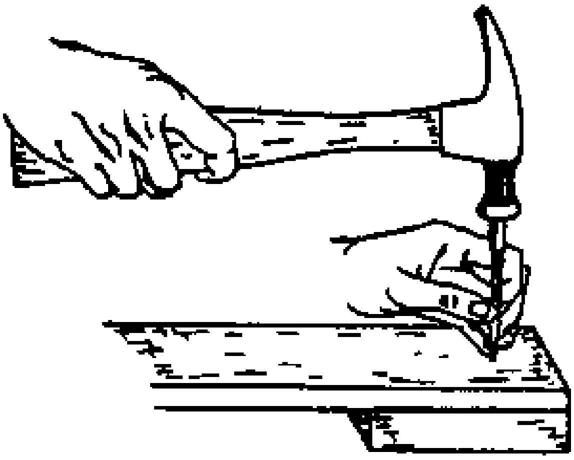


Fig. 5

OTHER TOOLS FOR EXTRACTING AND PUNCHING NAILS

PINCERS

Pincers (Fig. 1) are used chiefly for extracting nails which have become bent in driving. When using the pincers, protect the wood surface from bruising by using a small piece of wood underneath (Fig. 2).

Pincers have three main parts: the arms (a), made of steel, the jaws (b), made of hardened steel and sharpened to grip nails etc. and the rivet (c) which connects the two arms.

THE CROWBAR

This is an iron bar with a forged end (Fig. 3) used for pulling big nails out of timber and as a lever to move heavy objects. Other uses are: to open crates, or to loosen boards of concrete forms.

When a lot of force is needed to get out a nail, you use a crowbar so as not to break the handle of your hammer.

For lifting very heavy objects, an iron bar should be used in place of the smaller crowbar.

THE NAIL PUNCH

The nail punch (Fig. 4) is used along with the hammer to drive the heads of nails below the surface of the wood and to clench nails that go through to the other side of the board and stick out.

Nail punches are generally cylindrical in shape, with concave points to keep the punch from slipping off the nailhead (Fig. 4a). If no punch is available, a large blunt nail can be used instead.

– To punch a nail under the surface of the wood, hold the punch in place on the nailhead, steadying your hand on the board (Fig. 5), and hit it with the hammer.

NOTES:

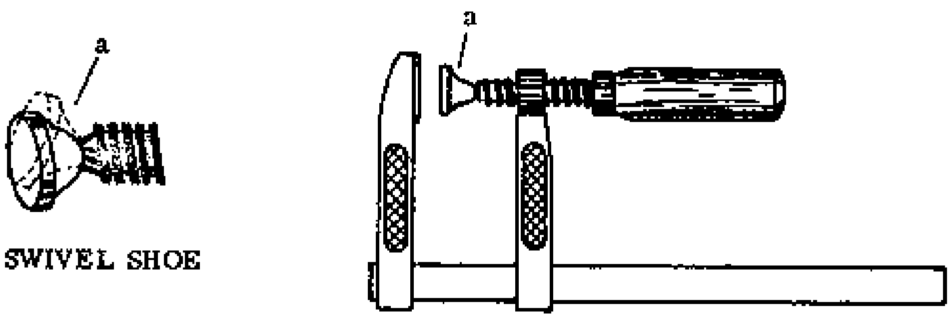


Fig. 1

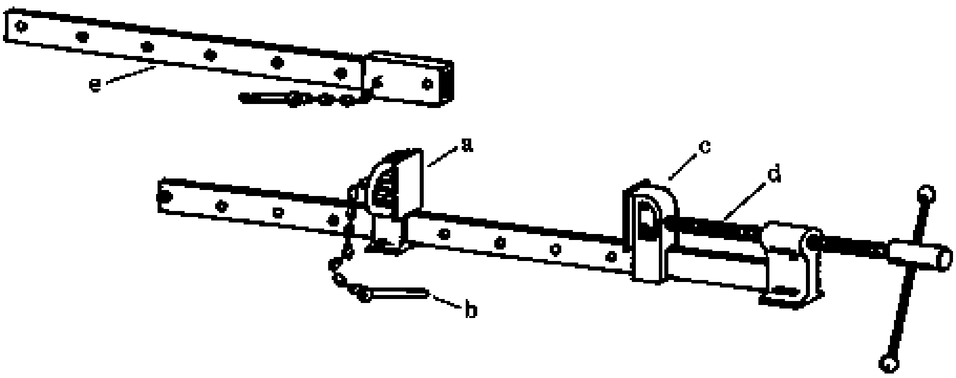


Fig. 2

Fig. 3

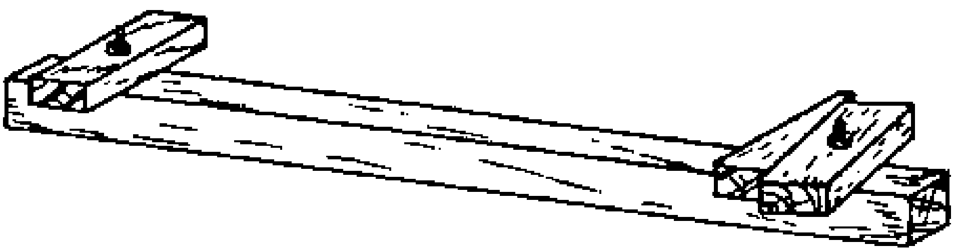


Fig. 4

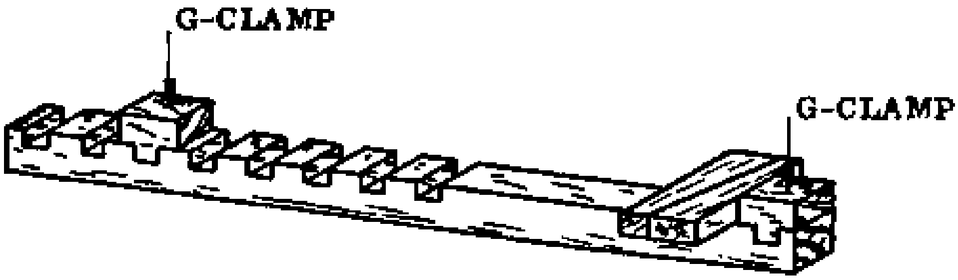


Fig. 5

CLAMPS

THE G−CLAMP

The G−clamp (Fig. 1) is used to hold the job under control while it is worked upon. It is used in the workshop as well as on the building site and can be used for holding small pieces together while they are being glued.

Except for the handle, which is made of wood, the parts are all steel. The shoe (a) is set on a swivel, which allows it to move and adapt to the surface of the job. These clamps are available in different sizes, up to 240 cm.

THE METAL SASH CLAMP

Sash clamps (Fig. 2) are used for pushing together joints and holding parts for glueing or nailing, or holding wood when making rebates.

The adjustable shoe (a) is fixed on the bar by the pin (b). The clamping shoe (c) is tightened against the job by the screw (d).

The length of the clamps can be between 100 and 200 cm, and they can be made longer by an extension bar (e).

− If more than one clamp is used on a piece, take care that they are set in line, so that they don't twist the piece.

THE WOODEN SASH CLAMP

Homemade clamps (Figs. 3, 4 & 5) can serve the same purposes as a metal one. The job is tightened by means of a wedge.

For quick jobs, a clamp can be made as shown in Fig. 3. Here the different members are nailed together according to the required size of the sash clamp.

If a more permanent, adjustable clamp is required, it can be made as shown in Figs. 4 or 5.

NOTES:

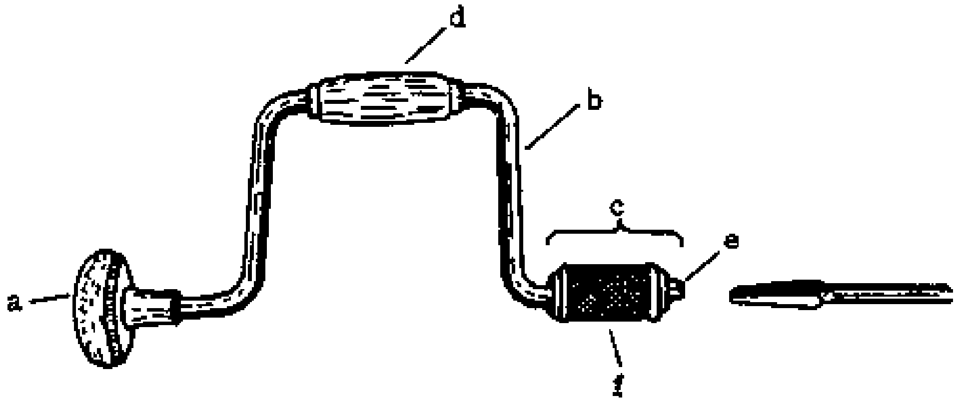


Fig. 1

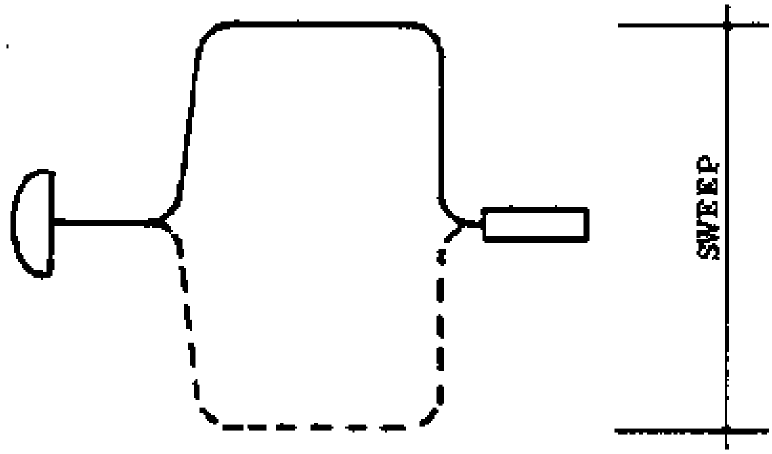


Fig. 2

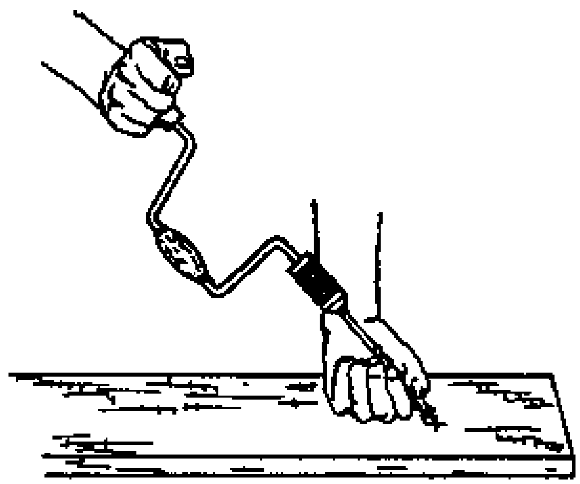


Fig. 3

THE BRACE (PLAIN AND RATCHET)

This is a cranked tool used to turn drill bits and countersinks, thus making holes in wood.

Its parts are (Fig. 1): the head (a), the crank or bow (b), and the chuck (c).

The head is a hard wooden or plastic knob, which is fixed to the bow and turns on a ball bearing.

The crank, which is formed by the rectangular bend, can be 10 to 20 cm in width giving a sweep of 20 to 40 cm, which determines the size of the brace (Fig. 2).

The wider the brace, the more force you can apply with it, but also, the distance your arm must travel is longer and more tiring and the bit may be broken more easily.

A handle (d) is attached to the crank by steel collars. It should revolve freely.

The chuck holds the various bits (the drilling parts). The bits are gripped by jaws (e). There are different kinds of jaws. The square shank of the bit fits into the square opening of the chuck. When the socket (f) is turned, it tightens the jaws over the shank of the bit.

There is a more advanced type of brace available, which is the ratchet brace. The ratchet makes it possible to use the brace in places where it is impossible to make a complete turn of the crank with an ordinary brace.

HOW TO USE THE BRACE

1. For accurate boring, first mark the location of the centre of the hole with two lines crossing each other, or by making a small hole with a sharp tool (Fig. 3).

2. With the knuckles of one hand down against the board, guide the point of the bit carefully into place, while with your other hand you exert a slight pressure on the head of the brace (Fig. 3).

3. As the bit starts boring, be careful to keep it perpendicular to the surface (unless you want the hole to be bored at an angle).

NOTES:

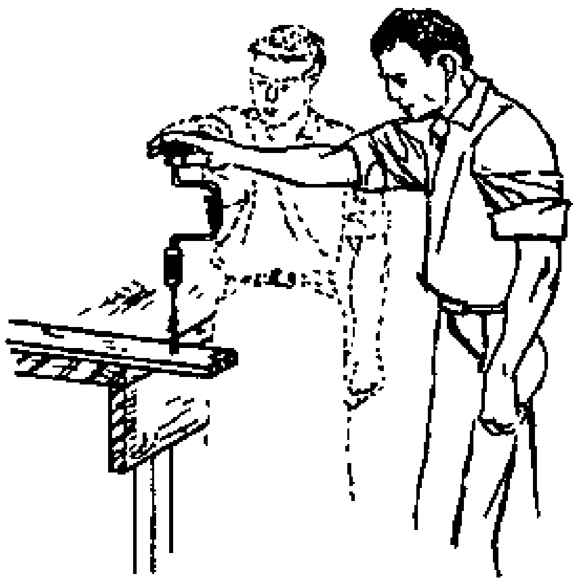


Fig. 1

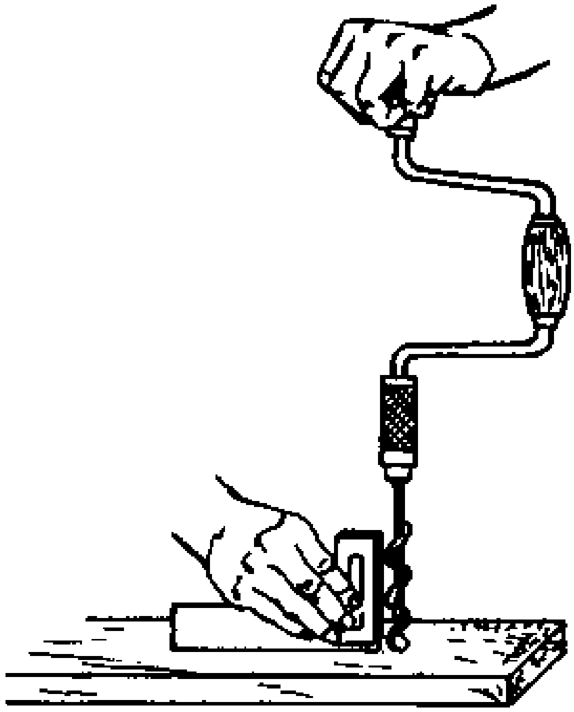


Fig. 2

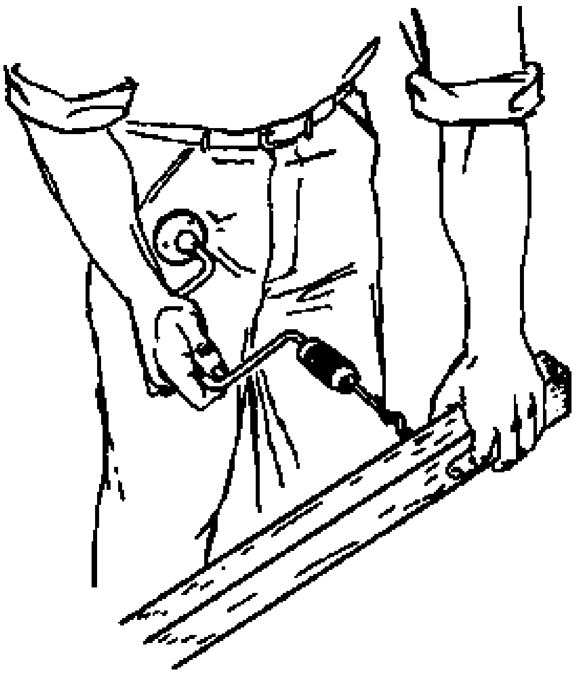


Fig. 3

It is fairly easy to tell if the brace is leaning to the right or left, but difficult to know if it is leaning away from you or towards you.

– For jobs where this is important, it is best to ask another person to stand to one side and tell you whether you are holding the brace upright.

– Another way to see whether the brace is boring square to the surface is to step. back a little, steadying the brace with one hand, and sight. Then move around and sight in the other direction, at about right angles to the first sighting (Fig. 1).

– A square can be used to check if the bit is boring straight (Fig. 2).

– If a hole is to be bored completely through a board, bore until the point of the bit can be felt on the other side (Fig. 3), then turn the board over and bore from the other side. This prevents splintering around the edge of the hole where the drill comes out.

– You can also prevent splintering by clamping a piece of waste wood on the other side of the board where the drill will come out. The drilling can then be done from one side only with no danger of splintering the wood.

NOTES:

Fig. 1

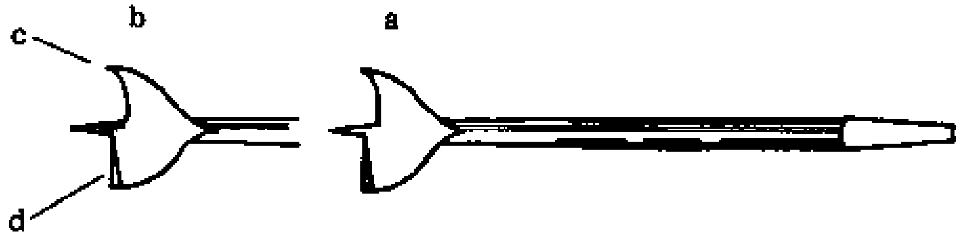


Fig. 2

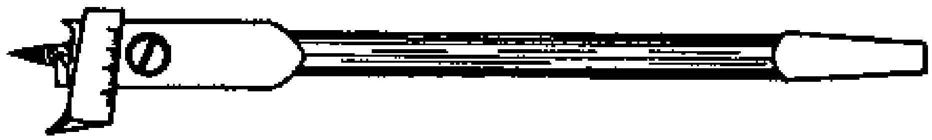


Fig. 3

Fig. 4

BITS AND DRILLS

Boring bits are used with a brace to bore holes in wood. They have a square−head shank, which fits the chuck of the brace. The shank below the head is cylindrical.

Boring drills usually have a cylindrical shank which fits into a special kind of hand operated drilling machine.

The size of the bit or drill is stamped on the shank, in mm.

AUGER BITS

The twisted part of the auger bit (Fig. 1) guides it and removes the waste. The screw−nose (a) draws the bit into the wood, the two spurs (b) scribe the diameter of the hole, and the cutter (c) cuts it.

Auger bits are used to drill deep holes. They come in sizes from 4 to 40 mm.

CENTRE BITS

The centre bit is used for boring holes in thin timber only, because it doesn't guide itself as the auger bit does.

Centre bits are available with either a point or a screw−nose (Fig. 2a or b). The screw−nose type is preferred over the type with a point, because it draws the bit into the wood.

The spur (c) cuts the rim of the hole and the router (d) removes the waste.

EXPANSION BITS

These bits are used for drilling large holes. The cutter is adjustable with a screw (Fig. 3). The size of the hole can range from 13 to 40 mm in diameter. Special types can expand up to 80 mm and more.

TWIST DRILLS

These drills have twisted flutes (Fig. 4) to bore clean holes in hard or soft woods. One of the main advantages of the twist drill is that it is available in sizes from 1 mm and up.

Besides the drill for wood, there are harder types which can drill holes in metal, stone and concrete. Even though they may look the same, you should never use woodworking drills for metal work.

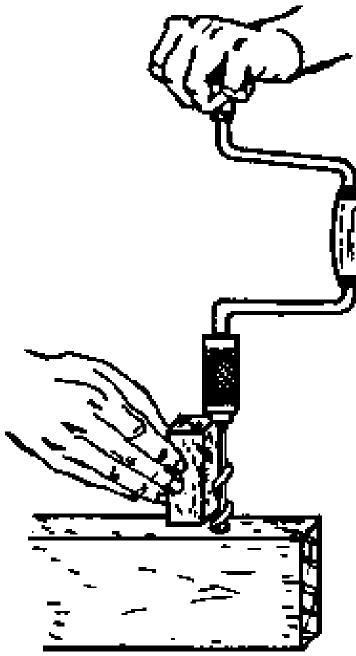


Fig. 1

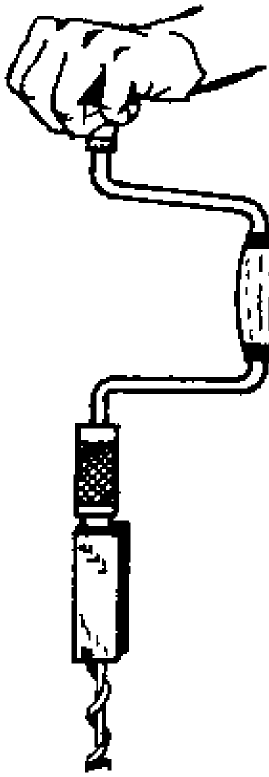


Fig. 2

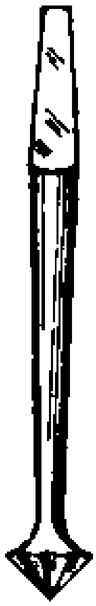


Fig. 3

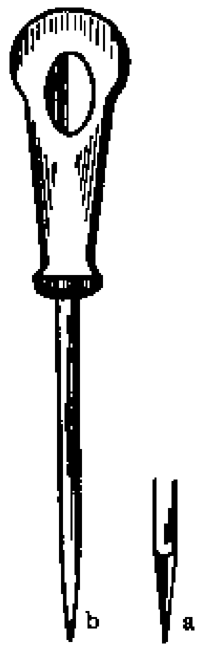


Fig. 4

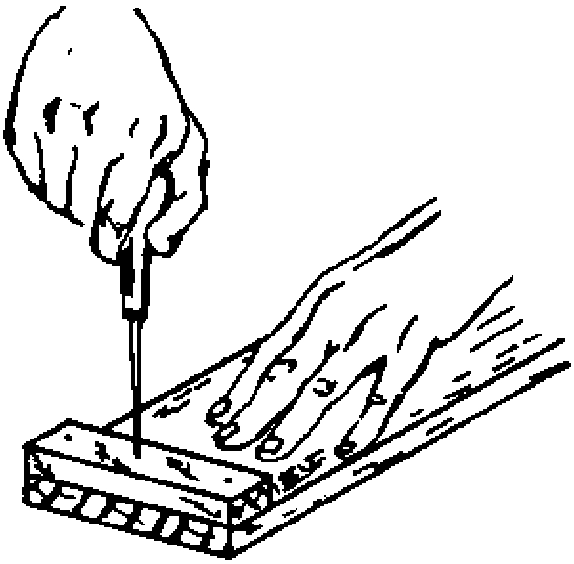


Fig. 5

DEPTH STOPS

If you are drilling a number of holes at the same depth, you can save time by cutting a wooden block to the correct size and using it as a gauge (Fig. 1), or boring a hole through the block and fitting it on the bit as shown in Fig. 2.

COUNTERSINKS

Countersinks are used to enlarge the top of a screw hole so that the screw head can fit below the surface of the wood. The most common type is the rosehead countersink (Fig. 3).

AWLS

An awl is a thin, pointed steel rod, which is fitted with a wooden or plastic handle.

Awls are used for marking or piercing holes in wood. The tip can be either square or rounded (Fig. 4a or b). Awls with square shaped tips are preferred for piercing holes for small screws or nails.

– Force the awl into the wood with a turning motion, left and right, so that it cuts its way through the wood (Fig. 5).

– An awl can easily be made from a thin steel rod, by hammering one end to a square shape and sharpening it, then fitting a handle to the other end.

NOTES:

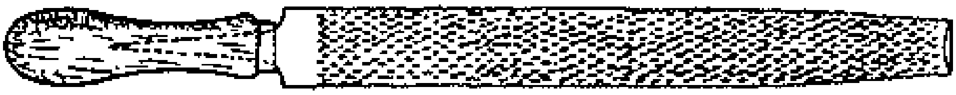


Fig. 1

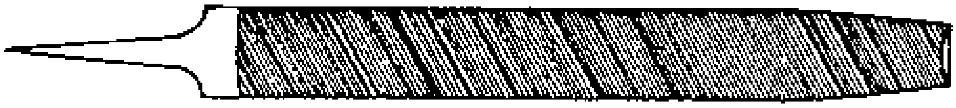


Fig. 2

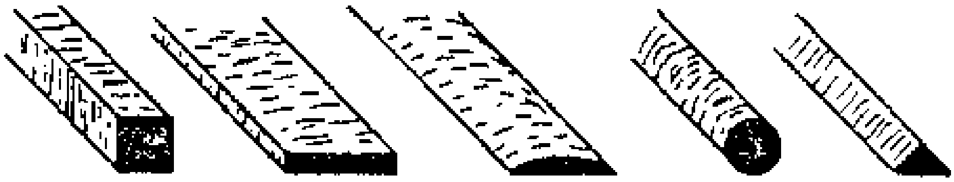


Fig. 3

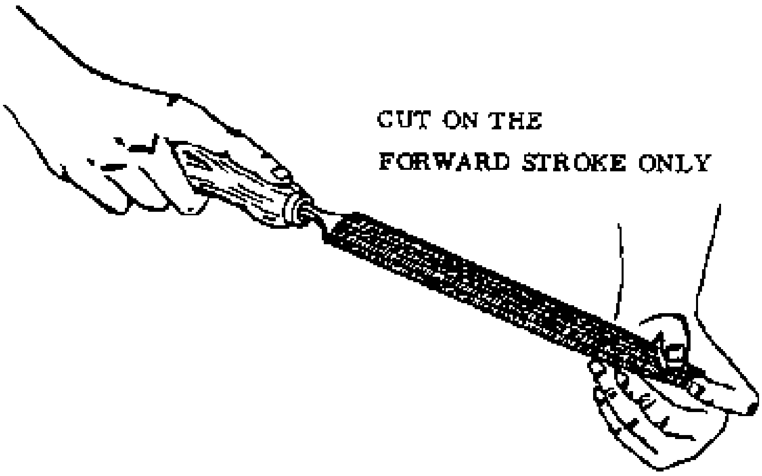


Fig. 4

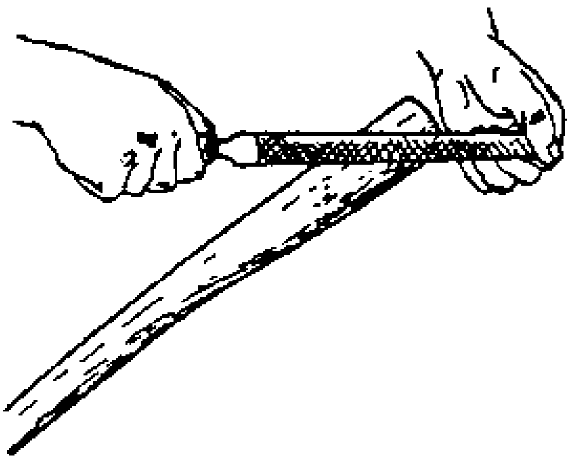


Fig. 5

RASPS AND FILES

Rasps (Fig. 1) and files (Fig. 2) are used in woodwork for smoothing wood which cannot be worked easily with any other kind of cutting tool.

> – NOTE: Special metalworking files are used to work metal and sharpen tools. Never use woodworking files on metal.

The difference between the rasp and file is in the cut. Files have a series of chisel cuts across their surface, while rasps have many separate small teeth. The rasp is more coarse and cuts faster and rougher than the file.

The handles on both rasps and files must be firmly seated.

Files and rasps are available in different grades of coarseness and in different shapes. Some common shapes for files are (Fig. 3): square, flat, half–round, round and triangular (sawfiles). Rasps are usually half–round or round in section.

HOW TO USE RASPS AND FILES

– Hold the tool at a slight angle to the direction of filing (Fig. 4). By doing this, you file over a wider area and avoid making a hollow spot in one place.

– The actual cutting is done on the forward stroke only.

– When you are filing a curved piece, give the file a sideways sliding motion at the same time as you move it forwards. This is so that the file follows the curve better and doesn't produce flat spots (Fig. 5).

– The rasp is used first, to get the rough shape as quickly as possible. Then the file is used to remove the coarse marks left by the rasp.

– Do not clean rasps or files with sharp tools or steel brushes. To clean them, scrub them with a hard–bristled brush.

NOTES:

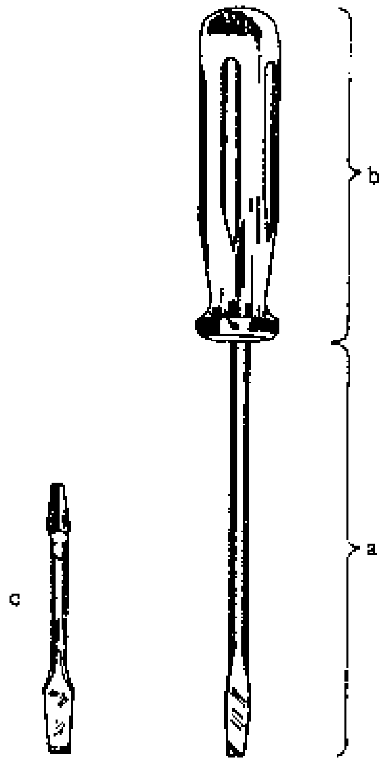


Fig. 1

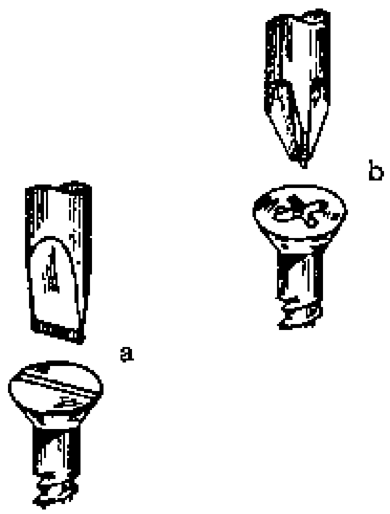


Fig. 2

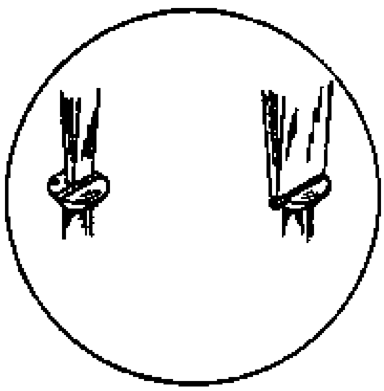


Fig. 3

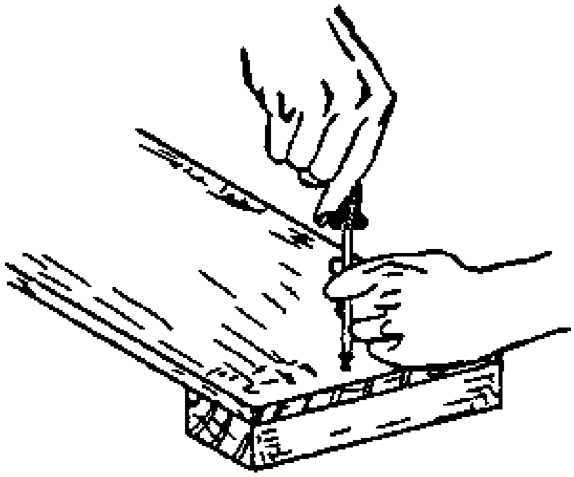


Fig. 4

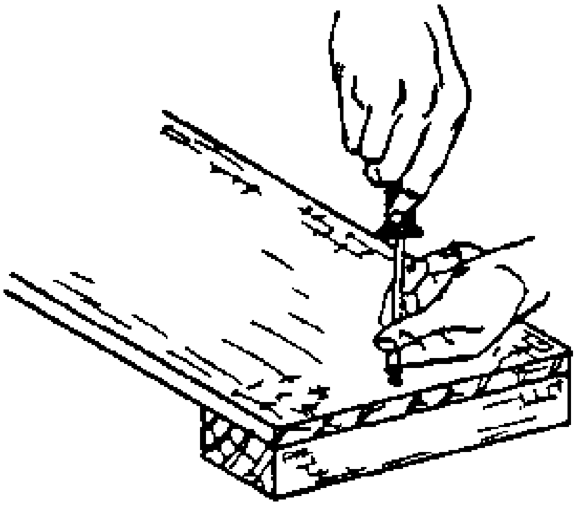


Fig. 5

THE SCREWDRIVER

Screwdrivers are used for inserting and removing screws. Many different types of screwdrivers are available. There are also screwdriver bits (Fig. 1, c) to be used with a brace.

The parts of the screwdriver are (Fig. 1): the blade (a) and the handle (b). The blade is either flat or cylindrical and the tip is either ground to a flat straight edge (Fig. 2a) or has a Philips shape (Fig. 2b) to fit different screws. The other end of the blade is shaped to a tang to fit into the handle.

The handle is made out of tough wood or plastic and is sometimes fitted with a ferrule to prevent splintering and keep the blade from turning in the handle.

The size of the screwdriver is determined by the length of the blade from the tip to the handle and by the diameter of the blade.

In order to work efficiently and not damage the slots of the screwheads, select a screwdriver with a tip that is the same width as the slot of the screw. A tip which is too small can slip and damage the slot, while one which is wider than the screwhead can scrape and damage the workface around the screw (Fig. 3).

The screwdriver tip must be properly formed (see Maintenance of Tools). A badly formed tip will cause the screwdriver to slip out of the slot and damage it.

HOW TO USE THE SCREWDRIVER

– Grasp the handle firmly in your right hand with your palm resting on the end of the handle; the thumb and forefinger extend along the handle.

– While the right hand changes grips to turn the handle, the left hand steadies the tool and keeps it in the slot. Figs. 4 and 5 show two methods of using a screwdriver.

NOTES:

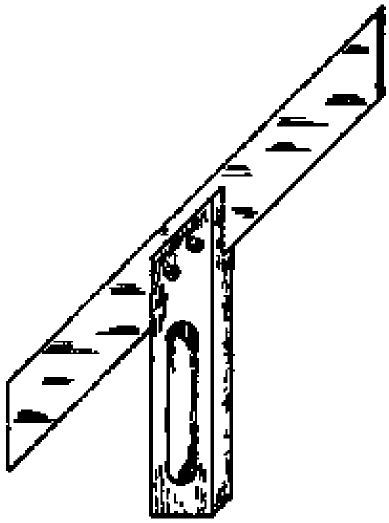


Fig. 1

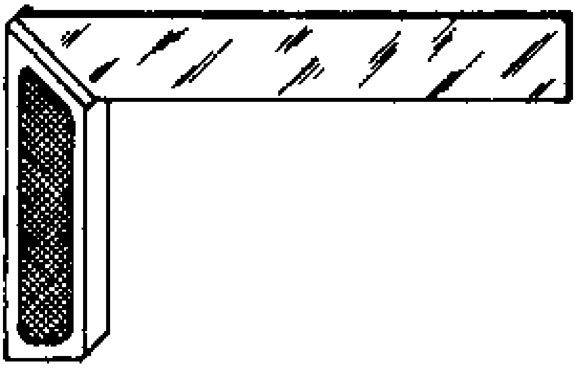


Fig. 2

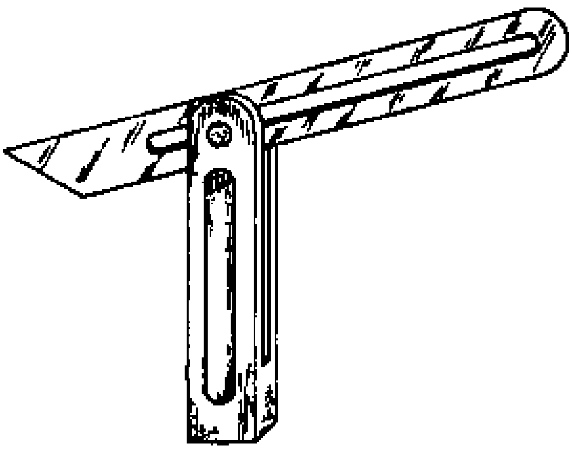


Fig. 3

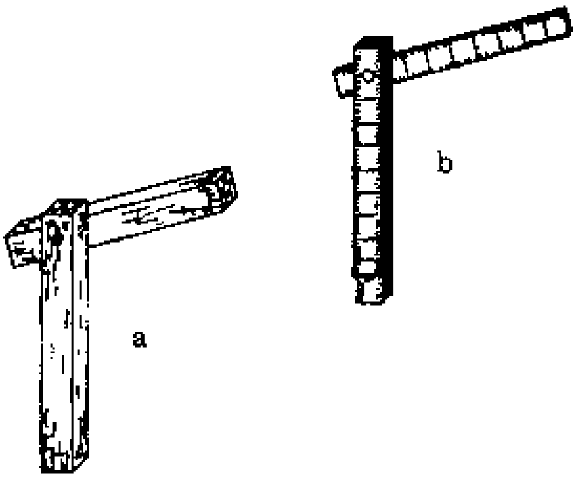


Fig. 4

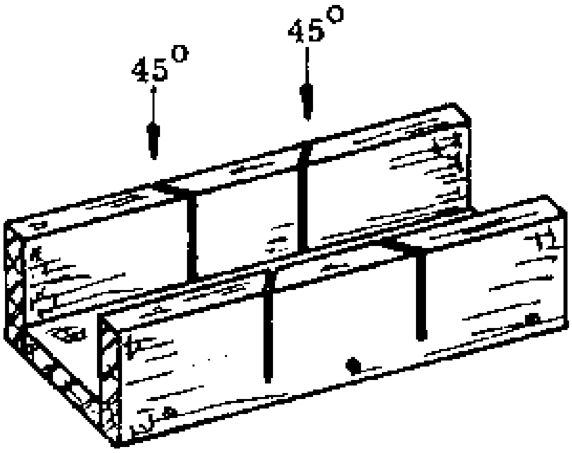


Fig. 5

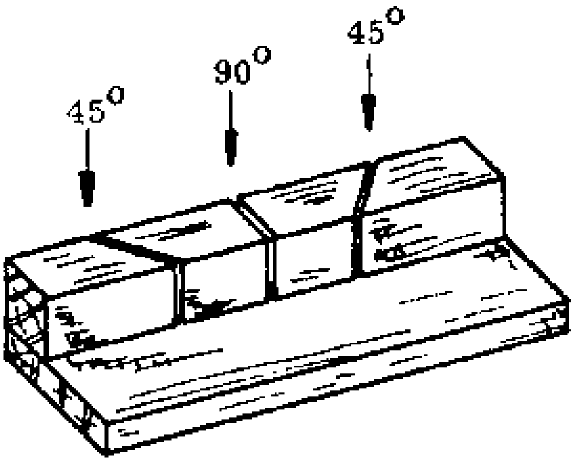


Fig. 6

TOOLS FOR MEASURING AND MITRING ANGLES

THE MITRE SQUARE

This is used to mark and test angles of 45 and 135 degrees. The blade is fixed at 45 degrees to the stock (Fig. 1).

THE TRY AND MITRE SQUARE

This is a combination of a try square and a mitre square. The end of the stock where it meets the blade is cut at 45 degrees (Fig. 2), so the square can be used for setting out and testing angles of 45 and 135 degrees, as well as 90 degrees.

THE SLIDING BEVEL

This is an adjustable square for marking out, testing and duplicating angles from 0 to 180 degrees. It has a stock and a slotted blade which can be adjusted to any angle and is held in place by a screw or a wing nut (Fig. 3).

A simple sliding bevel can be made by fixing two pieces of wood together with a nail or screw (Fig. 4a). Another method is to use the first section of a folding rule (Fig. 4b).

THE MITRE BOX

The mitre box (Fig. 5) is built of three pieces of wood, one forming the base and two parallel sides. It has saw kerfs in the sides at 45 degrees to the left and right to guide the saw in cutting mitres (cutting at a 45 degree angle).

THE MITRE BLOCK

This is used to mitre small sections of wood accurately. It is made of two pieces of wood with three cuts in the top piece; 45 degree cuts left and right and a 90 degree cut in the centre to help in sawing accurately square (Fig. 6).

– Mitre boxes and mitre blocks should be made of very hard wood and the saw cuts should be made with the same saw which will be used in them.

NOTES:

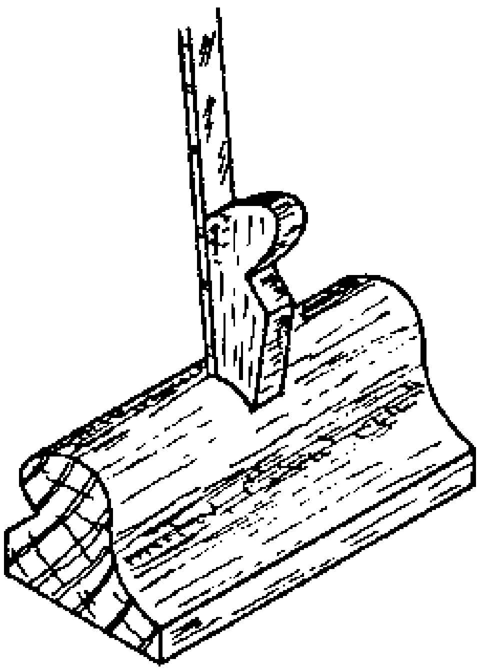


Fig. 1

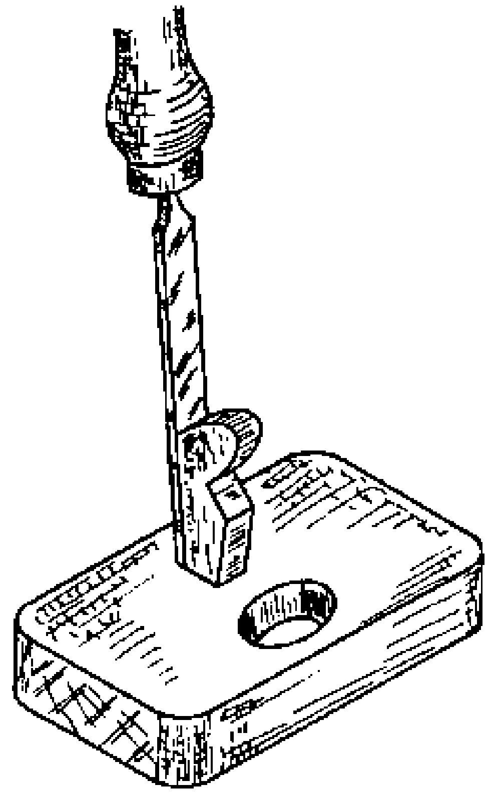


Fig. 2

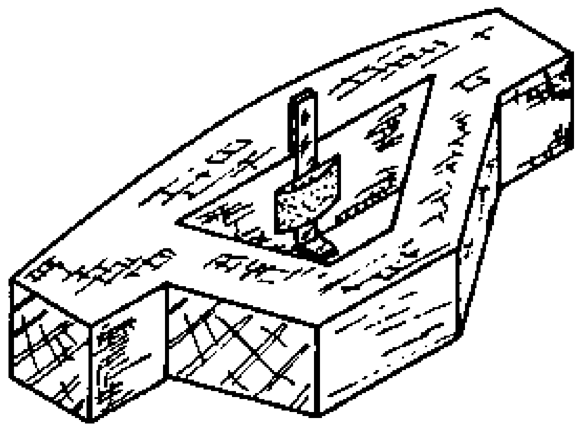


Fig. 3

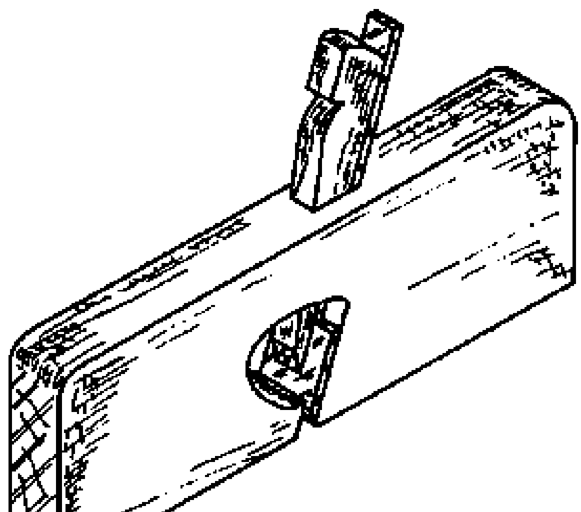


Fig. 4

ADDITIONAL PLANES FOR THE RURAL BUILDER

THE ROUTER PLANE

This is a tool adapted from the "old woman's tooth" (Fig. 1) shown on the left page. It is used for planing the bottoms of grooves, trenches, etc. after they have been chopped out with a chisel and mallet.

There is a wooden type as well as a metal type. The wooden type has the advantage that it can be made locally (Fig. 3).

For our Rural Building course, the old woman's tooth has the advantage that an ordinary chisel can be used as a cutting iron (Fig. 2), making it unnecessary to obtain a special iron.

THE REBATE PLANE

The rebate plane is used for working along the edge of timber. It is used for making rebates as well as for cleaning them up.

The use of the rebate plane is described in the section on Rebated Butt Joints, in Rural Building, Basic Knowledge, page 132).

NOTES:

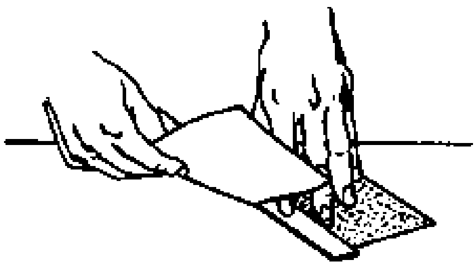


Fig. 1

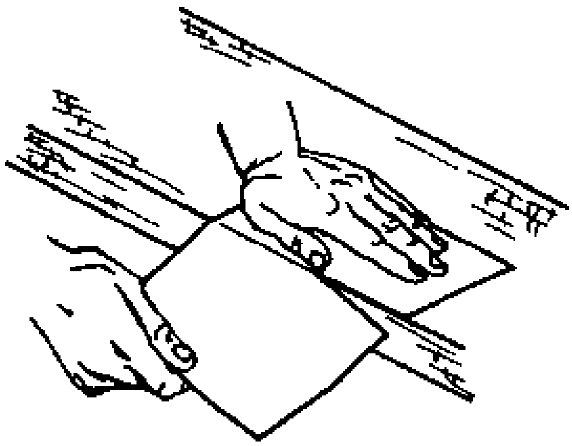


Fig. 2

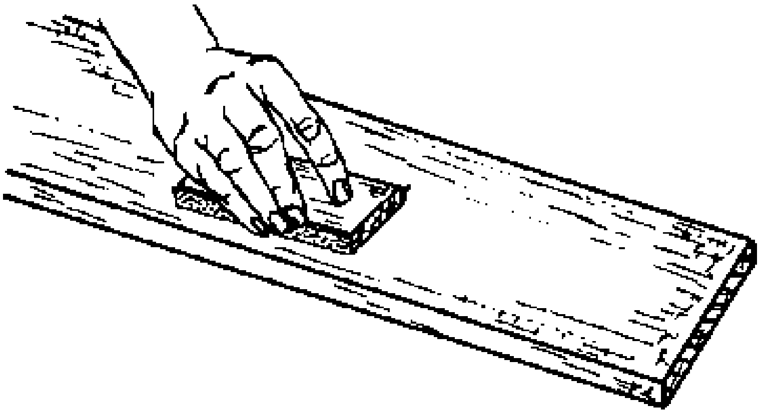


Fig. 3

SANDPAPER

Sandpaper is used to smooth wood surfaces, remove old paint, etc. It is used after all the planing work is done; sandpaper cannot be used instead of the smoothing plane.

Sandpaper is made from grains of very hard material glued to paper. The sharp edges of the grains are what cut into the surface of the wood. The sharper the grains, the better the sanding effect.

Sandpaper is graded according to the space between the grains: the more widely spaced the coarser the grade. Use coarse grades for rough surfaces or for the first sanding and finer grades for the final sanding. The commonly used grades are from No. 00 (fine) to No. 2 (coarse). Usually No. 1/2 or No. 1 is satisfactory for coarse sanding on wood and No. 0 for the final or finished sanding.

HOW TO USE SANDPAPER

– Tear the paper to the right size by creasing it and then tearing it over the edge of a bench or ruler (Figs. 1 & 2).

– Wrap it part way around a flat block of wood (Fig. 3).

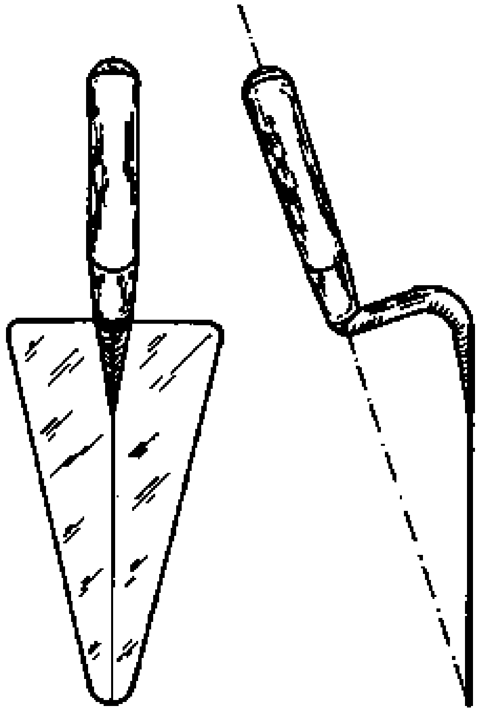
– For ordinary sanding, move the block back and forth with the grain; not in a circular motion or across the grain, which will roughen and scratch the wood instead of smoothing it (Fig. 3).

– If you are sanding off old paint, this may be done across the grain.

– Keep the block flat to the wood surface, particularly on narrow edges and be careful not to round the corners.

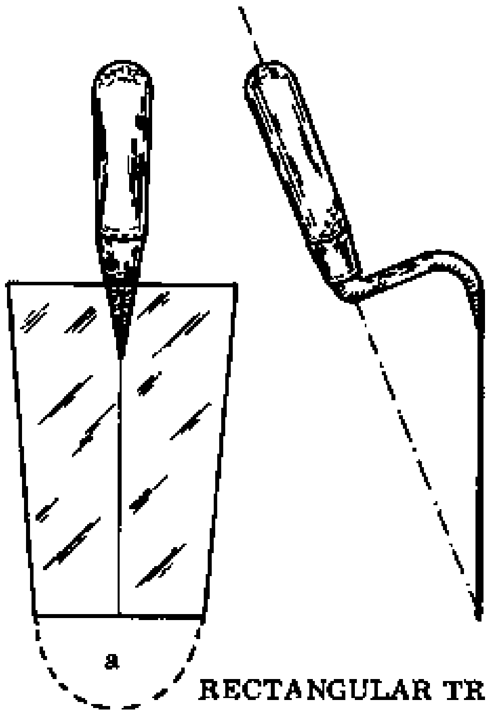
– Use only moderate pressure on the sandpaper block. Too much pressure may cause the paper to wrinkle or tear. Keep the sandpaper free of dust by knocking and shaking it out often.

NOTES:



TRIANGULAR TROWEL

Fig. 1



RECTANGULAR TROWEL

Fig. 2

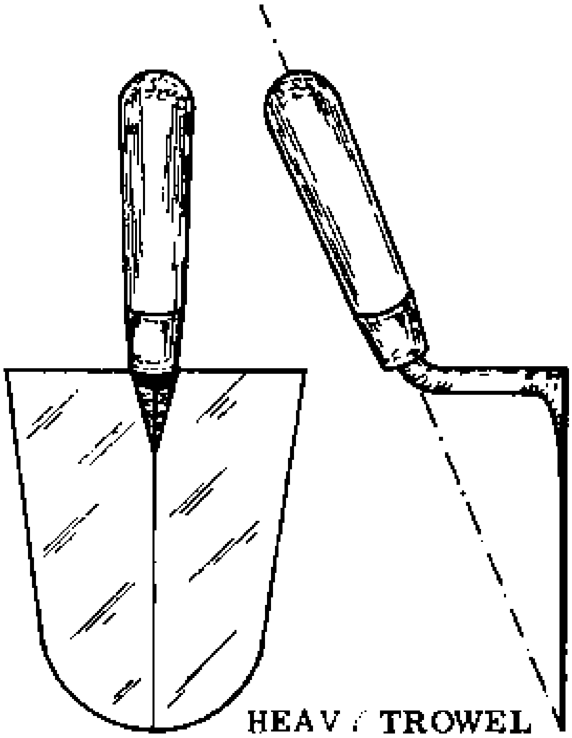
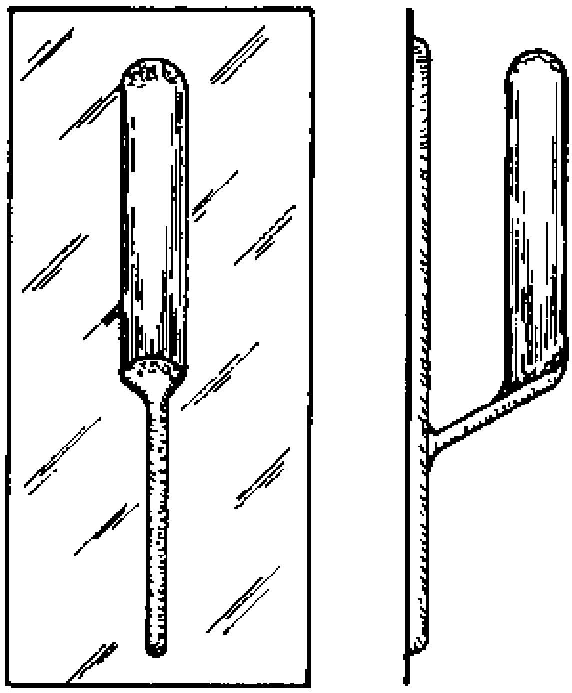


Fig. 3


STEEL FLOAT
Fig. 4

OPTIONAL TOOLS

There are many useful tools which the apprentice will eventually come into contact with and which perhaps he would like to purchase.

Although the set of tools supplied to the Rural Builder will be adequate to do the work, a good craftsman will always try to improve upon his tool set.

Therefore, the purpose of the following introduction to some additional tools is simply to round out the apprentice's general knowledge about tools.

OTHER TYPES OF TROWELS

Fig. 1 shows a triangular trowel, while the one in Fig. 2 is almost rectangular. The rectangular type of trowel is also available with a rounded tip (Fig. 2a). All three types of trowel are useful in Rural Building and the decision of which one to use depends merely upon their availability and the Builder's personal preference.

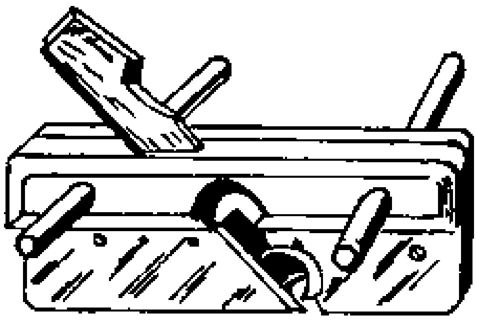
Fig. 3 shows a heavier trowel designed specially for concrete work. The head is rounded to make it easier to pick up concrete. The blade is rather thick compared to other trowels and the straight shank is connected to the blade at a 90 degree angle to reduce the flexibility of the trowel.

STEEL FLOAT

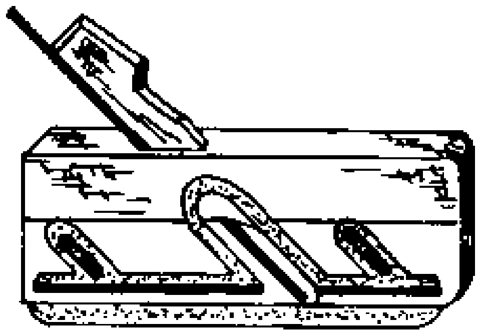
The steel float consists of a thin rectangular blade about 12 cm wide by 28 cm long. There is a handle fitted to the back side of the blade (Fig. 4).

This is a finishing tool used for smoothing surfaces such as floors and plaster.

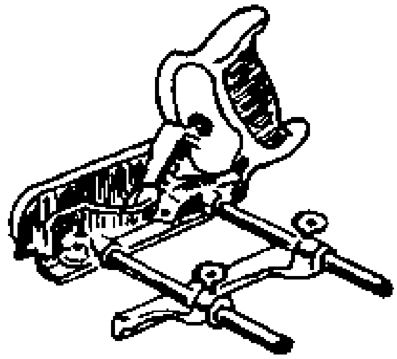
NOTES:



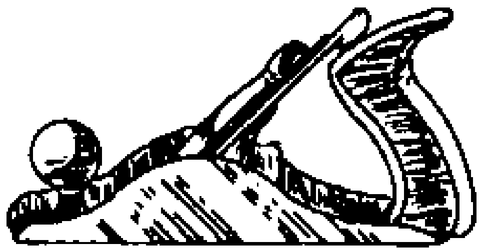
PLOUGH PLANE
Fig. 1



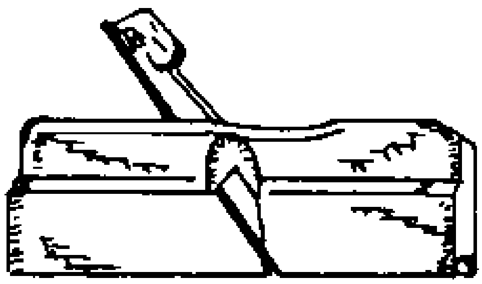
FILLISTER PLANE
Fig. 2



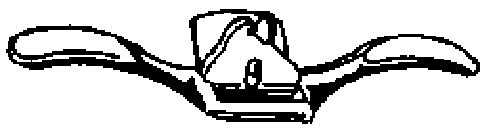
COMBINATION PLANE
Fig. 3



METAL PLANE
Fig. 4



MOULDING PLANE
Fig. 5



SPOKE SHAVE
Fig. 6

OTHER PLANES

There are many varieties of planes available for different jobs. However, in Rural Building, we can do a good job with the four different planes we have and we will leave it to the future craftsman to decide if it is necessary to obtain any other plane in addition.

Below we describe briefly some other planes which might be a choice for the future builder. They are shown on the left page.

The plough plane (Fig. 1) is used to make grooves in wood.

The fillister plane (Fig. 2) is used for making rebates.

The combination plane (Fig. 3) is a combination of the fillister plane, plough plane and moulding plane.

There are various types of metal planes (Fig. 4) used for different purposes in furniture making.

The moulding plane (Fig. 5) resembles a rebate plane and it is used for making profiles.

The spoke shave (Fig. 6) is used to true and smooth edges after sawing. NOTES:

NOTES:

PART 2: MAINTENANCE OF TOOLS

The importance of good tool maintenance is something which is readily appreciated by everyone; the beginner will quickly realize that without maintenance, the finest tools are no more useful than the most inferior ones.

Apart from their general maintenance in terms of cleanliness, rust prevention and avoidance of damage from rough handling, the most important aspect of maintaining tools is in the preparation and preservation of good cutting edges.

Until one has some experience in tool maintenance, one easily overlooks the fact that from the moment that a fine cutting edge is formed, it becomes the most delicate and easily damaged part of the tool. Even the lightest touch of another piece of metal can spoil the edge, wasting the work which has gone into making it.

Such damage can be avoided in commonsense ways such as:

- By keeping the bench clear of tools which are not in use.
- By laying planes down on their sides or keeping the toe raised on a wood support so that the plane iron does not touch the bench top.
- By keeping chisels and saws in the box when they are not in use.
- By keeping the bench clear of ironmongery such as nails, screws, hinges, etc.
- And by putting tools down on wooden surfaces only.

NOTES:

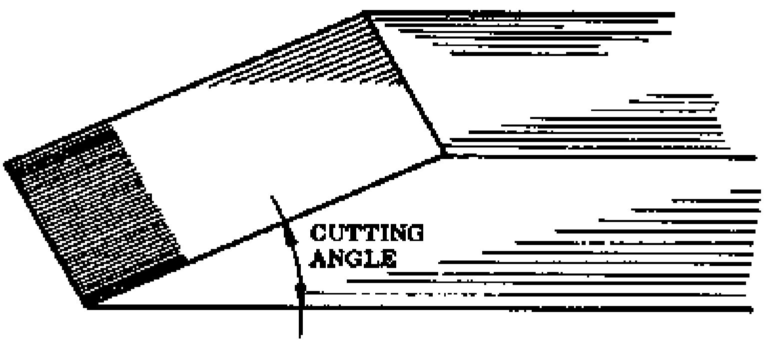


Fig. 1

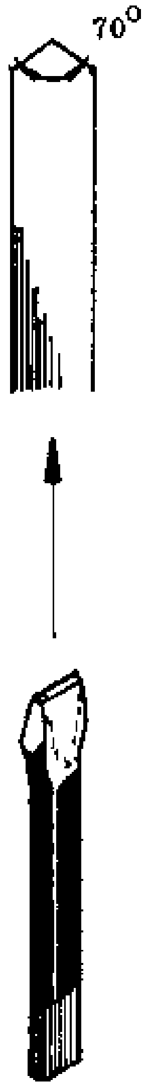


Fig. 2

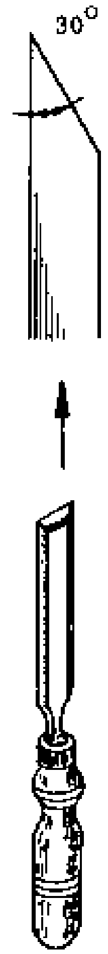


Fig. 3

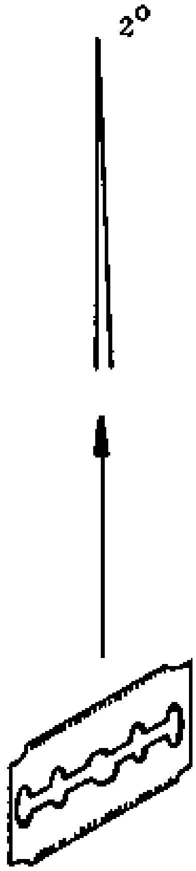


Fig. 4

CUTTING ANGLES

Before you can properly maintain your tools, you need to know something about the shape of the cutting edges on tools like plane irons and chisels. A cutting edge is formed where the two faces of a wedge come together at an angle, which is the cutting angle (Fig. 1).

In general, the harder the material that you want to cut, the larger the cutting angle you need. For example, to cut steel or stone you need a tool with a cutting angle of about 70 degrees, like the cold chisel (Fig. 2). To cut a soft material like leather, a knife or a razor blade with a cutting angle of only a few degrees (Fig. 4) will work efficiently. Of course, you would not be able to cut steel with a razor blade.

In both these cases, it is important that the cutting edge of the tools is sharp, although they have different cutting angles.

For cutting wood, we generally have one standard cutting angle for the tools like plane irons and chisels, although different kinds of wood can vary quite a bit in hardness. This standard angle of between 25 and 35 degrees is more or less suitable for all types of wood (Fig. 3). The craftsman will find with experience the right cutting angle for his needs.

Note that the smaller the cutting angle, the more easily the tool will cut and also the sooner it will become dull.

NOTES:

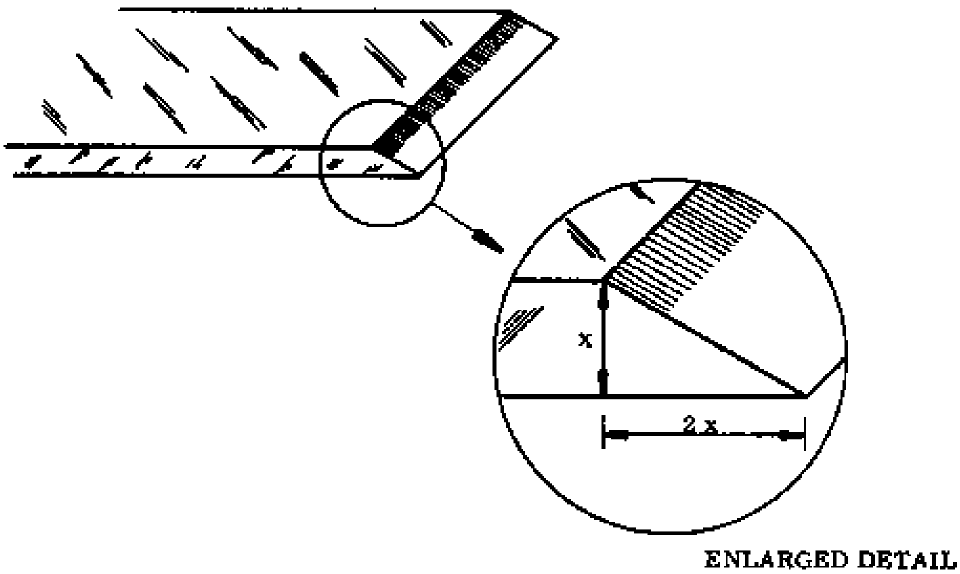


Fig. 1

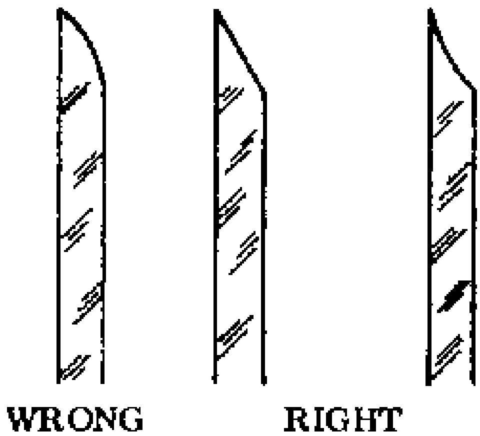


Fig. 2

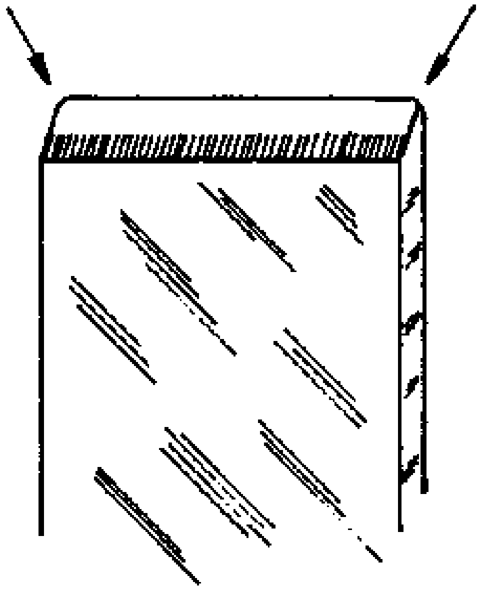


Fig. 3

SHARPENING PLANE IRONS AND CHISELS

Two different operations may be needed to produce a keen edge on these tools: grinding and honing.

Simply honing tools on a sharpening stone is all that is needed to sharpen them if they are dull but undamaged.

If the edges have been damaged, or worn down by many honings, they will need to be ground first and then honed. The grinding step is done on the rough side of the sharpening stone, or if the damage is very bad, on the grinding wheel.

ANGLE AND SHAPE OF THE CUTTING EDGE

– For normal work, grind plane irons and chisels so that the length of the bevel is a little more than twice the thickness of the blade (Fig. 1). This gives an angle of 25 to 30 degrees.

– The bevel should be ground straight or slightly concave, not rounded or convex (Fig. 2).

– For jack planes it is desirable to grind the corners of the blade slightly rounded as shown in Fig. 3. This lets the iron cut thicker shavings without causing deep grooves or plane marks in the wood surface.

– The cutting irons of smoothing planes, rebate planes and chisels should not be rounded.

– When you sharpen the cutting iron of a plane, always remove the cap iron first.

NOTES:

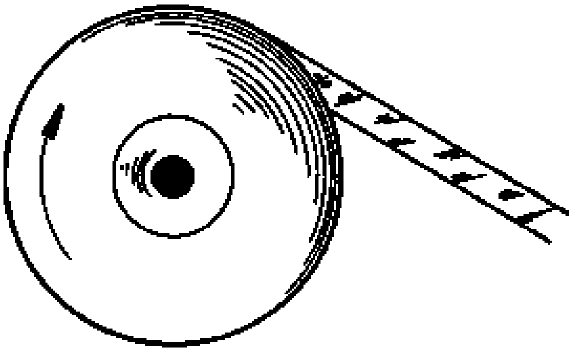


Fig. 1

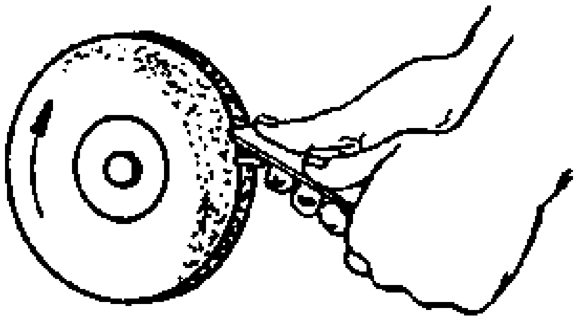


Fig. 2

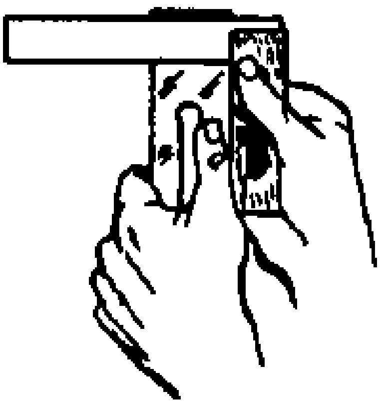


Fig. 3

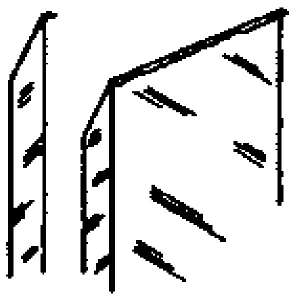


Fig. 4

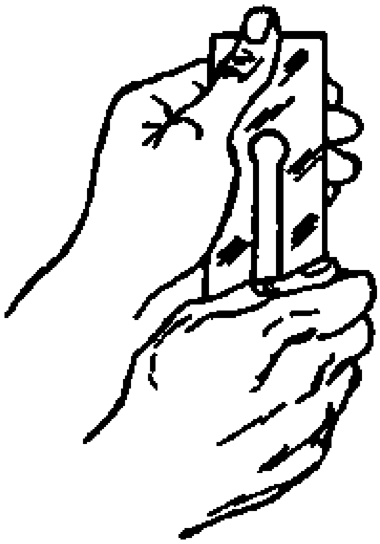


Fig. 5

HOW TO GRIND PLANE IRONS AND CHISELS ON THE GRINDING WHEEL

When the cutting edge of a tool is badly damaged, it is ground on the grinding wheel. This is done by holding the tool at a constant angle to the rotating edge of the wheel (Figs. 1 & 2).

Each grinding makes the tool a bit shorter, and thus shortens its life. Use your tools carefully so that they don't need to be reground as often.

When you grind a plane iron or chisel on the grinding wheel, the following points are important to keep in mind:

– Before grinding, test the cutting edge for squareness. Put a try square on top of the chisel or plane iron, with the cutting edge projecting slightly past the try square blade (Fig. 3). Be careful not to touch the cutting edge with the square.

– Hold the tool against the wheel in a manner that will produce a smooth, even bevel, with the desired angle.

– If possible, adjust the work rest of the grinding wheel, so that when the tool is held firmly against the rest it will come into contact with the wheel at the correct angle (Fig. 2).

– Grasp the tool so that your first finger is against the work rest; this will enable you to replace the tool in the proper position after removing it for inspection or to dip it in water (Fig. 5).

– During grinding, a wire edge or burr is formed on the tool. You can feel this burr if you run your thumb across the edge at the back (Fig. 4).

– It is important that the grinding wheel always turns towards you (Fig. 1), so that the burr that is formed remains on the blade. If the wheel were rotating away from you the burr would tear off, leaving an uneven edge.

– Turn at a moderately fast speed, not so fast that the gears whine or the grinder vibrates.

– Always work with another person on the grinding wheel, so that he can turn the wheel while you do the grinding.

– Hold the tool against the wheel with a medium firm pressure.

– Move the tool from side to side across the face of the wheel.

– Take care that the cutting edge does not become overheated and thus softened during grinding. Prevent overheating by frequently dipping the cutting edge into a tin of water.

– Inspect the edge often, to see if the tool is being ground to the proper shape and angle.

– With a bit of practice, you can check the cutting angle by eye, remembering that the length of the bevel should be a little more than twice the thickness of the blade. Use a rule at first to check the length of the bevel and the thickness of the blade.

– Continue grinding until the dull edge is removed, all the marks are removed, the edge is straight and square and the bevel has the required angle. If the edge is not square, correct it during the grinding by pressing carefully more on one side than on the other.

– Remove the burr or wire edge left by the grinding wheel by honing the tool on a sharpening stone.

NOTES:

GRINDING ON THE COARSE SIDE OF THE SHARPENING STONE

If the tool has a cutting edge with only a few marks in it and no serious damage, it can be ground on the coarse side of the sharpening stone, instead of using the grinding wheel.

– Soak the stone in water and grind the bevel of the tool on the coarse side of the stone, until a slight burr or wire edge is formed.

– When grinding, place the cutting iron on the stone so that the bevel lies flat (Fig. 1) and rub it with circular movements. Do not rub it just back and forth, as this makes the stone wear unevenly.

– Be particularly careful to move your hands parallel to the surface of the stone and do not allow them to make a dipping movement, as this will round the cutting edge.

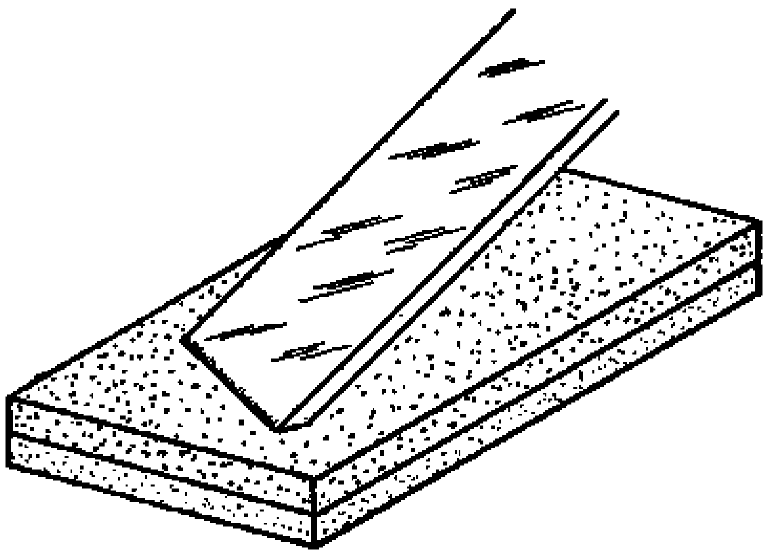


Fig. 1

NOTES:

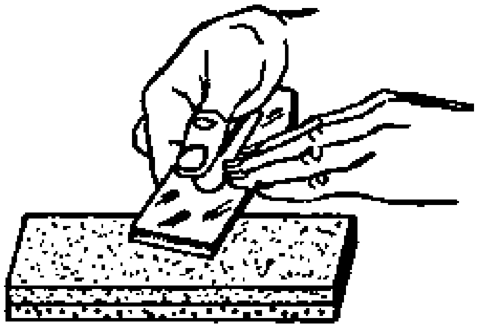


Fig. 1

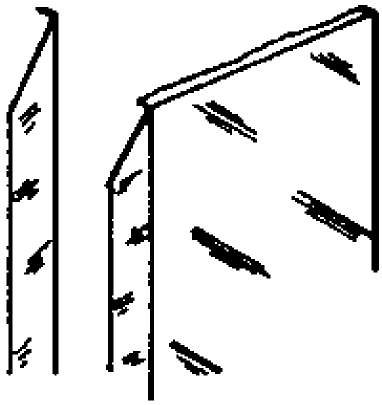


Fig. 2

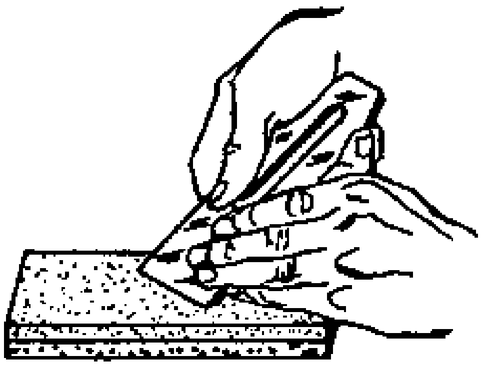


Fig. 3

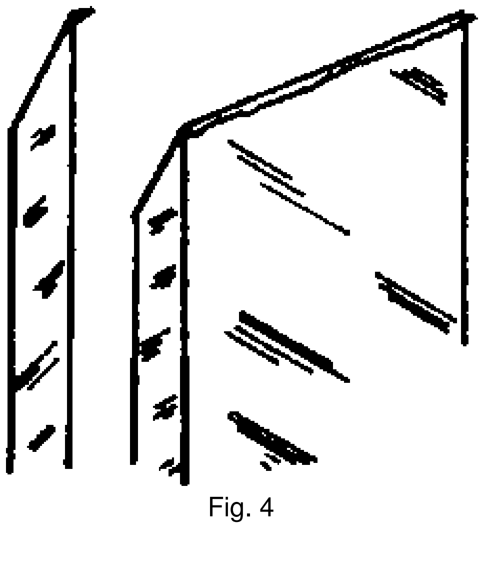


Fig. 4

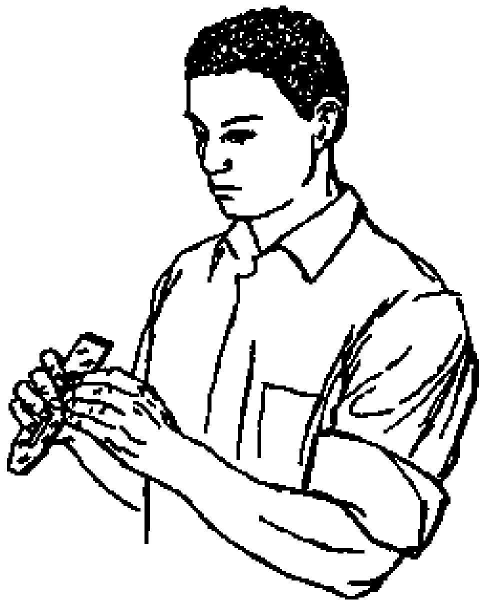


Fig. 5

HOW TO HONE PLANE IRONS AND CHISELS

Honing is done on the fine side of the sharpening stone. Honing produces a keen edge.

After a slight wire edge has been produced on the coarse side of the sharpening stone, or on the grinding wheel, it is removed by honing on the fine side of the stone.

– First, soak the stone in water. Place the tool perfectly flat on the stone with the bevel up and push it forward (Fig. 1). A few strokes will turn the burr from the flat side of the tool to the side with the bevel (Fig. 2).

– When the wire edge turns, turn the tool over so the bevel is flat on the stone and hone lightly on the bevel (Fig. 3).

– Then reverse the tool again and hone on the flat side.

If the honing is properly done, the wire edge will quickly become smaller and smaller (Fig. 4) and eventually disappear. The tool will then be sharp.

To check whether the tool is sharp, draw the nail of your thumb across the edge of the tool.

Marks, such as may have been caused by a nail, can be detected by holding the iron to the light. A sharp edge cannot be seen, while a dull one will show up in the light and appears as a narrow, shiny surface (Fig. 5).

If the tool is not held perfectly flat when the flat side is honed, a small bevel may be produced on the flat side and it will then be impossible to put the edge in good condition without regrinding it.

– In alternately honing the flat and bevelled sides, make sure that the wire edge is actually turned from the flat to the bevelled side before you reverse the tool for honing on the bevelled side (Figs. 2 & 4).

– To hone a slightly dull edge without grinding it, rub it on the sharpening stone in the same way, but only on the bevel side, not on the flat side.

Chisels are sharpened in the same way as cutting irons. Keep in mind that they are narrow and they should not be worked all the time in the centre of the stone, as this will quickly cause the centre of the stone to become hollow.

NOTES:

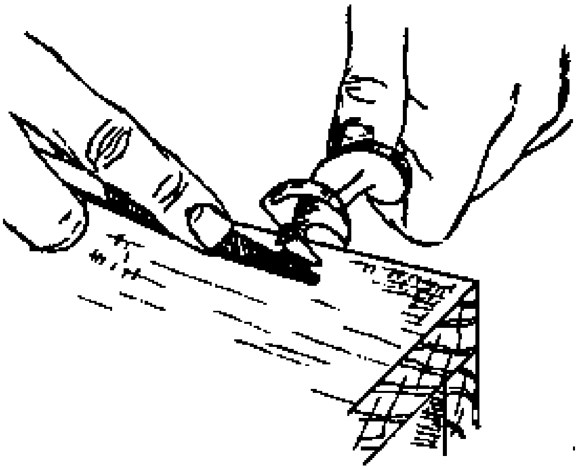


Fig. 1

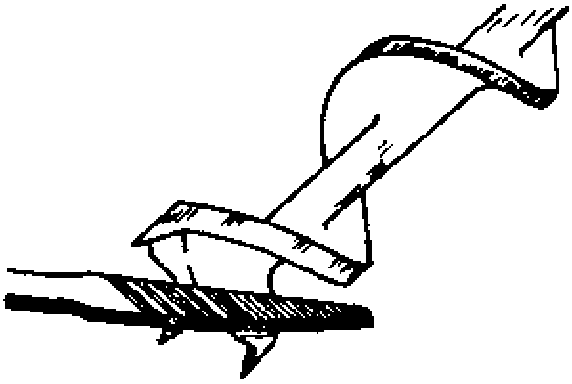


Fig. 2

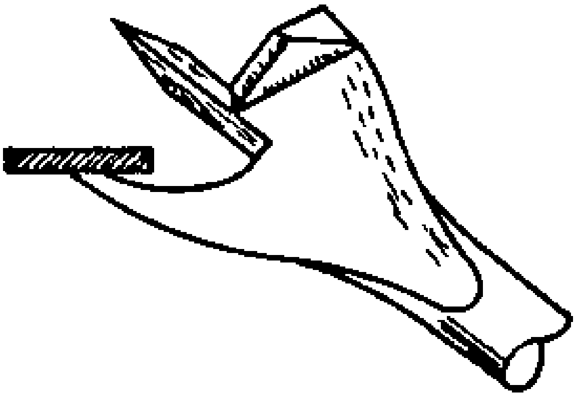


Fig. 3

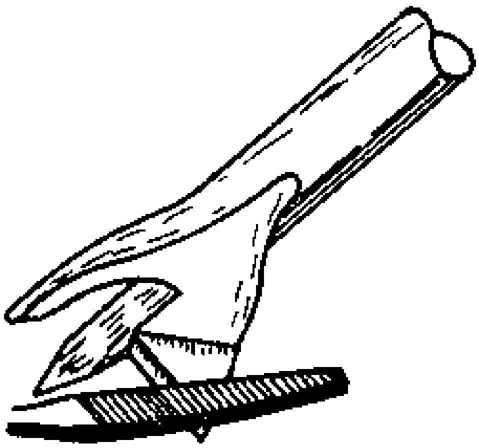


Fig. 4

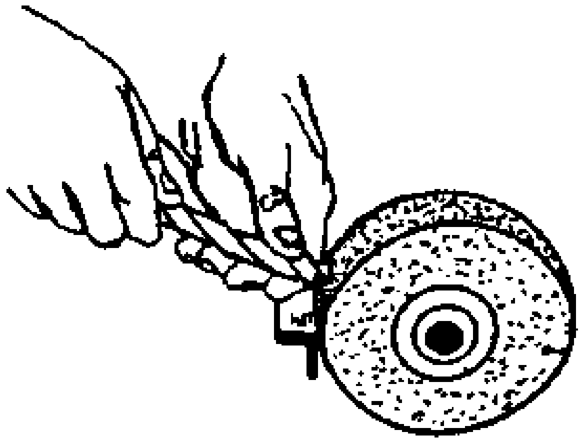


Fig. 5

SHARPENING BITS AND DRILLS

Manual wood bits are usually sharpened with a small file. It is best to avoid too much sharpening. Your tools will last longer if you use them carefully and keep them in a good case, so they won't need sharpening so often.

SHARPENING THE AUGER BIT

Auger bits are sharpened as shown on the left (Figs. 1 & 2).

– For the spurs, use a small file and sharpen from the inside face only (Fig. 1). The spurs are never sharpened on the outer faces, as this would change their diameter.

– For the cutters, file from the top side (Fig. 2). Retain the original bevel and remove about the same amount of material from each side.

– Hold the bit firmly to the edge of the bench during filing.

HOW TO SHARPEN THE CENTRE BIT

– To sharpen the spur, file from the inside (Fig. 3). To sharpen the router, file the bevel from the top side (Fig. 4).

– When sharpening the centre point, take care that the point remains exactly in the middle between the spur and the outside of the router.

HOW TO SHARPEN THE TWIST DRILL

– Grind the nose from the bottom (Fig. 5). Keep the original shape and angles and remove the same amount from each side.

– Never file the flutes as this would change the diameter of the drill. If the drill is really out of shape, contact someone with metalworking experience.

HOW TO SHARPEN AWLS

– To sharpen an awl you can use the sharpening stone, or if it is damaged rub it down with a file. Pointed awls can be sharpened on a grinding wheel.

NOTES:

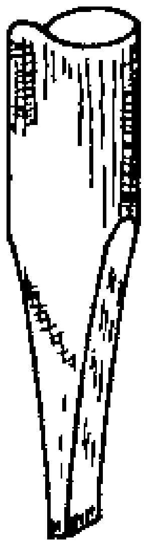


Fig. 1

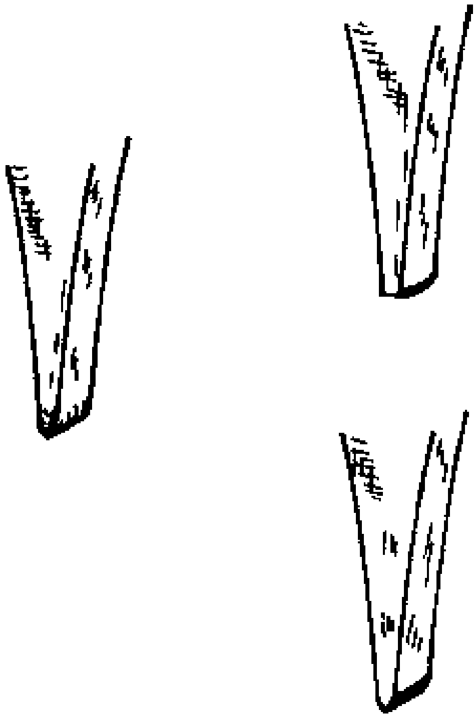


Fig. 2

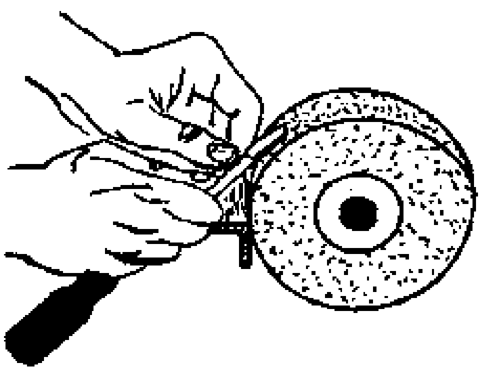


Fig. 3

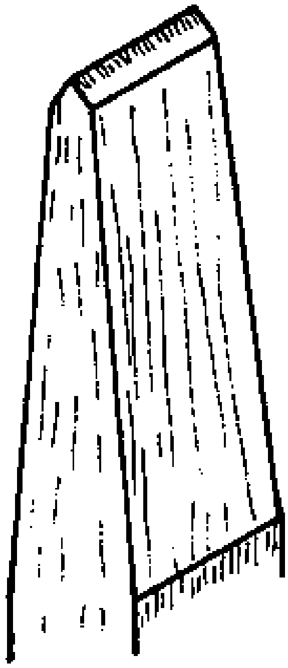


Fig. 4

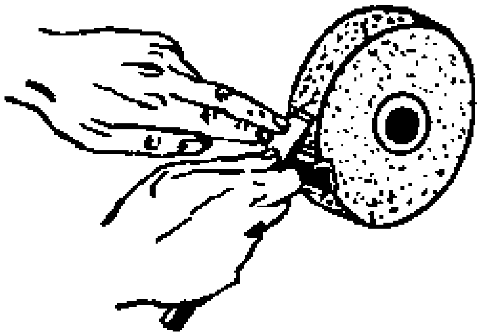


Fig. 5

SHAPING SCREWDRIVERS

A screwdriver should be ground or filed to a very blunt end (Fig. 3). The two flat surfaces should be straight and parallel near the tip. The end should be square to the flat sides, and should be "a little less thick than the width of a screw slot (Fig. 1).

If the end is rounded or sharpened to a knife edge, it will easily slip out of the screw slot and damage the slot (see Screwdrivers, page 77). In Fig. 2 there are some examples of badly shaped screwdriver tips.

SHAPING COLD CHISELS

Cold chisels should be ground or filed with the bevels on the cutting edge making an angle of about 70 degrees to each other (Figs. 4 & 5).

SHAPING BLOCK SCUTCHES

A block scutch should be shaped and filed to an angle of 70 degrees. Unlike the cold chisel, it is filed only from the inside (Fig. 6).

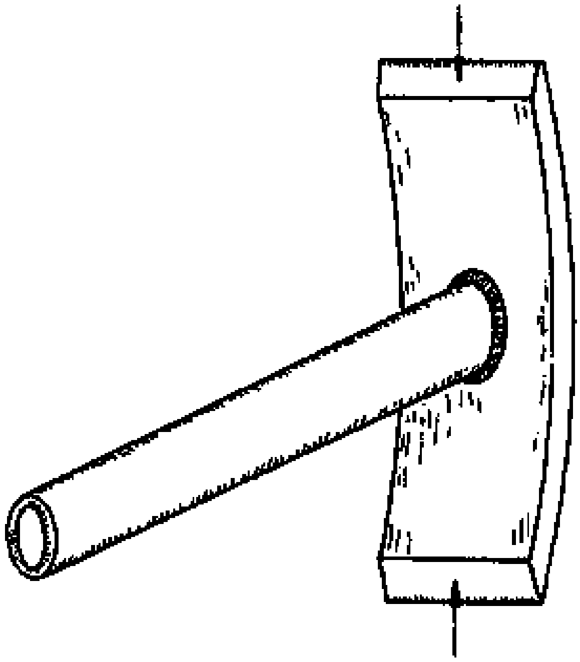


Fig. 6

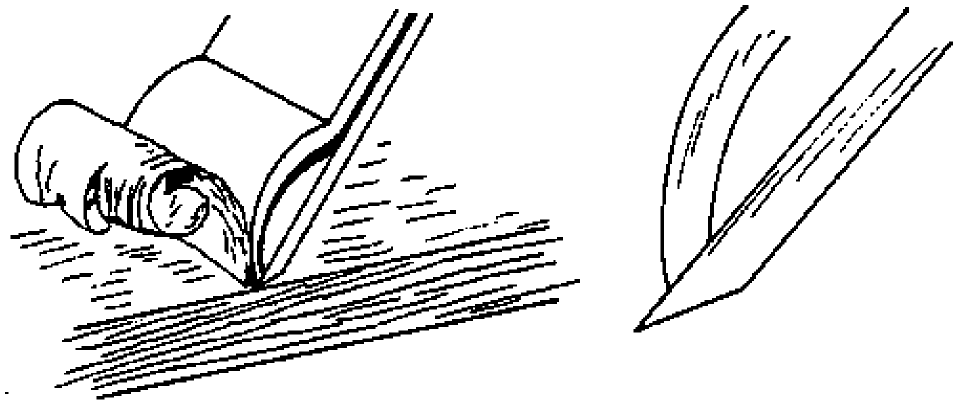


Fig. 1

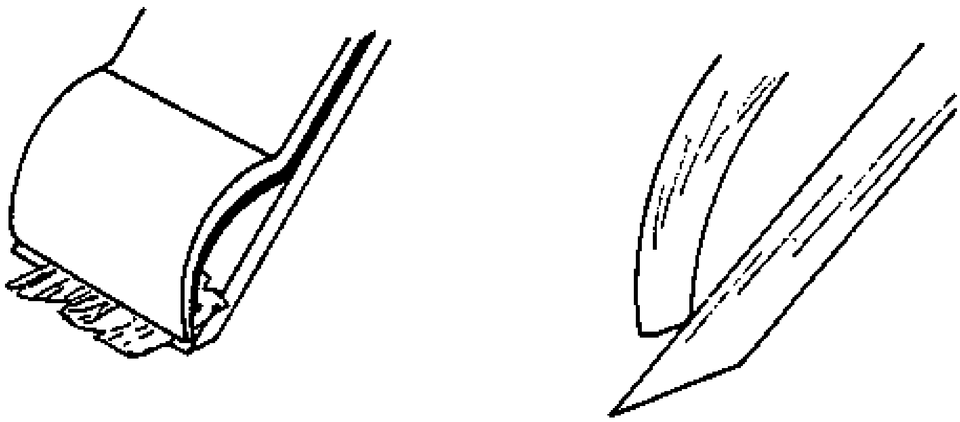


Fig. 2

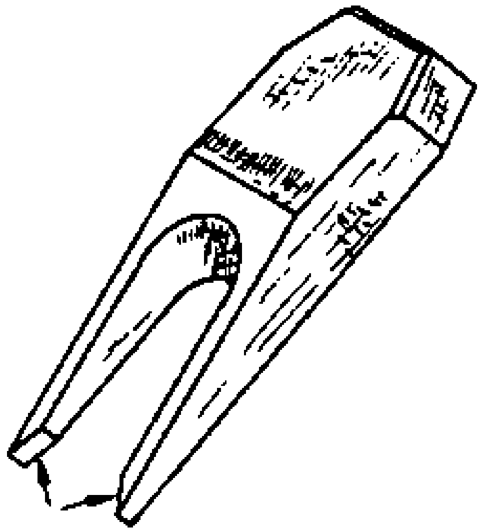


Fig. 3

MAINTAINING WOODEN PLANES

HOW TO REFACE THE SOLE

Whatever the quality of the wood stock, the soles of all wooden planes eventually wear and require refacing.

Refacing can be done on a large sheet of sandpaper, which is fastened to a true flat surface. The cutting iron of the worn plane is pulled inside the mouth, not removed, for it is best to have the stock held in the usual pressure by the wedge.

– Sand the surface down, test it with a straight edge and winding strips and oil the wood lightly.

ABOUT THE BEDDING OF THE CAP IRON

It is essential that the edge of the cap iron should bed perfectly on the face of the cutting iron when they are screwed together (Fig. 1). Even the slightest gap between the two will allow a shaving to enter and block the mouth of the plane (Fig. 2).

Usually this problem is caused by a fault in the cap iron. The cap iron should be rubbed on a sharpening stone or filed to restore the true edge. Keep the cap iron clean and shiny.

FITTING THE WEDGE

After much use, the wedge may no longer fit well into the stock. Heavy use of the hammer when knocking it in may cause the wedge to become misshapen because of the pressure.

When it becomes difficult to remove the wedge in the usual way (by hitting sharply on the striking button), the wedge should be removed, cleaned and filed or sandpapered to the correct fit again.

The ends of the wedge can become worn and cause the plane to stuff because they are too far inside the plane. If this happens, recut the ends of the wedge (Fig. 3).

NOTES:

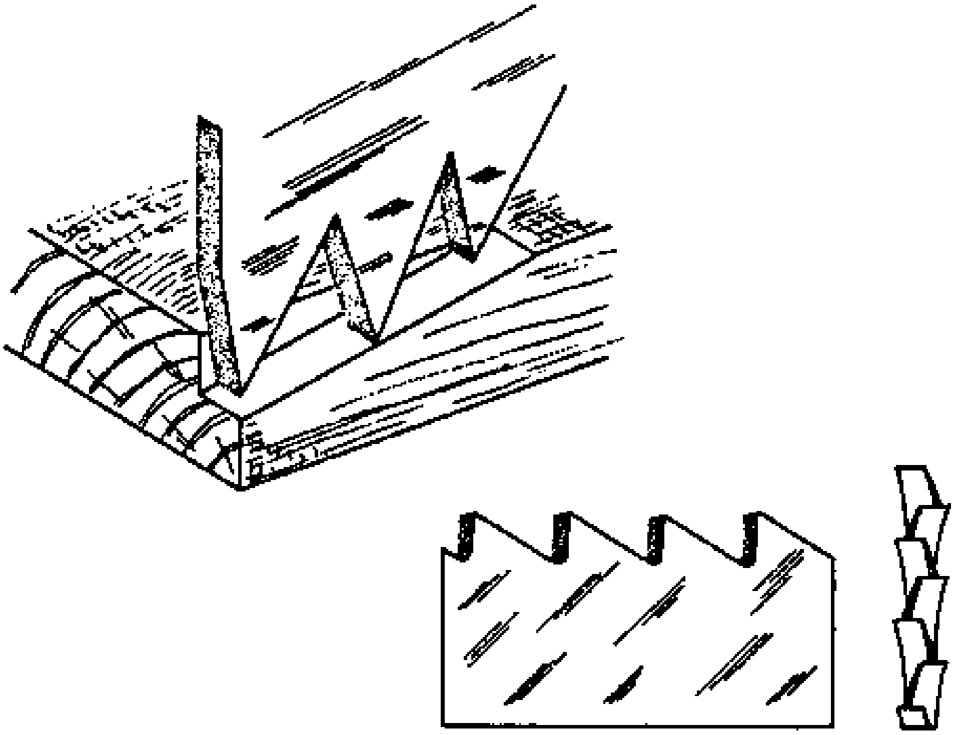


Fig. 1

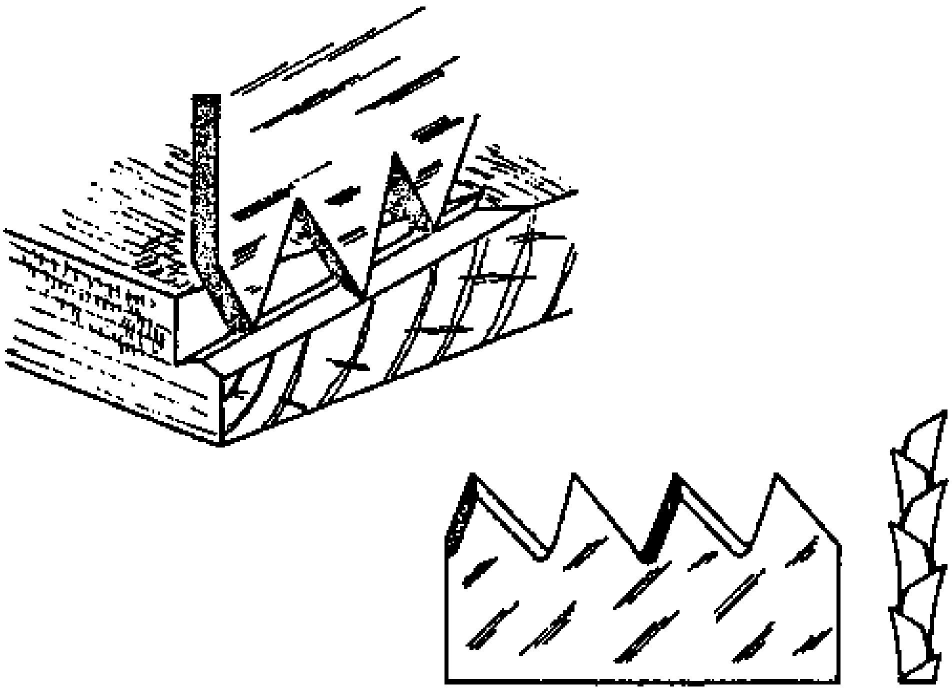


Fig. 2

MAINTENANCE OF SAWS

GENERAL MAINTENANCE

– Frequently give the saw a light coat of oil on the blade, to prevent rust. Keep the saw away from water.

– Keep the saw in the toolbox and be careful not to damage the blade by putting other tools on top of it.

– Keep the workbench uncluttered and be careful where you put the saw down.

– If the blade gets bent or buckled, straighten it at once.

THE ACTION OF THE TEETH

In order to properly maintain saws, it is necessary to understand how the teeth should look and how they work.

The ripsaw tooth resembles the cutting edge of the chisel. Its cutting edge strikes at practically a right angle to the wood fibres and the effect is as if a series of small chisels were set one behind another. Each tooth cuts out the full width of its edge and carries away the shaving (Fig. 1).

The teeth of the crosscut saw and the backsaw have a different shape, size and action from those of the ripsaw.

The form of the teeth is more like a series of knives that cut alternately on the two sides of the kerf (Fig. 2).

In sawing across the grain of the wood, the wood fibres must be cut on each side of the kerf so that a clean cut can be made. The teeth are therefore formed into sharp points on the outer side, so that they cut the fibres accurately.

The cut is started as the teeth make fine cuts, similar to the cuts of a knife, across the wood surface. Then as pressure is applied, the teeth go deeper and deeper, gradually bringing into action the full cutting edge of the teeth.

NOTES:

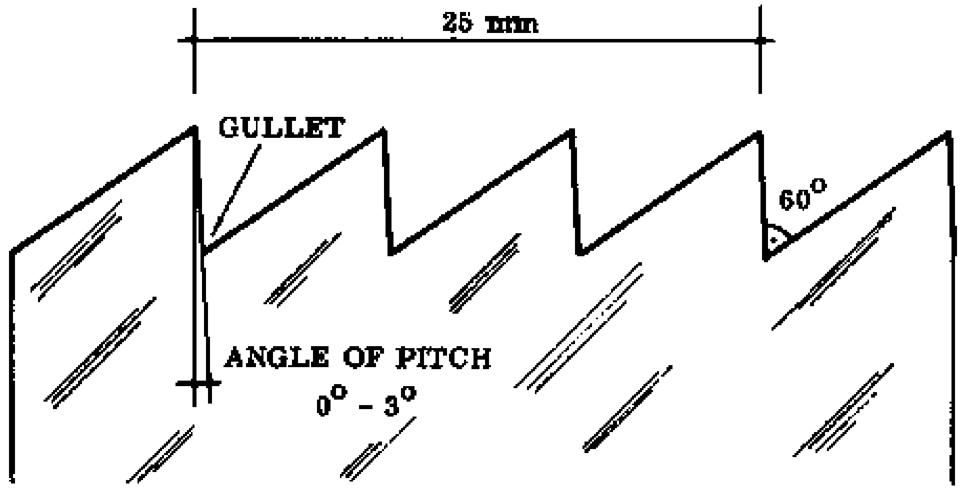


Fig. 1

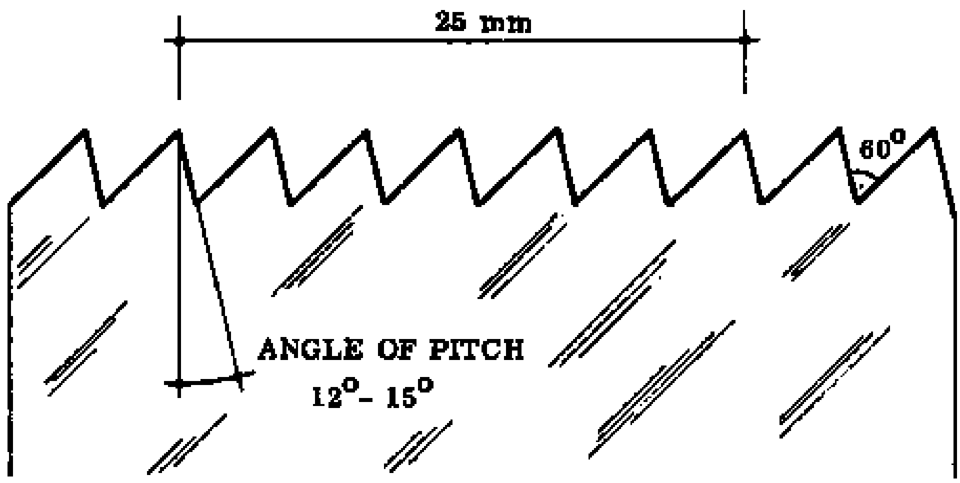


Fig. 2

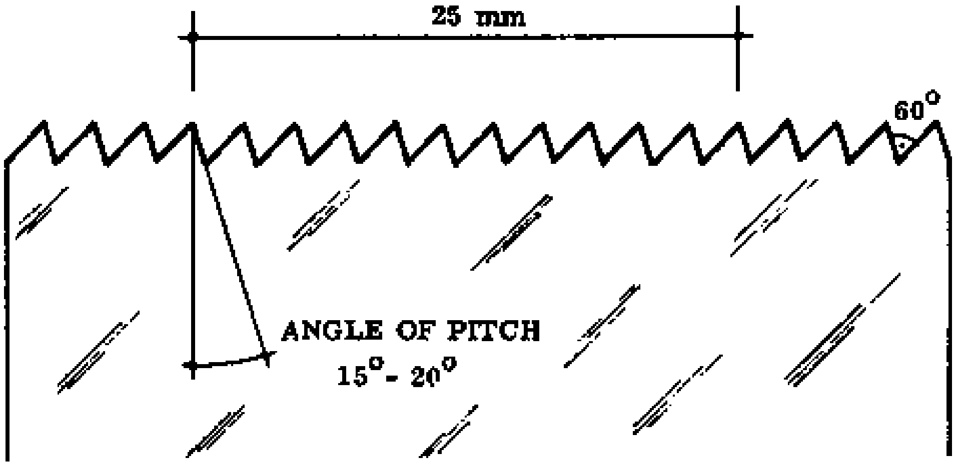


Fig. 3

ANGLE OF PITCH. SHAPE AND NUMBER OF SAW TEETH

The angle of pitch of the saw teeth is important in the maintenance of the saw. This angle is the measure of how far the face of the tooth is leaning from the vertical. The angle of pitch for the different saws is shown on the left page.

The smaller the angle of pitch, the faster the saw will cut and the more often it will need re sharpening. A large angle of pitch means a longer life for the blade, while a small angle means more frequent re sharpening and thus a shorter life.

THE RIPSAW

The blade of the ripsaw has 4 points (teeth) per 25 mm. The teeth of the ripsaw are rather big (Fig. 1).

The angle of pitch of these teeth is very small, from 0 to 3 degrees. This small angle means that the ripsaw will not cut properly across the grain, because the teeth will tend to tear the fibres. This saw is used only for cutting with the grain, where there is not any danger of tearing the fibres.

THE CROSSCUT SAW

The blade of this saw has 6 to 8 points per 25 mm, so' its teeth are smaller than those of the ripsaw. The angle of pitch of the teeth is greater in order to get cleaner cuts; this also makes the work slower. The angle is between 12 and 15 degrees for this kind of saw (Fig. 2).

Do not use this saw for cutting along the grain; it is not designed for that and it will not guide as well as the ripsaw.

THE BACKSAW

The blade of the backsaw has 10 to 15 points per 25 mm, so the teeth are still smaller than those of the crosscut saw. The angle of pitch is between 15 and 20 degrees (Fig. 3).

NOTES:

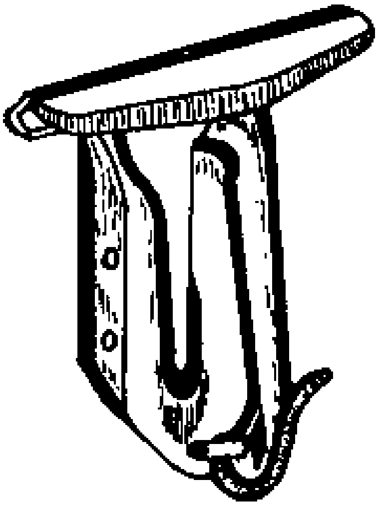


Fig. 1

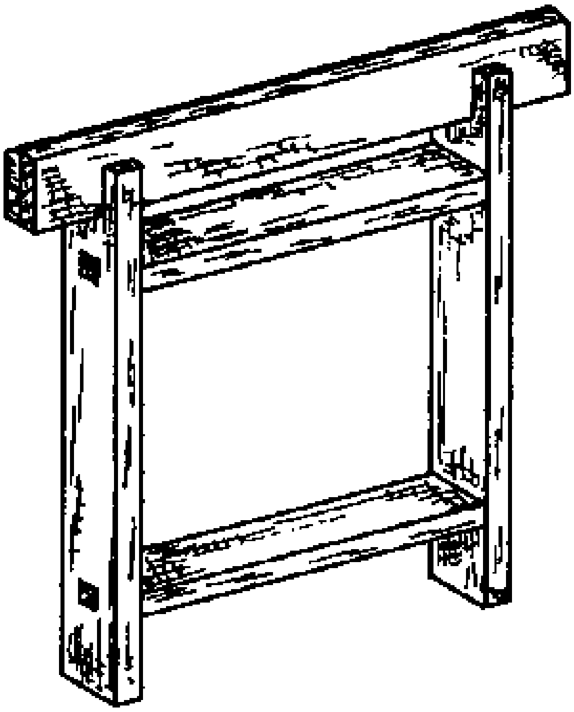


Fig. 2

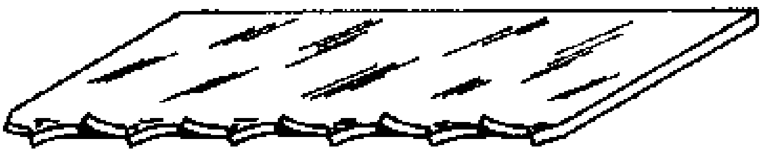


Fig. 3

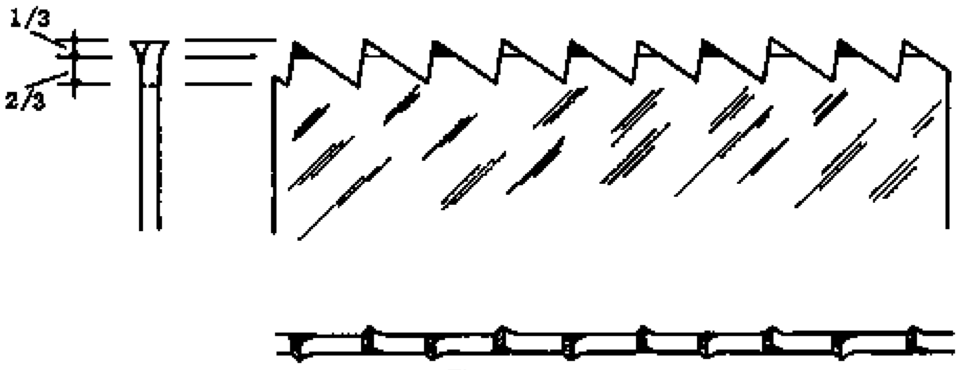


Fig. 4

SETTING HANDSAWS

There are two main operations involved in sharpening a handsaw:

a. Setting
b. Filing

In order to make sure that the saw blade moves freely in the saw cut without any side friction, the saw teeth must be set. This is done by slightly bending the teeth at their tips (Fig. 3) to give more clearance in the kerf (saw cut). A saw should never be given more set than is necessary for the blade to move easily in its kerf. Too much set will cause the blade to wander out of line, too little set can cause the saw blade to buckle.

Only the tips of the teeth are set, never more than about 1/3 rd of the length of the tooth (Fig. 4). If you set the saw deeper than that you will buckle or crack the blade.

A saw need not be set every time it is filed, particularly if only a light filing is required. A saw can sometimes be filed two or three times before it needs to be reset and filed again.

– SAW VICE: During the maintenance of a saw, it must be securely fixed in position. A saw vice is used to hold it; either the wooden type (Fig. 2) called a horse, or the metal type (Fig. 1) which grips the blade more strongly but does not grip the whole length of the blade.

Another type of wooden saw vice can be made by fixing the two wooden jaws to the handle of your toolbox.

NOTES:

Fig. 1

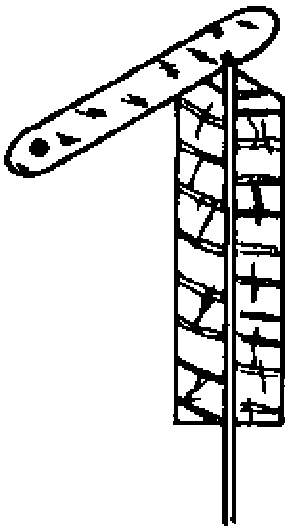


Fig. 2

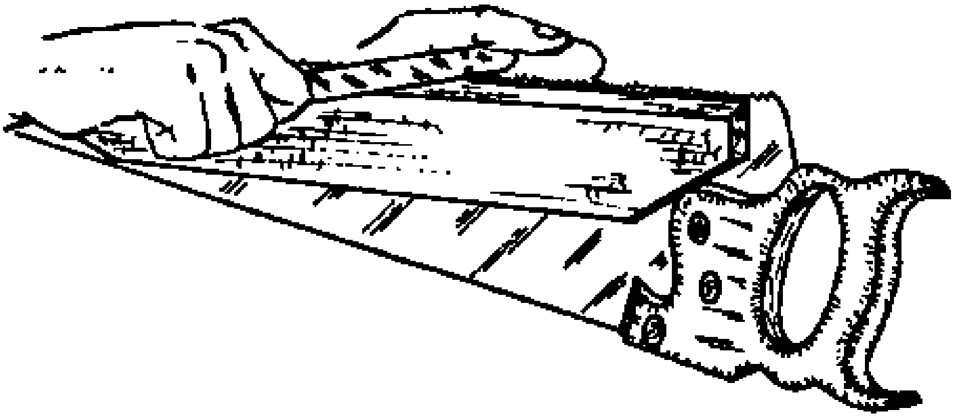


Fig. 3

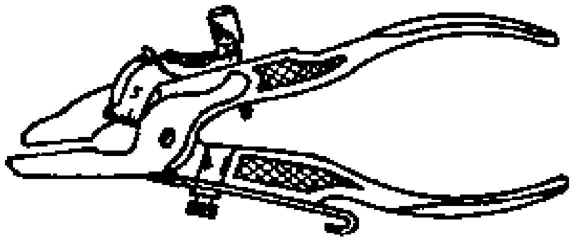


Fig. 4

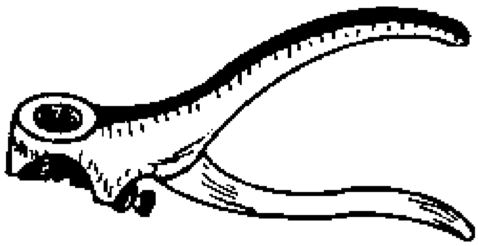


Fig. 5

HOW TO SET A SAW

To do the setting, we use a setting tool. This can be a strip of metal with some cuts in it, the cuts being the thickness of the different saw blades (Fig. 1). Setting has to be done by eye, and practice is needed to get the right bend. The top of the saw vice can be bevelled to act as a guide for the setting tool (Fig. 2).

– Hold the saw firmly in a good position. When setting the first tooth, take care that you bend it to the same side that it was bent before.

– Start at the heel of the blade and bend every second tooth. When you finish one side, turn the blade around and do the other teeth (Fig. 3).

– It is important that the set is exactly the same on each side, otherwise the saw will run (saw out of line).

Instead of the setting tool mentioned above, pincer type sawsets (Figs. 4 & 5) are often used. You simply place the set over the tooth and squeeze the handles. These sawsets are adjustable, so when you use an unfamiliar one, it is best to set a few teeth and examine them before you set the whole saw. If the teeth are set too much or not enough, you can then adjust the sawset accordingly.

SETTING THE RIPSAW

When the saw cuts with the grain, like the ripsaw, the fibres of the wood don't tend to move back into the cut, so the ripsaw doesn't need a big set to have enough clearance between the blade and the kerf.

SETTING CROSSCUT AND BACKSAWS

Crosscut fibres tend to move back into the kerf, so these saws need a bigger set to get enough clearance.

It is important to note that the wider setting of these saws makes them unsuitable for cutting with the grain, because the kerf will be too wide to guide the saw.

NOTES:

Fig. 1

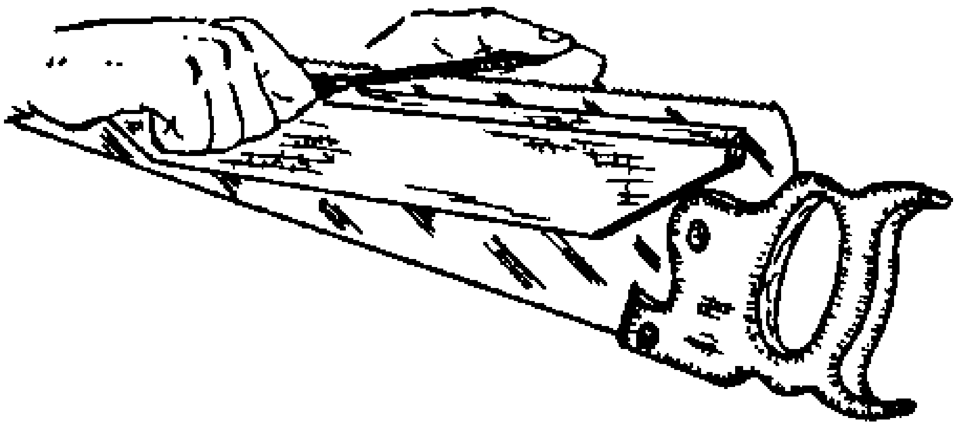


Fig. 2

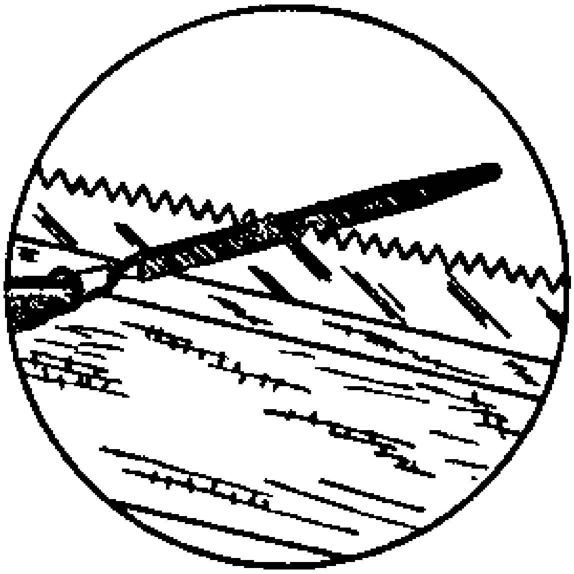


Fig. 3

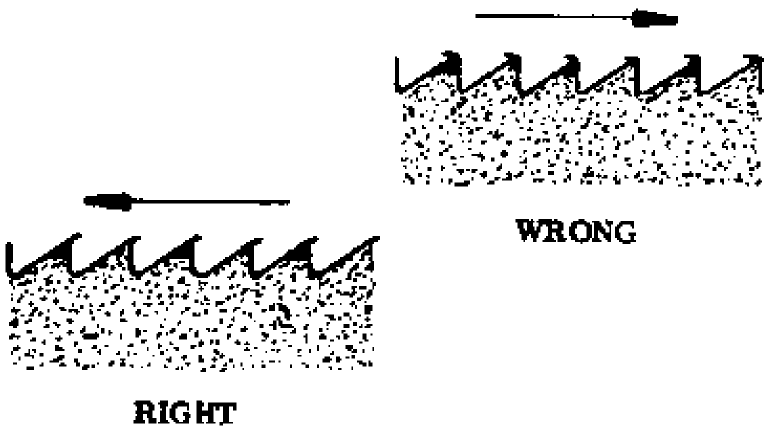


Fig. 4

FILING HANDSAWS

After the saw has been set it can be filed.

Secure the saw in a saw vice, with the teeth sticking out just a little way from the vice jaws. If the teeth stick out too far, the filing will cause a screeching sound.

The top of the saw vice should be at about the level of your armpits, or slightly below (Fig. 1). While filing, you must be able to constantly check the shape of the teeth and this rather high position enables you to see them properly.

In order to avoid eyestrain and ensure a good job of filing, it is essential to have good light. Work in front of an open window if possible, so that the light shines on the saw teeth.

USING THE SAWFILE

Small metalworking files with a triangular cross section are used for filing saws. The following points are important to remember in using the saw file:

– Hold the file handle in your right hand (Fig. 2).

– Hold the tip of the file gently between your thumb and forefinger of the left hand (Fig. 2).

– Exert pressure on the forward stroke only.

– Make long slow cutting strokes, not short fast ones.

– Keep the file level (Fig. 3).

– Use enough pressure to make the file cut, but no more.

During filing, a small burr is formed at the tip of the teeth. This burr can improve the cutting action of the saw when it is filed in the right direction. Therefore the saw must always be filed from toe to heel (Fig. 4).

NOTES:

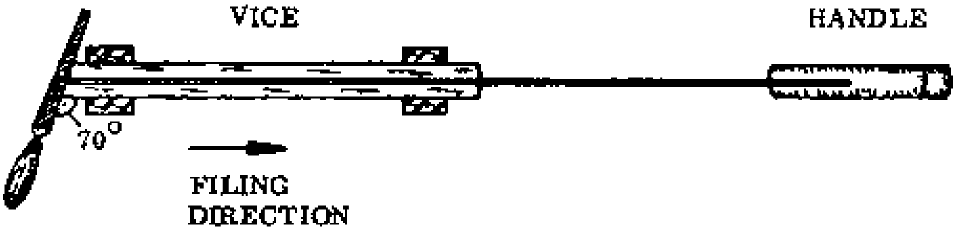


Fig. 1

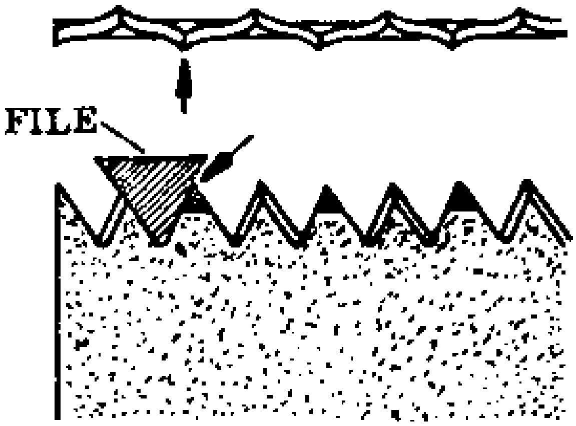


Fig. 2

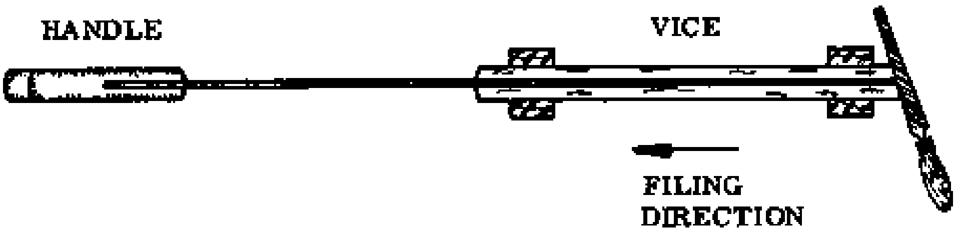


Fig. 3

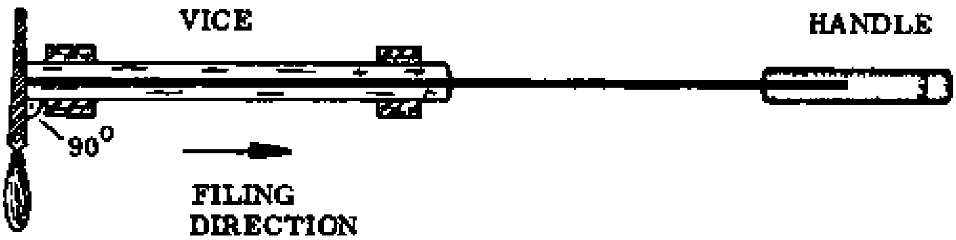


Fig. 4

HOW TO FILE THE CROSSCUT SAW

Study Fig. 1 very carefully to understand the proper starting position for filing this saw. Work according to the following sequence:

1. Place the toe of the saw in the saw vice with the handle to your right.

2. Find the first tooth in the toe that is bent towards you. Place the file in the first gullet (V–notch between the teeth) to the left of that tooth (Fig. 2, arrow).

3. Hold the file across the saw blade at an angle of about 70 degrees, with the point towards the saw handle.

4. If the teeth are of the proper shape (see section on Angles of Pitch) press the file gently into the gullet and let it find its own placement against the two teeth (Fig. 2). Remember to keep the file level.

5. Push the file forward, cutting the front surface of one tooth and the back surface of another.

6. Release the pressure on the file during the backstroke.

7. File every other gullet until you are about halfway through the saw, then make a pencil mark at this point.

8. Shift the blade in the vice until the head end is held more securely and continue filing every other gullet until you reach the handle.

9. When every other gullet has been filed from one side, turn the saw around in the saw vice so the handle is to the left (Fig. 3).

10. Find the first tooth in the toe of the saw that is bent towards you and put your file into the gullet to the right of that tooth.

11. Hold the file at an angle of about 70 degrees across the blade, with the point towards the saw handle.

12. File every other gullet as before, until you reach the saw handle.

– REMEMBER:

– Inspect your work frequently to make sure that you are getting the teeth properly shaped. Remember that the angle of pitch must be correct.

– Throughout the filing, give each tooth the same number of strokes with the file. This helps keep the teeth all the same size and shape.

– If you get one tooth out of shape, don't be too concerned; it can be left as it is.

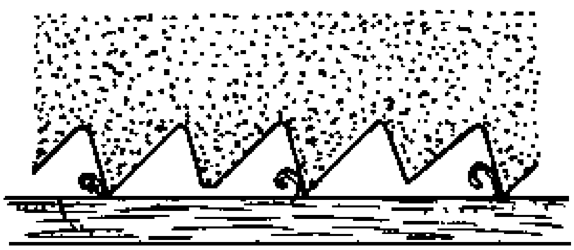


Fig. 1

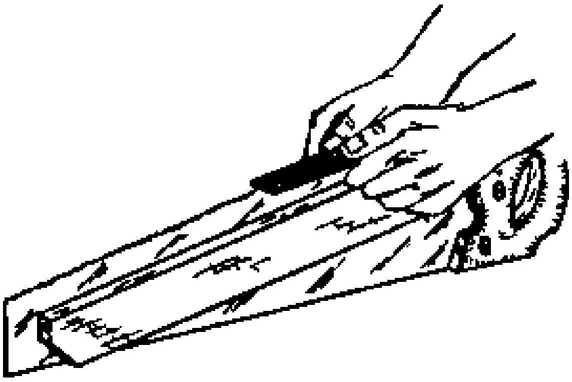


Fig. 2

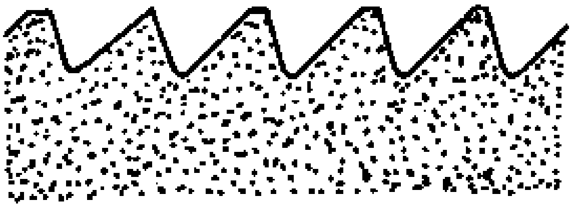


Fig. 3

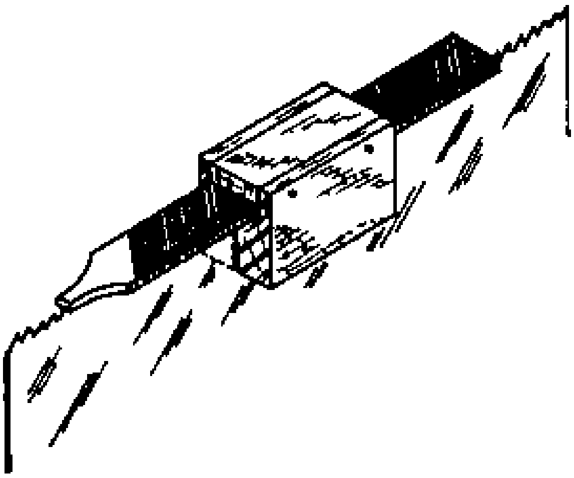


Fig. 4

– Turn the file occasionally, so that it is used evenly.

– If you think you have lost your place or skipped a gullet, look for the last shiny tooth in the light.

HOW TO FILE THE BACKSAW

This saw is filed in the same way as the crosscut saw, except that the angle of pitch is different.

Be careful with the pressure you apply with the file, because the teeth are very small and are easily filed out of shape.

HOW TO FILE THE RIPSAW

The same general procedure is used for filing ripsaws as for crosscut saws. There are two important differences:

1. The angle of pitch is different.

2. The file is held at 90 degrees, not 70 degrees, to the blade (Fig. 4, previous page).

(Some people file the ripsaw from one direction only, filing all the teeth at once instead of filing every other tooth and reversing the saw).

TOPPING A HANDSAW

If you always file the saw correctly, without twisting the file or filing some teeth more than others, the teeth will always have the correct form and equal height.

When you make small mistakes in filing, or use the saw carelessly, the teeth will become out of line, different in height and irregular in shape. The result is that only some of the saw teeth can cut; the others don't touch the wood (Fig. 1). Topping is done to correct this problem.

WELL KEPT AND MAINTAINED SAWS NEVER NEED TOPPING!

HOW TO TOP A SAW

Topping must always be done before you set or file the saw.

– To top a saw, you run a flat metalworking file over the ends of the teeth, moving along the length of the saw. Be very careful to keep the file square to the saw blade and flat.

– One way to do this is to grasp the file in both hands by the edges, thumbs on top and the fingers under, touching the saw blade and guiding the file (Fig. 2, previous page).

– A wooden block may also be used to hold the file in the proper position (Fig. 4, previous page).

– File until there is a small shiny point on each tooth. When you have made two or three light strokes and there are still some teeth that have not been touched (Fig. 3, previous page), don't keep on filing. Too much topping will make it difficult to reshape the teeth.

– Next, file the teeth to the correct form again. This is called reshaping the teeth. When all the teeth have the same height and shape they are ready to be set and filed again after setting, to sharpen them.

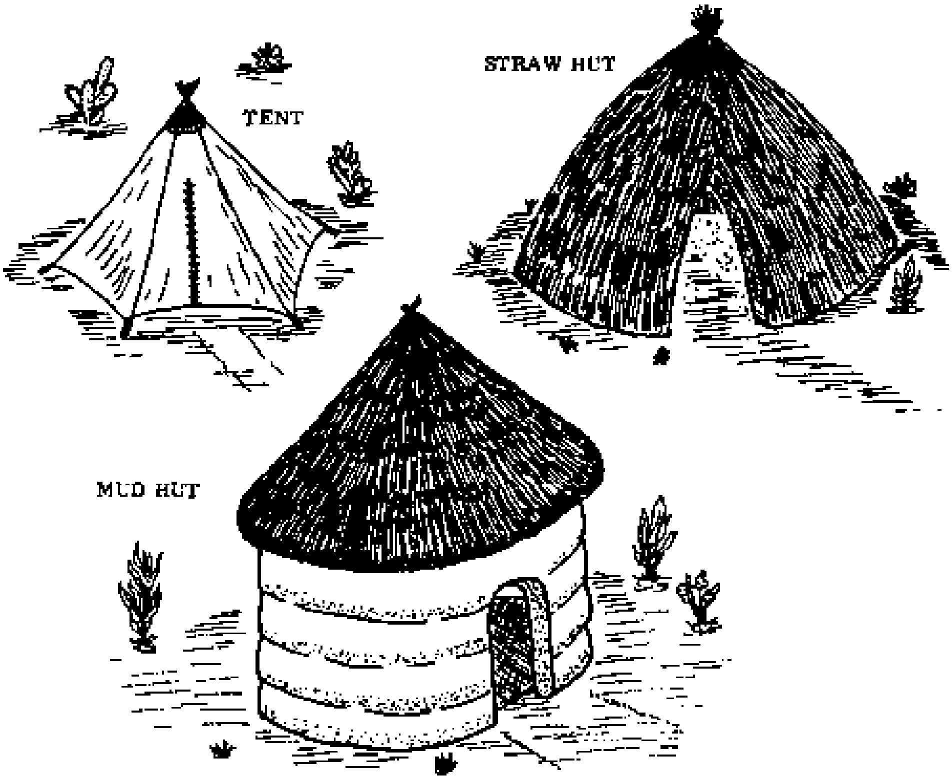
NOTES:

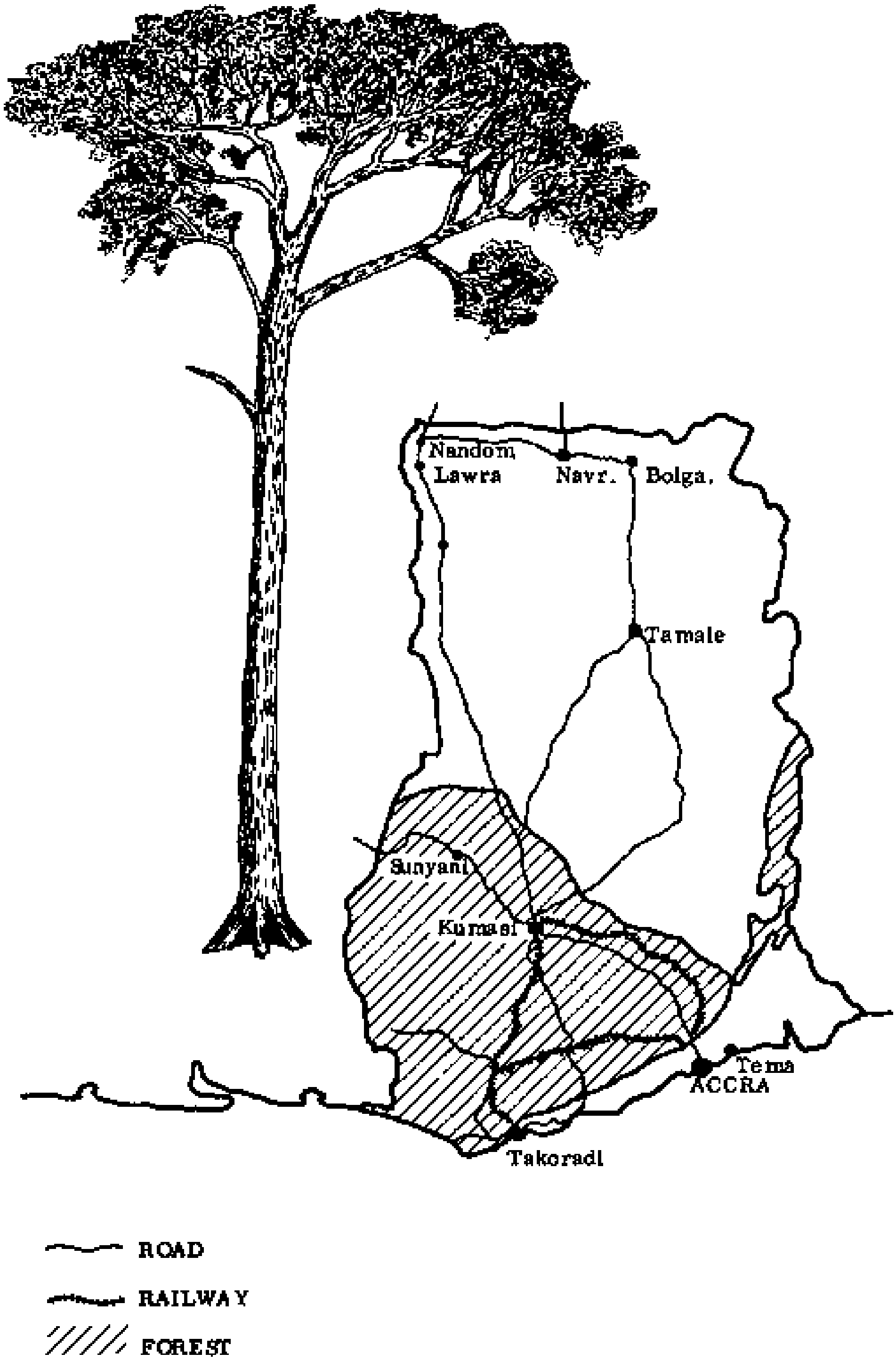
PART 3: RURAL BUILDING MATERIALS

Man learned early to protect himself from the weather as well as from his enemies by making shelters of various kinds.

The type of structure he made depended on the locally available building materials, and on whether the shelter was meant to be permanent or not. Compare the sketches below, for example.

The extreme northwest of Ghana provides the inhabitants with such universally used building materials as sand, mud, stone, laterite, timber, grass and straw. However, the traditional way of building with these materials does not always produce a very permanent structure; with the result that almost every dry season the houses must be thoroughly maintained, repaired and even rebuilt. In order to make more durable structures, the Rural Builder should include in his technical knowledge the uses of local and modern materials, and of binding materials such as lime or cement. Building materials are described in the following chapters.


TENT
STRAW HUT
MUD HUT



ABOUT WOOD IN GENERAL

In Rural Building we work a great deal with wood. Wood has always served man for many different purposes: for tools (handles of hoes, knives and axes), for weapons (bows and arrows), for housing (ladders, doors and windows), furniture and firewood.

For traditional building purposes, nearby trees and bushes are cut and the branches as well as the trunks are used.

In Rural Building, we work with sawn timber. Sawn timber is cut from the trunks of very tall trees. Such trees are not common in the northern parts of Ghana. They are found in the rainforest areas of the south, where they are felled (cut down), sawn into boards and transported to the north and elsewhere.

The most common woods we use in northern Ghana are Wawa and Odum. Others, like Emire or Mahogany, are sometimes used.

There are 85. 000 square kilometres of forest in Ghana, from which comes more than 200 different species of wood. Most of the wood that is cut is not used in Ghana but is sold to other countries to bring in money. It is one of the largest sources of income for Ghana. The principal kinds of wood that Ghana exports are Afromosia, Wawa, Utile, Sapele, Odum and Mahogany.

To make sure that these woods are available in the future, the cutting is controlled by Forestry Acts and efforts are made to reforest the cut areas. These new trees will not be ready to cut for a long time.

The map on the left page shows the areas where the trees are cut, the locations of the roads and railways that bring the wood into the harbours at Takoradi and Tema and the roads by which wood is exported to neighbouring countries. It is transported either as whole logs or as sawn timber and also as timber products made from waste wood or wood chips, like chip board or plywood. The mills that convert logs to sawn timber and timber products are located all over the forest.

THE STRUCTURE AND GROWTH OF THE TREE

A tree has three main sections: the Toots, the trunk and the crown. The crown is made up of the branches, twigs and leaves (Fig. 1, next page).

In order to grow, the tree must have water and minerals from the soil. The water and minerals are taken out of the soil by the roots and brought to the leaves through the outer layers of the sapwood (Fig. 2).

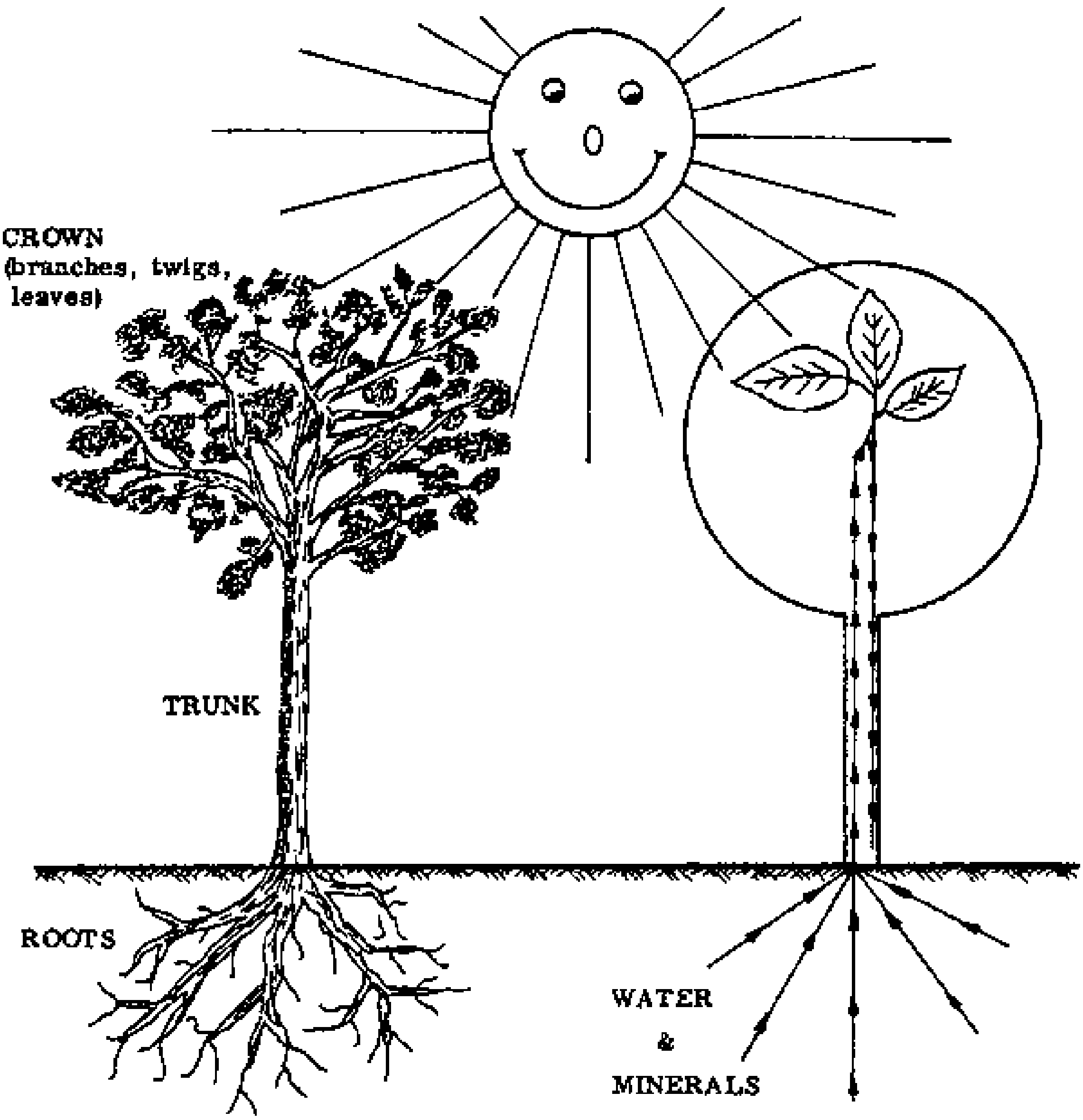


Fig. 1 – Fig. 2

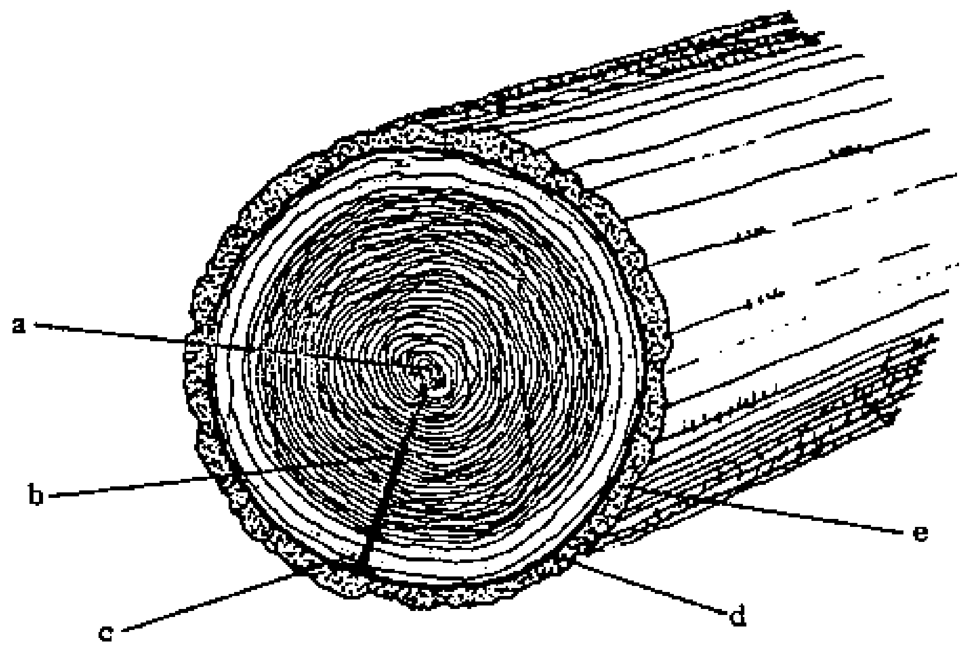


Fig. 3

In the leaves, the sunlight acts on the water, minerals and air to make the materials that the tree uses to build new roots, wood and leaves.

The material made by the leaves is brought down to the roots and growing parts of the tree by the inner layers of the bark. If the bark is damaged by cutting or bush fire, the sap can't move up and down and the tree might die.

HARD AND SOFT WOOD

We talk about two main categories of wood: hardwoods and softwoods. These categories are only trade terms, they do not indicate that the wood itself is either hard or soft. The difference comes from the way of growth of the tree. Almost all the trees that grow in Ghana are hardwoods, but the actual wood itself may be hard or soft in character. For example Wawa, which is classed as a hardwood, is actually very soft in character and easily worked.

THE STRUCTURE OF WOOD

The tree trunk is made up of five layers (Fig. 3).

The pith (a) is the centre or heart of the tree.

The heartwood (b) is the fully developed mature wood which surrounds the pith. It is usually dark in colour and hard. The heartwood does not play an active part in the growth of the tree; it is only for strength, to support the tree.

The sapwood (c) is the layer around the heartwood which is lighter in colour and softer. Sapwood is immature wood, it will harden and darken and become heartwood as the tree grows. A new ring of sapwood is added every year on the outside of the older wood.

Sapwood should not be used for construction purposes, because it is soft and easily attacked by termites. It is always removed when wood is cut for construction purposes.

The cambium (d) is a soft, greenish layer between the sapwood and the bark. It is the "factory" of the tree, making new wood at the inside and new bark at the outer side. The cambium is fed by materials brought from the leaves by the inner layers of the bark.

The bark (e) protects the cambium from cold, fires, insects and animals, and it also transports food material from the leaves to the cambium and to the roots.

The annual rings are the rings you see (Fig. 3) in the heartwood and sapwood.

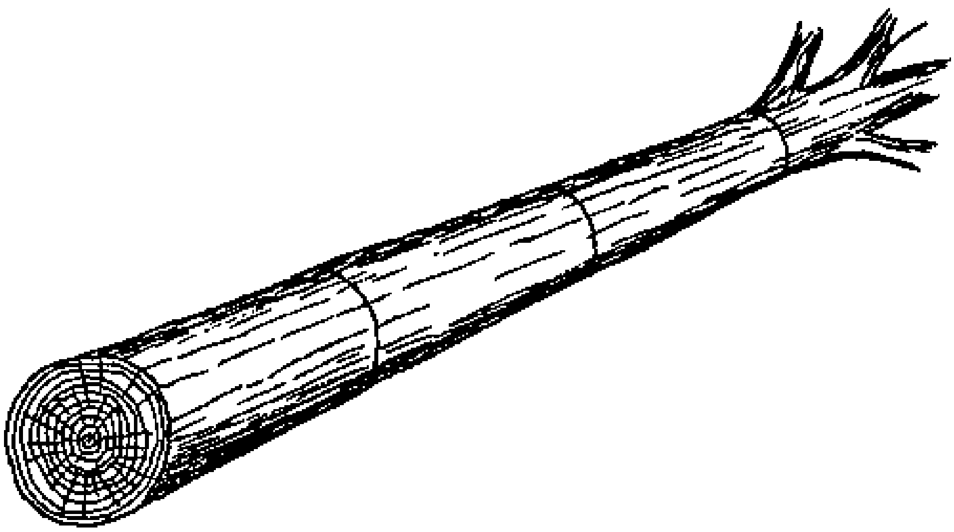


Fig. 1

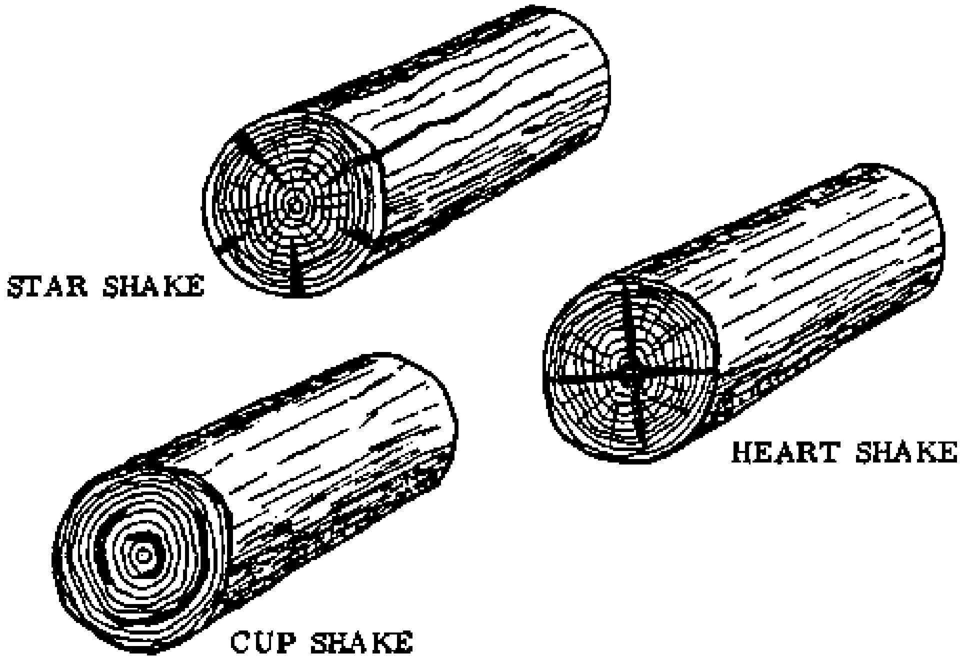


Fig. 2

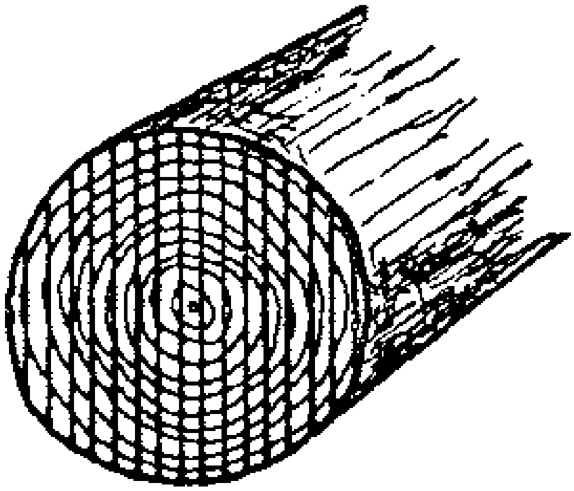


Fig. 3

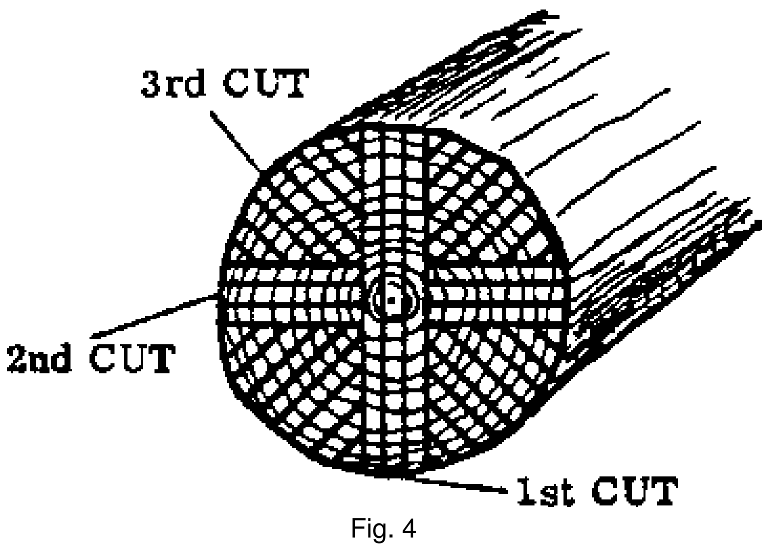


Fig. 4

These are formed by the growth of the tree, by the layer of new wood that is added each year.

The tree grows all year long but in the rainy season, when it gets more water, it grows faster than in the dry season. The new wood formed in the rainy season is lighter in colour than the wood formed in the dry season, so they appear as light and dark rings in the wood. One light ring and one dark ring are formed each year; together they make an annual ring (annual means every year).

Don't forget: HARD WOOD is not the same as HARDWOOD is not the same as HEARTWOOD; they all mean different things.

THE PATH FROM STANDING TREE TO SAWN TIMBER

After the tree is felled, the crown is removed and the bark is taken off so no insects can hide in it. The trunk is cut into logs up to 12 metres long (Fig. 1) for transport and handling purposes. These logs are brought to the sawmill where they are converted to sawn timber. Converting the logs to timber means sawing them into boards, planks etc., which can be used for construction purposes.

If the logs cannot be converted immediately, they are kept in water to prevent the formation of shakes. These are long cracks in the unsawn log (Fig. 2). The most common ones are: cup shakes, which occur when the annual rings fail to grow together and star and heart shakes, which can occur in the growing tree or in the cut log as it dries.

There are different ways of converting logs. The method which is chosen depends on the thickness and species of the tree, and the quality of the wood that is needed.

Plain sawing is the easiest, cheapest and most common way of converting tropical woods. It is also called the "through and through" method.

The log saw starts cutting from one side and continues, cutting off one board after another until the whole log is converted to timber (Fig. 3).

The second method, quarter sawing, requires better equipment and more work than plain sawing. With this method, almost ail of the annual rings will be square to the surface of the board, which we will see later is an advantage over plain sawn boards (Fig. 4).

There are still other methods of conversion, but they are not important for us in this course.

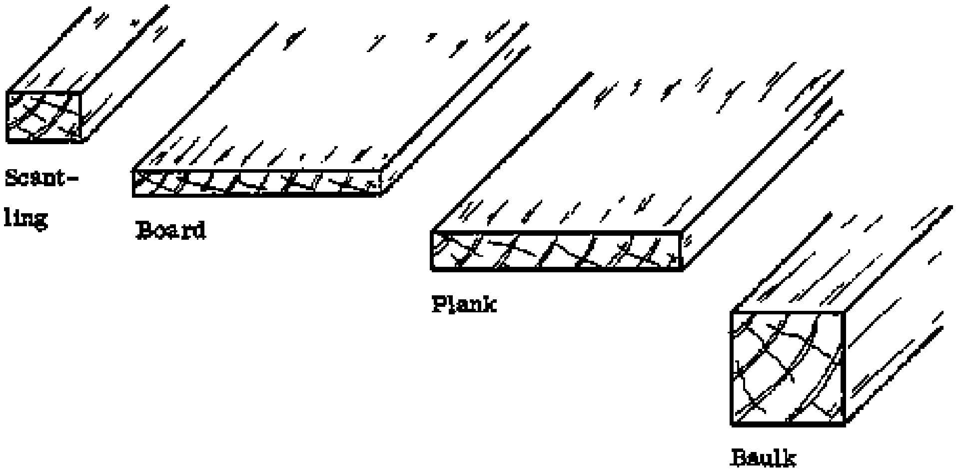
CONVERSION TERMS FOR SOLID TIMBER

– Scantlings are pieces about 75 mm wide by 50 mm thick.

– Boards are pieces more than 150 mm wide and less than 50 mm thick.

– Planks are pieces above 200 mm wide and between 38 and 100 mm thick.

– Baulks are more square shaped pieces, about 100 mm wide and 50 mm or more thick.



HOW TO ORDER TIMBER

Before you place an order for wood, make sure that you list the correct sizes, quantities and kinds of wood.

Boards are sold in different measurements. Very often the sizes are still given in the imperial system, but the metric system is becoming more common everywhere.

The surface of sawn timber is still rough, so you have to allow for planing the boards when you order timber (refer to Rural Building, Basic Knowledge, p. 90).

Example:

		Size		
No.	Kind of wood	Thickness	Width	Length
50	Odum	2,5 cm	30 cm	2,5 m up
40	Wawa	3,8 cm	30 cm	3,0 m up

If a minimum length of sawn timber is required, the word "up" is added. So "3,0 m up" would mean 3,0 m and longer.

THE PROPERTIES OF WOOD

To be able to use timber properly and store it in the correct way we need to have some knowledge about:

- the moisture content of wood, and
- wood shrinkage.

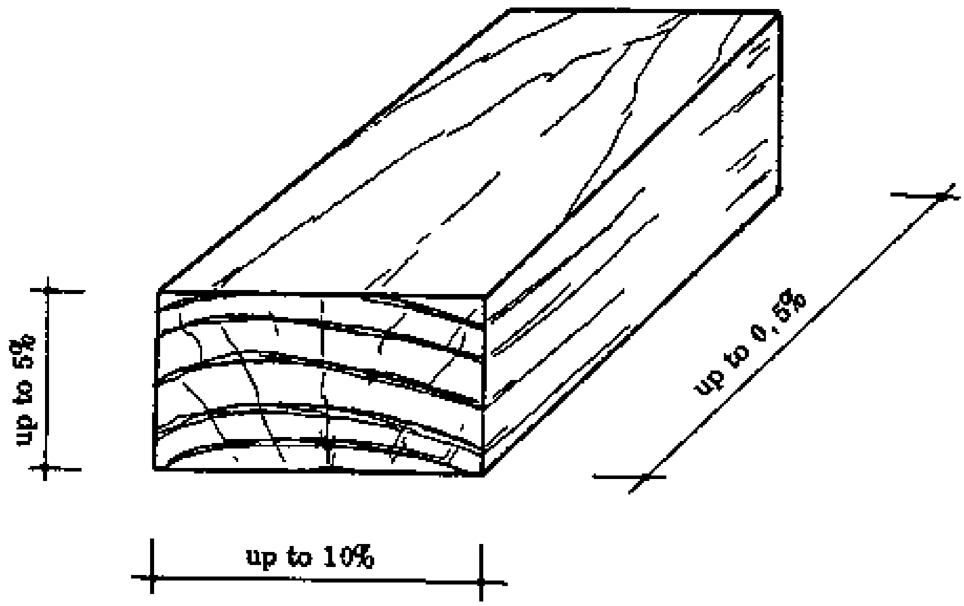
THE MOISTURE CONTENT OF WOOD

When a tree is cut down, the trunk still contains a large amount of water which has been stopped on its path through the trunk and remains trapped there. The weight of the water at this time is between l/3rd to 1/2 the weight of the tree.

Thus the moisture content (amount of water remaining in the wood) is very high when the tree is freshly cut. Some of the water evaporates (dries off) as the logs are brought to the mill and more will evaporate after the logs are sawn into timber. Each time the moisture content changes, the size of the timber also changes.

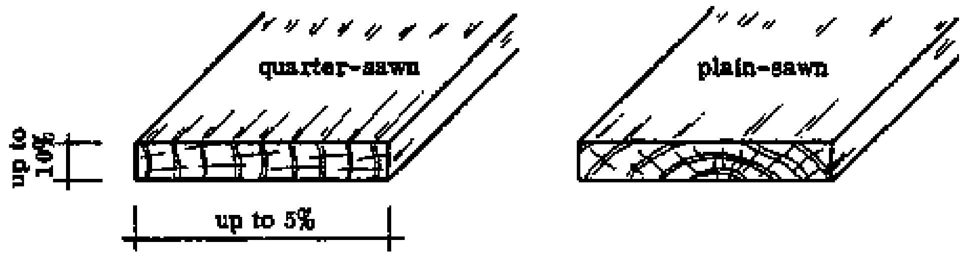
SHRINKAGE

As the wood dries, it becomes smaller in size. This is what we mean by shrinkage. Because of the wood structure, it does not shrink equally in each dimension; shrinkage will be up to 10% along the annual rings, about 5% at right angles to the rings and no more than 0, 5% in the length of the board.



Here we can see the advantage of quarter−sawn timber, in which the annual rings are mostly at right angles to the width of the board. The biggest size change (10%) will be in the thickness of the board, where it usually doesn't matter so much. The shrinkage in the width will however still be up to 5%.

In plain−sawn boards, the rings lie mostly across the width of the board and the board will shrink more and also tend to get out of shape as it dries, because the rings change directions within the board.



Shrinkage in the length of the timber can almost be ignored, and will only matter when you join boards together end to end over longer distances.

You should know that different woods shrink differently, for example Odum will shrink more than Wawa.

The weather has a great effect on the size of wood. In northern Ghana especially, the very great changes in the humidity (the moisture in the air) between the dry and rainy seasons result in a lot of problems for the builder.

The very dry air of the dry season and especially that of the harmattan causes wood to dry out too much and shrink. You will find that the boards easily crack or split when you work on them.

During the rainy season the humidity is very high and this results in a higher wood moisture content. This means that the wood actually expands quite a bit. The wood may feel wet to the touch. You might plane a board straight and true one day, and find the next day that it is bent again.

Keep the effects of the weather in mind when you construct anything out of wood. For instance, you want to build a solid door out of Odum. If you build it in the dry season it should not fit tightly into the door frame, so that it can still open when it swells in the wet season. If you build it in the wet season it should fit well, so that the gap between it and the frame is not too wide when it shrinks in the dry season.

NATURAL SEASONING

The builder should know that he must never use freshly sawn timber. The timber must first be seasoned, which means that it is dried to a certain moisture content which is most suitable for building work, so that it changes its size as little as possible after it is used in a piece of work.

The kind of seasoning we do in Rural Building is "natural seasoning", and it is done by storing the wood for some months.

After seasoning, the moisture content of the wood should be low enough to use it for building work. However, even well seasoned timber will still be affected due to the changes in humidity from the dry to rainy seasons.

Well seasoned timber will still shrink or expand up to 6% in the direction of the annual rings. For example, a board which is sawn in such a way that the annual rings are along the width (see plain sawing) might have a width of 30 cm during the dry season, while in the rainy season it can expand up to 31 1/2 cm wide. This means that whenever possible you should choose your boards in such a way that the changes in size don't cause problems in the finished piece.

NOTES:

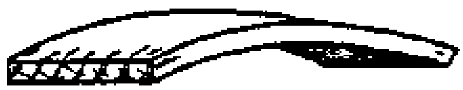
WARPING

Seasoning can cause boards to bend. This happens because the moisture content differs from one part of the board to another, especially if one part gets more sun or rain, when it is stored improperly. The boards should be stored in such a way that air can reach every side of them and all sides are equally dry.

Wood that is not straight grained also tends to warp as it dries.

There are four different kinds of warping: bowing, cupping, springing and twisting. These are illustrated below.

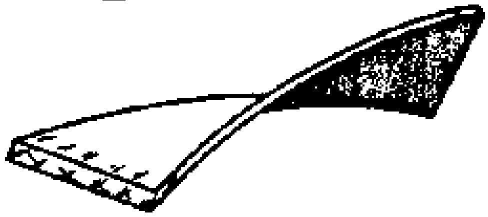
Warping of boards can be partly avoided by proper storage of the wood, which we will discuss in the next section. To prevent warping of finished workpieces such as door and window frames, they should be installed as soon as possible after they are completed.



BOWING

CUPPING

SPRINGING



TWISTING

TIMBER PILING

In previous lessons, we learned about why seasoning is important to reduce shrinkage. Seasoning also helps to prevent decay and attack by insects and fungi. In natural or air seasoning, the wood is kept protected from sun, rain, and insects, but air is permitted to circulate freely around the wood.

The site where we put the wood to season is very important. It must be open and well drained; all weeds and grass should be removed and the base should be covered with gravel, or even better, with concrete, to prevent growth of new weeds under the stack. Ashes can also be spread around to keep away termites.

Strict cleanliness should be observed around the stacks. Sawdust and short pieces of wood left lying around can start rotting and attract termites or fungi, or they might even catch fire during the dry season and destroy the entire stock of wood. Take extra care with Wawa, as it is easily attacked by insects or fungi.

The entire pile should be shaded from the sun, to keep the timber from drying out too rapidly. The stack should be oriented with the length in the east−west direction, to minimize the effects of rain and sun.

LAYOUT OF THE WOOD STACK

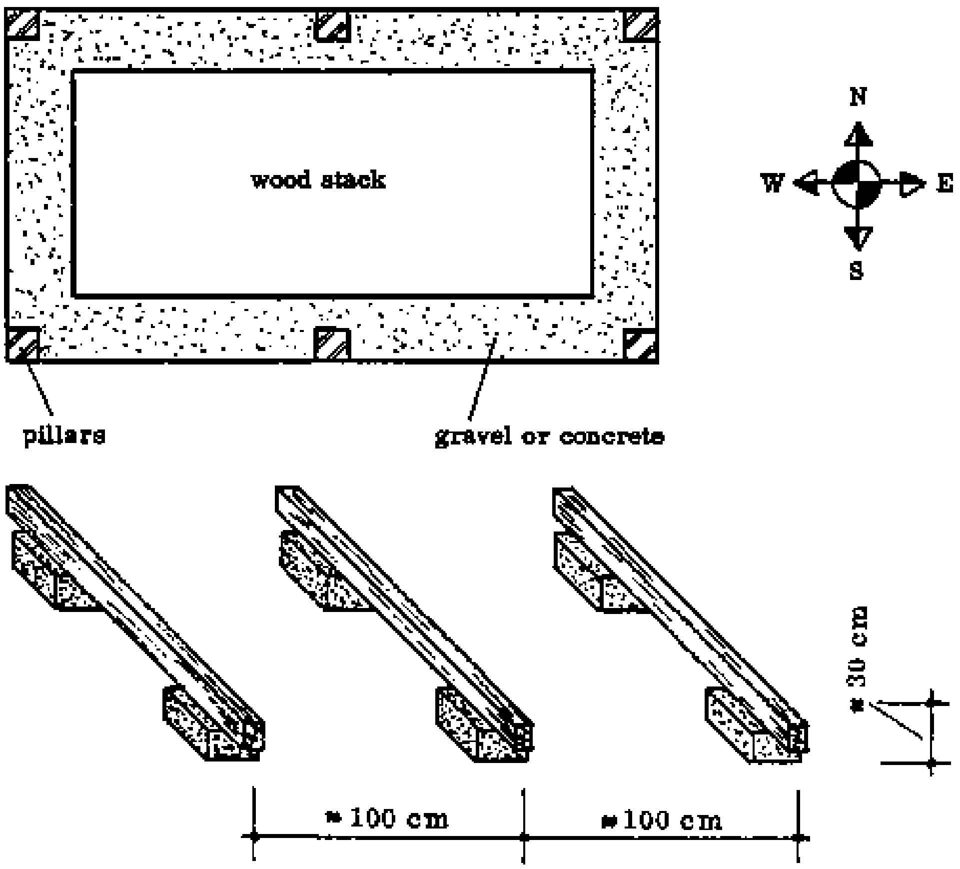


Fig. 1

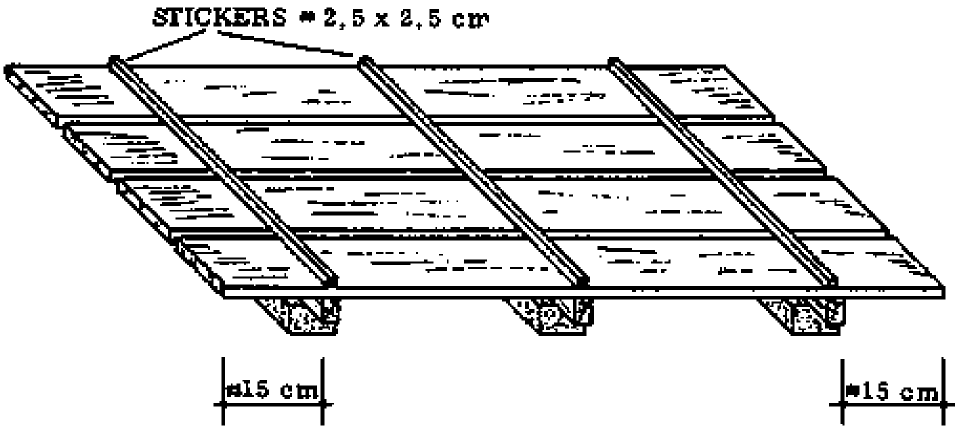


Fig. 2

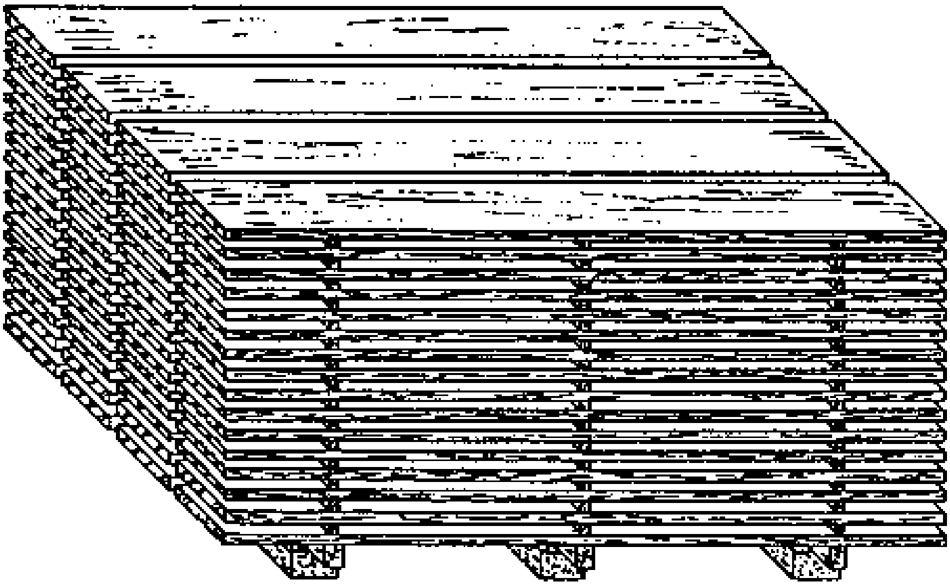


Fig. 3

MAKING THE STACKS

The bases of the stacks are sandcrete blocks (not wood, which might be attacked by termites). On these blocks we set the cross pieces, which are straight baulks without any twisting, because they must carry the whole weight of the stack. The length of the cross pieces will be the width of the stack. They should be perfectly in line on top of the bases (Fig. 1).

The pile should be level from side to side, but may slope a bit lengthwise. Place the cross pieces about 100 cm apart. The end pieces should be about 15 cm from the ends of the boards (Fig. 2).

On top of the cross pieces, put the first layer of boards. Between the layers of boards, put wood strips (stickers) to allow air to flow between the layers (Fig. 2). The stickers should be all exactly above the cross pieces and each other as we build up the stack (Fig. 3). If this is not done correctly the boards may start bending.

The stickers should be square in section so you don't have to take care to put them all flat or all edgeways. They should be around 25 mm thick. All the stickers should have the same thickness, or they may cause the boards to bend or the stack to collapse.

Always stack the wood in such a way that the pieces you will need first are on top.

If you have some wood that you want to reserve for a special purpose, it may be secured by tacking a short stick across the end of the pile.

The stack should always be covered. Make sure that you leave the stack covered and in order after you take out wood.

NOTES:

SPECIFICATIONS OF WOODS WIDELY USED IN NORTHERN GHANA

ODUM

Local trade name: Odum

Standard (international) trade name: Iroko

The tree is up to 60 m high and 7 m in girth (circumference).

Wood characteristics:

The wood is hard and of medium weight.

It is variable in colour, from yellow to dark brown. When freshly felled, it is yellowish green.

The sapwood is paler, about 2,5 to 7,5 cm wide and it is quite distinct from the heartwood.

Durability:

Odum is very resistant to decay when kept dry but it is liable to be attacked by fungi in damp situations. The sapwood is often attacked by pin−hole borers and termites.

Seasoning:

It is easily naturally seasoned.

Working qualities:

It can be worked with moderate ease by most hand tools and it finishes well. Stonelike deposits are sometimes present and these may cause damage to cutting edges. The wood can be nailed, screwed or glued with no problems. When very dry it can be difficult to nail.

Uses:

Odum is probably the most generally useful tropical African hardwood and it is widely used locally for all kinds of construction work and carpentry.

WAWA

Local trade name: Wawa

Standard trade name: Obeche

The tree is up to 55 m high and 5,5 m in girth.

Wood characteristics:

The wood is soft and light in weight. It is nearly white to pale yellow in colour and there is no clear distinction between the sapwood and heartwood. The sapwood is about 7,5 to 10 cm wide.

Durability:

Wawa is not resistant to decay. Seasoned timber is liable to be attacked by powder post beetles and termites.

Seasoning:

Natural seasoning is rapid and satisfactory, with only very little warping and little inclination to split.

Working qualities:

It works easily with all hand tools. To avoid roughening the surface, use very sharp tools. The wood is rather soft and takes nails and screws easily, but it does not hold them well under hard use.

Uses:

It is used for formwork, scaffolding and furniture, where it is not exposed to attack by termites. It can be used only where it will be protected against moisture and rain.

NOTES:

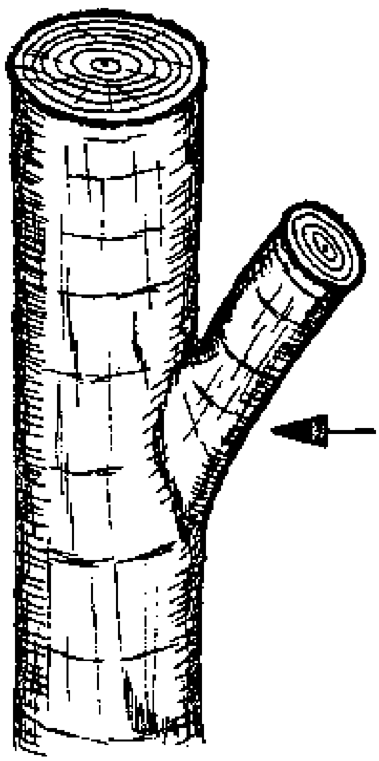


Fig. 1

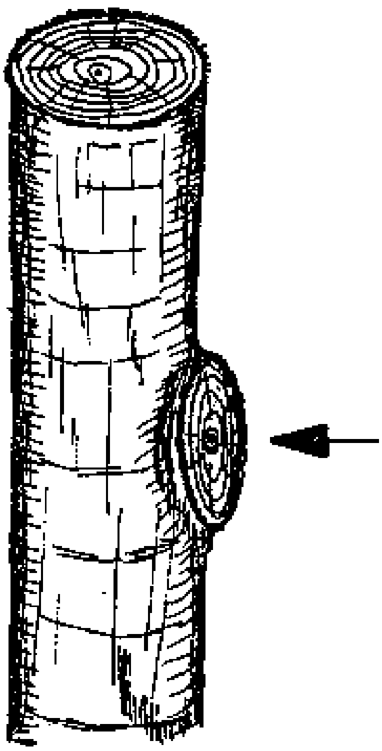


Fig. 2

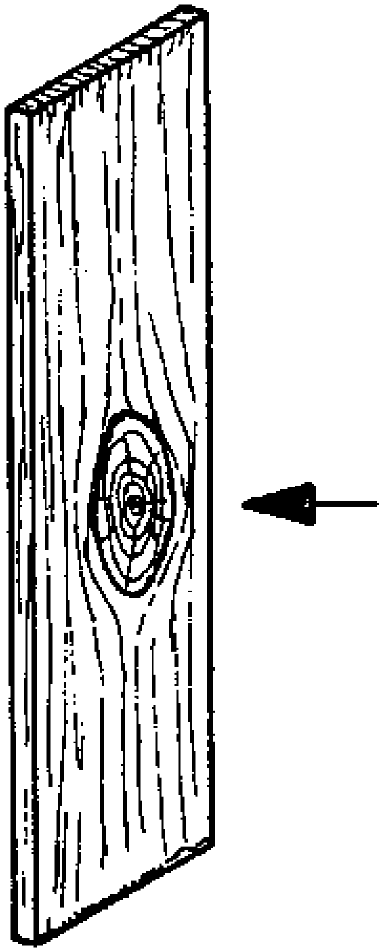


Fig. 3

DEFECTS IN TIMBER

In order to choose the right timber for the work, we need to have some knowledge about defects and diseases in timber. A defect is an irregularity or weakness in the wood which reduces its usefulness and suitability.

The common defects in timber are: knots, twisted grain, checks, wane or waney edge and deadwood.

KNOTS

The place in a tree trunk from which a branch has grown out is called a knot. Each knot marks the junction of a branch with the stem.

There are "live" and "dead" knots.

When a branch is broken off or damaged, a small piece is left attached to the tree. The tree continues to grow around the branch piece, eventually burying it in new wood. These dead pieces of branches are known as dead knots. They have no connection to the living wood, but they occupy a place in the tree, with living wood surrounding them. When the tree is converted to timber, these knots often fall out.

When a tree is felled, all the branches along the stem will be cut off (Figs. 1 & 2). They will leave a knot which is called a live knot (Fig. 3), because it comes from a living branch. Live knots are sound, healthy knots and are always firmly fixed in the wood.

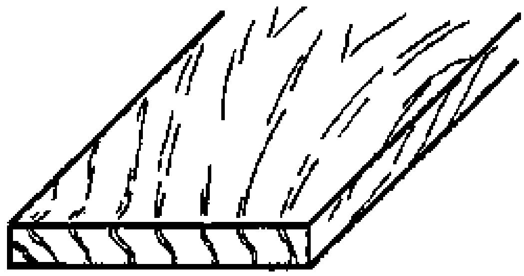
Knots are more or less common in all timber. As long as they remain in place, the presence of a few knots will not harm a piece of timber. However, knots also weaken the wood in some ways and pieces with many knots should not be used for parts which carry heavy loads.

Trees grown in the forest are usually tall, with all the branches at the crown and not along the stem where they could leave knots. Trees which stand apart from other trees tend to have more branches lower on the stem, forming knots which appear when the log is converted.

NOTES:

TWISTED GRAIN

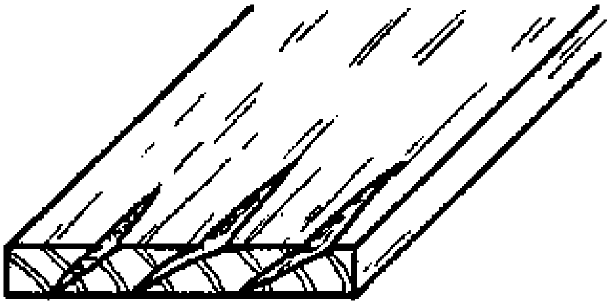
This defect occurs when the tree grows crookedly. The sawn timber tends to twist and it is difficult to plane and chisel because of the changing direction of the grain.



Twisted grain

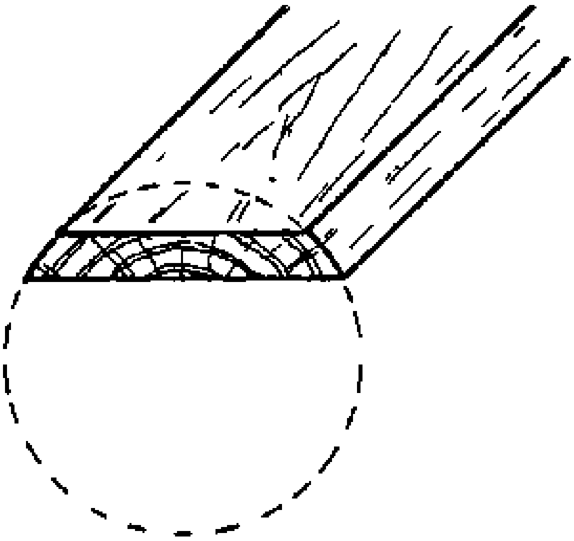
CHECKS

Splits which occur during the seasoning of the wood are known as checks.



WANE OR WANEY EDGE

This defect is due to a lack of wood on the edge of the timber, from whatever cause.



DEADWOOD

Timber made from dead standing trees is called deadwood.

DISEASES IN TIMBER

Diseases in building timber are caused mainly by attacks from fungi and insects

FUNGAL DISEASES

A fungus is a kind of plant which is not able to make its own food from sunlight, air and water, as most plants make theirs. Instead, it must get food by breaking down dead matter such as wood.

The best places for fungi to grow are dark, damp, warm places with little air movement.

There are many kinds of fungal attack on wood. We will only deal with the most common ones, dry rot and blue stain.

Dry rot is the most common fungal disease of building timber. It spreads easily and since the fungus actually feeds on the wood, it can cause a tremendous amount of damage. Dry rot is especially a problem with built–in work such as frames or cupboards where the wood is in direct contact with masonry work, because there; it is often damp.

The appearance of the Infected timber depends on the age and the extent of the disease. In the early stages, it looks as if pieces of thread are hanging from the wood. These quickly develop into a network that looks like a spiderweb, gray in colour. If the wood is very damp, clumps like cotton wool may form and turn into brown or dark red sponge−like growths that often are greater than 30 cm in diameter. On the surface of the sponge−like mass, seeds are produced which spread the disease to the other parts of the building.

Blue stain is one of a few relatively harmless fungi which cause stains on wood. It appears as a light blue discolouration, usually in lighter coloured wood such as Wawa, in sapwood and sometimes in unseasoned timber. The strength of the timber is not affected by this stain.

NOTES:

PREVENTION OF FUNGAL DISEASES

It is always better to prevent disease in healthy wood than to wait until disease is present and then try to treat it. Infection of timber can be prevented by following some simple precautions:

− It is important to ensure that fungi cannot find the conditions that they need to live, namely warmth, dampness and poor air circulation. Therefore the places where timber is built−in should always be dry and well ventilated.

− Use only healthy, well seasoned timber.

− Workpieces should be designed and constructed so that water drains quickly away from the wood.

− Use paint or preservatives on the wood if possible.

− Wood should not be in direct contact with concrete or masonry. If that cannot be avoided, the wood must be treated with a preservative. It is best to also use tarred paper to separate the wood from the concrete or plaster.

− Good storage, especially of unseasoned timber, helps to prevent attack by fungi (see Timber Piling).

REMEDIES FOR FUNGAL ATTACKS

Dry rot is very difficult and expensive to get rid of, once the timber is infected.

− First find if the timber is still strong enough to serve its purpose, if not replace it.

− Cut off and burn the affected parts.

− Find the cause of the dampness and provide good ventilation to the area (for example, repair defective roofs). Repair the damaged areas with new timber.

− Apply preservative to the timber.

− For blue stain, simply remedy the damp conditions, and provide good ventilation to the wood.

NOTES:

INSECT ATTACK

Most damage to wood by insects is caused by members of the beetle family and by termites.

BEETLES

The eggs of the beetles are laid in cracks on the wood surface and they develop into grubs or larvae. The larvae damage the wood by making small holes in the surface and then digging tunnels into it. They chew the wood and convert it into powder. Small piles of wood powder are pushed out of the holes and these are the sign that the wood is infested. When the larvae have eaten their way through the wood, they will leave it and fly away as fully developed beetles.

PREVENTION OF BEETLE ATTACK

It is quite difficult to prevent attack by beetles, especially in Wawa wood, since most beetles can fly. Some simple precautions can help.

- Paint, varnish, wax or wood preservative should be applied on all surfaces. The smell often keeps insects away. Chemicals are available which protect the wood; you should always follow the manufacturer's directions in using these.

- Beetles usually attack the sapwood first, because it is softer than the heartwood. This is why the sapwood should always be cut off.

- If whole logs, poles or sticks are to be stored, remove the bark first. Insects quickly multiply in wood from which the bark is not removed.

REMEDY FOR BEETLE ATTACK

When you suspect an attack, immediately inspect the wood for beetles. Check whether the wood is still strong enough to serve its function. There are chemicals available to kill the insects. Use them carefully and follow the manufacturer's instructions, as most of them are poisonous.

TERMITES

The greatest damage to wood here in Ghana is done by termites. They build their tunnels from the soil into the timber, leaving the surface of the timber untouched, which makes it very difficult to detect an attack in the early stages.

PREVENTION OF TERMITE ATTACK

The best way to prevent termites from attacking wood is to make sure that they cannot reach the wood.

- The wood should never be in contact with the soil, it should always rest on concrete etc.

- All sapwood should be cut off, because that will be attacked first.

- Protect the wood with wood preservatives.

- Do not use Wawa for construction wood, because it is very likely to be attacked.

- When wood must be in contact with the ground, for example with fence posts, it can be partly protected by scorching it over a fire, or by adding ashes around it when you set it in the hole. Termites do not like scorched wood or ashes.

– When wood is stored for seasoning etc., the ground under the stack should be covered with ashes.

REMEDIES FOR TERMITE ATTACK

– Destroy the path of the termites from the soil to the wood.

– Check if the wood is still strong enough for its function.

– Apply a wood preservative or a chemical to kill the termites.

PRESERVATION AND PROTECTION OF TIMBER AND MASONRY

It is important for the Rural Builder to protect timber and masonry in some way, to make them last longer. There are two basic types of protection we use:

- timber preservatives
- protective finishes

Timber preservatives are used only for wood, and they penetrate into the wood. The deeper they penetrate the wood, the better they work.

Protective finishes are used for both timber and masonry. They work by covering the surface with a protective "skin". Protective finishes are discussed on pages 200 and 201.

NOTES:

TIMBER PRESERVATIVES

Wood used in construction is often destroyed by fungal diseases or insects, especially termites. It is very important for a builder to find ways to protect wood from these dangers.

Some methods of protection have already been discussed in the sections on fungal and insect attack. There we mentioned the uses of wood preservatives. Wood is food for fungi and insects. This food can be poisoned for them by wood preservatives. The wood absorbs these preservatives easily and the fungi and insects that try to eat the treated wood will die.

There are two classes of preservatives: waterborne preservatives and oil preservatives. The type we choose will be determined by the intended use of the wood and by what further surface treatment (painting, etc.) will be done.

– WATERBORNE PRESERVATIVES: These are usually available as powders which are dissolved in water and applied to the wood. Since water is the base the preservative can also be washed out again by water. This can happen if rain should reach the wood. For this reason use waterborne preservatives only under dry conditions and not for outside work where the rain can wash them out.

Kinds of waterborne preservatives:

– Aldrex 40 (mix 1 part of Aldrex 40 with 40 parts of water; use 1½ Ideal milk tins of the powder in a No. 28 bucket of water, which will give the correct proportions)

– Any other chemical preservative which is mixed with water.

– OIL PRESERVATIVES: These have an oil base. They not only kill insects and fungi, but also keep water from penetrating the wood. They do not wash out with water, so they are useful for outside work.

The most common oil preservatives are:

- solignum
- creosote
- used engine oil
- Aldrex 40 mixed with engine oil or kerosene; 1 part Aldrex to 40 parts oil or kerosene.

– NOTE: While it is possible to apply an oil preservative over wood that has already been treated with a waterborne type, paint or waterborne preservatives cannot be applied over oil preservatives because they cannot penetrate.

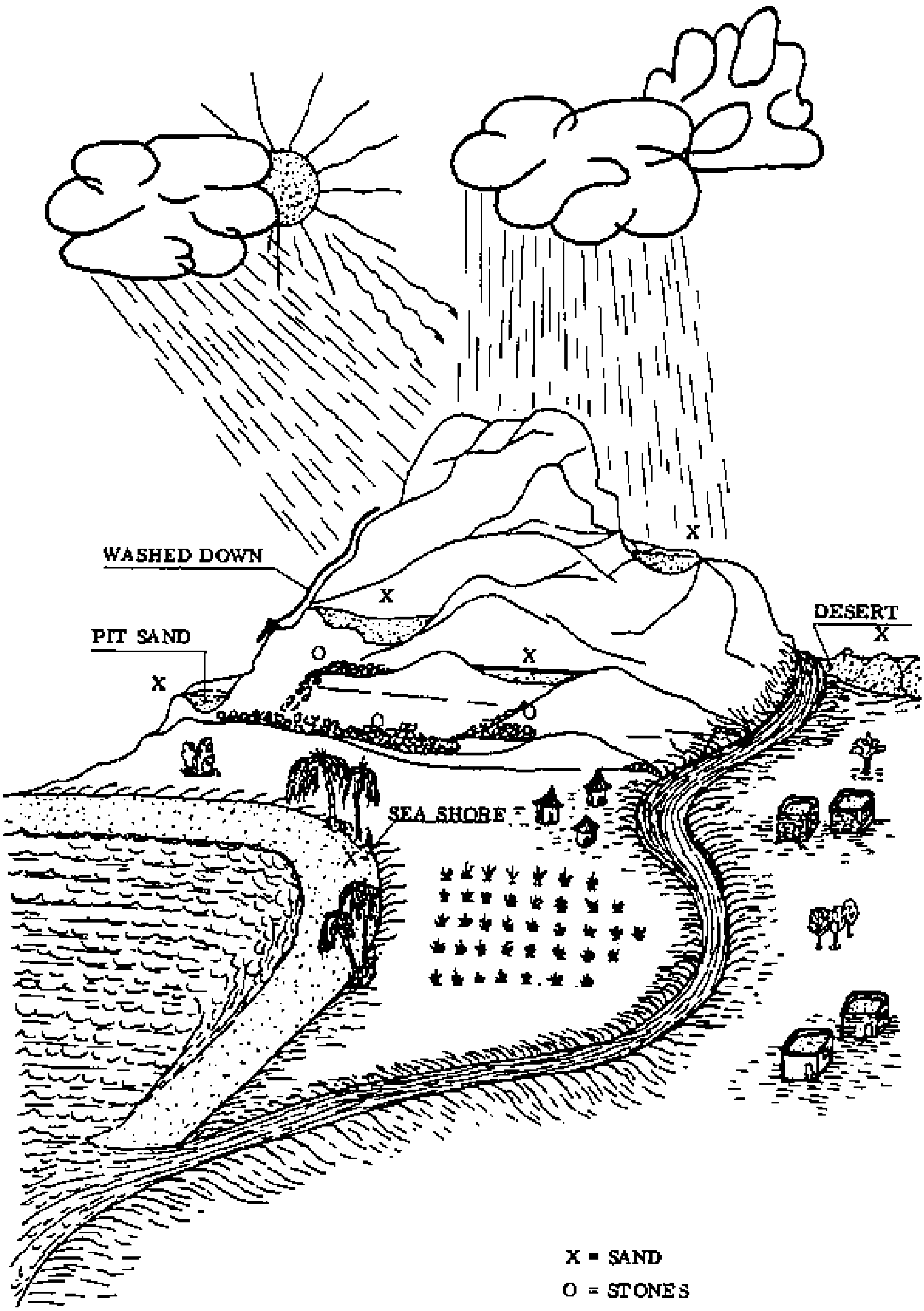


Fig. 1

AGGREGATES

"Aggregate" is the term used for the mixture of different sized stones that form the body of mortars and concrete. Ideally the stone should be graded so that the smaller sizes of stone fit exactly into the spaces between the larger ones and no gaps or holes are left in the mass of mortar or concrete.

SAND

Sand is a mass of finely crushed rock. It is either crushed naturally as seen on the sea shore, in river beds, or in deserts (Fig. 1); or it is artificially produced in crusher plants near rock quarries (where rock is dug out of the earth).

Sand is classified according to the shape of its particles (which differs depending on where the sand came from originally). It is also graded according to the size of its grains (the individual particles of sand).

GRAVEL

"Gravel" is the term commonly used for the larger sized stones of the aggregate. Originally, gravel meant an "all−in−one" aggregate, a mixture of sand and stones of all sizes which can sometimes be found all together in a natural deposit. The individual particles are rounded by the natural action of water and weather.

BROKEN STONES

These are the largest stones of the aggregate, they make up the bulk of concrete. They are found either in natural deposits or scattered on the ground surface; or they are artificially produced in crusher plants. The Rural Builder often must break up large stones with hammers, to make them a convenient size (see Tools, page 14).

> − NOTE: These aggregates are the most common ones used for building in the Northern and Upper Regions of Ghana. Of course there are many other types of aggregates (chips, pebbles, rubble etc.), but as far as the Rural Builder is concerned they are of little importance.

NOTES:

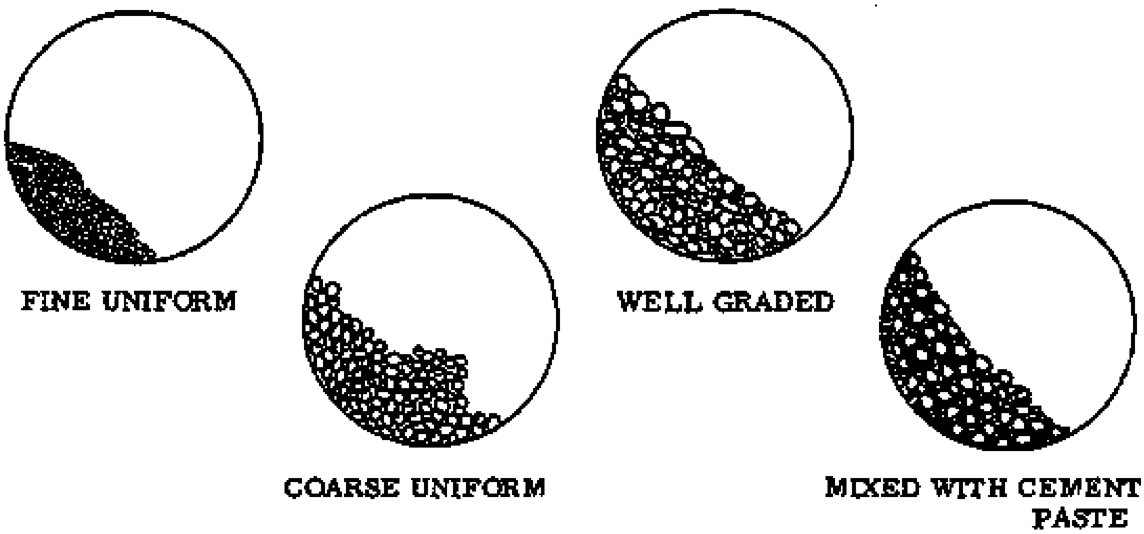
QUALITY AND PROPERTIES OF AGGREGATES

Good mortar and concrete can never be made with poor materials. The cement, sand and stones must all be good quality and the correct types. Sand and stone (the fine and coarse aggregate) together make up more than four−fifths of the concrete mass, so there can be no doubt about their importance. It is not safe to take for granted that every load of sand or gravel brought to the site will be up to standard. Remember that aggregates are either dug from a pit or river bed or they are quarried, and although they may look the same there is a possibility of variation in the quality of different loads.

Particle sizes, the shape and texture of the particles and their surface areas are all important factors in the strength and durability of the concrete or mortar.

− GRADING: A graded aggregate is one that is made up of stones or particles of different sizes, ranging from large to very small. It sometimes happens that a load of sand will have too many coarse particles to make a good mortar, while another load will have too many fine particles. Depending on the job to be done, you might have to mix the two sands together in different proportions to get a suitable aggregate. If the sand contains too many bigger particles it may be necessary to sift these out before using the sand to make mortar, but it could work well for concrete.

The idea is to come up with a "well graded" aggregate; which means that the smaller grains will fit in between the larger ones, leaving only small spaces to be filled with the cement paste. The result will be a good workable mix of adequate strength, using a minimum amount of cement (see sketches below).



– CLASSIFICATION OF AGGREGATES; For making concrete and mortar, the Rural Builder has two types of aggregate: the fine one which is sand; and the coarse one which is broken stones. Both aggregates are classified according to their grain size and are each divided into two main groups:

Fine sand – from 0–1 mm		Fine broken stones – from 5–25 mm
Coarse sand – from 1–5 mm		Coarse broken stones – from 25–50 mm

Another classification is made according to the shape and texture of the single particles. Some sands and stones have particles which are rounded, with relatively smooth surfaces. This sort of aggregate is found mainly in river beds, along the shores of lakes and coasts, and in deserts. This weather– and water–worn sand is called "river sand" or, because of its properties and workability, "soft sand" (Fig. 1).

The other type of sand has a fairly rough surface and it is found mainly in deposits close to hills and mountains. Artificially made sand made from crushed rock also comes under this classification. It is known as "pit sand" or else "sharp sand" (Fig. 2).

Whether the sand is soft river sand, or sharp pit sand; it will have various grain sizes and is classified as fine or coarse, as in the table above.

– NOTE: In the Northern and Upper Regions of Ghana, most sand is dug from river beds. This does not necessarily mean that the sand will be "soft". Often it is a sharp sand or between soft and sharp, because the particles don't get exposed long enough to weather and water to become rounded and smooth.

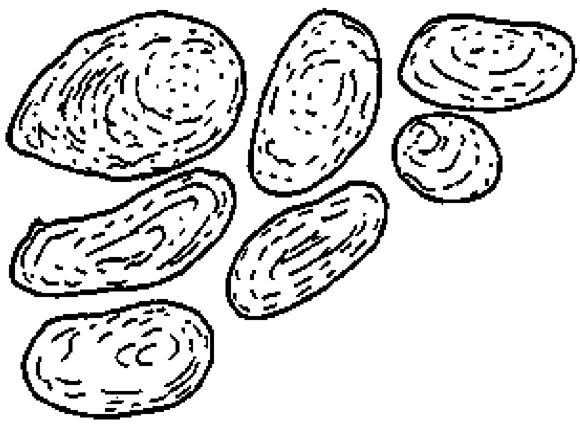


Fig. 1: SOFT SAND (SMOOTH SURFACE)

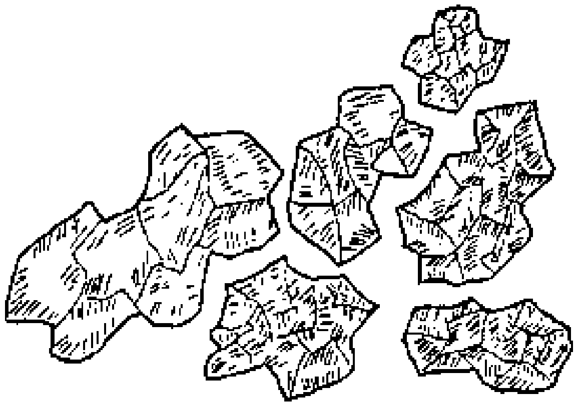
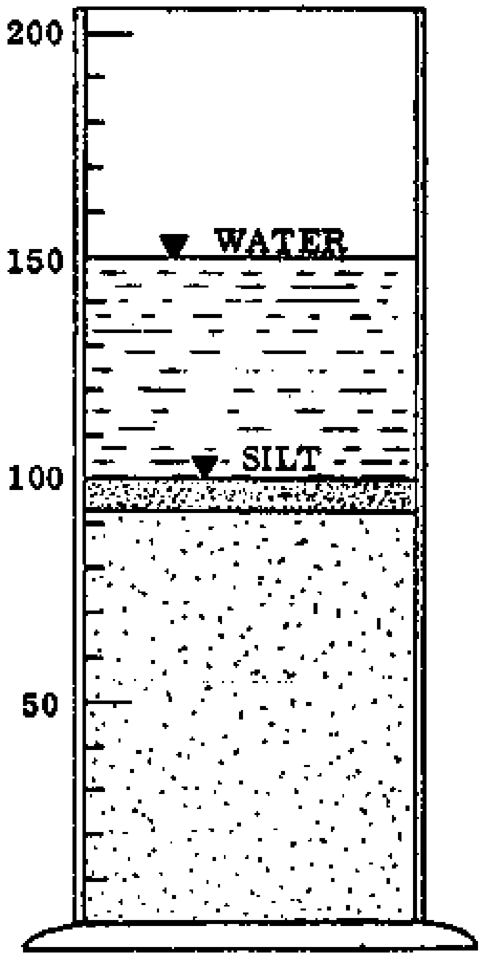


Fig. 2: SHARP SAND (ROUGH SURFACE)

An important factor in the quality of an aggregate is its cleanliness. Clay, mud, or fine dust (known as silt) in the aggregate will weaken the concrete or mortar; while any rotting vegetable matter (organic impurities) like leaves, grass or roots may interfere with the setting of the cement.

– THE HAND TEST FOR SAND: As a first test for cleanliness, simply pick up a little sand and rub it between your hands. If your palms stay clean, the sand is clean enough. If not, the sand may contain too much silt.

– THE SILT TEST FOR SAND: You yourself can carry out a simple test to get an idea of the amount of silt in a natural sand (though not in an artificially crushed rock sand).



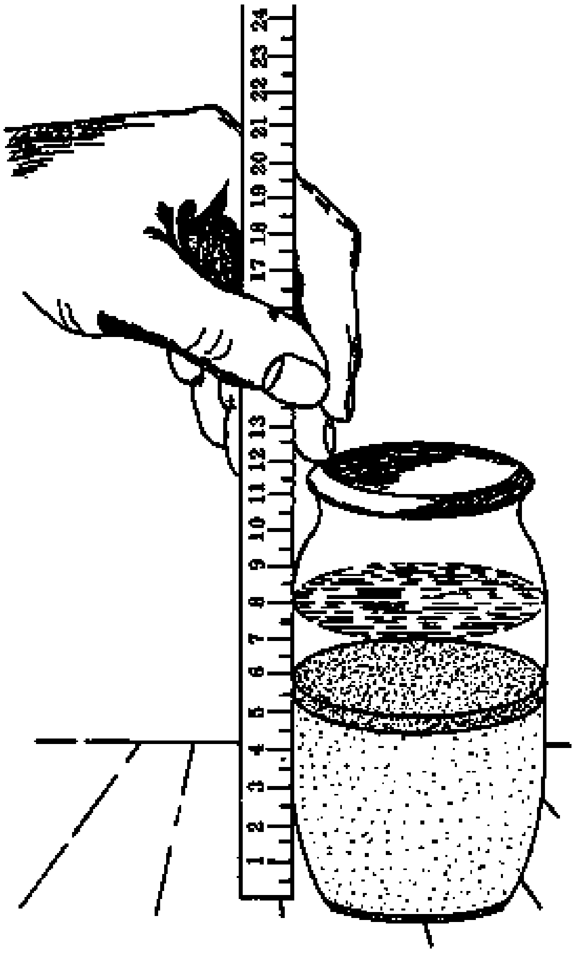
To test accurately you should have a measuring cylinder which is marked in millilitres, shown as "ml", usually up to 200 ml.

First make a salt–water solution by putting one teaspoon of salt into 1/2 litre of water. Fill this solution into the measuring cylinder, up to the 50 ml mark.

Next pour in the sand until the level of the sand is up to the 100 ml mark. Add more salt water until the water reaches the 150 ml mark, cover the cylinder and shake it well.

Stand the cylinder on a level surface and tap it gently until the top surface of the sand is level. Leave it to settle for 3 hours and then measure the height of the silt layer on top of the sand. This should be no more than about 6 ml, or about 6% of the total amount of sand.

– NOTE: If the sand contains more than 6% silt, you would have to use more cement and the concrete would shrink more during the hardening process, causing cracks in the product.



If you have no measuring cylinder, you can use a 0,5 kg jam jar, though this may not be quite accurate.

Put about 5 cm of sand loosely into the jar and pour some salt water on it until you have about 2, 5 cm. of water above the sand. Now cover and shake the jar, and leave it to stand for about 3 hours.

You will see a layer of silt on top of the sand. Measure the depth of the layer, and measure the sand below it. There should be no more than about 3 mm of silt, or about 6% of the amount of sand.

– ORGANIC IMPURITIES: The Rural Builder can carry out a test for organic impurities using a glass jar. Put sand into the jar and fill up the rest of the jar with water. Cover and shake the jar and leave it standing for some minutes. If the water above the sand is brown or very dirty, the sand contains organic impurities and cannot be used.

Better sand can be found by simply removing the top layer of sand, about 5 cm deep, before taking sand from a dry river bed. This top layer consists mainly of excessive silt as well as organic impurities such as vegetable matter and cow dung. None of this is wanted, because it would cause problems with the concrete or mortar.

– REMEMBER: Wherever your sand comes from, it must be clean and suitably graded. If you use dirty sand, you may find that it mixes very nicely, but you will find problems before the job is finished. The impurities in it may affect the rate of setting and hardening of the concrete or mortar, and decrease the final strength of the work. The fine appearance of the just finished work may be spoiled by cracking and flaking as it dries.

BINDING MATERIALS

LIME

Litre is a very fine white powder, used in mixes for mortar, plaster and render. It is made from limestone or chalk which is burnt in a kiln and becomes quicklime.

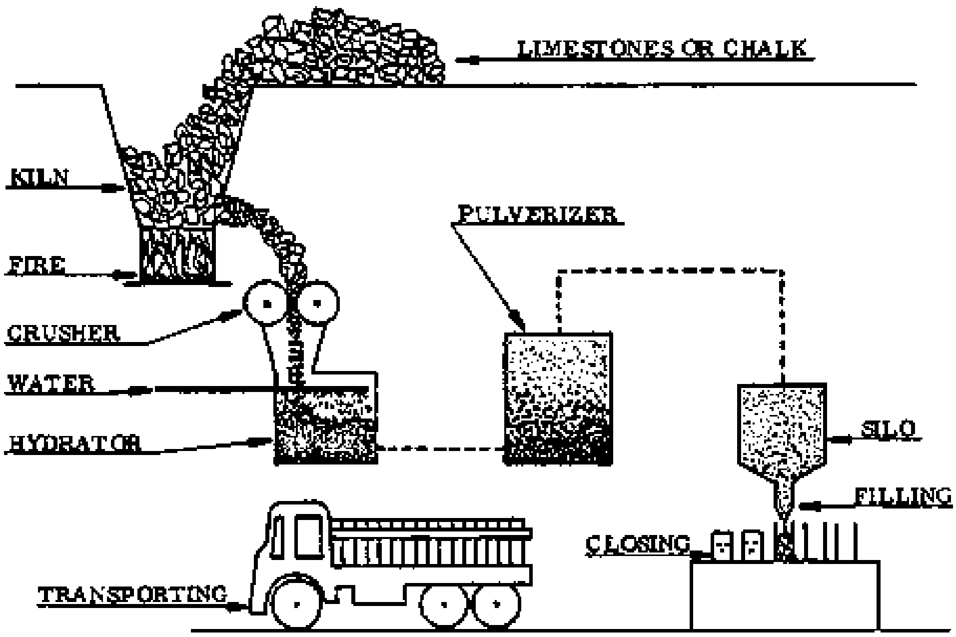
The quicklime is usually passed through a machine called a hydrator, where it combines with water and becomes hydrated lime. This is dried, crushed to a fine powder, then bagged and sold. Below is a diagram of the whole process.

Sometimes the lime is sold as quicklime, and the builder adds the water to it himself. This process is called "slaking" the lime or "running it to putty", and it is not described here.

Slaked lime and hydrated lime are chemically the same, but slaked lime has more water in it.

Hydraulic lime is made from limestone or chalk containing clay. It hardens when combined with water; and it also hardens well in damp places or even under water. It is stronger than other limes, although weaker than Portland cement.

Non−hydraulic lime comes from the purest limestones and chalks. It hardens by drying out and then slowly combining with the carbon dioxide in the air.



PORTLAND CEMENT

Portland cement is a fine grey powder. Among the various kinds of cements, it is the most commonly used as binding material. It is made of a mixture of chalk or limestone and clay.

The following description of the manufacturing process is illustrated below.

The limestone or chalk and the clay, in appropriate proportions, are fed into a "wet grinding mill" and reduced to a creamy substance known as slurry. The slurry is pumped to a large cylindrical "kiln" which is about 90 m long and 3 m in diameter. The slurry enters the kiln at its upper end while pulverized (crushed) coal, gas or other fuel is blown in at the other end. The temperature inside the kiln at the lower end is very intense, approximately 1500 degrees C; gradually decreasing towards the top end. So the slurry as it moves down the kiln is first dried, then heated, and then finally burnt. It leaves the kiln in the form of very hard "clinkers" shaped like small balls and of a dark brown to black in color. The clinkers are ground up to an extremely fine grey powder, which is the cement. The cement is packed in paper bags of 50 kg capacity.

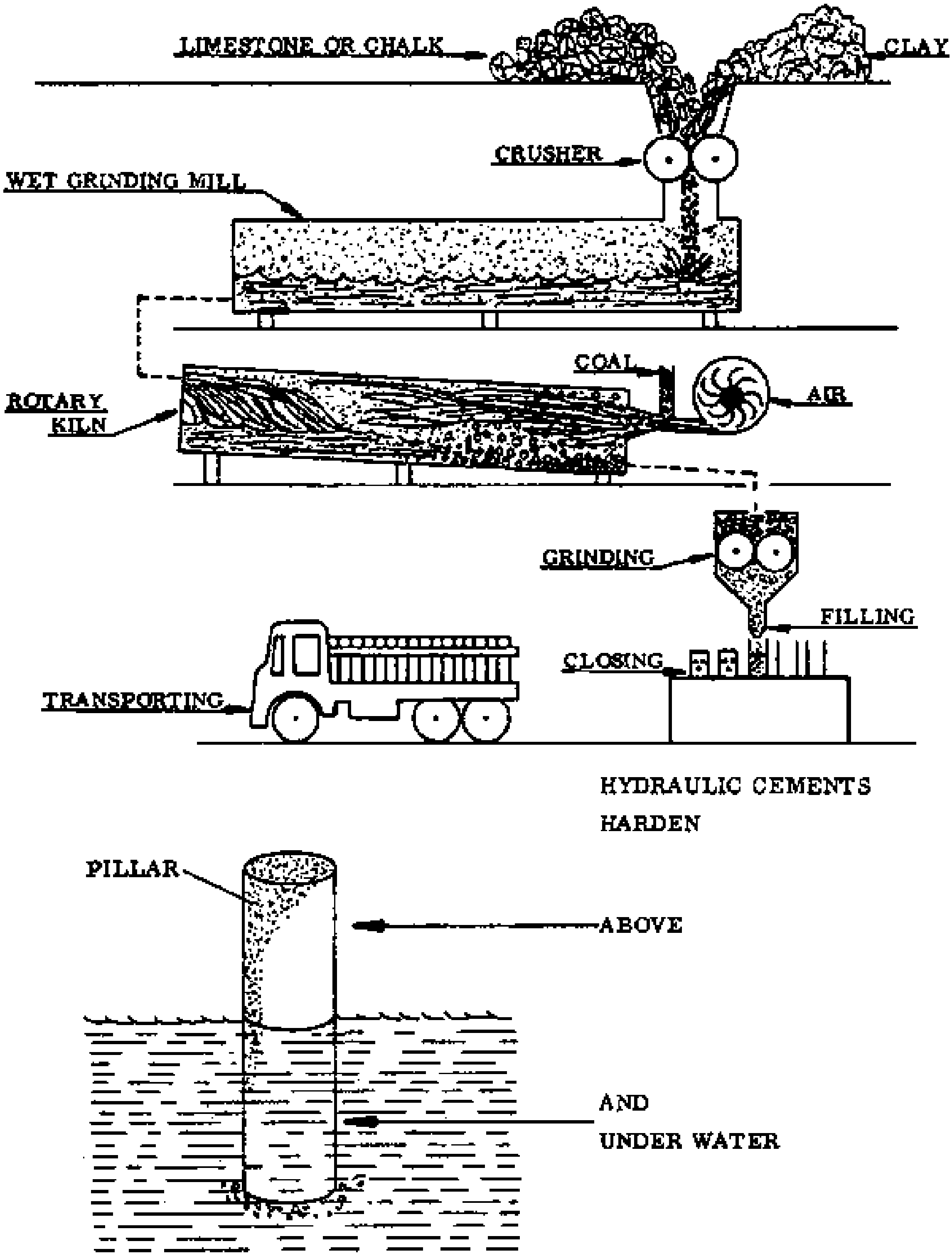


Fig. 1

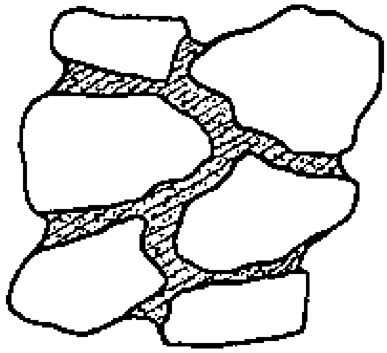


Fig. 2a: HARDENED CEMENT PASTE BINDS STONES TOGETHER AND FORMS A SOLID MASS

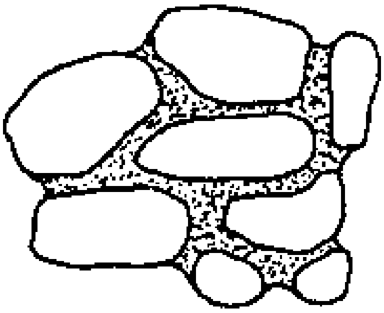


Fig. 2b: BITUMEN OR TAR ALSO BINDS STONES TOGETHER BUT REMAINS A BIT SOFT (WATCH FOR EXAMPLE TARRED ROADS IN THE HEAT)

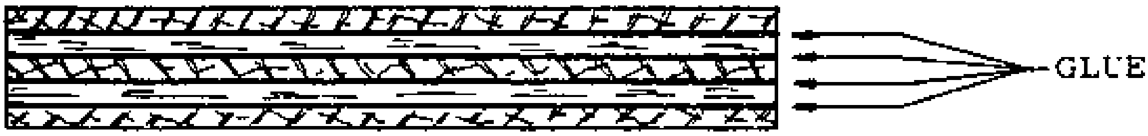


Fig. 2c GLUE HOLDS WOOD, PLASTIC, ETC. TOGETHER TO MAKE JOINTS OR SOLID PIECES, FOR EXAMPLE PLYWOOD

HISTORY OF CEMENT

Some sort of binding substance has been used since ancient times to hold together the stones, bricks etc. used in building. The earliest building cement was probably clay or ordinary mud. The Romans were master builders in brick and stone, and a large part of their success was because of their discovery of a cement that was made by mixing a volcanic ash with burned lime. The Romans also made pure lime mortars and gypsum plasters. These materials were the only building cements until modern times.

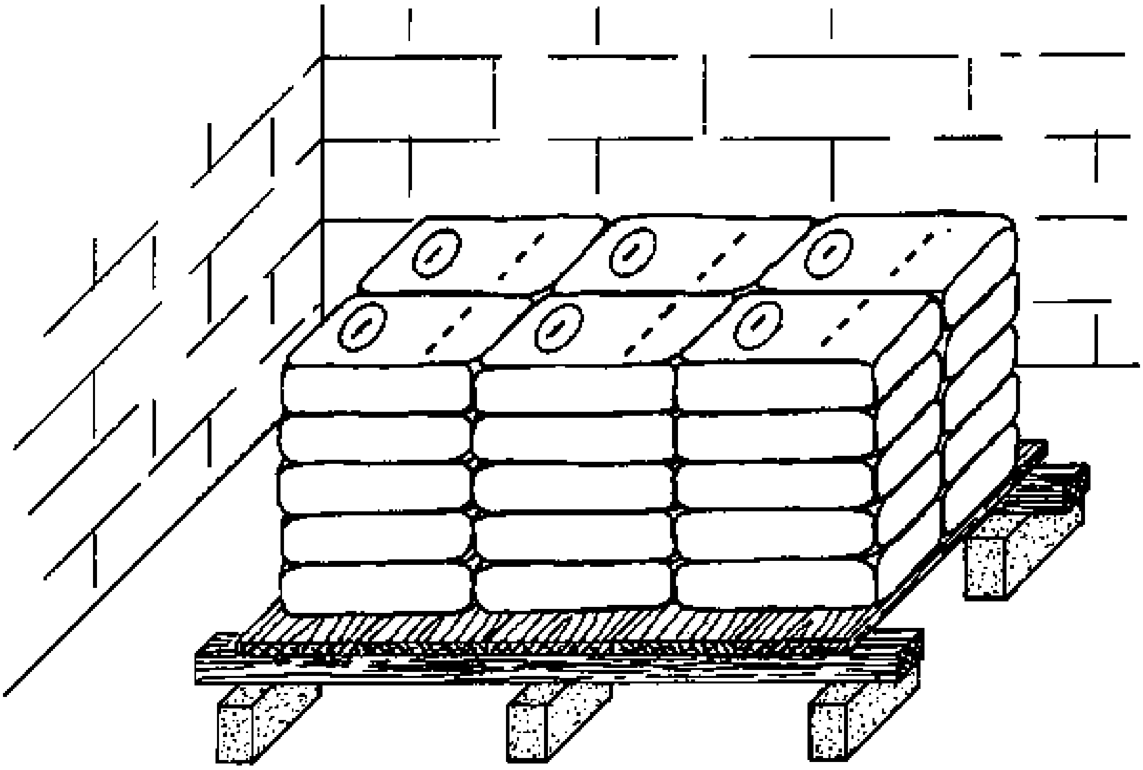
The modern era of building cements began about 1760, when an English engineer discovered the most suitable composition for hydraulic cements. These are cements which will harden even under water (Fig. 1). A few years later, in 1824, another Englishman invented Portland cement. He named it because of its similarity in appearance to a natural stone from Portland in England.

– DEFINITION: A cement is any material which attaches or unites two surfaces, or serves to combine particles into a whole.

– TYPES OF CEMENTS (Fig. 2):

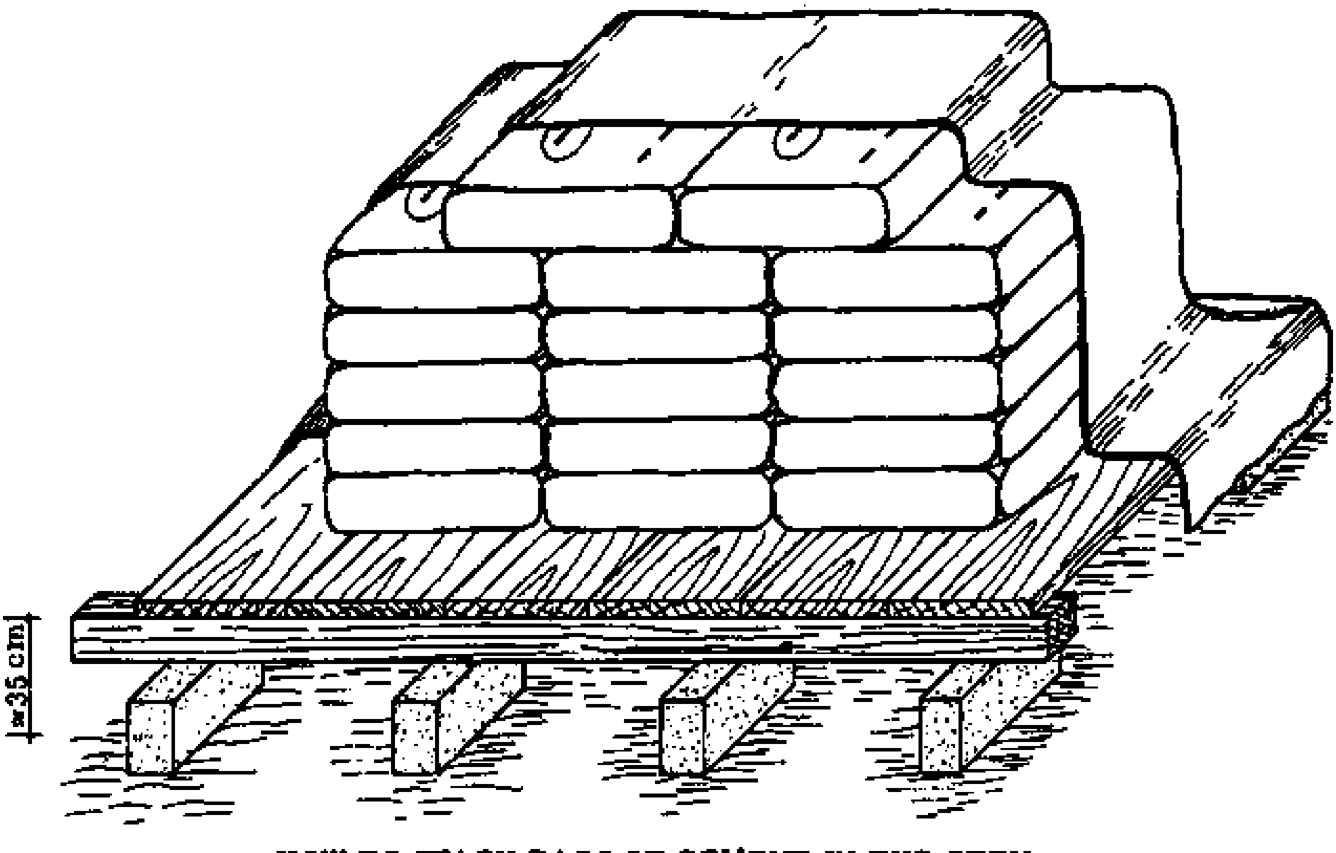
a – Building cements (eg. Portland cement and lime)
b – Bituminous cements (eg. tar and asphalt)
c – Adhesives (eg. animal glues and synthetic resins)

NOTES:



HOW TO STACK BAGS OF CEMENT IN A STORE

Fig. 1



HOW TO STACK BAGS OF CEMENT IN THE OPEN

Fig. 2

STORING BINDING MATERIALS

The quality of mortar and concrete depends on so many factors, but one of the most important of these is the cement. Cement must be stored properly, to prevent it from setting (hardening) before it is used. If the cement gets damp, it will become unusable. Everyone knows that cement should be kept dry, but they don't always realize that contact with damp air can do as much harm as direct contact with water. On all jobs where bagged cement is used, there should be a shed or room to store it.

– STORING IN A SHED: Make sure that the shed or room is water–tight and has a sound, dry floor. If the floor is not dry, make a platform out of boards set on blocks and timber, to raise the bags off the ground (Fig. 1). Stack the bags closely together to keep out air, and away from the walls so that they are not in contact with any dampness on the walls. In very large sheds it is better to cover the bags with plastic sheeting to keep out damp air, especially during the rainy season.

Check the bags from time to time for termites: these may damage the bags and with them the cement. Check also that the roof doesn't leak and that the walls are waterproof.

– STORING IN THE OPEN: On some jobs, bags of cement may have to be stored in the open, with no more protection than a dry base and a covering of tarpaulins or plastic sheets. The sheeting must be properly overlapped to keep out the rain; and the top sheet should lay over all the ones below like a roof, so that the rain can run straight off without getting into the tarpaulin "tent" and wetting the cement.

Even if the cement is to be stored in the open for only an hour or so, there must be a dry platform raised about 35 cm above the ground for the bags to lie upon (Fig. 2).

Whether the cement is stored indoors or out, arrange the bags so that the first batch brought in can be the first ones used, and the old bags don't get left at the bottom of the stack and never used. Prevent accidents by keeping the piles to a height of about 1, 20 m, and never stack them more than 10 bags high.

– REMEMBER: The important thing with cement is to always KEEP IT DRY! Cement starts to set about 30 minutes after mixing or coming into contact with water or moisture.

MORTAR

Mortar consists of the body or aggregate, which is fine sand; and the binding material, which is cement mixed thoroughly with water.

Mortar is used to bed blocks as well as for plastering. A good mortar should be easy to use and should harden fast enough that it does not cause delays in the construction. It must be strong enough, long lasting and weatherproof.

TYPES OF MORTAR

The best mortar for a particular job is not necessarily the strongest one. Other properties like workability, plasticity or faster hardening can be more important, though the strength of the mortar must of course be sufficient for the job.

Mortar should neither be much stronger or much weaker than the blocks with which it is used.

– CEMENT MORTAR: This sets quickly and develops great strength. It is used in proportions of one part cement to three parts sand (1: 3), which makes quite a strong and workable mix; down to a 1:12 mix, a lean mix which will be rather harsh and difficult to use.

– LIME MORTAR: This is usually very workable and does not easily lose water to the blocks, but it is weaker than cement mortar and hardens slower. Lime mortars are nowadays largely replaced by cement mortars or combinations of lime and cement.

– CEMENT–LIME MORTAR: This combines the properties of cement and lime to give a workable and strong mortar. The cement makes the mortar stronger, denser, and faster setting; while the lime makes the mortar workable and reduces the shrinkage during drying, because it retains the water better.

In some areas, lime is not always available, so in this book we will concentrate on the use of cement mortars.

NOTES:

SELECTING THE RIGHT KIND OF SAND

Sand for plaster, mortar and renderings must always be chosen with care. The sand used to make mortar for blocklaying should be well graded, sharp and must not be too fine if a strong mortar is needed (eg. for footings).

The more fine particles the sand contains, the better its workability in the mix, but more cement paste will be needed to cover the surfaces of the particles. This means that in order to improve the workability while maintaining the same strength, more cement must be added which results in higher costs.

The Rural Builder is always faced with this problem and it takes a lot of experience to be able to find a good compromise.

If the sand is found to be too sharp so that it makes a mortar with poor workability, we suggest replacing about 1/3 of it with fine soft sand; but don't replace more than about 1/2 unless you add more cement.

We can do this because the common mix proportion of our mortar is 1:6, while the sandcrete blocks are mixed in a proportion of 1: 8 (cement: sand). When the fine sand is added, the strength of the mortar is reduced to about the same as the strength of the blocks, which is acceptable.

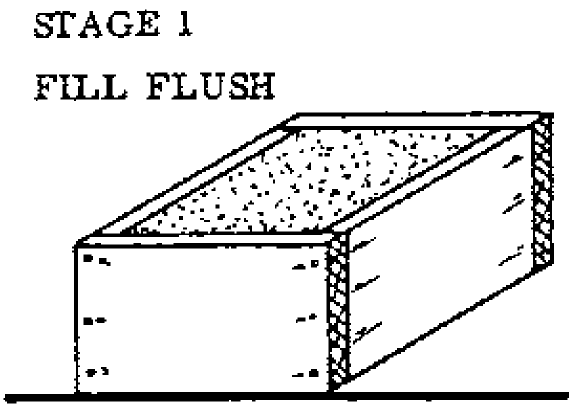
The information above is meant to show the problems concerning the selection of the right sort of sand for a particular job. This book will address these problems repeatedly as we introduce the different kinds of blocks as well as the different jobs.

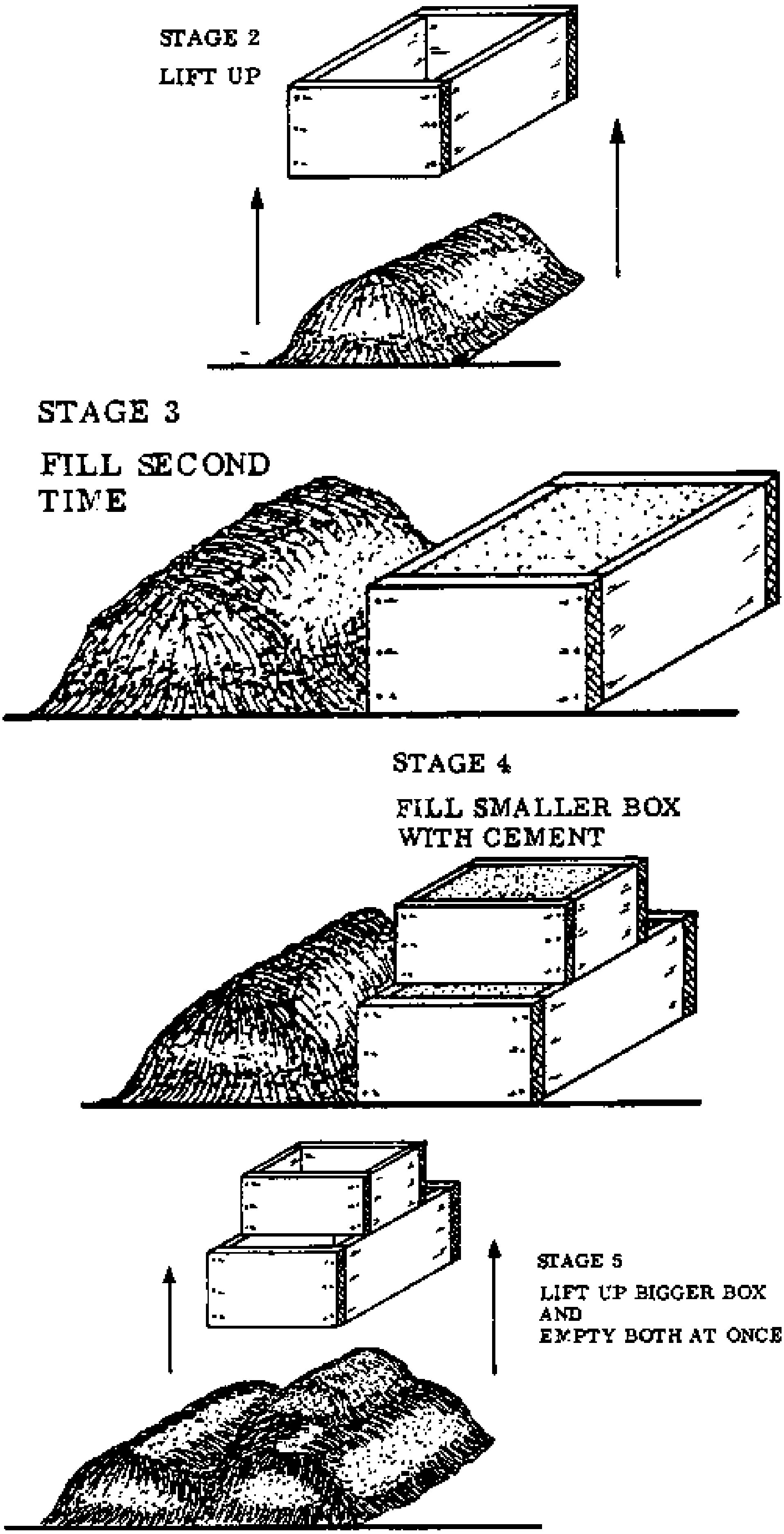
– REMEMBER: A good mortar should:

a – be easy to work with
b – harden fast enough not to delay the construction
c – stick well to the blocks
d – be long lasting and weatherproof
e – if possible, be as strong as the blocks.

NOTES:

Fig. 1




STAGE 2
LIFT UP
STAGE 3
FILL SECOND TIME
STAGE 4
FILL SMALLER BOX WITH CEMENT
STAGE 5
LIFT UP BIGGER BOX AND EMPTY BOTH AT ONCE

BATCHING

By the term "batching" we mean that we measure the proportions of the various ingredients of a mix. We already know that the ingredients for a mortar should be mixed in certain proportions. To help us to obtain the correct amounts we can make boxes with the appropriate sizes; this method is known as "batching by volume".

Since a common mix proportion is 1:6 and some special jobs require a mix of 1:3, two batching boxes are made with corresponding measurements. The smaller one for cement measures 15 cm high, 30 cm wide and 38 cm long (inside measurements) giving a volume of 17,1 litres, which is about half a bag of cement or one slightly heaped headpanful (one bag of cement contains 34,1 litres or two slightly heaped headpans).

For the sand, a bigger box is made which must hold exactly three times as much as the smaller one. Therefore its inside measurements are: 30 cm high, 30 cm wide, and 57 cm long. This gives a volume of 51,3 litres, which is 3 x 17,1.

Both boxes are bottomless; they are only frames in order to make it easier to work.

– PROCEDURE: Before you start batching and mixing, it is advisable to make a mixing platform out of lean concrete for all future mortar and concrete work. This provides a firm and clean place so that your mix will not become dirty, no cement paste will be lost, and shovelling will be easier.

For small jobs, the mixing platform can measure approximately 1,5 m by 2 m and may be 5 to 7 cm thick.

For a 1: 6 mix, place the bigger box on the platform and fill it with sand flush to the top edge. Then lift it up and set it down again next to the first pile and refill it in the same way (Fig. 1, stages 1 to 3).

Now put the small box on top of the sand–filled big one, and fill it with cement. It must be filled flush to the top edge in order to get the right proportions (Fig. 1, stage 4).

Now lift up the lower box, taking the smaller one with it and emptying both at once. The result is a heap of sand (6 parts) covered with cement (1 part), ready to be mixed (Fig. 1, stage 5).

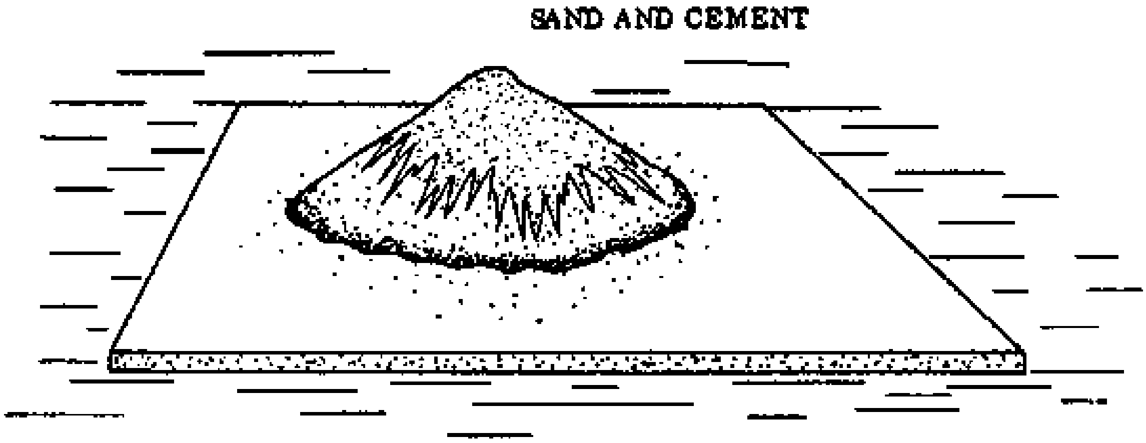


Fig. 1

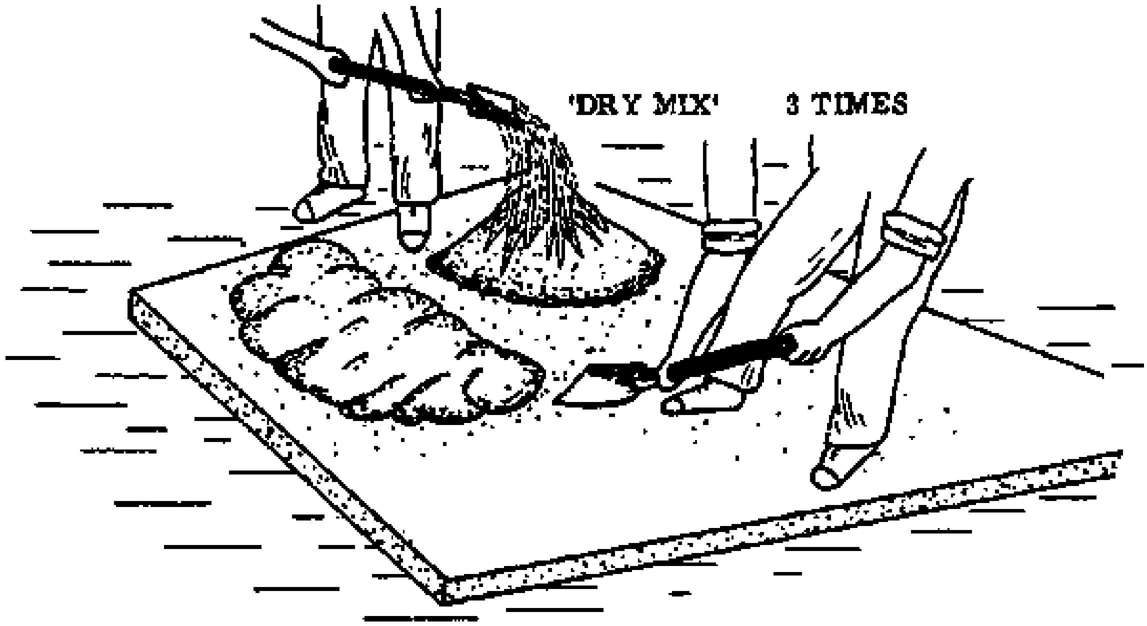


Fig. 2

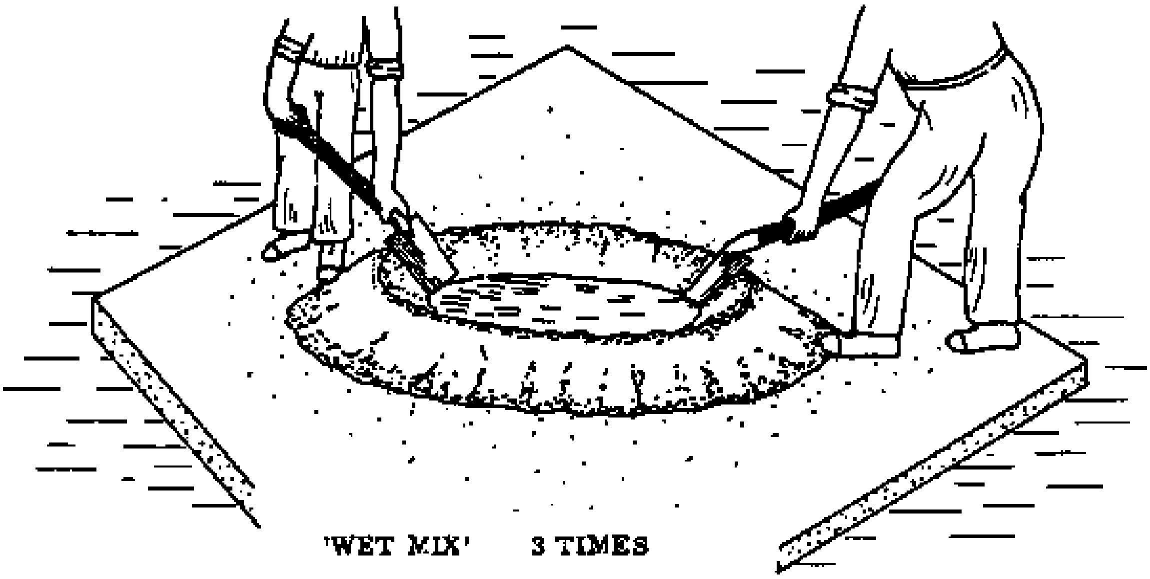


Fig. 3.

MIXING THE MORTAR

Mixing is one of the most important stages in the process of making mortar because the workability and strength of mortar depend so much on the way it is mixed and on the amount of water added to the mix.

– WHAT WATER DOES: Water in the mix does two things: it makes the mortar workable and it combines chemically with the cement to cause hardening. However, only about half the water is required for the chemical reaction and the rest will remain or evaporate slowly as the mortar hardens, leaving small holes or "voids" in the cement.

Obviously, the more water there is in the mix, the greater will be the number of voids and the weaker the mortar.

For your 1:6 mixture, a maximum of 15 litres of water should be added (almost one headpanful); never any more than this even if the mix appears to be too dry, as sometimes happens in the first stage of mixing.

– THREE TIMES DRY: The sand and cement is measured on one end of the mixing platform. With two men facing each other across the pile and working their shovels together, turn the whole heap over once to form a pile at the other end of the slab (Figs. 1 & 2). This turning must be repeated twice and results in a so-called "dry mix".

The correct method for turning over is to slide the shovel along the top of the platform, pick up a load and spill the load over the top of the new pile. The main point is that each shovelful runs evenly down the sides of the cone. This is the best and easiest way of mixing dry mortar and all other motions should be eliminated. When the dry mix is a uniform colour throughout, it is considered to be well mixed.

– THREE TIMES WET: Form the heap of dry mix into a crater or pool, with the sides drawn out towards the edges of the mixing platform. There should be no mixture left in the centre of the pool.

Now gently pour about 3/4 of the total required water into the crater. Turn the shovel over and with the edge scraping along the platform, push some of the dry mix into the pool in such a way that it spreads out, without separating the sand and cement. Handle the shovel carefully so that no water can, escape by breaking through the ring (Fig. 3).

When all of the dry mix has been heaped up in the centre of the platform, it should have taken up all the free water and have a rather stiff consistency (earth–moist).

Now make a second pool, add the remaining water and repeat the rest of the mixing procedure. This will result in a mortar of a plastic consistency. To make sure the mixing is thoroughly done, turn the mortar over a third time,

– CONSISTENCY TEST: You can carry out a simple test to get a rough idea whether the consistency of the mortar is correct (this means the water content).

Fill a headpan with mortar and smooth the surface (Fig. 1). With the blade of your trowel, make a straight cut clear through the mortar to the bottom of the headpan (Fig. 2). Now push the trowel flat under the mortar along the bottom of the headpan, so that the cut in the mortar centres the length of the trowel.

When the trowel is lifted up 2 or 3 cm, the gap in the mortar must open into an oval shape along the outer edge but remain closed along the bottom (Fig. 3).

– NOTE: If you want to improve the workability of the mortar by adding water, remember that this will also decrease its strength. You are therefore strongly advised to add both cement and water in equal quantities (for example 1/2 bucket of water plus 1/2 bucket of cement).

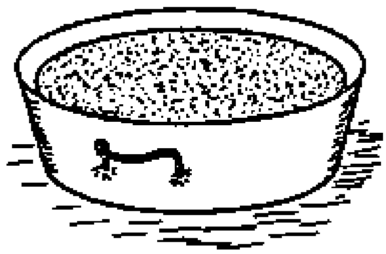


Fig. 1: FILL HEADPAN HALF FULL AND SMOOTH THE SURFACE

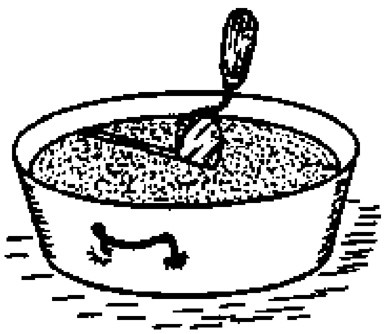


Fig. 2: MAKE A CUT WITH THE TROWEL

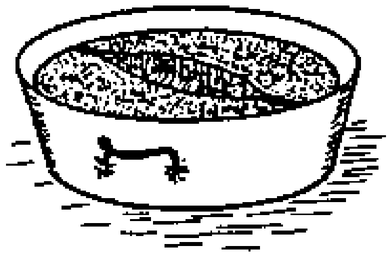


Fig. 3

– REMEMBER: Ready mixed mortar starts setting after only 30 minutes! Never prepare more mortar than you can use within this time.

It is certainly better to mix smaller amounts more often than to allow mortar to spoil; or to do the work very quickly (and sloppily) in order to get rid of the mortar.

Always cover freshly mixed mortar with empty cement bags to keep it from drying out.

NOTES:

CONCRETE

To concrete something means to form it into a mass, or to solidify it.

As far as building is concerned, the term concrete means an artificial stone made by mixing sand, stone, Portland cement and water. This mixture, cast into a form of the desired shape and size, hardens into a stone–like mass: the concrete.

There are basically three materials we start with to make concrete:

– The aggregate, which is made up of the fine and coarse aggregates together, ie. the sand and broken stones. The aggregate makes up the main mass of the concrete; its function is mostly just to add bulk.

– The water.

– The binding material, which is usually Portland cement.

When the three materials are mixed together, the cement and water combine chemically to make a cement paste, which surrounds the particles of the aggregate and holds them together.

NOTES:

CEMENT PASTE

The cement paste component of concrete is what causes it to harden, the aggregate simply remains passive (inactive).

Thus the cement paste must completely cover the surface of every single particle of the aggregate. This means that each stone, no matter whether tiny or big, must be covered all over by a thin layer of cement paste.

This is achieved by mixing all three components very thoroughly and in the correct proportions (see Batching, and Mixing The Mortar, pages 160 to 163).

The cement paste fills up all the spaces between the particles of the aggregate and bonds them firmly together as it hardens.

The hardening process requires a certain amount of water; how much depends on how much cement is added to the mix. The correct proportions can be found in the Tables of Figures, page 234.

After it is set, the hardened cement paste cannot be dissolved again (except by the use of certain acids).

An undesirable further reaction of the cement paste is the drying shrinkage as it hardens. Because of the evaporation of the extra water, the volume of the concrete is gradually reduced. The concrete shrinks and develops cracks.

This reaction can be effectively reduced, if not prevented, by correct curing; as will be discussed later in this book.

Also to prevent cracking, large areas that are covered with concrete; such as floors, should be divided up into bays.

PROPERTIES OF CONCRETE

Concrete has many properties, but most of them are of little interest to the Rural Builder. Therefore this chapter deals only with the three most important properties:

a – Compression strength
b – Tensile strength
c – Protection against corrosion.

NOTES:

– COMPRESSION STRENGTH: It is commonly known that concrete becomes very hard and can withstand enormous pressures; a property which is called compression strength.

This compression strength depends mainly on the properties and quality of the cement paste and the aggregate.

– If the aggregate consists of a soft or weak material, the concrete will be weak also.

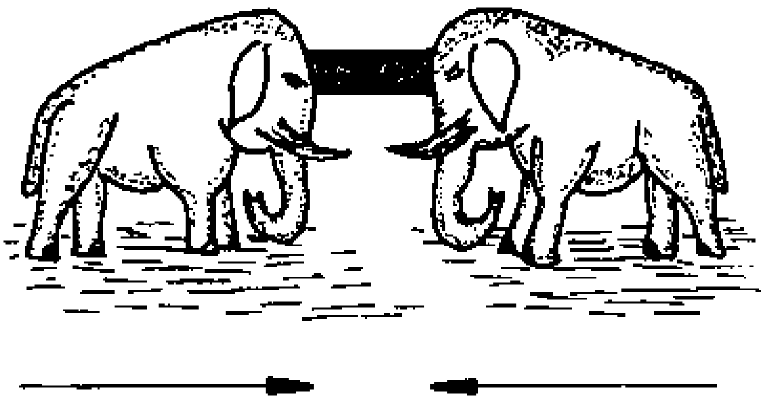
– If the aggregate is so dirty that there is no direct contact between the surface of the particles and the cement paste, the concrete will again be weak.

Provided that all the rules for producing a good concrete are observed, the strength of the concrete can be controlled by choosing the mix proportions. For example, a mix proportion of 1:10 is weaker than a 1:3 mix. This is because in a 1:10 mix the particles of aggregate are not completely coated with cement paste, but in the 1:3 mix they are fully embedded in it.

– If not enough water was added to the mix, the cement paste remains too dry and stiff and the concrete will be weak.

– If too much water was added, making the cement paste too thin, the concrete will again be weak.

Therefore the Rural Builder must always carefully follow the correct concrete recipe.



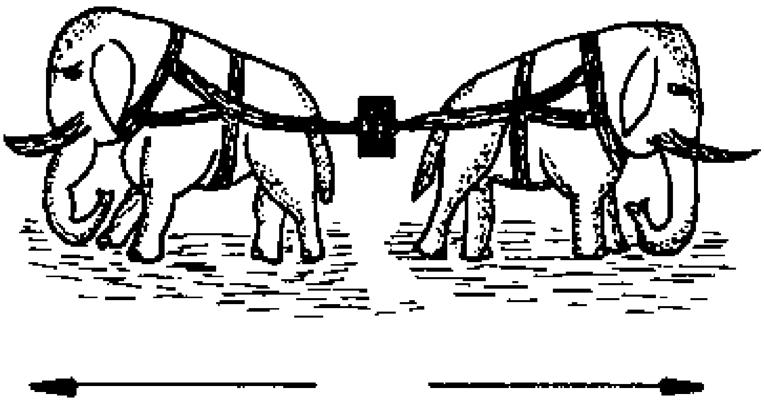
COMPRESSION STRENGTH

– TENSILE STRENGTH: The tensile strength of a material means its capability of being stretched to a certain extent without breaking.

Although concrete becomes very hard, its tensile strength is very limited. It is so low that in practice, the tensile strength of concrete is regarded as being nonexistent. This is why sometimes concrete members of a structure must be reinforced by steel bars embedded in them.

Some types of wood, while they are softer and have a much lower compression strength than concrete, have a far higher tensile strength because of their fiber structure. The wood fibres act in a way like the reinforcement iron embedded in concrete.

Wood is a good building material because of its tensile strength. However, its flexibility makes it subject to bending under loads. Because of this problem, short–span constructions are chosen; or, among other possibilities, reinforced concrete can be used instead of wood.



TENSILE STRENGTH

NOTES:

– PROTECTION AGAINST CORROSION: Corrosion means a wearing away, a slow destruction caused by a reaction with air, water or chemicals.

Reinforcement iron which is left unprotected and exposed to air and humidity will eventually start to corrode on the surface and become rusty.

If this process is not halted in time, the rust goes into the bar and it becomes too weak to be used.

In order to maintain the strength of steel–reinforced concrete, the steel has to be protected from rust. This is partly done by the hardened cement paste and partly by structural means.

Ideally, the hardened cement paste hermetically seals the iron so that direct contact with air and humidity is cut off. Even slight rust stains on the iron cannot do any harm because the cement paste protects it against further corrosion.

The protection will not be enough however, unless the builder observes the following rules:

– The reinforcement bars must be completely covered by concrete which is well compacted and without voids.

– The concrete cover must be sufficiently thick, and without cracks.

– In most cases ordinary Portland cement is used and the mix proportion should be no less than 1: 5 for reinforced concrete. (see Tables of Figures, page 234).

Apart from these, all the other rules for producing a good concrete must be observed.

– NOTE: Quality concrete is not a brand. It does not have a trademark on it to say "This is quality concrete". Sometimes the concrete does not even look different from poor concrete, but it is different. This depends not only on the mix proportion, but on the awareness and skill of the builder.

NOTES:

PART 4: RURAL BUILDING PRODUCTS

REINFORCEMENT STEEL

To reinforce a material means to add something to it, in order to make it stronger.

One of the strongest reinforcement materials available is steel or iron. In reinforced concrete, a concrete member is strengthened with steel bars or metal netting embedded in it.

TYPES OF REINFORCEMENT STEEL

There are various types of reinforcement steel; how they are used depends on the function, shape and dimensions of the reinforced concrete member as well as on the required strength.

Reinforcement steel is classified according to its shape and surface texture. The most common reinforcement is single round bars which can have either a smooth or a ribbed surface.

– CIRCULAR BARS: Round, smooth bars are called circular bars and are available in diameters ranging from 5 mm to 28 mm (Fig. 1, next page). The four sizes most often used in Rural Building have diameters of 6 mm (1/4"), 10 mm (3/8"), 12 mm (1/2") and 18 mm (3/4").

– RIBBED BARS: The round bars with a ribbed surface are called ribbed bars and are available in diameters ranging from 6 mm to 40 mm, if the bar is cross–ribbed (Fig. 2, next page). For obliquely ribbed bars, the diameters range from 6 mm to 28 mm (Fig. 3, next page). This last type of reinforcement is also called "tentor bar" and it is the strongest reinforcement steel available.

The standard length of reinforcement bars is 9 m.

– ADVANTAGES / DISADVANTAGES: Although the strength of circular bars is sufficient for all Rural Building purposes, it is advisable to purchase ribbed bars if they are available in the market. Ribbed bars are preferred because their rough surface texture provides a better grip to the concrete. This, along with their greater strength, allows the Rural Builder to space the ribbed bars wider apart, thus saving materials and reducing the total weight of the member.


Fig. 1

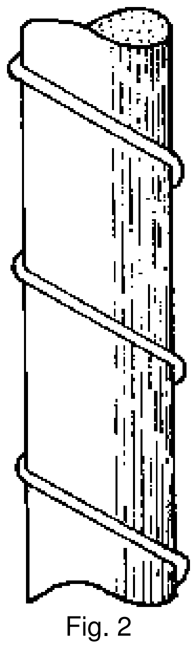


Fig. 2

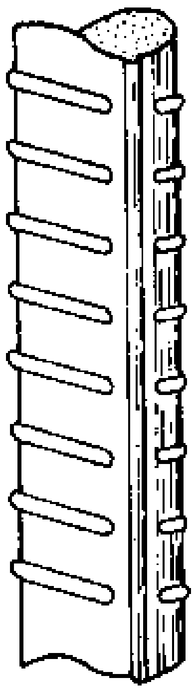
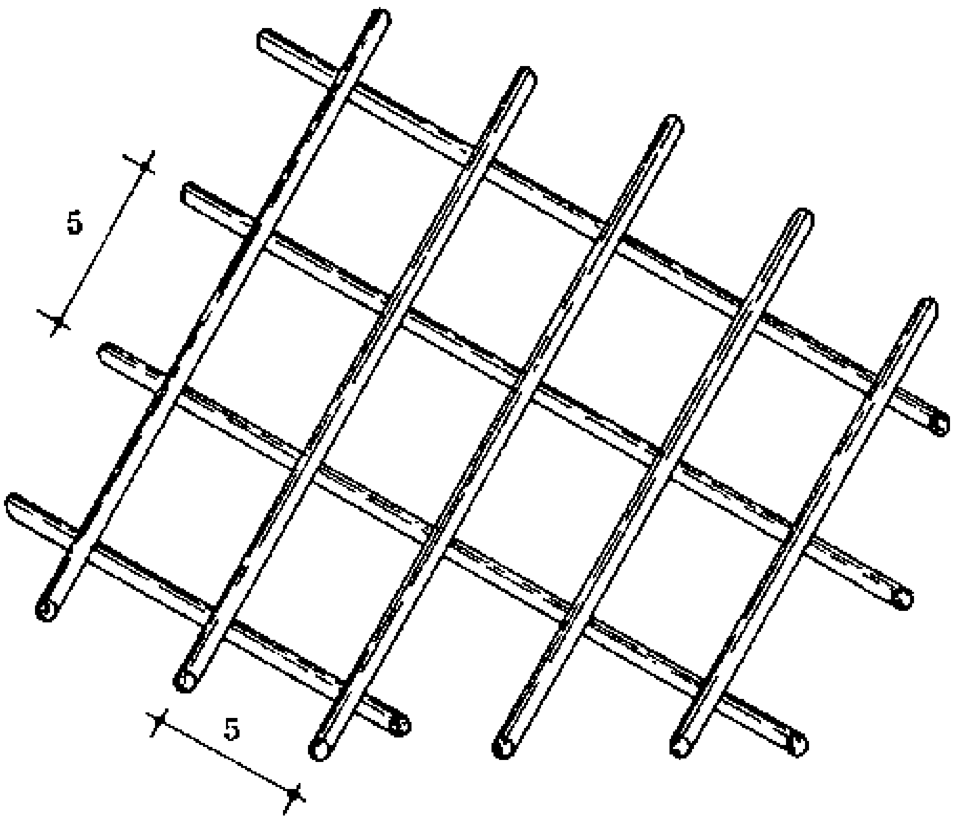
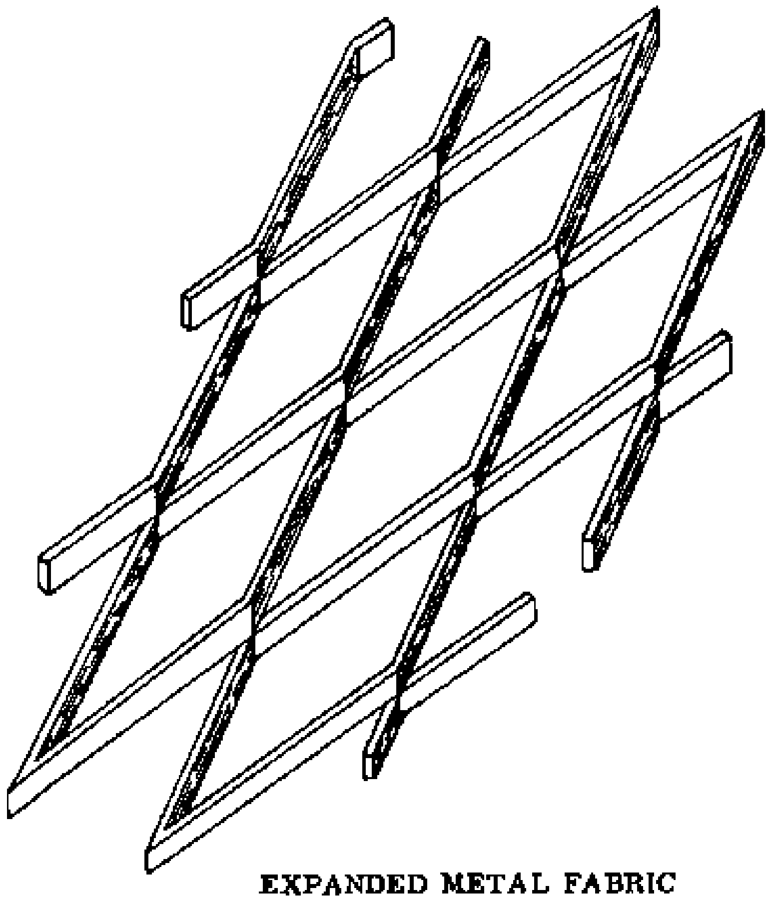


Fig. 3



STEEL WIRE NETTING

Fig. 4



EXPANDED METAL FABRIC

Fig. 5

REINFORCEMENT MATS

A variety of reinforcement mats are available. They are usually made out of two layers of reinforcement bars laid across each other and secured together by welding.

The mats are either square or oblong in shape. They reduce the work needed to reinforce large members of the structure such as floors, walls, slabs, etc.

Regular reinforcement mats are hardly necessary in Rural Building, but two special kinds are frequently used for burglar proofing and to reinforce thin concrete slabs like manhole covers, draining boards in kitchens, and coping slabs.

These two are "expanded metal fabric" and "steel wire netting".

− STEEL WIRE NETTING: The most common steel wire netting (Fig. 4) has square meshes measuring 5 by 5 cm and is manufactured in the same way as reinforcement mats. The same kind of wire mesh can also have oblong meshes.

− EXPANDED METAL FABRIC: This is made by slitting metal sheets and then stretching them to form a diamond−shaped mesh (Fig. 5). Always wear leather gloves when working with expanded metal fabric, as the edges are very sharp.

Reinforcement mats are sold in sheets approximately 2,15 m wide and 5 m long.

Expanded metal fabric and steel wire netting can be purchased in sheets of about 1,5 m wide and 2,5 m long.

BINDING WIRE

This is a soft steel wire about 1 mm in diameter, used for binding reinforcement bars at the points where they cross each other. It is bought in rolls and may also be called lashing wire, annealed wire or tying wire.

NOTES:

LANDCRETE BLOCKS

One of the smallest but most important members of the structure is the block. Almost all walls in Rural Building are erected with blocks, preferable landcrete blocks.

–LANDCRETE: This word comes from the words laterite, land, and concrete.

The land on which we live provides us with the laterite; the first syllable is a combination of the first two letters of laterite and the last two letters of land.

Concrete as well as landcrete contains cement. In order to show this, the last syllable of the word concrete is used, making the word LANDCRETE.

Landcrete is a low cost, long–lasting and attractive building product. This chapter is about making landcrete blocks using a hand operated block press.

– LATERITE: This type of soil is found throughout the tropics. Its colour can vary from white–grey to a dark red, depending on the iron content. Laterite consists mainly of fine and coarse sand mixed with clay.

Laterite has been used to make houses for a long time, but such walls break down easily and get washed away by rain. Pressing the soil into blocks makes it easier to build the walls, and they are stronger and more resistant to rain. By adding some cement to the laterite it is stabilized and makes even better blocks. The basic material, laterite, costs nothing and is usually found on the building site. It is easy to find good soil for building or to mix it with sand or clay to make it good.

The basic steps of the operation to make landcrete blocks are fairly simple: first good soil is found and tested; then it is prepared for the block press, with the addition of cement or lime if available. The soil or soil–cement is put into the press and compacted, raised out and removed for curing.

– NOTE: If the blocks do not contain cement they are not called landcrete; they are simply called "laterite blocks".

REQUIRED MATERIALS

a – Laterite soil: composed of sands, silt and clay
b – Water: to wet the soil; it should be clean
c – Cement: to stabilize the soil.

– NOTE: If you have no cement you can use lime (twice as much as the amount of cement recommended) or else just make plain laterite blocks.

REQUIRED EQUIPMENT

a – Block press with proper mounting rails and a wooden handle (2,5 m long)
b – Box for shrinkage test
c – Headpan, box or bucket for batching
d – Pick–axes and shovels for digging, mixing and filling.

TESTING AND CHOOSING THE SOIL

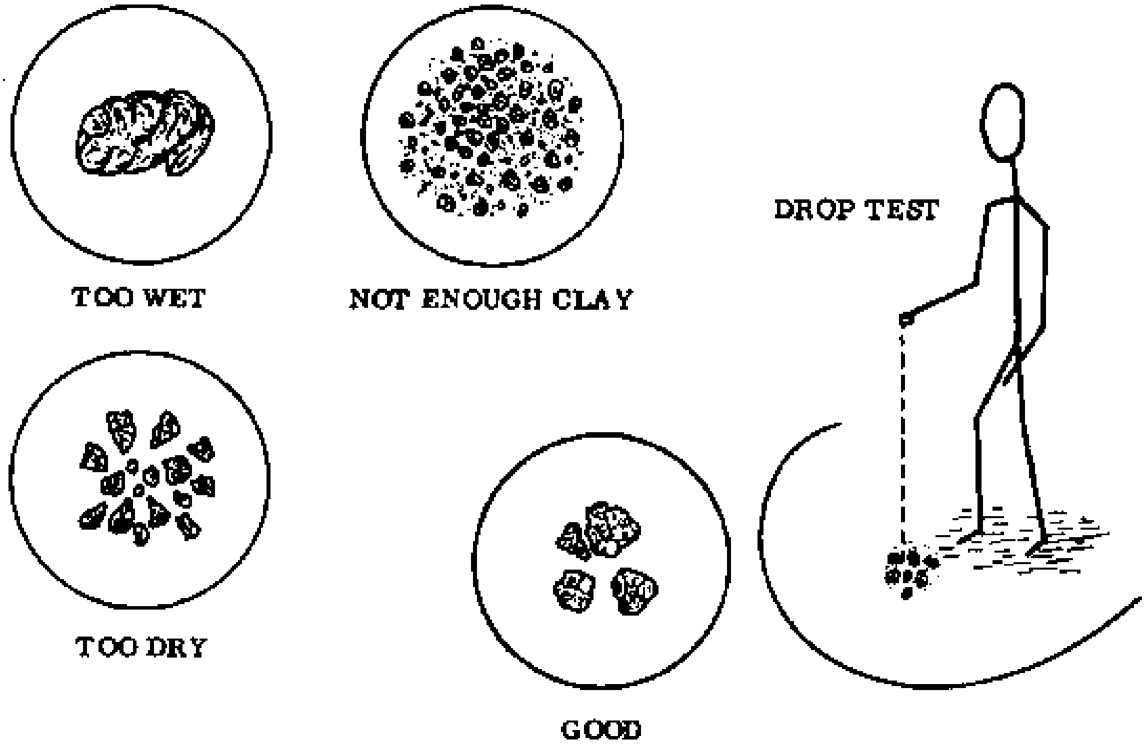
Most soil is suitable for making blocks, but it must be tested first to find out how much sand, silt and clay it contains.

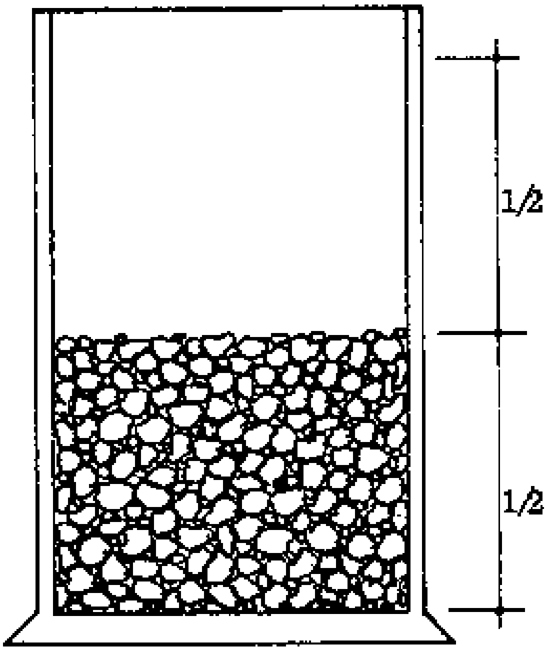
Dig a small pit for testing. First remove and set aside the top soil where plants or grass may be growing (25 to 50 cm deep). This soil should not be used for blocks. Dig out the soil under the top soil. The deeper soil may be sandier, which is usually better for making blocks.

Now make three tests: a – Drop test b– Jar test c – Box test.

– DROP TEST: Take a handful of soil which is wet enough to form a ball, and squeeze it in your hand, but not so tightly that the water is squeezed out.

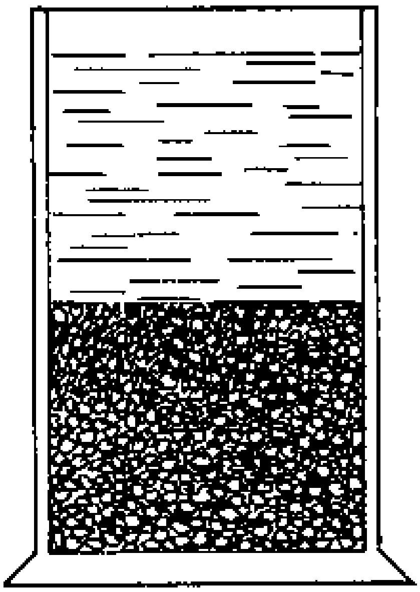
Drop the ball from about one meter high onto hard ground. If it breaks up into only a few pieces, the block–making quality is good. If it breaks completely up, there is either not enough water in it or not enough clay, and the quality is bad.





FILL GLASS JAR HALF FULL
WITH LATERITE SOIL

Fig. 1



FILL WITH WATER AND ADD
A LITTLE SALT
SHAKE IT THOROUGHLY !

Fig. 2

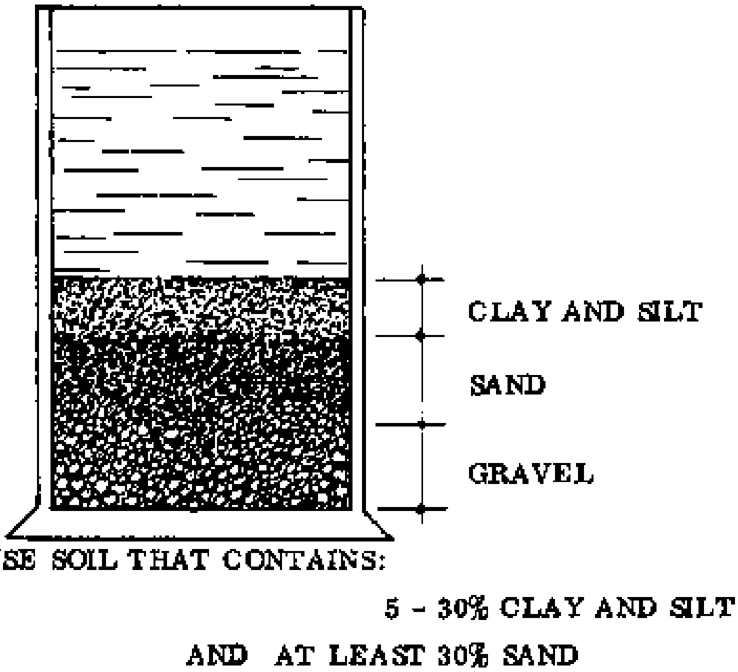


Fig. 3

– JAR TEST: This test separates the sand from the clay and silt, so that we can measure the quantity of each.

First dig out some soil (not top soil). Fill a glass jar half–full with the soil (Fig. 1).

Fill the jar up with water and add two teaspoons full of salt, to make the particles settle faster (Fig. 2).

Cover and shake or stir the jar for two minutes to mix the water thoroughly with the soil.

Set the jar on a level surface and leave the soil to settle for several hours. Sand and gravel will settle to the bottom, leaving the silt and clay on top (Fig. 3).

Measure the height of each layer to find the total amount of sand and the amount of clay and silt, compared to the total amount of soil.

The soil you use should contain at least 30% sand (about 1/3), and between 5% and 30% clay and silt. If there is not enough clay add more or else find some better soil. You can also add sand if necessary.

NOTES:

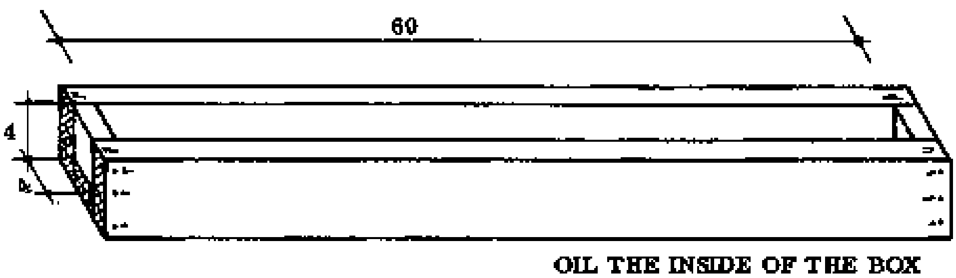


Fig. 1

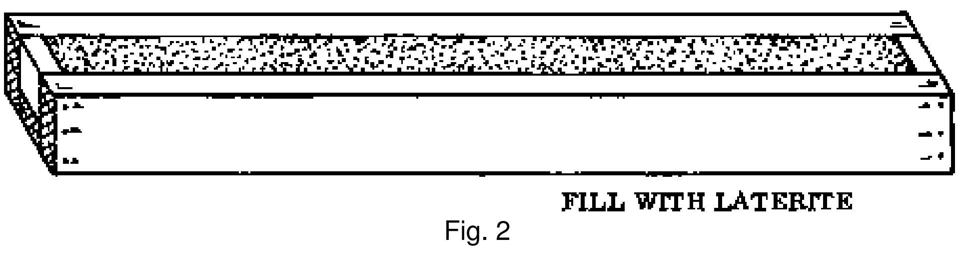


Fig. 2

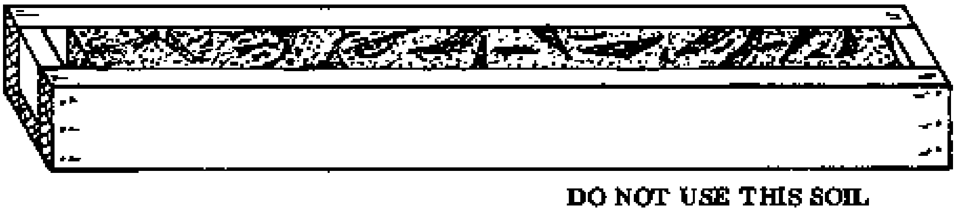


Fig. 3

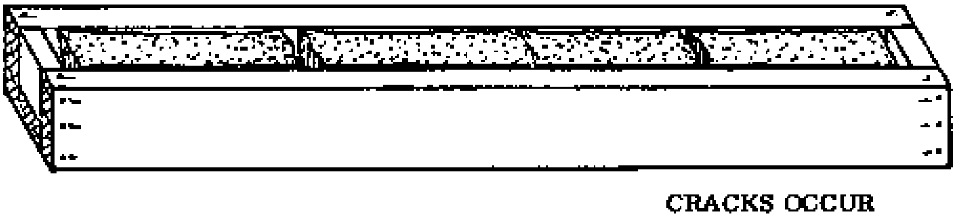


Fig. 4

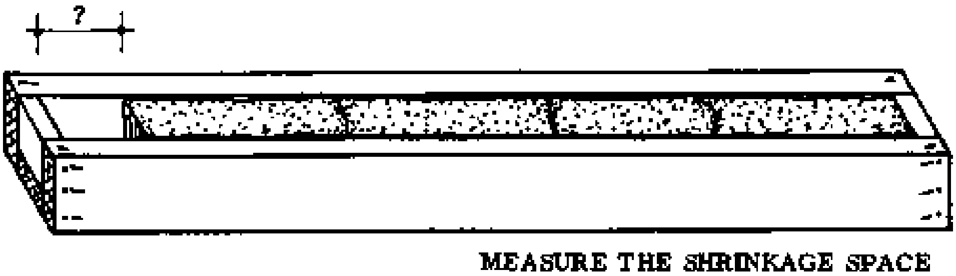


Fig. 5

– BOX TEST: This test shows the quality of the soil and allows you to determine the amount of cement you should use with it.

Use an open wooden box with inside measurements of 60 cm by 4 cm by 4 cm (Fig. 1). Oil or grease the inside of the box.

Fill the box with very wet soil. Compact it well, especially in the corners, and level off the top with a stick or the edge of your trowel (Fig. 2).

Put the box in the sun for three days to dry, or in the shade for seven days. It should be protected from rain.

The soil will shrink as it dries. Do not use soil for blocks if it has many cracks in it (Fig. 3) or if it has arched up out of the box. Don't use soil if it has shrunk more than 5 cm. Either find some better soil, or improve the soil by adding sand, since it is the clay which causes shrinkage.

Measure the shrinkage by tapping one end of the box on the ground so that all the soil slides down to one end (Fig. 4). The cracks will close and you can measure the shrinkage space at the top end (Fig. 5).

The amount of shrinkage tells you how much cement you should use. The more shrinkage, the more cement is needed. Use the table below as a guide for the amount of cement to be added to the laterite.

– TEST TABLE:

Shrinkage	Cement to soil
0–10 mm	1: 35
10–20 mm	1: 30
20 – 30 mm	1: 25
30 – 40 mm	1: 20
40 – 50 mm	1: 15

NOTES:

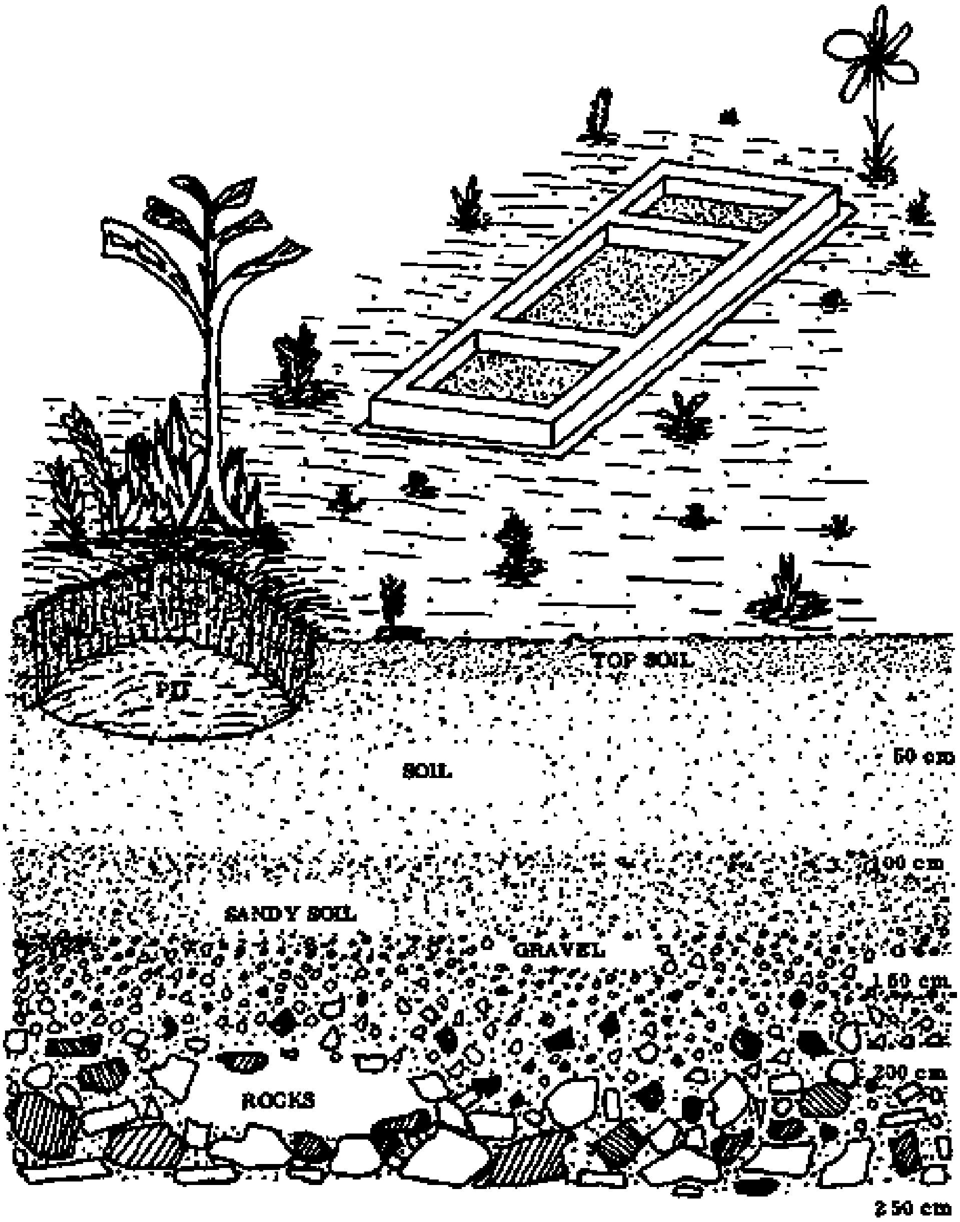


Fig. 1

MAKING BLOCKS

– PREPARATION OF THE MIXTURE: After you have found good soil and the correct amount of cement to use with the help of the box test, the soil mixture must be prepared for the block press.

If you have no cement and must make laterite blocks, you follow the same sequence as described below.

a – Remove the top layer of soil (Fig. 1).
b – Dig out the soil you want to use and pile it (Fig. 1).
c – Measure the required proportions of laterite and cement.
d – Make a dry mix of the batch.
e – Add water and make a wet mix.
f – Check the moisture content using the drop test.

If you are making laterite blocks, steps c and d are of course left out.

Before you start batching, the laterite must be broken up so that no lumps remain. This is usually done by beating the soil with the back of a shovel or with a piece of wood. Large stones are removed.

– MIXING: Use flat, hard ground for mixing. If no such place is available, prepare a mixing platform before you start working.

Spread the laterite out until it is about 10 cm thick. Spread the cement evenly over all the soil. Mix the cement and soil with a shovel until the mixture is of an even colour throughout (about 3 times – see Rural Building Materials, page 163).

Spread the heap again, sprinkle a little water over it and mix. At this point, test the mixture for moisture with the drop test. If it is too dry, spread it out again and add more water.

The soil–cement mixture is now ready for the block press. There should be enough mix for about 7 or 8 blocks in one batch at a time.

– NOTE: Never prepare more than you can use up within 30 minutes (about three batches). It is better to mix small amounts more often.

NOTES:

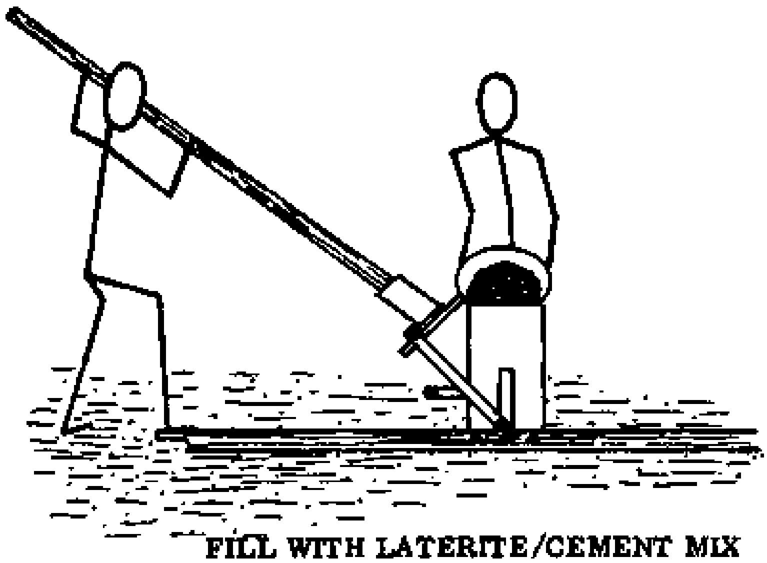


Fig. 1

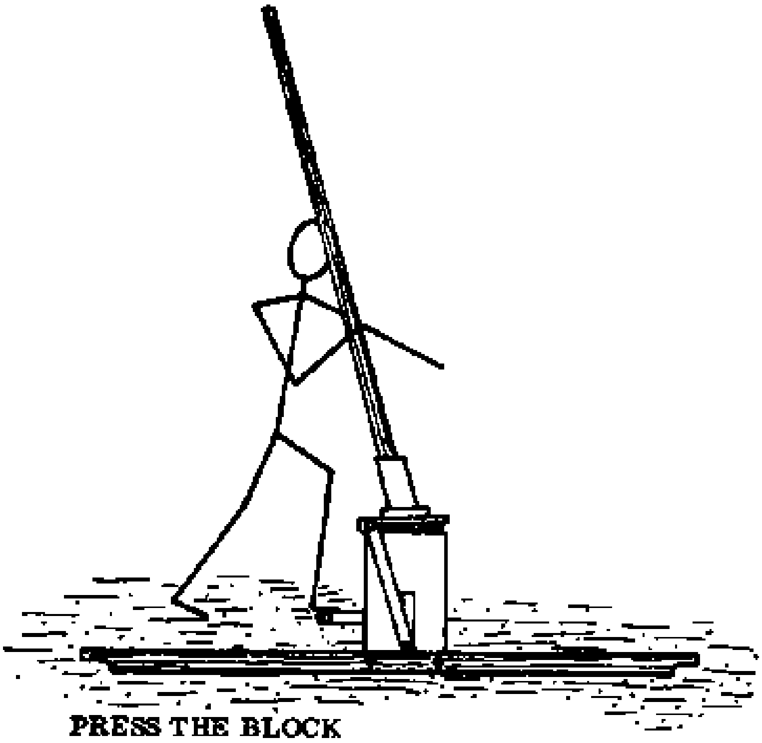


Fig. 2

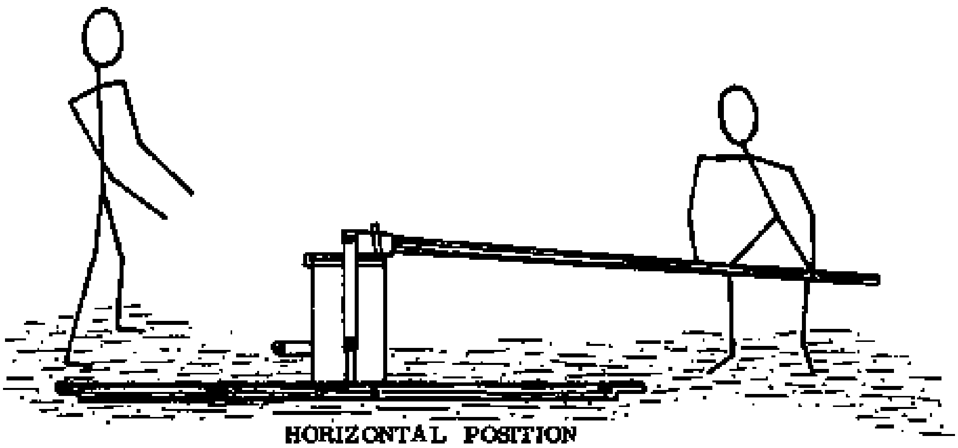


Fig. 3

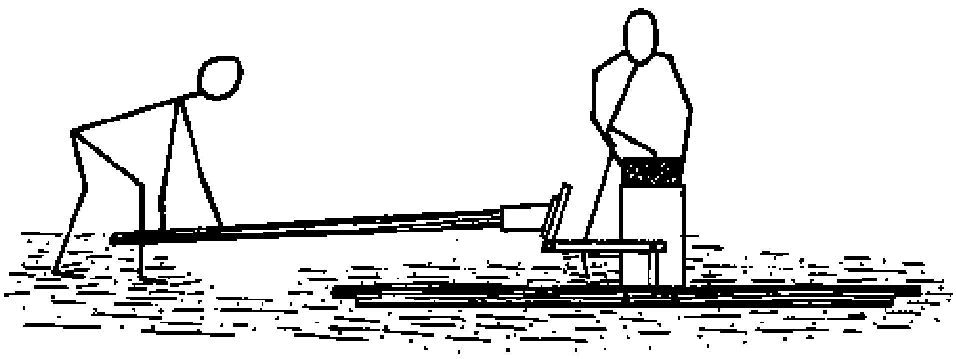


Fig. 4

– PRESSING THE BLOCK:

a – Place the block press in its rails on flat, solid ground near the mixing platform.

b – Open the mould box by swinging the handle down to the lower roller.

c – Half–fill the mould box with the laterite cement mix (Fig. 1).

d – Press the mix firmly into the corners with a piece of wood.

e – Fill the mould to the top and compact the corners again.

f – Add a little more so that the mould is filled flush to its top edge.

g – Swing the handle quickly over to the other side and press the block until the handle has reached a horizontal position (Figs. 2 & 3).

If the mix is too dry, the handle will not go all the way down to the horizontal position. In this case do not force it, as the handle may break.

Instead, eject the unfinished block so that you can refill the mould box after adding a little water to the mix.

On no account should more than one man at a time work the handle!

h – Raise the block out of the mould box by swinging the handle back against the lower rollers (Fig. 4).

i – Lift the block carefully off the machine and place it for drying.

The freshly made block is not strong yet. If it breaks or cracks very easily, the mixture is not correct. Try a different mixture.

Hold the block in such a way that your fingers are not caught under it when you put it down, so as not to crumble the edges.

NOTES:

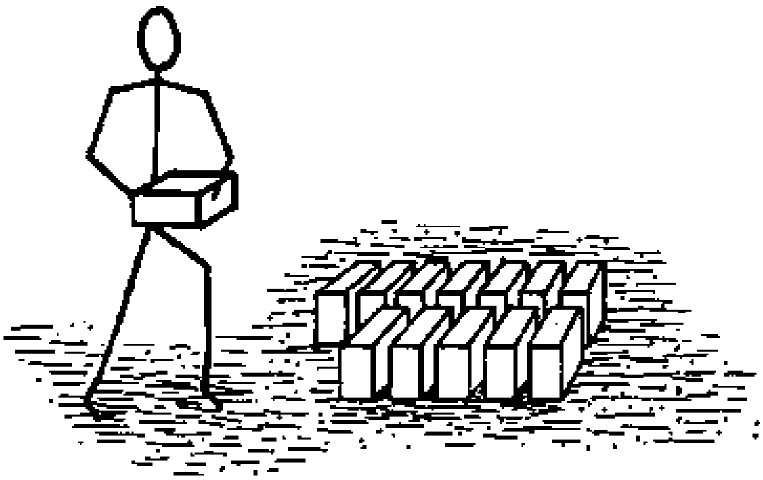


Fig. 1: DRYING FOR ONE DAY

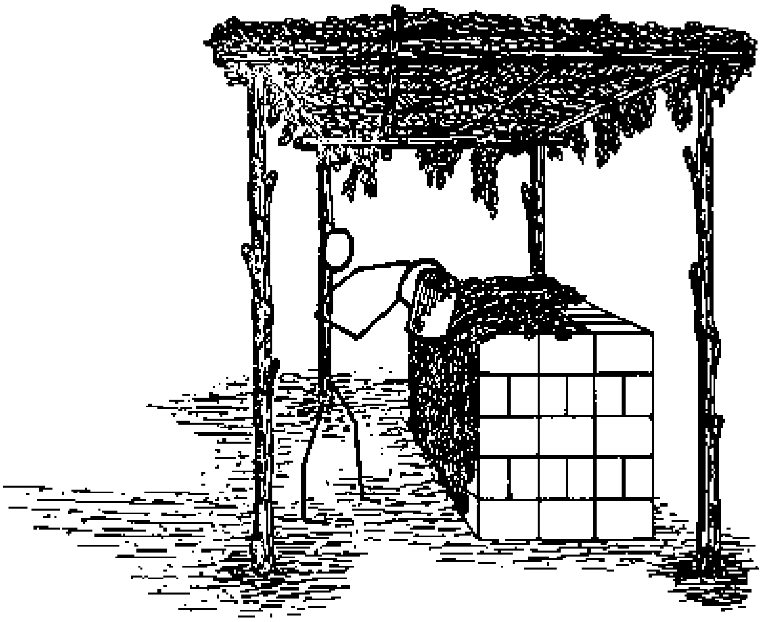


Fig. 2: STACKING FOR FURTHER CURING

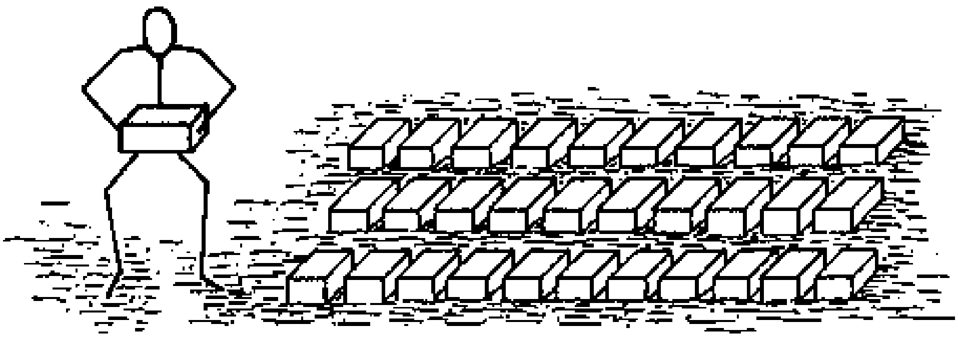


Fig. 3: BLOCKS WITHOUT CEMENT − SUN DRYING

− CURING: This is the term originally used to describe the chemical change in glues when they set, meaning when they become strong and hard.

As far as cement products are concerned, curing simply means the after−treatment of any of those products.

If the blocks contain cement, we talk about "curing". If the blocks don't contain cement, we talk about "sun−drying".

The blocks with cement must now be cured for about two weeks while the cement sets. It is important to follow the directions for curing. If you do not, the blocks may be weak and full of cracks, and therefore unusable for building.

a − Remove the block from the block press, holding it carefully.

b − Place it on leaves, grass or boards on flat ground. The block should not touch the ground (Fig. 1).

c − The blocks should be under shelter or covered with something so that they are out of the rain and sun for at least the first day.

d − Let the blocks dry like this for one day.

e − After one day the blocks are a little stronger so that they can be stacked for further curing.

Stack the blocks on boards or on very flat, hard ground up to five blocks high. Place them so that they touch each other. Make the stacks under a cover if possible, to keep them out of the sun (Fig. 2).

f – The blocks must be kept moist by sprinkling water on them twice a day. Put grass or leaves on top to help keep them moist (Fig. 2).

g – After two weeks of watering the cement has set properly and the blocks can dry completely. They are now ready for use.

Blocks without cement simply need to be dried in the sun. Let the blocks dry in the sun for two weeks; then they are ready for building (Fig. 3).

NOTES:

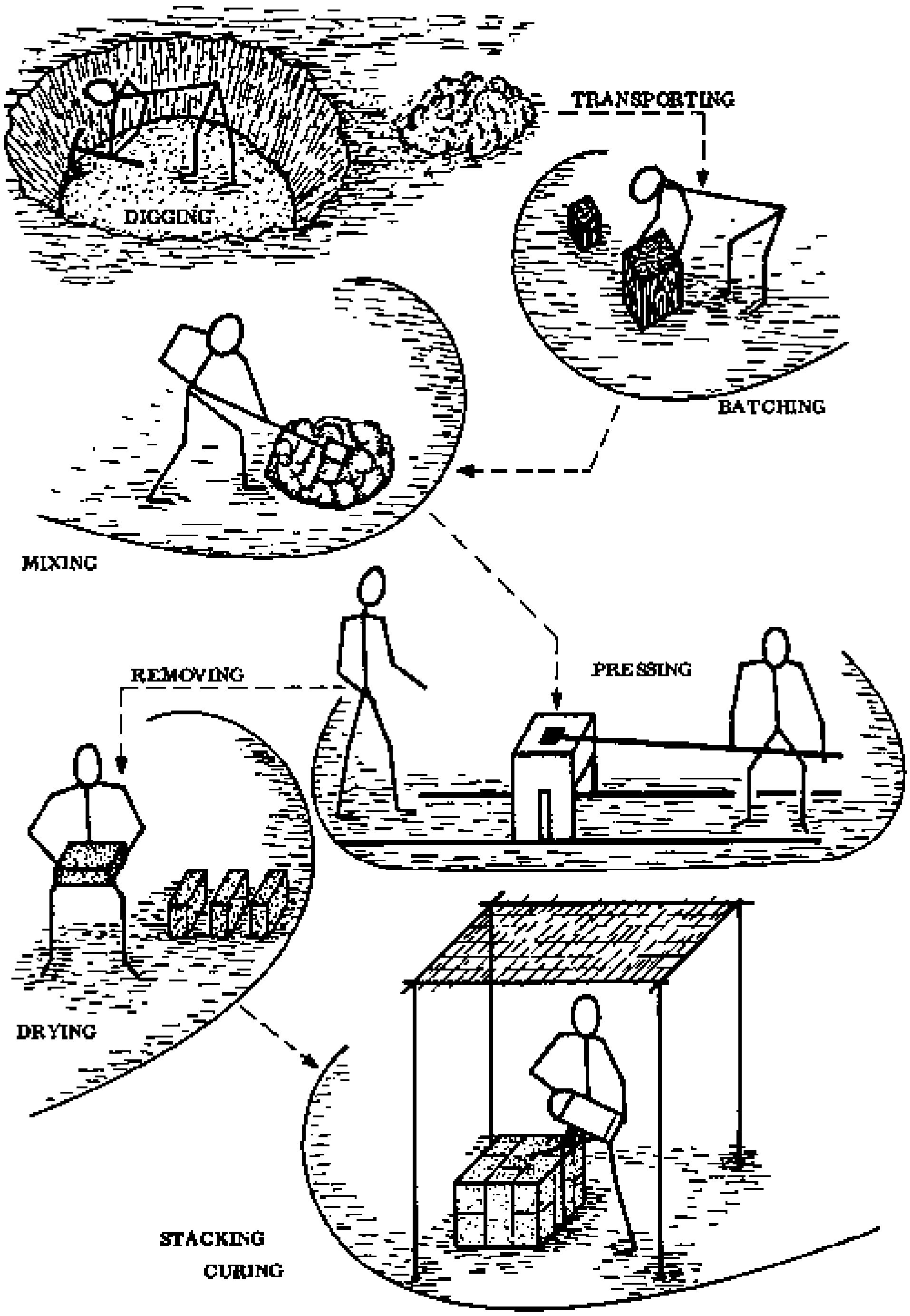


Fig. 1

PLANNING THE WORK

– PLAN OF OPERATIONS: Good planning can make the work of block–making go faster and easier.

The places where the different steps are carried out should be as close to each other as possible, so that there is a continuous step by step flow of laterite from the soil pit to the finished wall. The soil and blocks should be transported as little as possible.

If there is more than one building to erect, some operations can be moved.

There should be a smooth flow (Fig. 1) of:

a – digging
b – transporting
c – batching
d – mixing
e – testing
f – filling
g – pressing
h – raising
i – removing/drying
j – stacking/curing
k – walling up

You can make a layout like the one in the picture (Fig. 1) or you can lay out the operations in a straight line; or anything in between, whatever suits you and the situation best.

Several factors can be important in deciding what sort of digging pits you will have. If the good soil goes deep, all the soil can come from one pit. However such a large pit might be ugly and undesirable; several small pits could be a better solution in some cases.

The possible future uses of the pits should also be considered. They could form a part of a drainage system, a water storage tank, a sewage pit, a soak–away, and so on. This of course, provided that the planning is done beforehand.

NOTES:

<table>
<tr><th colspan="7">NUMBER OF MEN</th><th>KIND OF ACTIVITY</th></tr>
<tr><td rowspan="8">ONE MAN ONLY</td><td rowspan="5">1</td><td rowspan="2">1</td><td rowspan="2">2</td><td>2</td><td>3</td><td>4</td><td>DIGGING</td></tr>
<tr><td>2</td><td>2</td><td>3</td><td>TRANSPORTING</td></tr>
<tr><td rowspan="3">1</td><td rowspan="3">2</td><td rowspan="2">2</td><td rowspan="2">2</td><td>1</td><td>BATCHING AND TESTING</td></tr>
<tr><td>2</td><td>MIXING</td></tr>
<tr><td rowspan="2">1</td><td>1</td><td>1</td><td>FILLING AND OILING</td></tr>
<tr><td rowspan="3">1</td><td rowspan="3">1</td><td rowspan="3">2</td><td rowspan="2">1</td><td>1</td><td>PRESSING</td></tr>
<tr><td rowspan="2">1</td><td>1</td><td>RAISING OUT</td></tr>
<tr><td>1</td><td>2</td><td>REMOVING AND PLACING TO DRY</td></tr>
<tr><td>1</td><td>2</td><td>3</td><td>6</td><td>8</td><td>10</td><td>15</td><td>TOTAL MANPOWER</td></tr>
</table>

Fig. 1

Stacking, curing and transporting the blocks to the actual place of building can be done every morning by the soil diggers.

They can do this only if they have dug some soil in advance during the previous day, so that the rest of the workers have the materials to continue their operations of batching, mixing etc.

– LABOUR: From one to fifteen men can work on block–making. If there are plenty of workers, they should be organized to keep the block press going constantly, so it is used to maximum efficiency.

To do this, there must be a steady supply of soil–cement mix ready to put into the machine. Make the mixing platform big enough so that there is room for one pile of already mixed landcrete and one pile which is being mixed.

You can use the rough table at left as a planning guide to divide the labour, but experience will be the best guide (Fig. 1).

In any case the work should be divided so that everyone is busy all the time. If the block press filling worker has to stop and wait for prepared landcrete, he or another man should be switched to doing soil preparation.

Workers should relieve one another in their jobs every few hours to prevent boredom with the work. After a few days of such rotations, the workers will each become skilled and efficient at three or four of the different steps of block–making.

It is important to share the work fairly to keep up the morale and enthusiasm among the workers.

– NUMBER OF BLOCKS: You should know from the start approximately the number of blocks that will be needed for the building. This is necessary to be able to schedule the block–making, curing and building.

To find the approximate number of blocks to be made, you must know the size and plan of the building. Take measurements of the lengths of the walls and add these up to get a total. Multiply this wall–length by the total height from the plinth course to the top of the wall; this gives you the total wall area in square meters. This number, multiplied by 13, 5 (the approximate number of blocks per square meter) gives you the total number of blocks to be made.

– REMEMBER: Wall area in square meters × 13,5 = Number of blocks. (Also, see the Tables of Figures, pages 237 and 238).

NOTES:

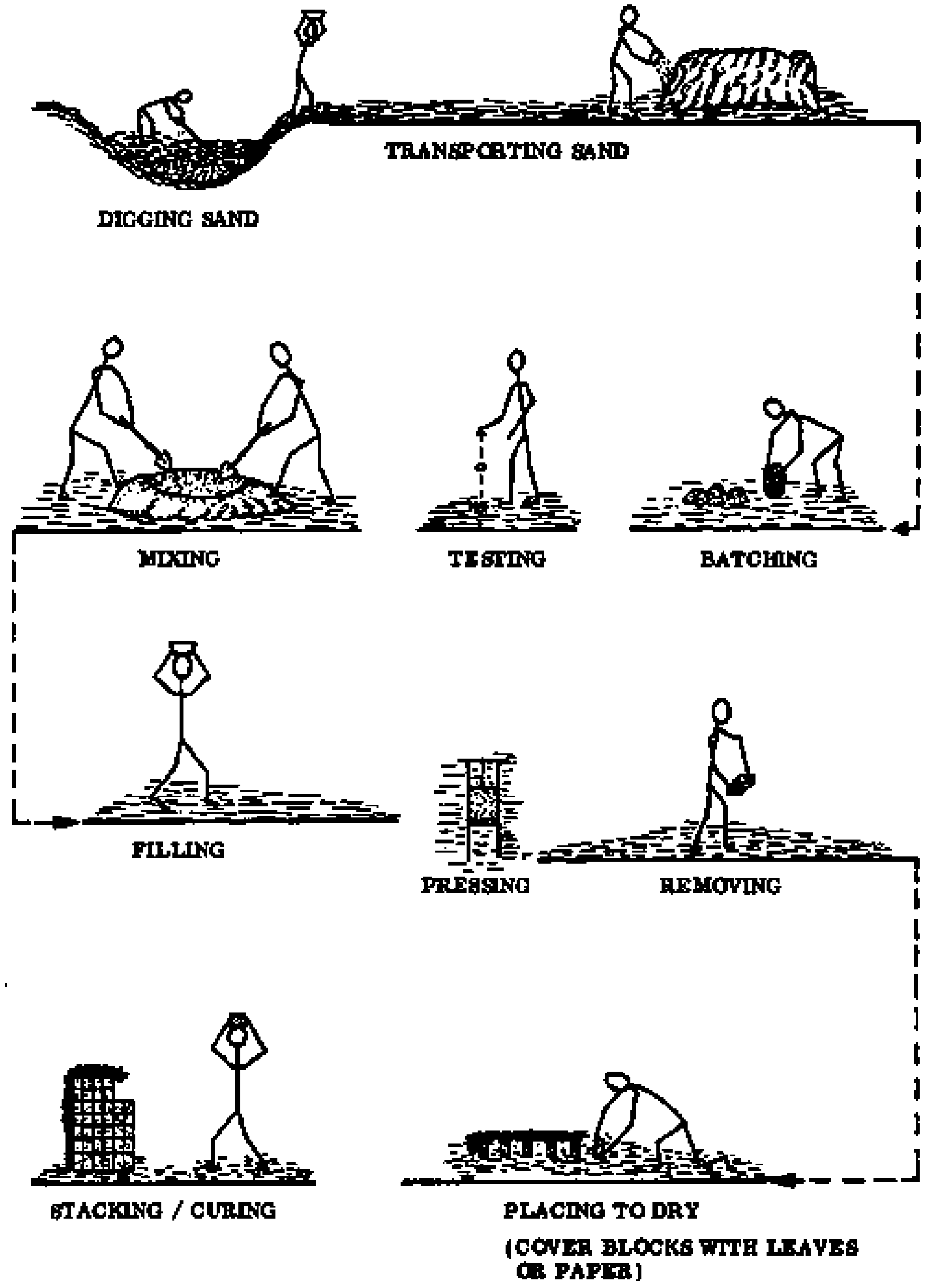


Fig. 1

SANDCRETE BLOCKS

The term sandcrete comes from "concrete" by replacing the first syllable "con" with the word "sand". This is done to make it clear that this building product contains only sand as an aggregate, and no stones. It can also be called "fine–grained concrete" but the new term sandcrete is preferred as it corresponds to landcrete.

A pallet is put into the mould box of the machine (see page 29) and the box is filled with a mixture of cement and sand; then the lid of the machine is used to compact the material to the required size (for proportions of the mix, see the Tables of Figures, page 234).

Unlike landcrete blocks, sandcrete blocks have to be made upon a pallet, as they are too soft to be carried when freshly made. Differently shaped blocks can be made with this machine by changing the height of the pallet or by using inserts.

MAKING THE BLOCKS

Making blocks with this machine is similar to making landcrete blocks.

a. Put one or more pallets into the mould box, according to how thick you want the blocks.

b. Half−fill the mould box with the ready mixed sandcrete.

c. Compact the corners with a piece of wood.

d. Fill the mould box completely and again compact the corners. Add a little more if necessary to fill the box flush to the top edge.

e. Compact the sandcrete by repeatedly banging the heavy lid on it, until the lid fits exactly in its lowest position. Sometimes the lid does not close properly because the mould box is too full. In this case, scrape off a small amount of sandcrete with your trowel and repeat the compaction. If you fail to do this the block will be wedge−shaped and difficult to set in the wall.

f. Open the lid wide and pull the handle to push the block out.

g. Remove both pallet and block at the same time and set them in place for hardening and curing.

− NOTE: Before use, the pallets must be soaked in water thoroughly, to prevent them from bending during the drying process. If this is not done the pallets will probably bend and crack the blocks.

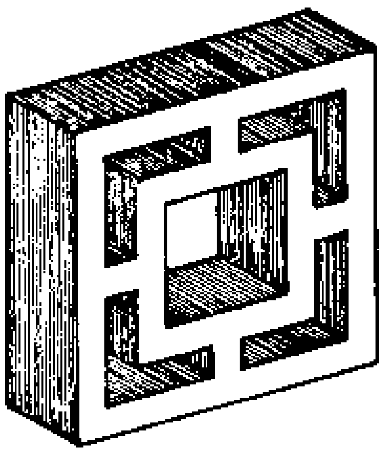


Fig. 1

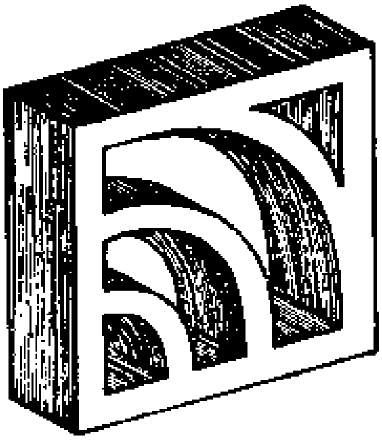


Fig. 2

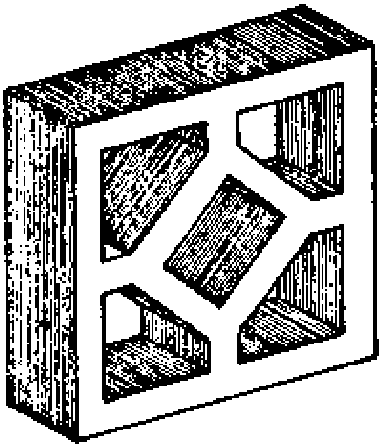


Fig. 3

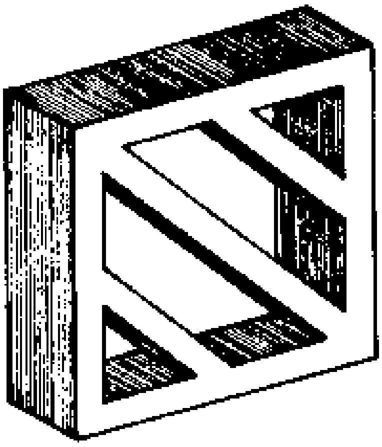


Fig. 4

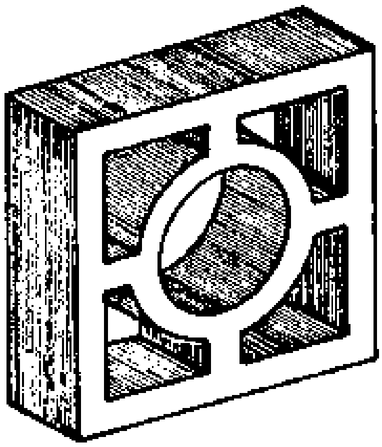


Fig. 5

PLANNING THE WORK

As in the plan of operations for making landcrete blocks (page 187), for sandcrete blocks also the speed and ease of the work depend on how well it is planned.

Fig. 1 on page 190 shows how the block−making can be planned.

DECORATIVE BLOCKS

Originally, a decorative block was understood to be a solid block with decorative textured faces. What we now commonly call decorative block is in fact part of a decorative openwork screen built into an opening. The correct term is "decorative grille" (also spelled "grill").

This kind of block is made in a special iron mould. It can serve several purposes:

- To give an attractive appearance
- To provide light without installing burglar−proofing or any kind of louvres, shutters, etc.
- To provide permanent ventilation without using ventilation blocks
- Or a combination of two or three of the above requirements.

The illustrations of blocks on the opposite page show that almost any design is possible, given a fertile imagination. Remember however that the strength of the blocks depends also on their shape (Figs. 1 to 5).

> − NOTE: To make it easier to empty the mould, short pins can be welded onto each corner at the top of the mould. This allows you to tap the pins gently on a hard, level surface; thus loosening the block from the mould (Fig. 6).

Drilling small holes into the bottom of the mould can also make it easier to remove the block. The holes allow air into the mould as the block comes out.

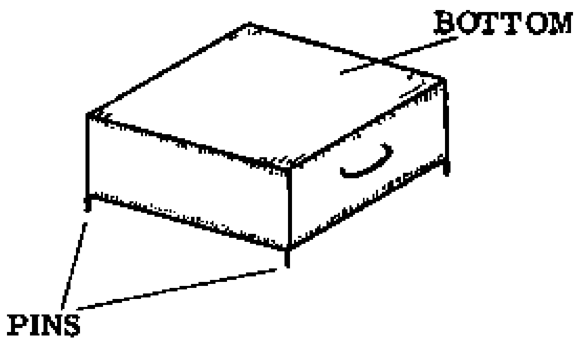


Fig. 6

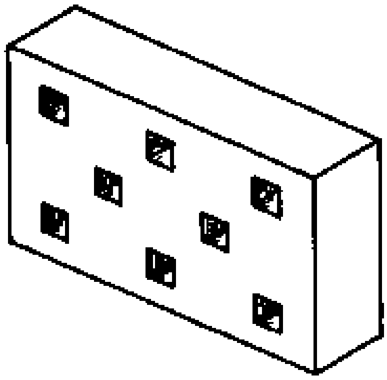


Fig. 1

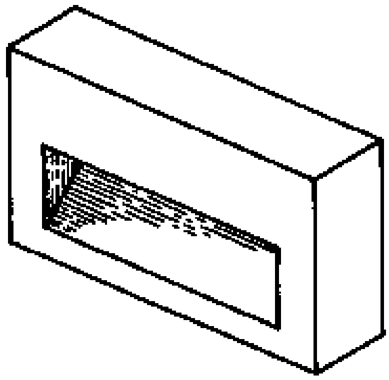


Fig. 2

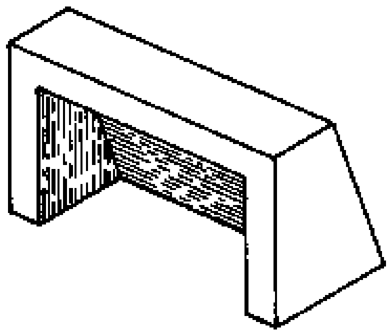


Fig. 3

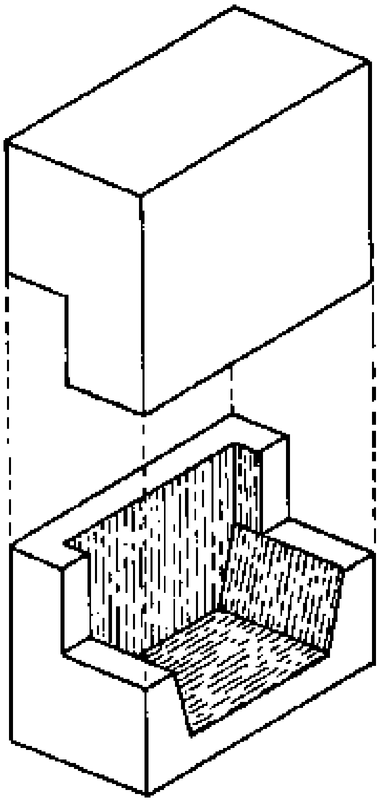
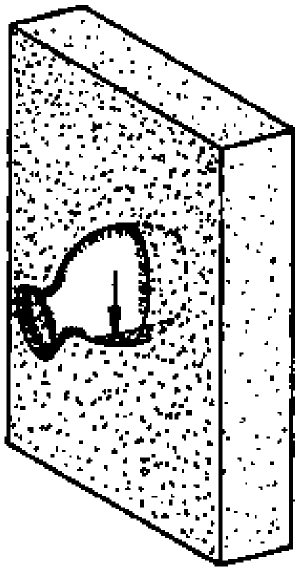


Fig. 4



INSIDE OF POT SHOULD
BE HIGHER SO THAT NO
WATER CAN BE TRAPPED
INSIDE (SEE ARROW)

Fig. 5

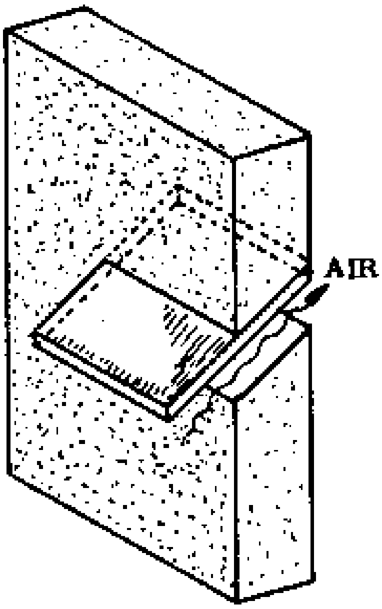


Fig. 6

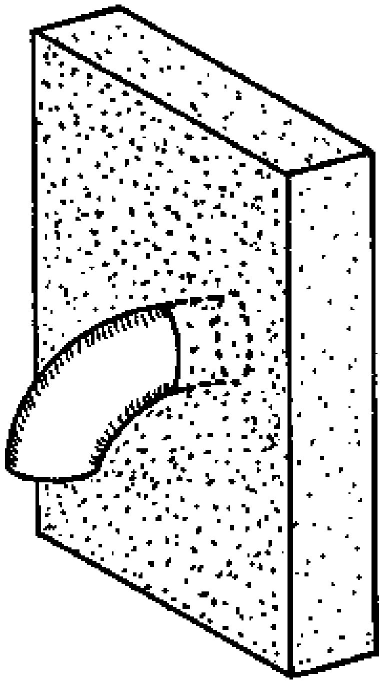


Fig. 7

VENTILATING BLOCKS

These are blocks which have an opening (or several openings) in them. They are used to ventilate rooms, stores, the spaces above ceilings etc.

There are various types of ventilating blocks. Some are designed to keep out rain, others include mosquito–proofing or a decorative front face (Figs. 1, 2 & 3).

In cases where a maximum amount of ventilation is desired, it is advisable to make a ventilating unit which is constructed out of two identical halves (Fig. 4). The inside of this unit can be painted in a bright colour, to increase the amount of light inside the room.

Simply shaped blocks for ventilation can be made in the sandcrete block machine by inserting wooden blocks according to the desired shape.

More complicated designs usually require a specially made wooden mould. The advantage of this kind of mould is that any size and shape of block can be made.

Pre−cast sandcrete or concrete are not the only choices of materials for ventilating units. Local potters' skills in baking earthenware can be used and one can design ventilating units from clay. Existing clay shapes can be used, such as tiles and pots (Figs. 5 & 6) or new shapes can be invented (Fig. 7).

When designing these ventilating units keep in mind the direction of the driving rain. Make sure that the inside of the unit is higher than the outside, and that there is no place for water to become trapped inside the unit to make a breeding place for mosquitos (Fig. 5).

Apart from the above considerations, there is no limit to the imagination of the Rural Builder in designing different shapes and kinds of ventilating units.

NOTES:

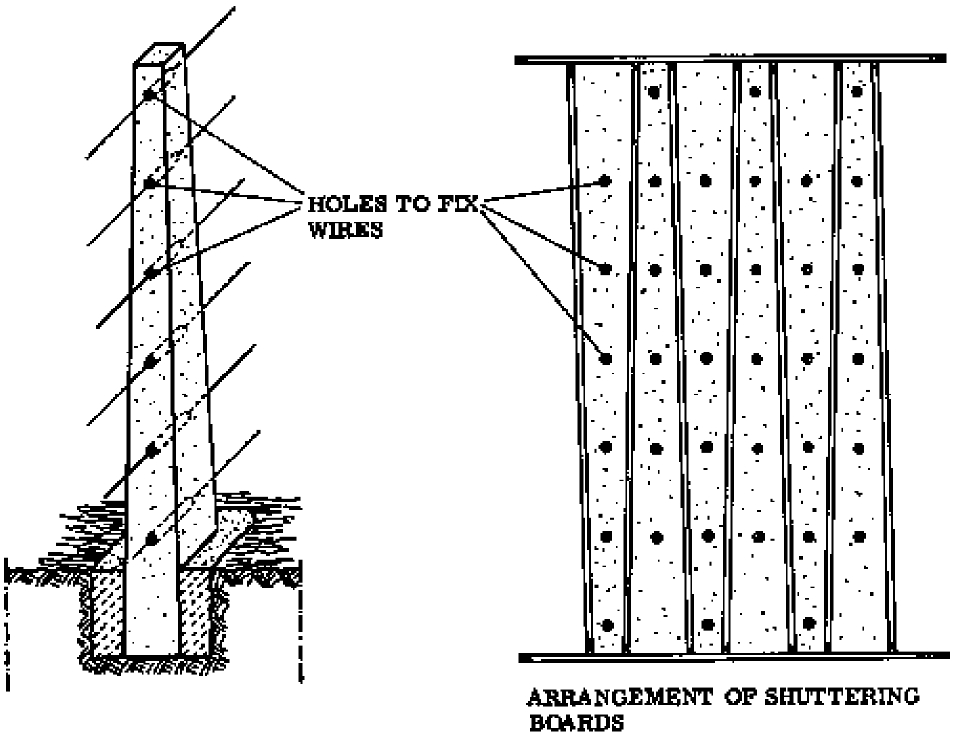


Fig. 1

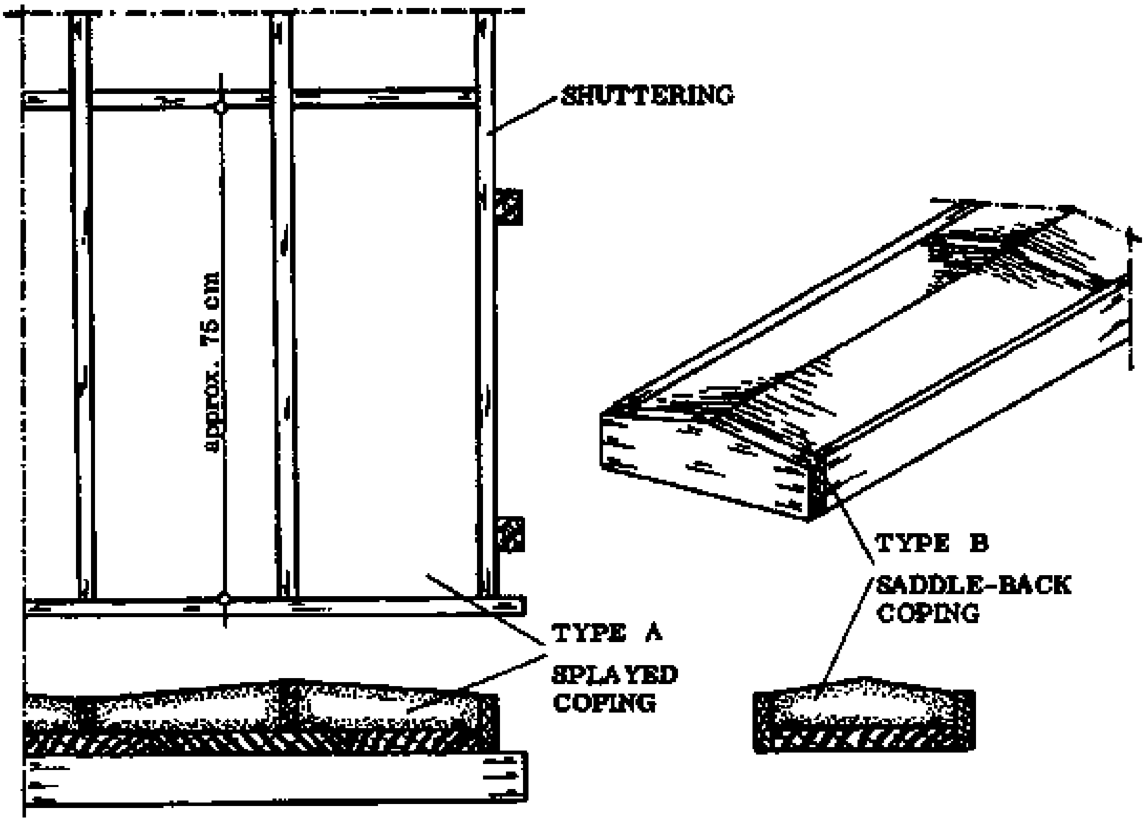


Fig. 2

PRECAST CONCRETE MEMBERS

Many of the components of a building are prefabricated. This means that they are made in advance at any time and place, and can be used for any building. The most common examples are the various sorts of blocks, plywood, roofing sheets etc.

In the same way, many reinforced concrete members of the structure can be made well in advance so that they are ready to be used as the construction proceeds and they are needed. These are referred to as "precast" members, as opposed to the "cast–in–situ" members.

Generally speaking, prefabricated construction is divided into two classes with regard to buildings:

a – Prefabricated units produced in a factory and transported to the building site
b – Units produced by the contractor in a yard next to the building site.

Since Rural Building is understood to be conventional building and not factory production, the first method does not apply to us.

It is becoming more and more common however for the contractor to prefabricate members near the building site, although the possibilities of this method are limited to small–scale applications.

In Rural Building the most frequently made precast concrete members are:

– REINFORCED CONCRETE LINTELS: These cannot exceed 1,5 m in their length, as otherwise they will be too heavy and impossible to set in place without using a lifting device.

– REINFORCED CONCRETE POSTS: For fencing purposes (Fig. 1).

– REINFORCED CONCRETE PILLARS: These should not be too heavy to be set up under rural conditions.

– CONCRETE COPINGS OR CAPPINGS: These are of various shapes, with or without reinforcement (Fig. 2).

– REINFORCED CONCRETE SLABS: Of limited size and thickness, used to cover manholes or to serve as draining boards in kitchens, etc.

NOTES:

PLANNING THE WORK

All the plans and if possible, detailed drawings must be available before you start to make precast concrete members. Careful planning, supervision and performance are all necessary in order to obtain the desired product.

– SAVING TIME: As soon as the required materials are available, a group of the workers can start production of precast concrete members. The earlier they begin the better, because the concrete needs to be cured for some time before it is used in the building. By the time the precast member, for example a lintel, is needed the curing process will be complete and the lintel can simply be set into place.

In contrast to the cast–in–situ method, this method allows construction to proceed without delays caused by waiting for concrete to harden; and without being hindered by shuttering and strutting. In this way the total construction time is shortened.

This time–saving can become very important, for example if the wet season is approaching and the building has to be done before that time.

– SAVING MATERIALS: Since precast concrete members can simply be made on levelled ground, there is no need for poles and braces or other strutting to hold up the shuttering. Curing is also made much easier.

In addition, the same formwork can be used repeatedly if several members of the same size and shape have to be made.

If there is no proper storage space for the cement on a job, it is better to precast as many members as possible; thereby using up the cement before it gets spoiled.

> – NOTE: The more time, materials and money you save, the happier your client will be. Not only that, but your reputation as a Rural Builder will grow in the eyes of the people around you and be appreciated in the society.

NOTES:

GLUE

Glue is a liquid which is used to stick materials together, particularly on wooden surfaces.

In Ghana's Upper Region, the Rural Builder cannot use glue very often, because of the problems caused by the difference in humidity between the dry and rainy seasons. Glue is sometimes applied to make joints stronger, but it should not be used alone. There must always be some additional fastening; either screws or nails. To rely on joints fastened simply with glue is asking for trouble.

Three points should be kept in mind when you use glue:

a – The parts to be glued have to be in close contact.

b – There must be a large area of contact for glueing.

c – End–grain does not glue well, so a joint which consists mostly of end–grain will be weak.

There are many different glues but in Rural Building we use only two kinds; synthetic glue and contact glue.

– SYNTHETIC GLUE: The most common synthetic glue is PVA (polyvinyl acetate) glue. It is a milk–white glue.

The parts to be glued should be clean and well–fitting. The parts are squeezed together immediately after the glue has been applied, and clamped together until the glue has set hard. The joint will have considerable strength after the glue has set for one hour. PVA glue is not waterproof. If the joint must be waterproof, special kinds of glue have to be used.

– CONTACT GLUE: This glue is used primarily to glue laminated plastics such as Formica or similiar materials to sheet materials.

The glue is spread evenly over both surfaces. A toothed spatula can be used for this purpose. After fifteen minutes the surfaces are pressed together. It is important to take care that the surfaces are exactly in the correct position when they are put together. Once the surfaces stick they cannot be separated again for adjustment.

Take care that no air is trapped between the two surfaces when they are glued, because afterwards it will be impossible to get the air bubbles out.

PROTECTIVE FINISHES

In Rural Building we have the following finishes which are applied on wood or masonry work:

– Oil paint	– Cement paint
– Synthetic paint	– PVA Emulsion paint
– White wash	– Varnish

OIL PAINT

The traditional type of oil paint has a vegetable oil base (linseed oil) and a pigment which gives it colour.

Oil paint is usually applied in three coats. Each coat is of a different composition and they cannot be mixed.

- Priming coat
- Undercoat
- Finishing coat

Follow the directions on the tin when using these paints. Oil paints can be diluted only with thinners, such as turpentine.

SYNTHETIC PAINT

Synthetic paints have a chemical base and a pigment. These paints dry more quickly than oil paints and they are more weather resistant.

Read the directions on the tin before using the paint.

WHITE WASH

White wash is often used for interior work. It is composed of lime and water and it is not water resistant. Its lack of water resistance and its poor wearing qualities make it inferior to emulsion paint as a finish for outside surfaces.

White wash is often used as a priming coat for emulsion paints. It fills in the pores in cement or plaster and makes the surface smoother so that less emulsion paint is needed.

After mixing the lime with water it is advisable to leave the white wash for a day to stand, to be sure that no more chemical reactions are taking place. Follow the manufacturer's directions on the label when mixing the white wash.

CEMENT PAINT

Cement paints are often used externally. They contain white or coloured Portland cement and are sold in powder form. This paint should be made workable with water only; when dry it forms a waterproof seal on the concrete or masonry.

PVA EMULSION PAINT

Polyvinyl acetate emulsion paint has a latex (rubber) base and a pigment for the colouring. This paint is used mostly for internal and external masonry work.

The latex paint can be diluted with water if necessary to improve its workability. The paint should be applied in thin layers and the directions on the label should be followed. Read them before you start work.

VARNISH

Varnishes are used to protect wood. There are two kinds of varnish: oil or spirit. Oil varnish can be used for external work. It is diluted if necessary with turpentine.

Spirit varnish is only used for internal work such as for furniture. This varnish is not very strong or water resistant. Spirit varnish can be diluted with commercial alcohol.

PAINTS AND VARNISHES: PURCHASING

Paints and varnishes are sold in containers of one or more litres. On each container there should be a description of how to apply the paint or varnish. There should also be a date stamped on the container, to indicate how long the paint or varnish will last (when it will be too old to use any longer).

NOTES:

PLYWOOD

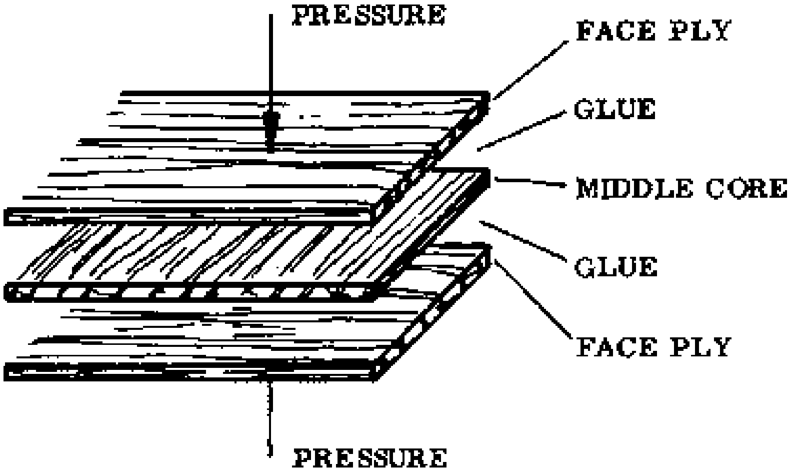
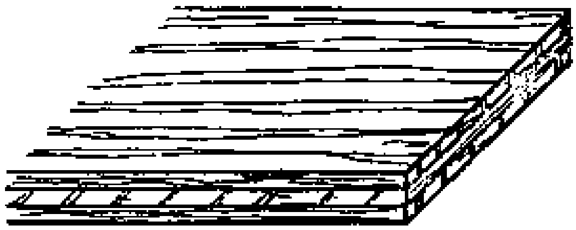
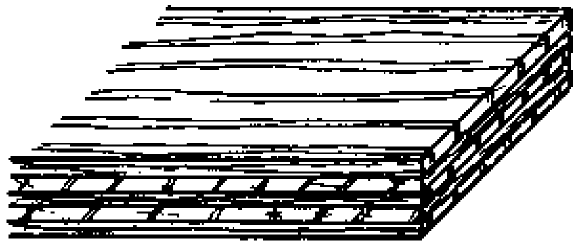


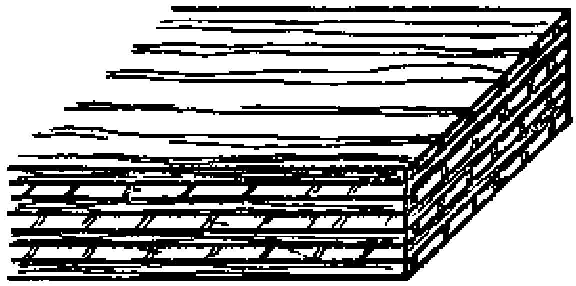
Fig. 1



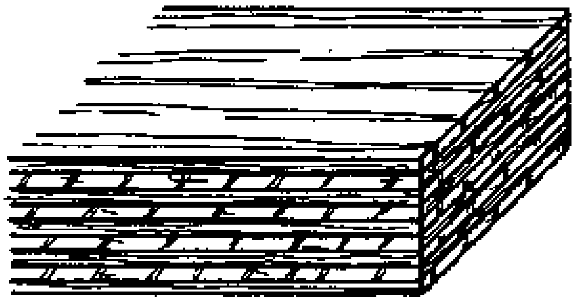
3-PLY-BOARD
Fig. 2



5-PLY-BOARD
Fig. 3



7-PLY-BOARD
Fig. 4



9-PLY-BOARD

Fig. 5

SHEET MATERIALS

Even as new and wonderful materials are becoming available to the Rural Builder, timber is still in very great demand. Wood is easy to work with, adaptable and durable when cared for properly.

Sheet materials manufactured from sawmill wastes are used more and more, both because they save money and because they do not have some of the problems with shrinking or splitting that affect natural materials.

The sheet materials we deal with in Rural Building are: plywood, blockboard, hard board, chip board and decorative laminated plastics.

PLYWOOD

Plywood manufacture is the oldest means of improving the properties of timber. Large sheets can be made, free from defects and unaffected by shrinkage and splitting.

The plywood is made by glueing together several thin layers, called plies or veneers, so that the grains of each run crosswise to its neighbours. There is always an odd number of plies so that the grains of the two outer layers run in the same direction. This is so that the plywood remains flat (Fig. 1).

Plywood is so useful because of its special properties:

– It is stable and will not expand or shrink like solid timber; however it will absorb moisture and may tend to curl as the surface layers expand a bit.

– It is very strong because of the crossed grain structure. Even the thinnest plywood cannot be split.

The number of plies can be from 3 to 9, making sheets which are 3 to 25 mm thick (Figs. 2 to 5).

NOTES:

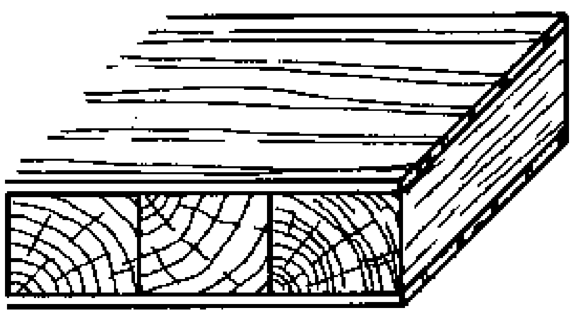


Fig. 1

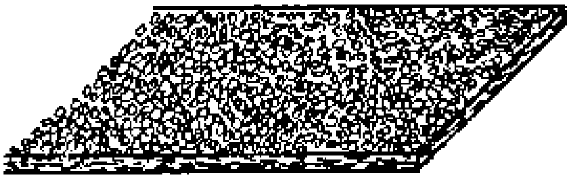


Fig. 2

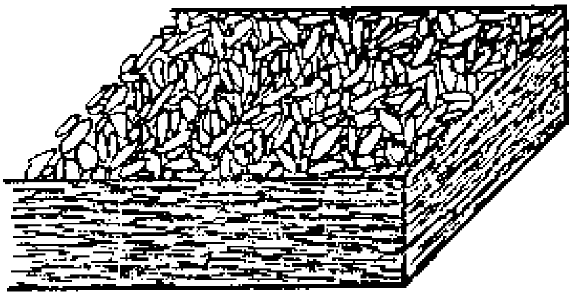


Fig. 3

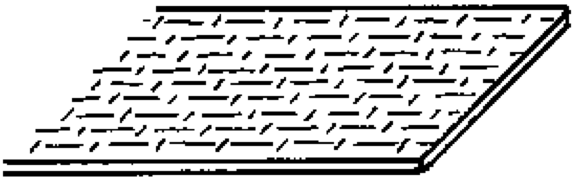


Fig. 4

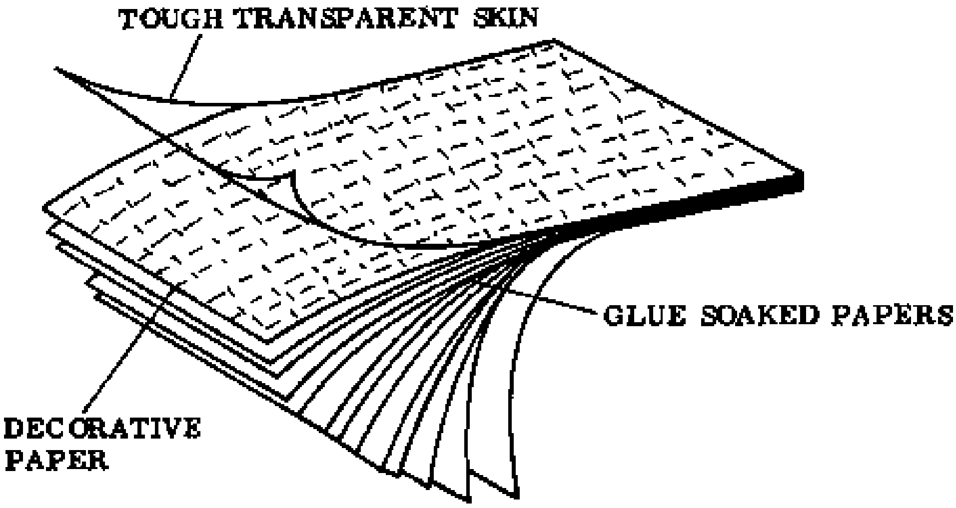


Fig. 5

BLOCK BOARD

This is a variation of plywood. A core of wood strips is glued together and faced with one or more veneers on each side (Fig. 1).

HARD BOARD

Low quality wood and wood wastes are ground and combined with water and glue to form a pulp. This mixture is spread between smooth aluminium sheets under great heat, forming a board. Hard boards have a smooth surface and a coarse side. They are available in thicknesses from 3 to 6 mm (Fig. 2).

CHIP BOARD

This is made from wood chips bonded together with glue. The chips are sorted, dried and mixed with the glue. Then they are spread on a plate and bonded with great heat and pressure. Chip boards are made in thicknesses from 6 to 60 mm (Fig. 3).

The edges of chip boards should always be protected, as they tend to split. This is done by glueing wood strips around the edges.

DECORATIVE LAMINATED PLASTIC

Laminated means consisting of a number of thin layers. Laminated plastics such as Formica (Fig. 4) are made by assembling many paper sheets soaked in glue. A decorative paper, also soaked in glue, is laid on top and over this is laid a transparent paper soaked in a very hard transparent glue which gives a tough surface. The assembled layers are placed between polished steel sheets and pressed at a high temperature (Fig. 5).

Decorative laminated plastics are durable, clean looking, smooth and attractive. They are made in a variety of patterns.

NOTES:

Fig. 1

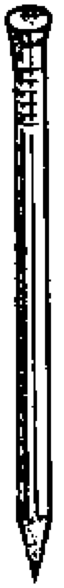


Fig. 2

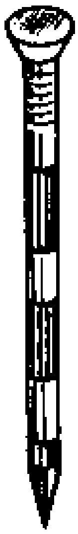


Fig. 3

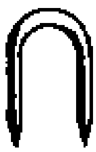


Fig. 4

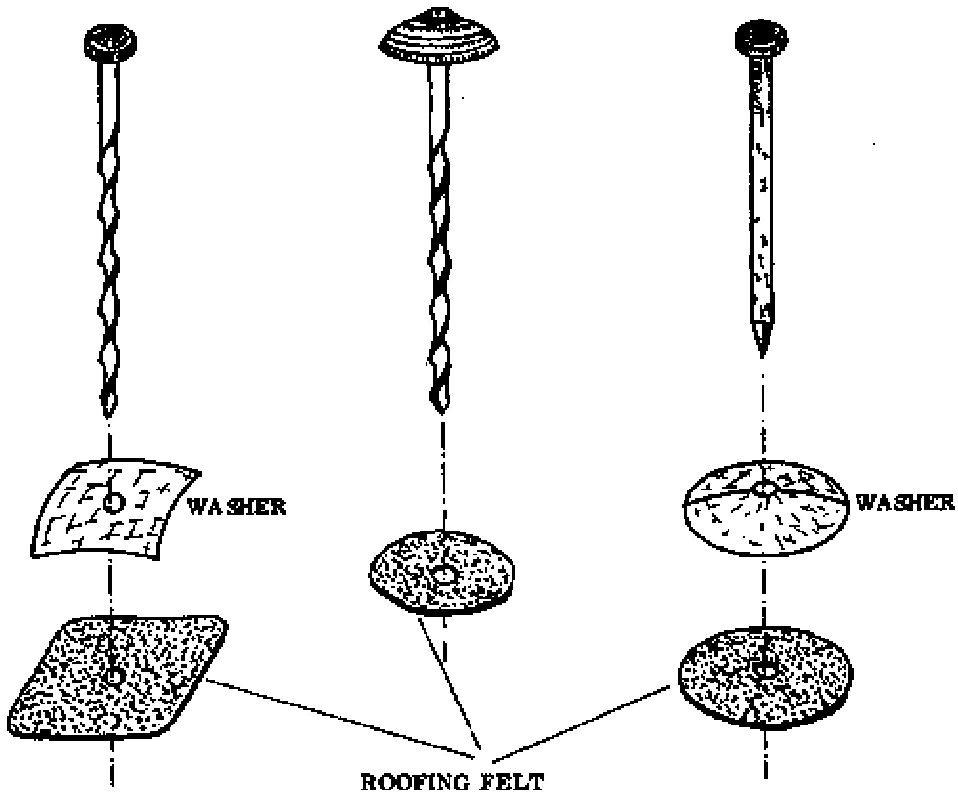


Fig. 5 – Fig. 6 – Fig. 7

WOOD FASTENINGS

NAILS

Nailing is a fairly strong, cheap and quick method of fastening wood (see Rural Building, Basic Knowledge, page 92).

Nails have a head, shank and point and are usually made from mild steel wire. Galvanized, copper−plated or aluminium nails are used for work which will be in contact with water.

In Rural Building we use mostly wire nails. We group these into two classes: wire nails with flat heads and wire nails with very small heads, known as lost head nails. Some nails are used for special purposes, like staples, concrete nails and roofing nails.

− WIRE NAILS WITH FLAT HEADS: These are nails with large flat heads (Fig. 1). The head prevents the fastened member from being pulled off over the head of the nail.

These nails are available in sizes from 7 to 310 mm long.

− WIRE NAILS WITH SMALL HEADS (LOST HEAD NAILS): These are wire nails with very small heads which can be punched or set below the surface of the wood and covered with putty. The disadvantage of this nail is that the nailhead can be easily pulled through the wood, so it cannot be used for heavy construction work (Fig. 2).

These nails are available in sizes from 7 to 100 mm long. Small lost head nails are called panel pins.

− CONCRETE NAILS: These are hardened steel nails, available in different shapes and sizes. They are used to fix things to concrete or masonry (Fig. 3).

− STAPLES: These are U−shaped nails (Fig. 4) with two points. They are used to fasten wires and screens to walls or timber.

– ROOFING NAILS AND WASHERS: Special roofing nails are used for fixing corrugated sheet materials. They should be aluminium or galvanized metal to prevent rust, which could cause the nailhead to break off. The nails must be long enough to go at least 2 cm into the wood.

Drive screws, or screw nails as they are sometimes called, are commonly used for roofing (Figs. 5 & 6) and they have largely replaced nails with plain shanks (Fig. 7). The drive screws are galvanized and the shank is 2 mm or more in diameter, with a steep thread around it.

Drive screws can be driven in with a hammer, but they are very difficult to pull out again.

There are different types: either with a metal washer already attached to the head of the nail (spring head roofing nail, Fig. 6, page 206), or with loose metal washers (Figs. 5 & 7, page 206)

The washers or the spring heads prevent the nails from being pulled through the roofing sheet. They should be thick and wide enough (at least 2 cm in diameter) so that they secure the sheets well.

Roofing felt is always used under the washer to prevent leaking. The felt should be larger in diameter than the washer. Place the washers correctly: the hollow side should face the roofing felt and the sheet.

ORDERING NAILS

When ordering nails, state the kind of nail; the thickness (in 1/10 mm) and the length (in mm). Also state the material of the nails.

Example: Lost head nails; 16 x 30; steel

NOTES:

SCREWS

After nails, screws are the next most common type of wood fastener used In Rural Building. Screws are superior to nails because:

- they have greater holding power,
- they cause less shock to the work when driven into it,
- and they are easily removed, without damage to the work.

Screws are made of mild steel, brass, copper or they are galvanized. Usually mild steel screws are used because they are stronger than the copper or brass ones.

The parts of a screw are: the head (a), the slot (b), the shank (c), the thread (d), the point (e) and the core (f) (Fig. 1, page 210).

Screws are classified according to the shape of their heads:

- Countersunk head screws (Fig. 1, page 210)
- Round head screws (Fig. 2, page 210)
- Raised countersunk head screws (Fig. 3, page 210)
- Coach screws (Fig. 4, page 210).

Posidriv or Phillips screws have a head which is not slotted across the full width like common wood screws. They have a cross–shaped recess into which a special screwdriver fits (see page 76).

– COUNTERSUNK HEAD SCREWS: The head of this kind of screw is flat on top and tapering underneath. The length is measured from the point to the top of the head (Fig. 1, page 210).

These are general purpose screws, used where the head of the screw must be flush with or below the surface of the wood.

– ROUND HEAD SCREWS: The head of these screws is round on top and flat underneath, and the length is measured from the underside of the head to the point (Fig. 2, page 210).

These are used only where the head can be visible and can project above the surface of the wood, and when fixing light metal, where the metal is too thin for countersinking.

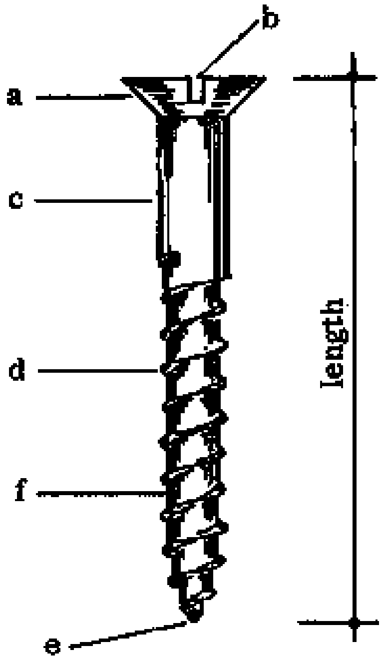


Fig. 1

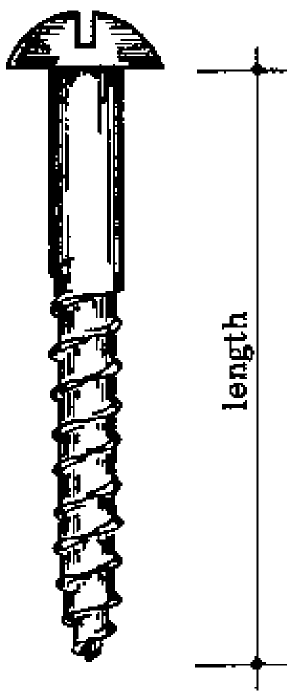


Fig. 2

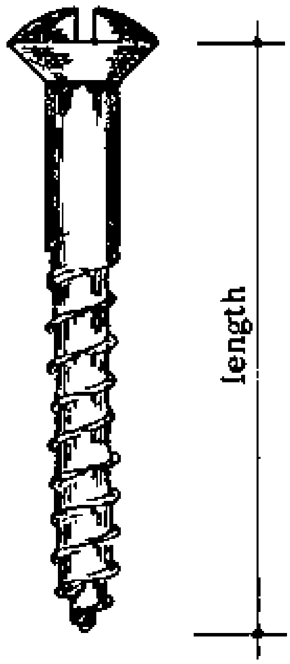


Fig. 3

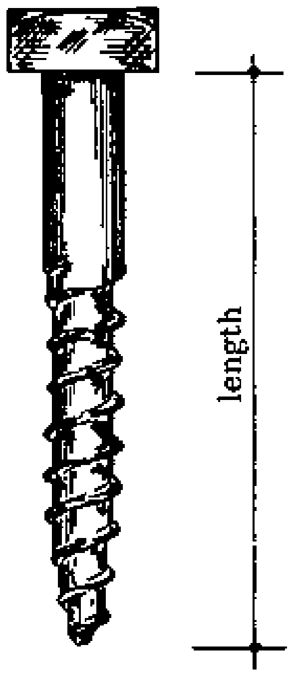


Fig. 4

– RAISED COUNTERSUNK HEAD SCREWS: The head of this screw combines the round and countersunk heads; round on top, tapering underneath. It is stronger than the round head screw because the head is less likely to break off. The length is measured as indicated in Fig. 3.

These screws are used in fixing heavy fittings and thick sheet metal, where strength is needed.

– COACH SCREWS: This is a strong screw with a square head. Unlike other wood screws, it is turned with a spanner. Always put a metal washer under the head to prevent damage to the wood surface. The length is measured from the point to the underside of the head (Fig. 4).

These are used for heavy construction work, for gate hinges, carriage work etc, where the head doesn't interfere.

ORDERING SCREWS

Screws are sold by number or in boxes containing a gross (144 screws). When ordering screws state the following in the order:

- – thickness in mm
- – length in mm
- – kind of screw
- – kind of metal
- – amount needed

For example: 3 × 30; round head; brass screws; 3 gross or,

5 × 50; coach screw, mild steel with washers; 2 gross.

NOTES:

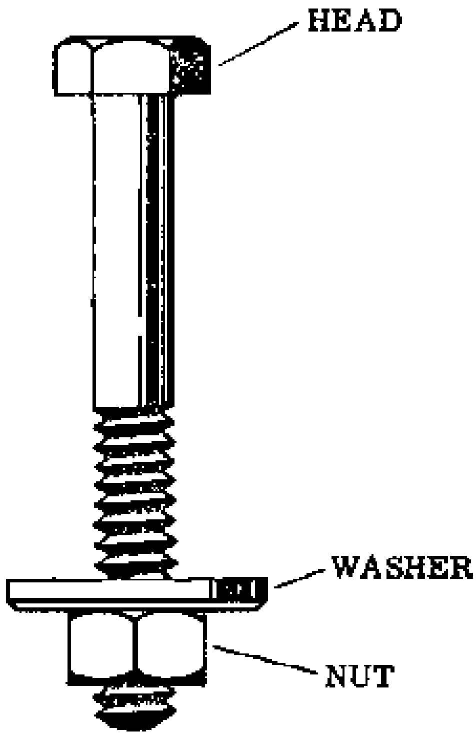


Fig. 1

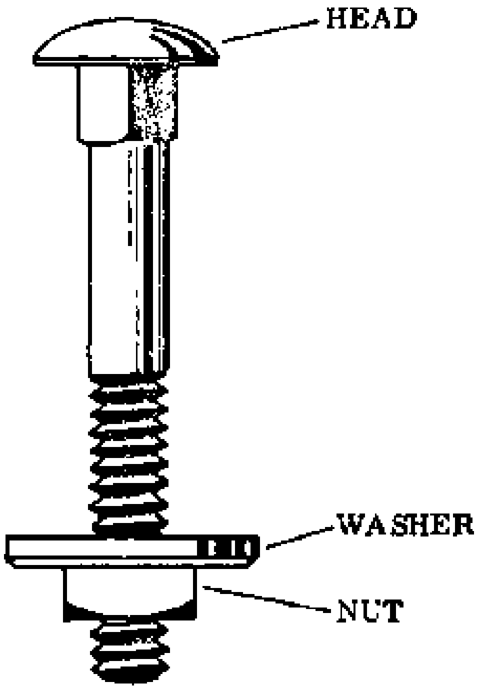


Fig. 2

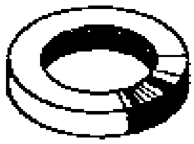


Fig. 3

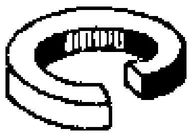


Fig. 4

BOLTS AND NUTS

Bolts and nuts are yet another means of fastening two pieces together. Bolts have hexagonal heads and are tightened up with the nuts. Bolts and nuts are used for heavy construction work (Fig. 1).

If bolts are used in timber, washers must be laid under the nut to prevent it from sinking into the wood (Fig. 3).

COACH BOLT

These bolts have oval heads and a square shank just under the head. This is so that the bolt grips the wood and doesn't turn when the nut is tightened up (Fig. 2).

The advantage of these bolts is that the head doesn't project up, since it is rounded and pulled into the wood.

WASHERS

A washer must always be used under the nut with both coach and regular type bolts. Never put a washer under the head of a coach bolt.

Washers can be made locally from a square piece of metal with a hole drilled in it.

SPRING WASHER

To prevent the nut from loosening when it is fastening metal to metal, a spring washer can be put between the metal and the nut. (Fig. 4).

NOTES:

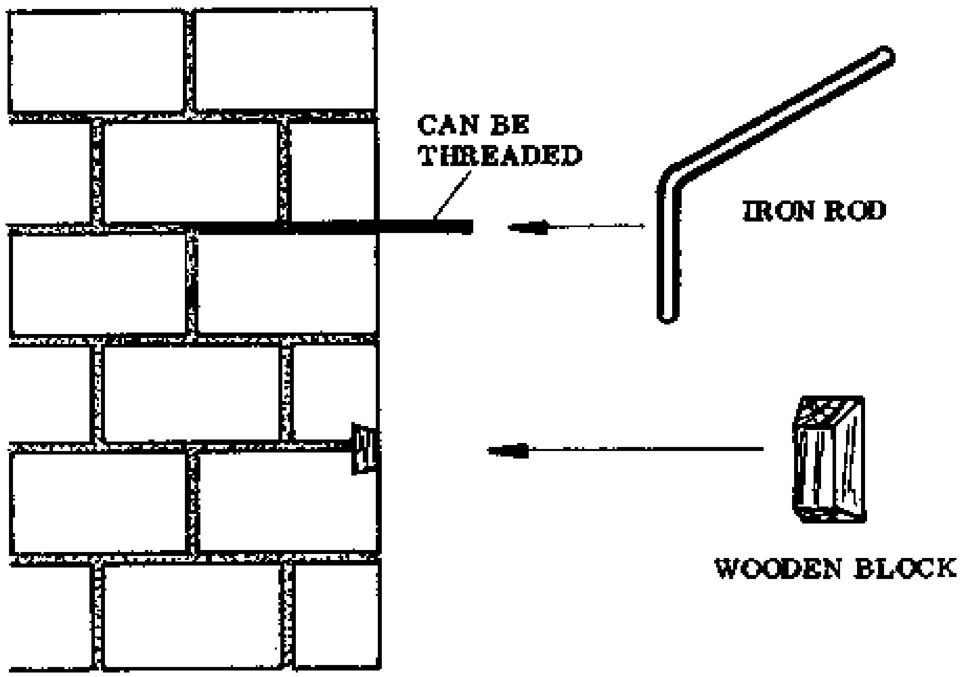
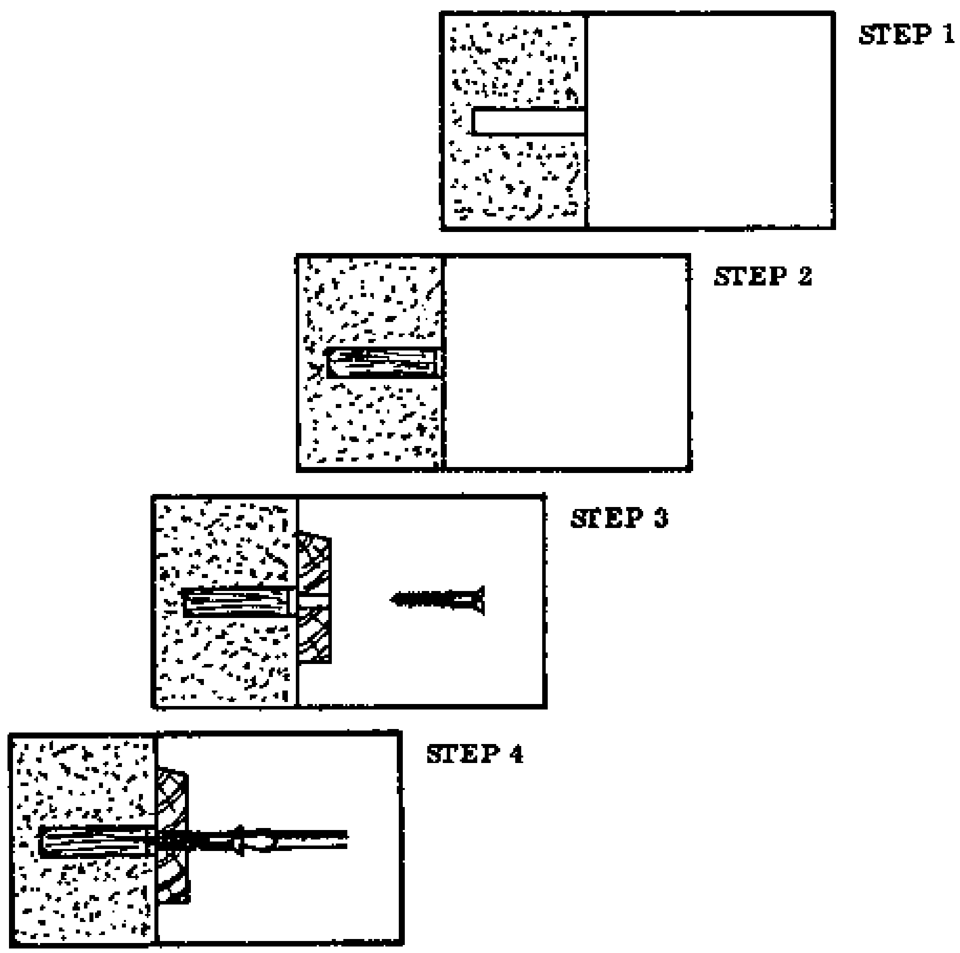


Fig. 1



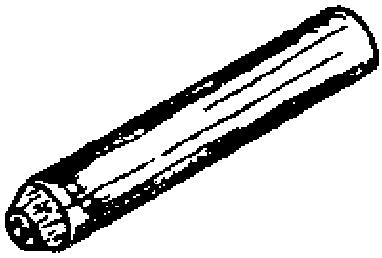


Fig. 2

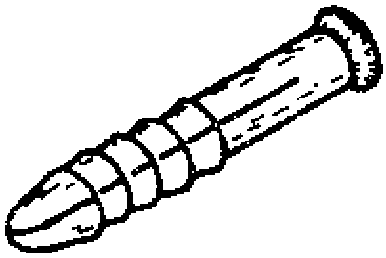


Fig. 3

ANCHORS

Fastening wood or other materials to concrete or masonry can be a problem. Often a screw will not hold in a landcrete block, or will not grip in concrete. Anchors can be used to solve this problem.

Anchors can be classed in two groups:

- anchors fixed during the initial construction and
- anchors which are fixed after the initial construction.

The first type of anchor can be an iron rod set into the wall during walling or casting, as is often done with the door frames. Threaded iron rods can be used, to receive a nut later on (Fig. 1).

Another way is to insert wooden blocks in the masonry; into which screws, etc. can be driven later. For maximum strength the wooden block should be dovetail shaped (Fig. 1) and it should be cut and fixed in a way that its shrinkage will have as little effect as possible on the wall.

The second group are the devices used to fix a piece to an already existing masonry or concrete work. The most simple of these is a wooden plug. A hole is chiselled or drilled into the masonry and into that hole is inserted a cylindrical plug of wood, which has the same diameter as the hole. The length of the plug should be a little less than the depth of the hole. The plug is made out of hard dry wood and the end which enters the wall is chamfered to enter smoothly. When a screw is driven into the plug, the wood will expand or even crack and the screw is wedged into position (Fig. 2).

More complicated devices, all sharing the same principle of holding a screw or nail by expanding, are now available. The most common one is a plastic plug (Fig. 3).

NOTES:

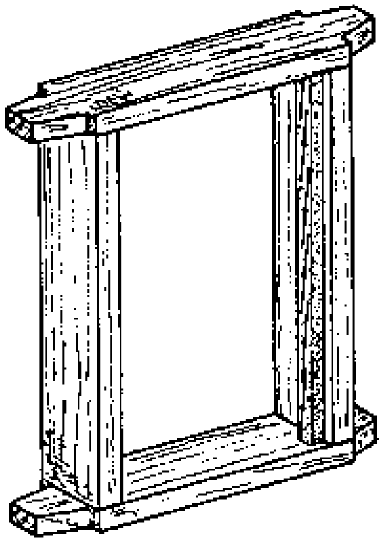


Fig. 1

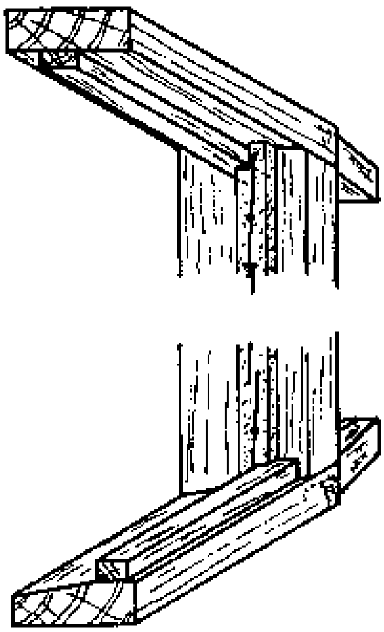


Fig. 2

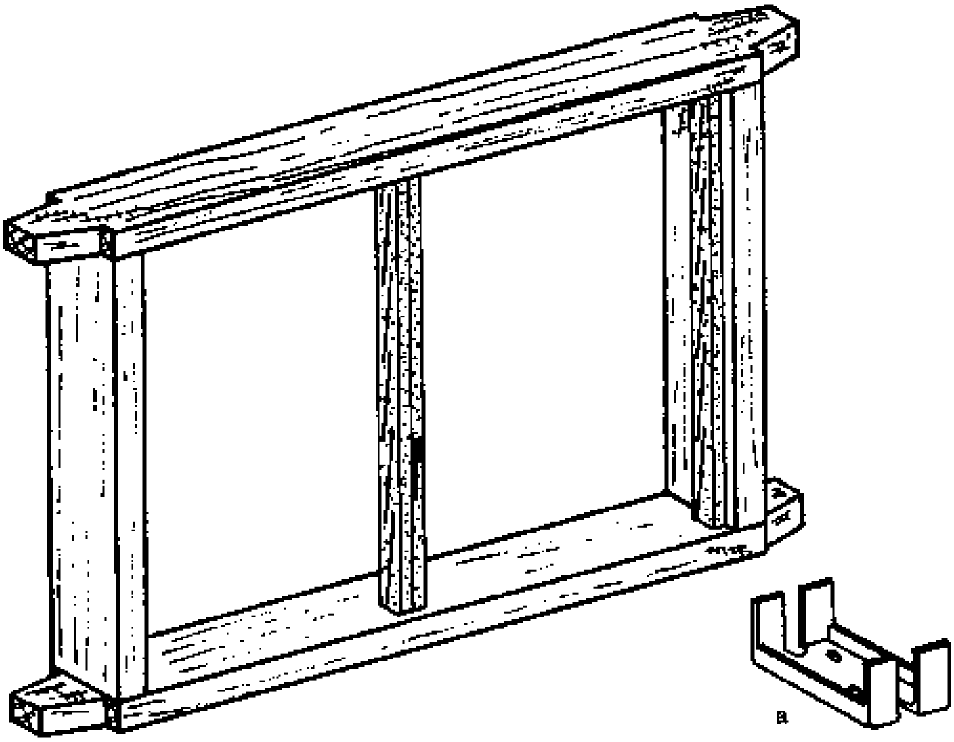


Fig. 3

DOOR AND WINDOW HARDWARE

LOUVRE WINDOWS

Windows with glass louvres are often used in the tropics because of their various advantages: they can be opened without any waste of space in the room and in the closed position they still admit light to the room. Their disadvantage is that it is very difficult to make them water−tight.

Louvre windows are installed ready−made into the window frame (Fig. 1). When the glasses are inserted in the window, wooden beads or ready−made aluminium waterbars are fitted to the head and cill to keep out dust and rain (Fig. 2).

In wide windows where two sets of louvres are installed in the frame, the metal posts of the louvre frame are fixed together in the middle, forming a metal mullion (Fig. 3). A separate wooden mullion is therefore not necessary. We will learn more in the Construction book (windows) about the installation of a self−mullioning louvre frame. Specially made mullion connectors are sold in a separate set (Fig. 3a).

Louvre windows are available in mild steel or aluminium frames. The aluminium frames need very little maintenance, but they are more expensive and less strong.

The size of the window frame is determined by the size and number of the louvre glasses. The inside width is:

− the length of the glass plus 3, 8 cm (the thickness of two frames).

If two or more louvres are set across the width of the window, then for each additional glass 3, 8 cm, plus the glass length must be added to the inside width of the frame.

The inside height of the window frame is determined by the number of louvre glasses.

Inside height (in cm) of window frames according to the number of louvre glasses:

No.	2	3	4	5	6	7	8	9	10	11	12	13	14
Ht.	30,5	44,5	58,4	72,4	86,4	100,3	114,3	128,3	142,2	156,2	170,2	184,2	198,1

All the above measurements are for 6 in. (15 cm) glasses. If you have other sizes, follow the manufacturer's instructions.

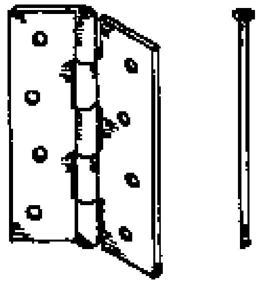


Fig. 1

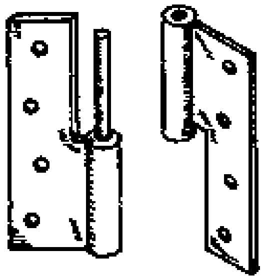


Fig. 2

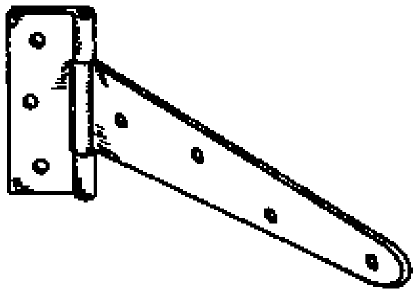


Fig. 3

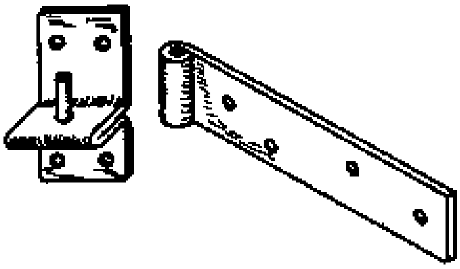


Fig. 4

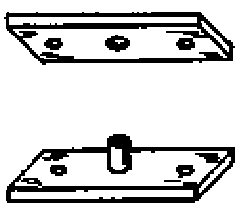


Fig. 5

HINGES

Hinges are available in almost countless different shapes, sizes and materials. The most common materials are steel, brass, and copper; or sometimes the hinge is only plated with brass or copper.

In Rural Building, we deal only with the most common types of hinges, which are butt hinges, H−hinges (Parliament hinges), T−hinges, band−and−hook hinges, and pivot hinges.

− BUTT HINGE: The ordinary steel butt hinge is cheap and durable, and it is the most common hinge for doors and casements (Fig. 1). It consists of two halves, also called leaves or flaps, held together by a pin. The pin may be removable or permanently fixed. If the pin can be removed from the outside when the door is shut and locked, the door is not burglar−proof.

When the door is shut, the two leaves (one attaches to the door post and the other to the hanging stile of the door) are folded together. The leaves are usually set into recesses in the door and post.

− H−HINGE (PARLIAMENT HINGE): The H−hinge, sometimes called the Parliament hinge, is similar to the butt hinge. It consists of two leaves, each with a knuckle. The pin is set permanently into the knuckle of one leaf. The H−hinge is installed in the same way as the butt hinge (Fig. 2).

− T−HINGE: T−hinges are mostly used for large and heavy doors, gates and ledged and battened doors. They are available in different sizes.

The hinge (Fig. 3) consists of a long mild steel strap, which is fixed to the outside of the door; and a cross bar which is hinged to the strap and attached with screws to the post of the door frame.

For security reasons, the strap of the T−hinge should be fixed to the door with at least one coach bolt, so that no one can unscrew the hinge to enter the building.

NOTES:

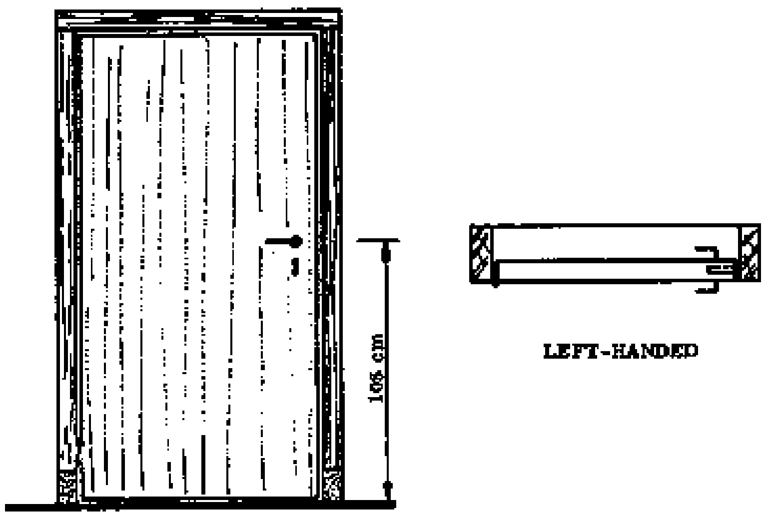
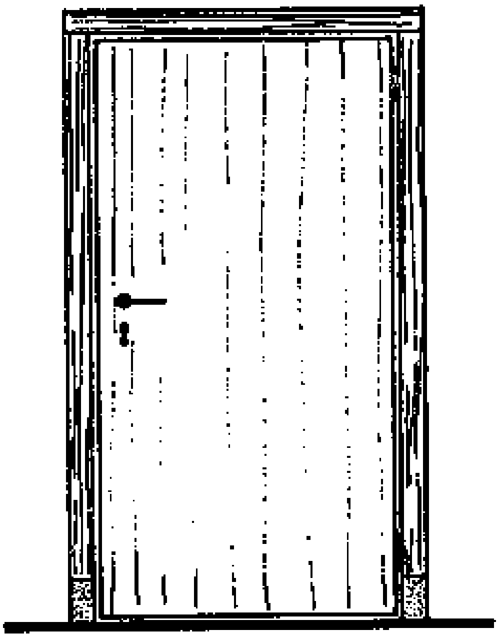
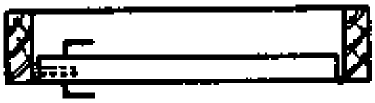


Fig. 1





RIGHT-HANDED

Fig. 2

– BAND–AND–HOOK HINGE: The band –aid–hook hinge is closely related to the T–hinge. It consists of an iron strip called the band, which drops onto a pin called the hook, which is attached to the frame of the door or window (Fig. 4, page 218).

They are used and installed in the same way as T–hinges.

– PIVOT HINGE: For windows, we sometimes use pivot hinges. These consist simply of a plate with a pin, which fits into a hole in another plate (Fig. 5, page 218).

LOCKS AND FITTINGS

There are many kinds of locks and fittings available for doors and casements. The choice between them depends on the type of door or casement and its function.

Doors and casements may be either left or right–handed. When the door opens towards you with the hinges on the left, it is a left–handed door (Fig. 1); if the hinges are on the right, the door is said to be right–handed (Fig. 2).

Some types of locks can be used on only one type of door, either right or left–handed. Therefore, we have to know whether the doors are right or left–handed before we order the locks, so we can buy the correct ones. Some types of locks have a latch bolt which can be changed to work in either type of door.

The most common types of locks are:

- the mortice lock
- the rimlock
- the padlock

The most common types of fittings are:

- the hasp and staple
- the barrel bolt
- the tower bolt
- the casement fastener

Locks are normally fixed at a height of 105 cm, measured from the floor to the centre of the handle (Fig. 1).

NOTES:

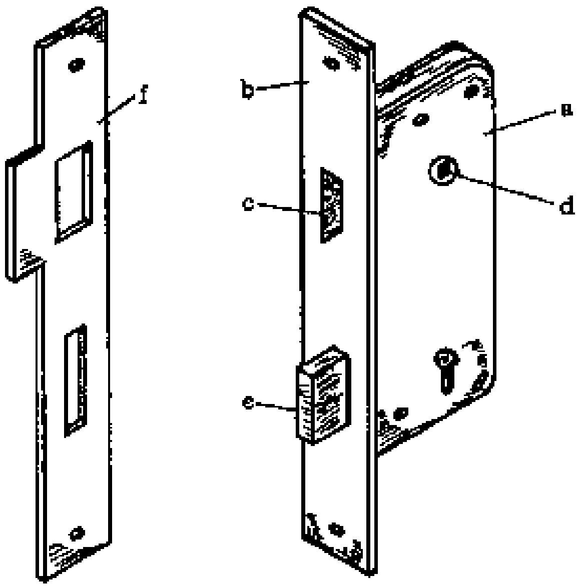


Fig. 1

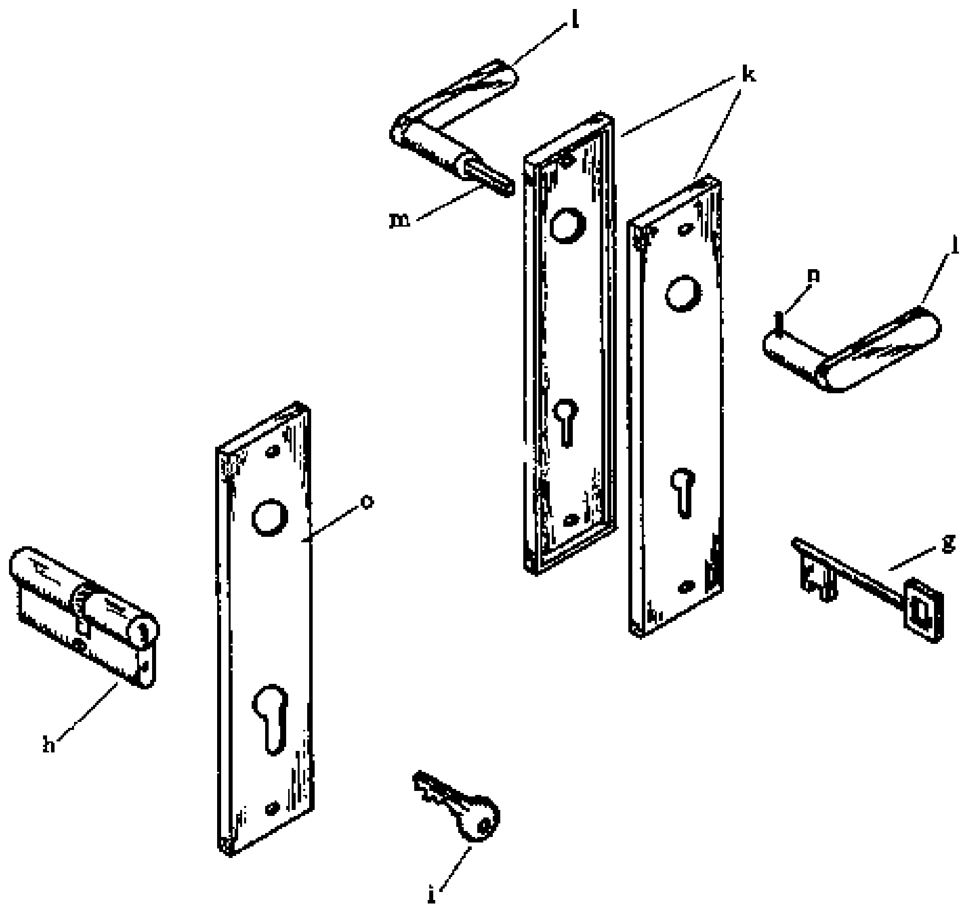


Fig. 2

– MORTICE LOCKS: Mortice locks (Fig. 1) consist of a stock (a), faceplate (b) and the latch bolt (c) moved by the handle. The handle fits into the bush (d) and there is a lock bolt (e) moved by the key. The two bolts fit into holes in the striking plate (f) which is attached by screws to the door post.

As the name suggests, the mortice lock fits into a mortice in the edge of the door. The stock should fit tightly against the sides of the mortice so that the door itself takes the strain, not the screws which only hold the lock in position.

Mortice locks can only be installed in doors which are thick enough to receive a mortice. They are difficult to force open, since they are inside the door.

Mortice locks are locked either with an ordinary key (g), which moves small levers inside the stock to push the lock bolt in and out, or with a locking cylinder (h), which operates the locking mechanism inside the stock. The advantage of the locking cylinder is that it is more secure, since a special key is needed to open and lock it (i).

– DOOR FURNITURE FOR MORTICE LOCKS: The door furniture (Fig. 2) consists of two leaf plates (k), two handles (1) and a spindle (m). The spindle is permanently fixed in one handle and secured in the other by a pin (n). The handle with the pin should always be inside the door, so that the pin cannot be loosened from the outside.

The leaf plates are attached to both sides of the door with screws; or better, with specially made bolts which cannot be torn out easily. The leaf plates hold the handle in place and prevent damage to the keyhole. Sometimes separate leaf plates are used for the keyhole and the handle.

The leaf plate for a mortice lock with a cylinder (o) has an opening into which the locking cylinder fits, instead of a keyhole.

NOTES:

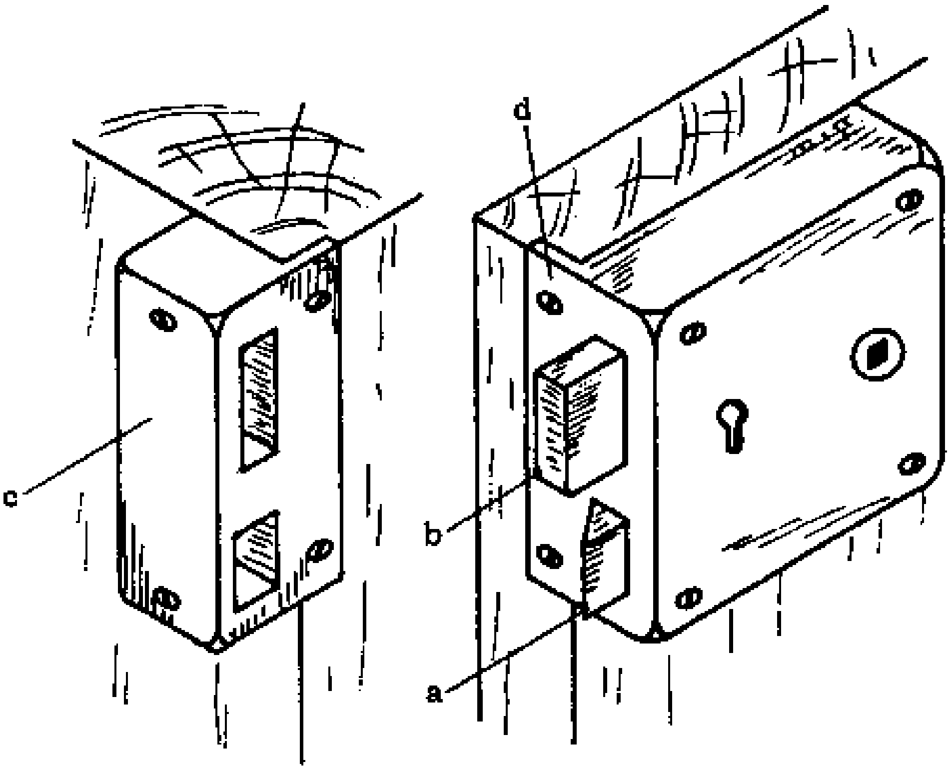


Fig. 1

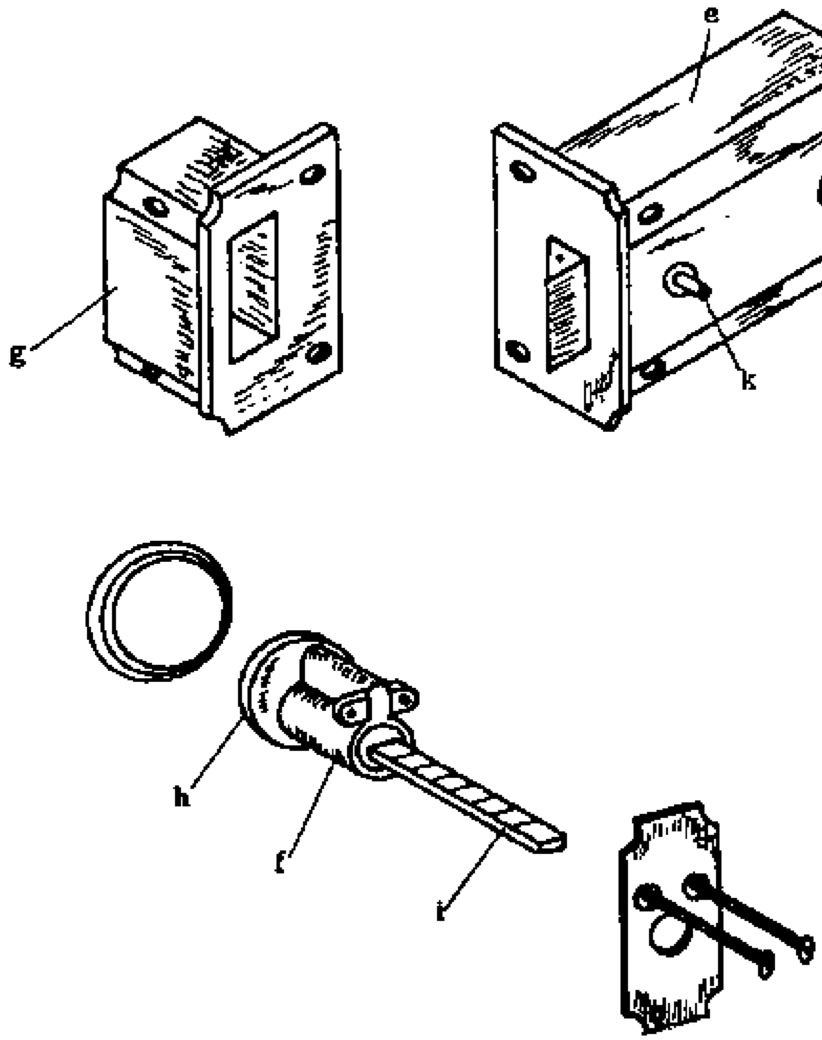


Fig. 2

– RIM LOCKS: Rim locks (Fig. 1) have a latch bolt (a) operated by a handle and a lock bolt (b) operated by a key from the outside or inside of the door. This kind of lock is attached with screws to the inside face of the door and the bolts shoot into a staple (c). There is a face plate (d) which is attached with screws to the door edge.

On the outside of the door, two round plates are attached with screws, one to hold the handle and the other to cover the keyhole. The handles have a square spindle which fits into the bush of the lock.

These locks are used on doors which are too thin to have mortice locks installed in them. Like the mortice lock, the rim lock is available with either an ordinary key locking system or with a locking cylinder.

– CYLINDER RIM NIGHT LATCH: This is a special kind of rim lock. It consists (Fig. 2) of a latch (e), a locking cylinder (f) and a staple (g). There Is a face plate (h) which is part of the shell of the cylinder. The spindle (i) is fixed in the cylinder.

The latch bolt is operated from the outside by a key which rotates the spindle. The spindle moves the bolt mechanism inside the latch.

The bolt may also be shot back from the staple by turning the knob (j) of the latch from the inside. The locking arm (k) is used to fix the bolt in place, so that it cannot be operated from either side by the key or the knob, making the lock more secure.

– PADLOCKS: Padlocks have a ring which locks into a body. The locking mechanism can be either a lever mechanism or a locking cylinder, as with the mortice lock.

NOTES:

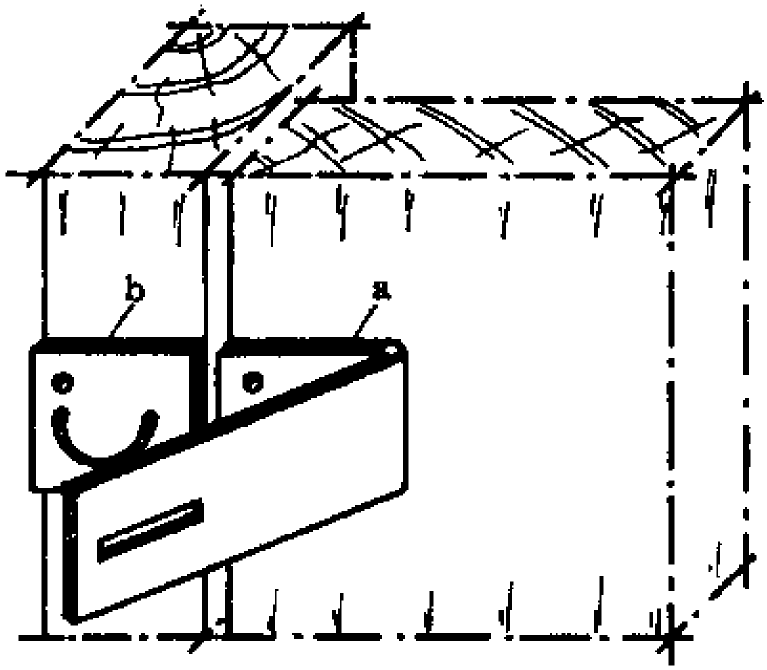


Fig. 1

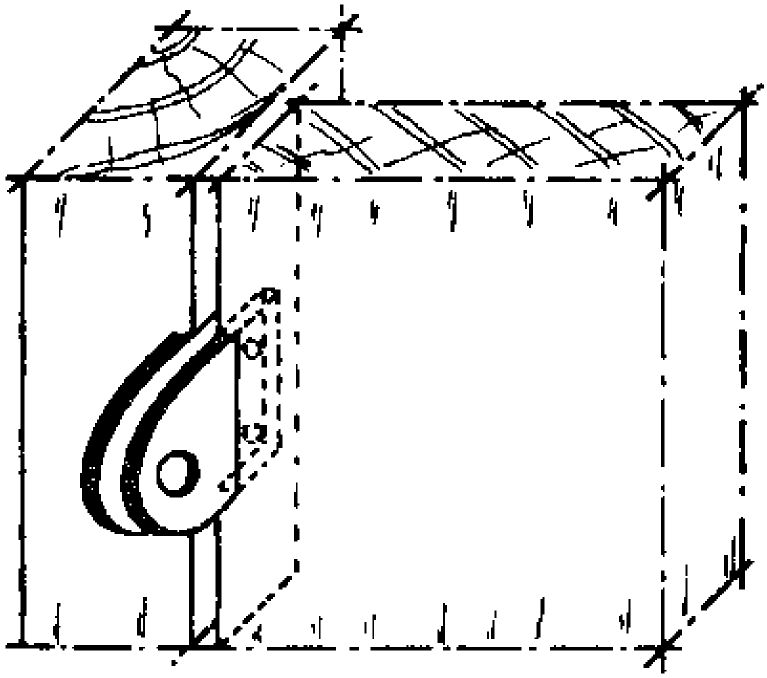


Fig. 2

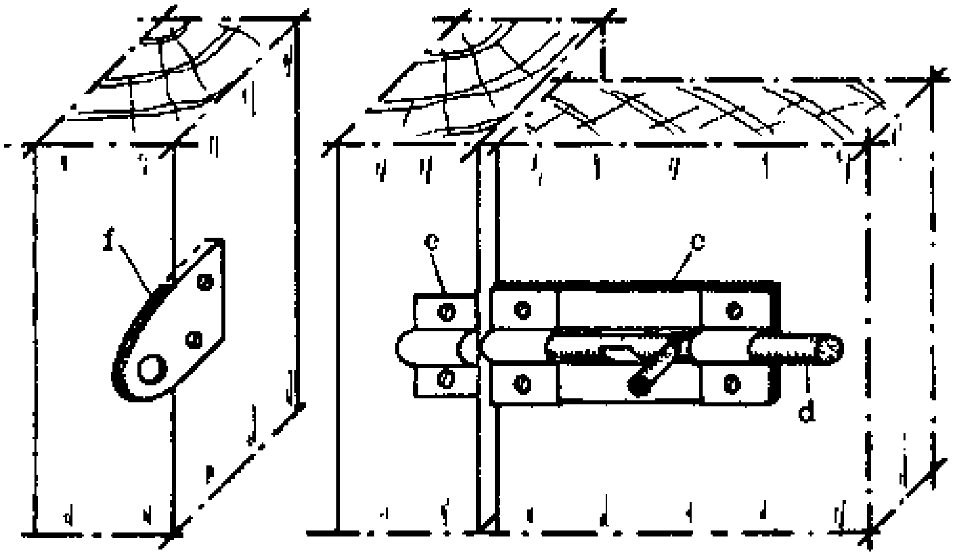


Fig. 3

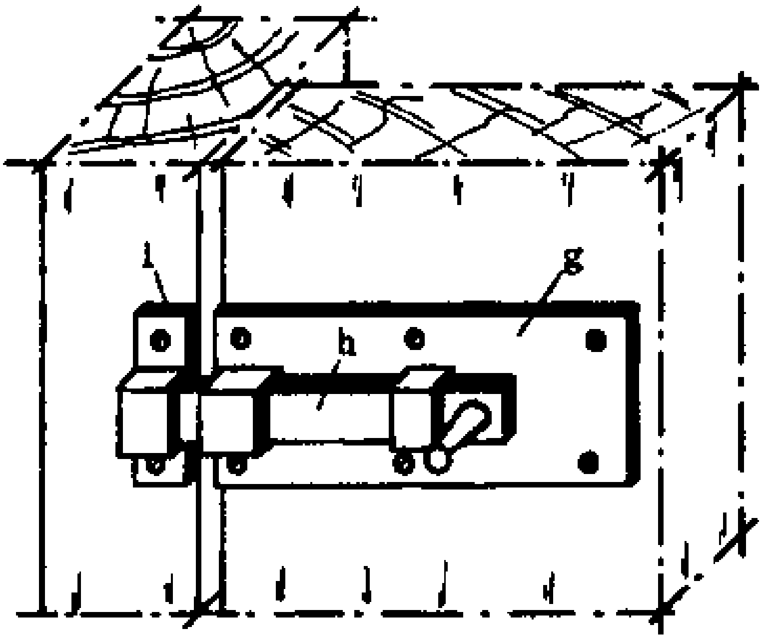


Fig. 4

– HASP AND STAPLE: The hasp and staple (Fig. 1) is usually used in combination with a padlock. It is installed on doors which do not have to be opened very often, as it takes time to open it.

The hasp (a) is screwed to the door or casement and the staple (b) to the frame. Some types of hasp and staple can be unscrewed from the outside. For security reasons, these types should be attached with bolts and nuts rather than with screws. The leaf of the hasp should be installed so that when closed it covers the screws.

An alternative to the hasp and staple is the device shown in Fig. 2. This is an efficient way of locking doors with a padlock and the parts can be made by hand. Two small plates have holes drilled in them for the padlock and screws to pass through. The plates are attached with screws to the edge of the door and the post.

– BARREL BOLTS: The barrel bolt (Fig. 3) consists of a plate (c) with a round bolt (d). The bolt engages in a staple (e). The plate is attached with screws to the inside of the door or window and the staple is attached to the frame. Barrel bolts are often used to lock casements.

A more effective staple can be made by hand (f), in the same way as the device in Fig. 2 above. It provides more security than the staple normally supplied with the barrel bolt since the screws are on the inside face of the post and cannot be so easily forced out. The bolt plate can also be attached with bolts and nuts to make it more secure.

– TOWER BOLTS: A tower bolt (Fig. 4) consists of a plate (g) with a flat bolt (h) fitted in it. The bolt engages in a staple (i) or in a striking plate in the frame. the plate and bolt are usually fixed on the door or casement.

NOTES:

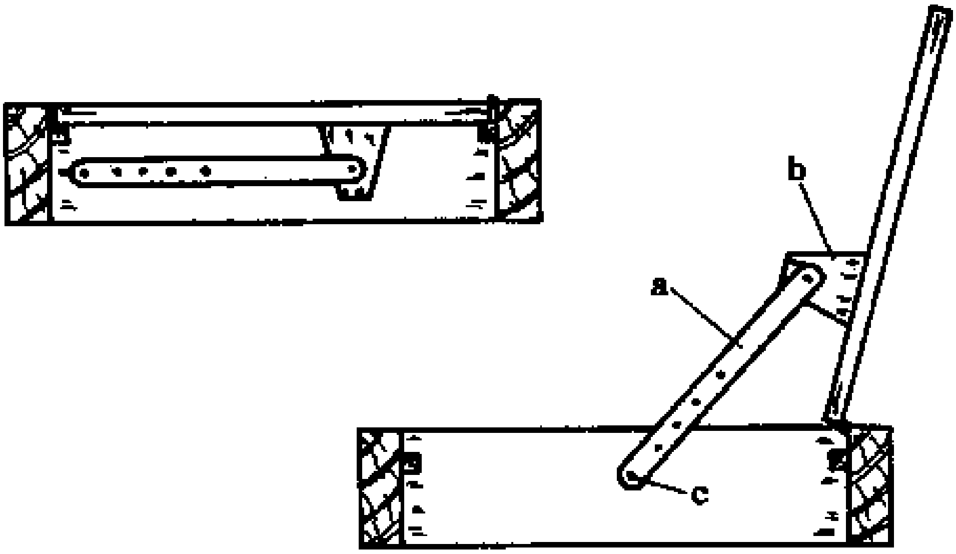


Fig. 1

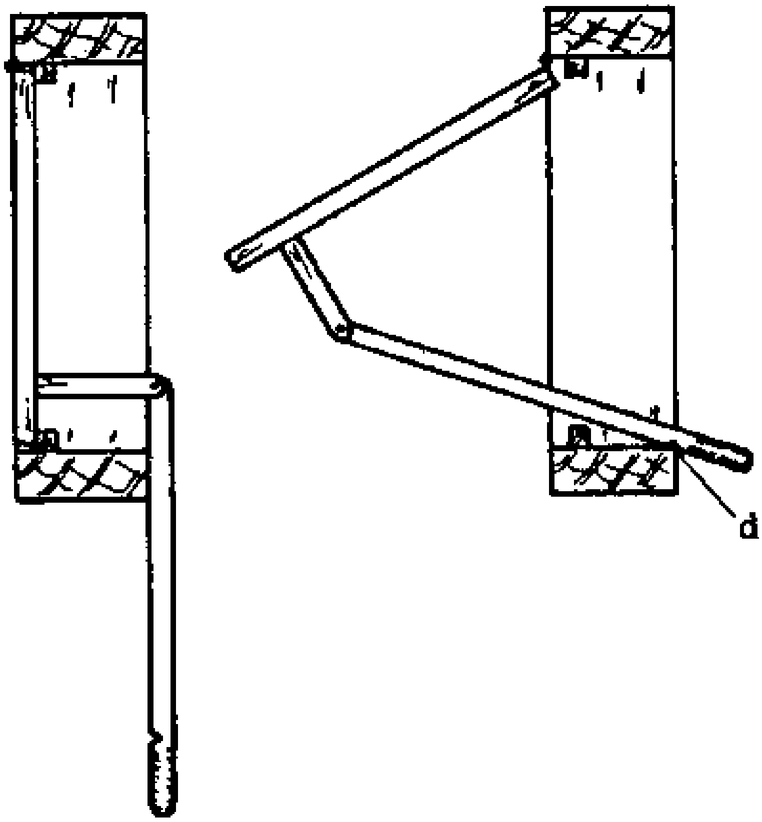


Fig. 2

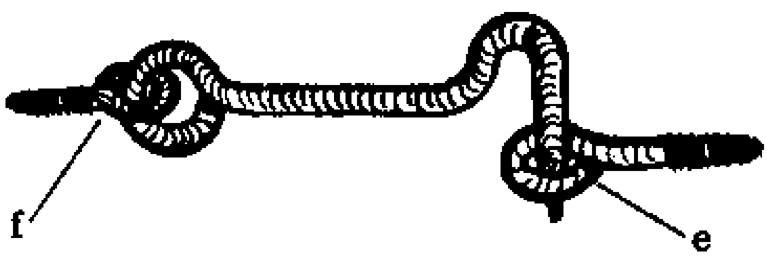


Fig. 3

– CASEMENT FASTENERS: Besides the barrel bolt and the tower bolt, there are some other methods for keeping casements in a closed or open position. These are the casement stay and the cabin hook.

The casement stay serves to keep the casement in the open position. It consists of a handle (a), either wooden or metal, which is fixed onto a plate (b) screwed to the casement. A hole in the handle fits over a small pin in the cill of the frame when the casement is open and holds the casement in position (Fig. 1, c).

If the casement opens upwards, the stay can be constructed so that it also serves as a lock when the window is closed (Fig. 2). A notch (d) holds the stay on the cill when the window is open.

The cabin hook (Fig. 3) is used to hold the casement in the closed position. It consists of a hooked bar which fits into a screw eye (e). The other end of the bar is held by a second screw eye (f) which is fixed on the door or casement.

– LOCKING DEVICE FOR LARGE DOORS: The drawings below show a locking device used for large doors on stores etc, where trucks or other vehicles may have to enter to deliver goods (Fig. 4). It consists mainly of a long baulk (a) which can hold the two doors securely shut. The baulk is fixed with a coach bolt (b) onto one of the doors.

Two wooden blocks (c) hold the baulk in position when the doors are closed and a catch (d) prevents the baulk from swinging open by its own weight or from a gust of wind (Fig. 5). A piece of flat iron (e) bent as shown in Fig. 4, keeps the baulk in the locked position. This iron should be firmly attached to the door.

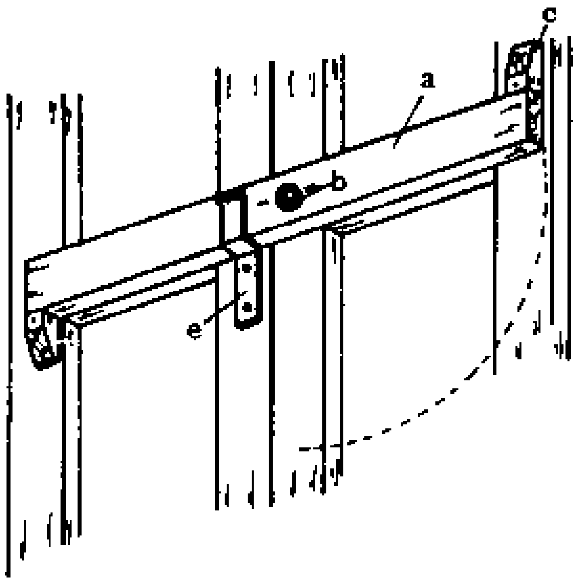


Fig. 4

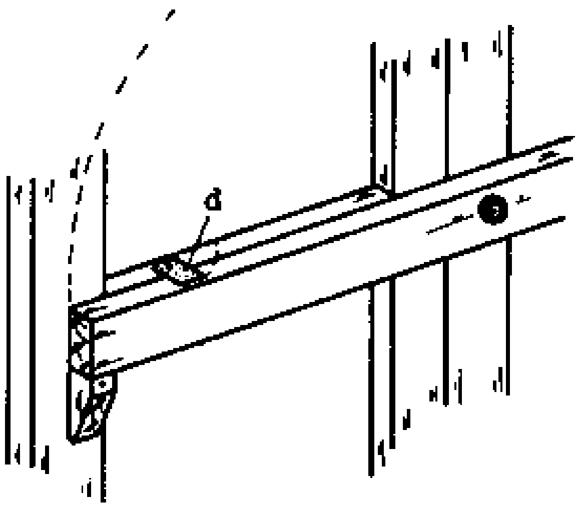


Fig. 5

ROOF COVERINGS

When we talk about roof covering, we mean the non–load–bearing clothing of the roof. In Rural Building, we deal with three different types of roof coverings. These are:

- corrugated aluminium sheets,
- corrugated galvanized iron sheets and
- corrugated asbestos cement sheets.

All of these sheets are corrugated because that makes them stiffer so that they can go across the gap between the purlins without sagging.

CORRUGATED ALUMINIUM SHEETS

This roof covering is lighter and far more durable than the other types. Lightness is important so that the sheets can be easily transported. Aluminium sheets are rust–proof, easily installed and have a bright reflective surface which helps to keep the building cool.

However, the thinner gauge sheets are especially vulnerable to being dented, punctured, or torn off by storms. The sheets also creak a lot when temperature changes make them expand or contract.

Aluminium roof covering is available in a variety of shapes and sizes. The sheets can be from 61 to 76 cm wide and 200 to 400 cm long. Sheets up to 18 metres in length can be ordered from the factory.

In Rural Building, we mostly deal with sheets which are 61 cm wide and 244 cm long. This size is the most commonly used and readily available.

The sheets are available in different thicknesses or gauges. The thinnest is 26 SWG (Standard Wire Gauge; 26 SWG = 0,446 mm) and the thickest is 18 SWG (=1,22 mm).

Store the sheets in a dry place. Avoid putting them in contact with fertilizer, lime or cement.

Further details and instructions concerning aluminium sheets can be obtained from:

Ghana Aluminium Products Limited
P.O. Box 124
Tema

Also look at the Tables of Figures, pages 239 and 240, for more information.

CORRUGATED GALVANIZED IRON SHEETS

These are steel sheets which are corrugated and galvanized on both sides. They are usually thicker and heavier than aluminium sheets, so they lack some of the drawbacks of the aluminium, like being easily punctured or torn away in storms.

The most common size of these sheets is 61 by 244 cm.

CORRUGATED ASBESTOS CEMENT SHEETS

This kind of roofing sheet is also widely used. The disadvantage of these is that they are brittle and break easily if they are walked on or if a heavy object falls on them. They can also break if the roof construction warps due to the humidity changes in different seasons. Another problem is that they are heavy, and so they are difficult to transport.

The standard size is again 61 by 244 cm.

HOW TO ORDER SHEETS

When ordering sheets, you must keep in mind that the overlap of two corrugations on each sheet must be subtracted to find the effective width of the sheet.

RIDGE CAPS

Ready made caps for covering the ridge of the roof are also available. They are made from aluminium, galvanized iron or asbestos cement, to fit with the roofing sheet material.

Ridge caps can be made locally out of aluminium or galvanized iron sheets as will be explained when we come to roof construction.

The caps have to overlap the sheets on both sides of the roof. In the case of a roof which has the ridge along the direction of the prevailing wind (in northern Ghana, this is the east−west axis) the cap must overlap the sheets by 20 cm on each side. If the ridge lies across the direction of the prevailing wind (north − south) the cap has to overlap by 30 cm on each side (see Tables of Figures, page 239).

NOTES:

APPENDIX I: TABLES OF FIGURES

WEIGHT OF AGGREGATES

Dry sand weighs about 1800 kg per cubic metre, or 1,8 tons.

Broken stones weigh about 1700 kg per cubic metre, or 1,7 tons.

One slightly heaped headpanful of dry sand weighs about 30,5 kg.

One slighty heaped headpanful of broken stones weighs about 29 kg.

TABLE OF LOADING CAPACITIES FOR VEHICLES

Loading capacity	Maximum number of headpans	
	dry sand (fine and coarse)	broken stones (small and medium)
1 ton	33	34
1,5 tons	49	51
2 tons	65	69
2,5 tons	82	86
3	98	103
3,5 tons	115	120
4	131	138
4,5 tons	147	155
5	164	172

5,5 tons	180	189
6 tons	197	207
6,5 tons	213	224
7 tons	229	241
7,5 tons	246	258

– REMEMBER: Never overload the vehicle! Observe the above quantities strictly.

NOTES:

TRANSPORTATION OF AGGREGATES

Supposing we have a 3,5 ton lorry available for transporting the aggregates, we can now figure out how many trips with the lorry will be necessary. If we know the total amount needed of each aggregate, we can find the number of lorry loads needed from the table on the left page.

For example, we need for the whole building: 429 headpans of fine sand;

152 headpans of coarse sand;

181 headpans of small broken stones;

165 headpans of medium broken stones.

The number of lorry loads required is found by dividing the number of headpans above by the number found in the table for the 3,5 ton lorry:

– Fine sand: 429 divided by 115 equals 3,73 or approximately 4 loads.

– Coarse sand: 152 divided by 115 equals 1,32 or approximately 1,5 loads.

– Small broken stones: 181 divided by 120 equals 1,5 loads.

– Medium broken stones: 165 divided by 120 equals 1,37 or approximately 1,5 loads.

– NOTE: It is always better to have a little extra material. Therefore, it is better to fill the lorry with every trip rather than take back a half–load. The cost of the transportation will be about the same anyway.

NOTES:

BUILDING MATERIALS REQUIREMENT FOR ONE CUBIC METRE CONCRETE
(approximation values)

USE	MIX	CEMENT		WATER		AGGREGATES (in headpans)			
codes (key below)	prop.	bags (50 kgs)	head–pans	buckets size no. 28	head–pans	fine sand	coarse sand	small broken stones	medium broken stones
1	1:15	2	4,5	4,5	3	21	19	23	21
1;4	1:12	2,5	5,5	5,5	3,75	21	18,75	23	21
1;4;5	1:10	3	6,75	6,75	4,5	20,5	18,5	22,5	20,5
2;4;5	1:9	3,25	7,5	7,5	5	20,25	18,25	22,25	20,25
2;3;4;5	1:8	3,5	7,75	10	6,5	20	18	22	20
3;4;5	1:7	4	9	11	7,5	19,5	17,5	21,5	19,5

3;4;5	1:6	4,5	9,5	12,5	8,5	19	17,25	21	19
3;5	1:5,5	5	11,25	13,75	9	19	17	21	19
6;7;8	1:5	5,5	12,5	14,5	10	18,75	22,50	33,75	–––
6;7;8	1:4,5	6	13,5	16,5	11	18,25	22	33	–––
6;7;8;9	1:4	6,5	14,5	18	12	18	21,5	32,5	–––
8;9	1:3,5	7	15,75	20	13,5	17,25	20,75	31,25	–––
8;9	1:3	8	18	22	14,5	16,5	20	30	–––

KEY FOR USE CODES

1 = foundations
2 = sandcrete blocks*
3 = mortar*
4 = plaster/render*
5 = floors
6 = columns
7 = beams/lintels
8 = slabs
9 = screed mortar*

– NOTE: Any reinforced concrete member of the structure must contain at least 270 kg of cement per cubic metre; and must be free of medium and large sized stones. Therefore, the figures in the upper part of the table are never used in mixing reinforced concrete.

* The items marked with a star are those which contain only sand as an aggregate. The amount of sand required is obtained by adding together the amounts of all the aggregates: fine and coarse sand, small and medium broken stones.

HOW TO USE THE TABLE

When the plans for the building are completed, the builder can make calculations to find how much cement needs to be ordered. From the dimensions in the plan, the volume in cubic metres can be found for the various parts of the structure such as the foundation, floor, footings, etc. This is done by multiplying the width, length, and height of a part to get its cubic volume.

The examples below show how to calculate the cement required once you have found the volumes.

– FOUNDATIONS: Mix proportion = 1:10, volume = 5,75 cubic metres.

– FOOTINGS: Mix proportion of sandcrete blocks and mortar = 1:8, volume = 3,3 cubic metres.

–FLOOR: Mix proportion = 1:7, volume = 2,4 cbm.

– CALCULATION:

FOUNDATIONS: According to the table, the mix proportion of 1:10 requires 3 bags of cement per 1 cbm. Therefore, we multiply 5,75 cbm x 3 = 17,25 bags of cement.

FOOTINGS: The mix proportion of 1:8 requires 3,5 bags of cement per cbm. We multiply the volume of 3,3 cbm x 3,5 = 11, 55 bags of cement.

FLOOR: The mix proportion of 1:7 requires 4 bags of cement per cbm. We multiply the volume of 2,4 cbm x 4 = 9,6 bags of cement.

We now add up the three results above and obtain a final result: 17,25

+ 11,55

+ 9,6

38,40 bags

The total of 38,40 means that 39 bags of cement have to be ordered.

Do not forget to include all the members which contain cement in your calculations: landcrete blocks, mortar, lintels, concrete ring beam, etc.

The cement requirements for landcrete blocks varies according to the soil used. For approximate values see the table on page 179.

NOTES:

When the cement requirements have been determined, we can use the table to find the quantities of aggregates that are needed. This is done by multiplying the same volume measurement by the appropriate number in the table.

– FOUNDATIONS:

5,75 cbm × 20,5 equals approximately 118 headpans of fine sand.
5,75 cbm × 18,5 equals approximately 106 headpans of coarse sand.
5, 75 cbm × 22,5 equals approximately 129 headpans of small broken stones.
5,75 cbm × 20,5 equals approximately 118 headpans of medium broken stones.

– FOOTINGS: Since the sandcrete blocks and the mortar require only sand, all four quantities under aggregates (fine sand, coarse sand, small and medium broken stones) are added together and the result is multiplied by the volume of the footings: 20 + 18 + 22 + 20 = 80; 80 × 3,3 cbm = 264 headpans of sand.

– FLOOR:

2,4 cbm × 19, 5 equals approximately 47 headpans of fine sand.
2,4 cbm × 17,5 equals 42 headpans of coarse sand.
2,4 cbm × 21,5 equals approximately 52 headpans of small broken stones.
2,4 cbm × 19,5 equals approximately 47 headpans of medium broken stones.

NOTES:

HEIGHT MEASUREMENTS FOR WALLS

This table can be used to calculate the height of a wall (not including copings, tie beams, or foundations) or to calculate the number of courses in the wall in order to make it a certain height.

LC = Landcrete wall; NC = number of courses; SC = sandcrete wall.

EDGEWISE LAID				FLATWISE LAID BLOCKS						
LC	NC	SC		LC	NC	SC		LC	NC	SC
24	1	25		16	1	17		256	16	272
48	2	50		32	2	34		272	17	289
72	3	75		48	3	51		288	18	306
96	4	100		64	4	68		304	19	323

120	5	125		80	5	85		320	20	340
144	6	150		96	6	102		336	21	357
168	7	175		112	7	119		352	22	374
192	8	200		128	8	136		368	23	391
216	9	225		144	9	153		384	24	408
240	10	250		160	10	170		400	25	425
264	11	275		176	11	187		416	26	442
288	12	300		192	12	204		432	27	459
312	13	325		208	13	221		448	28	476
336	14	350		224	14	238		464	29	493
360	15	375		240	15	255		480	30	510

USING THE TABLE

– FOR EXAMPLE: The walls of a common house (not including wall plate or ring beam) are supposed to reach a height of 3 m above the finished floor level. We find with the aid of the above table that the plinth course of sandcrete blocks must be followed by 12 courses of landcrete blocks to reach a height of: 0,25 m + 2,88 m = 3,13 m. The floor is 10 cm thick, so the height above the finished floor level will be 3,13 m – 0,10 m = 3,03 m.

– ANOTHER EXAMPLE: The bottom of a water tank must be at a height of 4 m above ground level. With the aid of the table, the Rural Builder can easily figure out that he needs to make 24 courses of flatwise sandcrete blocks to reach this height.

LENGTHS OF WALLS

LC = Landcrete blocks, length of wall (cm); No = number of blocks; SC = sandcrete blocks, length of wall (cm).

LC	No	SC		LC	No	SC		LC	No	SC		LC	No	SC
29	1	46		1114	36	1726		2199	71	3406		3284	106	5086
60	2	94		1145	37	1774		2230	72	3454		3315	107	5134
91	3	142		1176	38	1822		2261	73	3502		3346	108	5182
122	4	190		1207	39	1870		2292	74	3550		3377	109	5230
153	5	238		1238	40	1918		2323	75	3598		3408	110	5278
184	6	286		1269	41	1966		2354	76	3646		3439	111	5326
215	7	334		1300	42	2014		2385	77	3694		3470	112	5374
246	8	382		1331	43	2062		2416	78	3742		3501	113	5422
277	9	430		1362	44	2110		2447	79	3790		3532	114	5470
308	10	478		1393	45	2158		2478	80	3838		3563	115	5518
339	11	526		1424	46	2206		2509	81	3886		3594	116	5566
370	12	574		1455	47	2254		2540	82	3934		3625	117	5614
401	13	622		1486	48	2302		2571	83	3982		3656	118	5662
432	14	670		1517	49	2350		2602	84	4030		3687	119	5710

463	15	718		1548	50	2398		2633	85	4078		3718	120	5758
494	16	766		1579	51	2446		2664	86	4126		3749	121	5806
525	17	814		1610	52	2494		2695	87	4174		3780	122	5854
556	18	862		1641	53	2542		2726	88	4222		3811	123	5902
587	19	910		1672	54	2590		2757	89	4270		3842	124	5950
618	20	958		1703	55	2638		2788	90	4318		3873	125	5998
649	21	1006		1734	56	2686		2819	91	4366		3904	126	6046
680	22	1054		1765	57	2734		2850	92	4414		3935	127	6094
711	23	1102		1796	58	2782		2881	93	4462		3966	128	6142
742	24	1150		1827	59	2830		2912	94	4510		3997	129	6190
773	25	1198		1858	60	2878		2943	95	4558		4028	130	6238
804	26	1246		1889	61	2926		2974	96	4606		4059	131	6286
835	27	1294		1920	62	2974		3005	97	4654		4090	132	6334
866	28	1342		1951	63	3022		3036	98	4702		4121	133	6382
897	29	1390		1982	64	3070		3067	99	4750		4152	134	6430
928	30	1438		2013	65	3118		3098	100	4798		4183	135	6478
959	31	1486		2044	66	3166		3129	101	4846		4214	136	6526
990	32	1534		2075	67	3214		3160	102	4894		4245	137	6574
1021	33	1582		2106	68	3262		3191	103	4942		4276	138	6622
1052	34	1630		2137	69	3310		3222	104	4990		4307	139	6670
1083	35	1678		2168	70	3358		3253	105	5038		4338	140	6718

USING THE TABLE

Suppose you are planning a wall which is about 6 metres long, made from landcrete blocks. In this case it would be best to choose either 5,87 m or 6,18 m as the final length, so that it is not necessary to cut blocks to fit.

The table makes it simple to read off the number of blocks required per course, so it is easier to calculate the building materials that will be required. For example, a 34, 70 m landcrete wall contains 112 blocks per course. The number of courses required to reach a certain height can be found in the table on page 237.

ROOFING SHEET REQUIREMENT

This table is to help you to find the number of roofing sheets that need to be ordered, according to the length of the planned building. The number of sheets in this table refers only to the sheets along one side of the ridge line; so if you want to make a gable roof you have to double this number to get the number of sheets that will cover both sides of the roof. In addition, if the building is wide, so that more than one sheet is needed to cover the distance between the ridge and the lower edge; then the number from the chart has to be multiplied by the total number of sheets across the whole width of the building (see the example given on the next page).

The figures below are for the most commonly used roofing sheet size, which is 61 cm by 244 cm. The effective width of the sheets (minus 2 corrugations overlap) is approximately 50 cm (see pages 230 and 231). The figures include an allowance of 20 cm extra at each gable end.

NS = Number of roofing sheets; L (m) = the length of the building in metres.

NS	L (m)		NS	L (m)		NS	L (m)		NS	L (m)
3	1,1		14	6,6		25	12,1		36	17,6
4	1,6		15	7,1		26	12,6		37	18,1
5	2,1		16	7,6		27	13,1		38	18,6
6	2,6		17	8,1		28	13,6		39	19,1
7	3,1		18	8,6		29	14,1		40	19,6
8	3,6		19	9,1		30	14,6		41	20,1
9	4,1		20	9,6		31	15,1		42	20,6
10	4,6		21	10,1		32	15,6		43	21,1
11	5,1		22	10,6		33	16,1		44	21,6
12	5,6		23	11,1		34	16,6		45	22,1
13	6,1		24	11,6		35	17,1		46	22,6

SHEET REQUIREMENT FOR RIDGE CAPS

When the ridge of the roof is oriented in the direction of the prevailing winds (the direction from which the wind usually comes; in northern Ghana this is the east) then the ridge cap has to overlap 20 cm on each side of the ridge. Thus a common roofing sheet (244 cm long) will provide 6 ridge caps, each 40 cm long. To find the number of sheets required for the ridge caps, use the figure you get from the table above and divide it by 6.

For example: The building will be 10 metres long; looking in the table you find the figure of 21 sheets. Divide 21 by 6; this gives 3,5 (or approximately 4) sheets which are required for the ridge caps.

When the ridge of the roof is oriented across the direction of the prevailing winds (in northern Ghana this would be north–south), the ridge cap has to be wider so that the sheets are held better against the wind. In that case, the caps have to overlap each side of the ridge by 30 cm; therefore the roofing sheet can be cut into 4 pieces, each 60 cm long. To find the number of roofing sheets required for the caps, divide by 4 instead of by 6. Thus in our example, 21 divided by 4 gives 5,25 (or approximately 6) sheets required for the ridge caps.

ROOFING SHEET REQUIREMENT / WIDTH OF BUILDING

In order to avoid unnecessary waste, the Rural Builder should decide on the width of the building with the size of the roofing sheets in mind (see Construction, pages 158 & 159). The table below gives the span of the roof for a gable roof according to the number of sheets required to reach from ridge to eave level on each side of the roof. The sheets are standard 244 cm long roofing sheets, the roof has a 20 degree pitch, and there is an allowance of 50 cm extra on each side for the sheets to overhang (overhanging eave).

NS = Number of sheets; W (m) = Width (span) of the roof truss.

NS RIGHT	W (m)	NS LEFT		NS RIGHT	W (m)	NS LEFT
1	3,65	1		2½	9,95	2½
1	4,65	1½		2½	11,1	3
1½	5,65	1½		3	12,3	3
1½	6,8	2		3	13,3	3½
2	7,95	2		3½	14,3	3½
2	8,95	2½				

– EXAMPLE: If the roof is to be 21 m long and 8 m wide (span of the truss), with a pitch of 20 degrees, and oriented with the prevailing wind, the number of sheets required can be figured as follows:

From the table on the proceeding page, we see that 43 sheets will fit along the ridge line. The table above shows that 4 sheets are required to cover the width of the house. When we multiply both numbers, we get the total amount of sheets which is 172 sheets.

We must also find the number of sheets required for the ridge caps. Dividing 43 by 6 gives approximately 8 sheets, making a total of 180 sheets to be ordered.

APPENDIX II: GLOSSARY

Most new terms are explained in the text as they come up, but after that they are used without explanation. To make it easier for you, the words which tend to come up again and again are explained here once more, and references are given when possible to more thorough explanations in one of the text books.

> – NOTE: The other books referred to here are given as abbreviations: the Basic Knowledge book is referred to as "BK"; and the Construction book is written as "Con". Where the page number only is given, it refers to the page in this book.

<u>TERMS</u>

– AGGREGATE: The sand, rocks or gravel which make up the greater part of concrete, sandcrete blocks, mortar, plaster or render (see page 147)

– ANCHORAGE: This refers usually to iron rods which are embedded in one part of the building and serve to hold another part in place, for example the roof anchorage which is embedded in the walls and holds the roof construction in place.

– ANGLE OF PITCH: This means the slope of the face of a saw tooth (see page 109); or else it refers to the slope of the roof construction (roof pitch), depending on the context where it is used (see page 158, Con).

– BATTEN: This usually refers to a small piece of wood that is used to help fix another piece, or it refers to the lengthwise boards of a battened door (see page 93, Con).

– BEVEL: A sloping edge; the edge of a piece which is cut off so the angle is no longer 90 degrees (see page 72, BK).

– BOND: This refers to the arrangement of blocks in a wall, in Rural Building usually a half–block bond (see page 8, BK).

– BRACE: A piece added to a construction to make it stronger or more stable.

– BUILDING UNIT: This is usually used with reference to blocks to specify the measurement of a block in the wall, including the thickness of one cross joint and the bed joint (usually 2 cm) (see page 4, BK).

– CAST: To pour concrete into a mold so that it hardens to a particular form.

– CAST–IN–SITU: This means that the concrete member is cast in its permanent position (page 170, BK).

– CHAMFER: An edge which is cut to a 45 degree angle; this is a special kind of bevel (see page 72, BK).

– CLEARANCE: Free space; or space to allow movement between parts.

– CLENCH: To secure a nail by bending the point over where it comes through the piece of wood (see page 94, BK).

– CONCAVE: This describes a surface which is hollow or curved inwards.

– CONCRETE: This is a mixture of sand, stones, cement and water which hardens into a rock–like substance (see page 166).

– CONVEX: This means that a surface is curved outwards, like the outer surface of a ball.

– COUNTERSINK: This means to enlarge the top of a screw hole so that the head of the screw will be flush with the surface (see page 96, BK).

– COURSE: This refers to a horizontal layer or row of blocks in a wall, including the mortar bed (see page 2, BK).

– CROSS–GRAINED: The wood fibres do not run parallel to the length of the piece of wood, so it is difficult to work with the wood.

– CURING: This refers to the process of hardening for any product which contains cement. The piece must "cure" for a period of days or weeks before it is ready to carry out its function.

– CUTTING ANGLE: The angle to which a cutting edge is shaped (see page 91).

– DIMENSIONS: The measurements of the length, width, and height of an object.

– END GRAIN: The end surface which is exposed when wood is cut across the grain (see page 72, BK).

– FACE SIDE OR FACE EDGE: This is the first side or edge to be prepared when wood is planed for use in a work piece, usually the best side or edge (see page 84, BK).

– FLUSH: When we say that two surfaces are flush, we mean that they are in the same plane, they form one flat surface together.

– FOOTINGS: These are the first courses of flatwise blocks which are laid on top of the foundations (see page 36, BK; also page 43, Con).

– FORMWORK: This is the wooden structure which holds and supports the concrete pieces while they are being cast (see page 170, BK).

– FOUNDATIONS: The solid base, usually concrete, on which the building rests. It is the only part of the building which is in direct contact with the ground (see page 15, Con).

– GAUGE: A measure, a means of comparing sizes (for example, see pages 13 and 39).

– GRAIN: The natural arrangement of the wood fibres (see page 72, BK).

– GRIND: To polish or sharpen by rubbing on a rough hard surface (see page 95).

– HEADER: This is a block which is placed in a wall in such a way that the smallest face is exposed (see page 2, BK).

– HONE: To give a final polished keen edge to a tool by rubbing it on the smooth side of a sharpening stone (see page 99).

– KERF: The cut made by a saw blade.

– LANDCRETE BLOCKS: This is a mixture of laterite soil, cement and water which is pressed into blocks in a landcrete block machine (see page 2, BK).

– LEVEL: A line or surface which is parallel to the horizon; horizontal. This can also refer to the tool, the spirit level (page 5) which is used to determine whether a surface is level.

– LINTEL: The wooden or reinforced concrete member which bridges the opening of a door or window at the top (page 164, BK).

– MARKING OUT: This means to make marks on a surface to show where later operations have to be carried out; for example marking out joints on frames or marking out foundations on the ground.

– MILD STEEL: This is the same as iron. Hardened steel is iron which has been hardened by a special process.

– MITRE: This refers to a joint where the two pieces are cut at a 45 degree angle so that they form a corner where the connection between them bisects the angle of the corner (see page 98, BK).

– MORTAR: A mixture of sand, cement and water which is used to form the joints between blocks; or as plaster or render, depending on the proportions of the mix (see page 158).

– MORTICE: A hole which is cut in a piece to recieve the end of another piece (see page 104, BK).

– PLASTER: The mortar layer which is applied to the inside walls of a building to make them smoother and more durable (page 174, BK).

– PLINTH COURSE: This is usually one course of edgewise laid sandcrete blocks which is laid on top of the footings (see page 36, BK).

– PLOT: An area limited by certain boundaries, it may contain one or more building sites (see page 140, BK).

– PLUMB: Vertically straight, perpendicular to the horizon.

– PRECAST: This means that the piece is cast beforehand and set into into its permanent position after it is hardened (see page 170, BK).

– PREFABRICATED: This means that the piece or part of the building is made ready before it is installed in its final position in the structure. In Rural Building we usually mean those things which are manufactured on the site such as doors, casements or frames. We also call this "ready–made".

– QUOIN: The outside corner of a wall (see page 26, BK).

– REBATE: A step–shaped rectangular cut in the edge of a piece (see page 72, BK).

– REINFORCE: To make something stronger by adding another material, for example the iron rods which are sometimes used to make concrete pieces stronger (page 171)

– RENDER: The mortar layer which is applied to the outside of the building to make the walls water resistant so that the blocks are not destroyed by rain (see page 174, BK).

– RIGHT ANGLE: A 90 degree angle.

– RIPPING: This means cutting a board along the grain, using a saw (page 45).

– SANDCRETE BLOCKS: These are blocks made with sand, cement and water, shaped in a sandcrete block machine (see page 2, BK).

– SCALE: In a drawing, this means the relation between the size of the drawing and the actual size of the object which is drawn; for example a building may be drawn in a scale of 1:100 (cm), which means that 1 cm on the drawing represents 100 cm in the actual building.

– SCREED: This refers to a strip of mortar which is laid on the wall to act as a guide during plastering (see page 176, BK); we also talk about floor screeds, by which we mean the 2 cm mortar layer which is laid on top of the base layer during floor construction (see page 179, BK).

– SETTING OUT: Marking the dimensions of an excavation with pegs and lines, or marking the positions of the walls on the footings, etc., sometimes called lining out.

– SHUTTERING: This means the parts of the formwork which are in contact with the cement (page 170, BK).

– SITE: This is the piece of land on which a building is made; a plot of land can contain one or more building sites (see page 140, BK).

– SOFFIT: This refers to the under–surface of a piece; in a concrete form, the bottom board of the shuttering is called the soffit board.

– SPECIFICATIONS: This means a detailed description of something.

– SQUARE: By this we usually mean that a piece has all its sides at right angles to each other, or that all the angles are right angles; or it can mean a rectangular surface where all the sides have the same length.

– STRETCHER: This means a block which is laid so that one of the long faces is exposed (either the top face or a long side) (see page 2, BK).

– STRUTTING: These are the supports which hold the shuttering in place when the concrete piece is cast (see page 170, BK).

– TAPER: This means that something is thinner at one edge than at the other.

– TRUE: This is a description meaning that a surface is completely straight and flat.

– VENTILATION: The air movement in and out of a room or area.

– WARP: This is any change of shape in a piece of wood which is caused by uneven shrinking or expansion (see page 132).

– WEDGE: A piece, usually V–shaped, which is used to hold other pieces under pressure, usually to hold pieces together as for example the handle and head of a hammer are fixed together by wedges (see page 41).

NPVC