Stairmaking – Course: Timberwork techniques. Trainees' handbook of lessons

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Stairmaking – Course: Timberwork techniques. Trainees' handbook of lessons

1. Purpose of Stairs

Stairs (staircases) are sets of steps having more than three rises and a flight line under an angle of inclination of alpha (?).
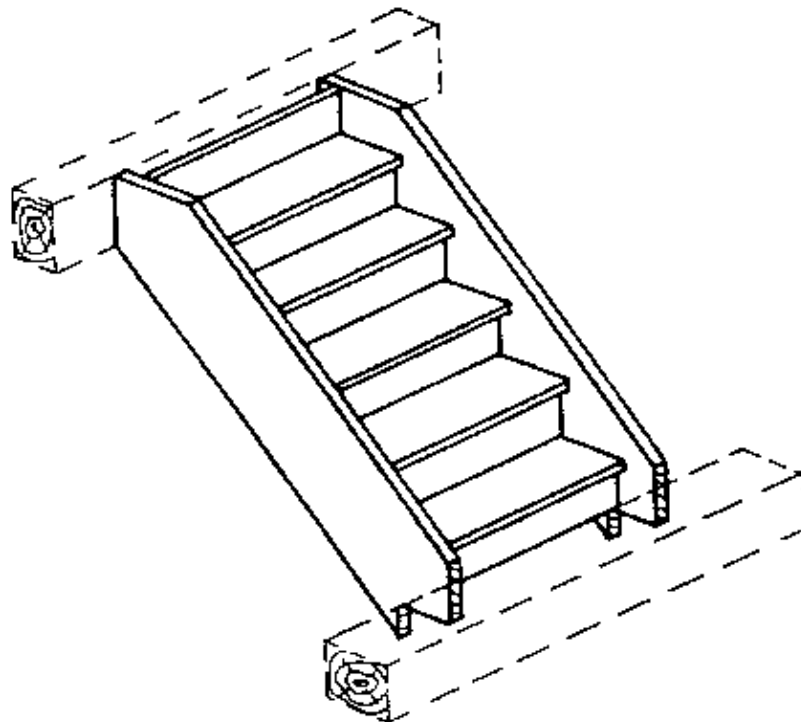

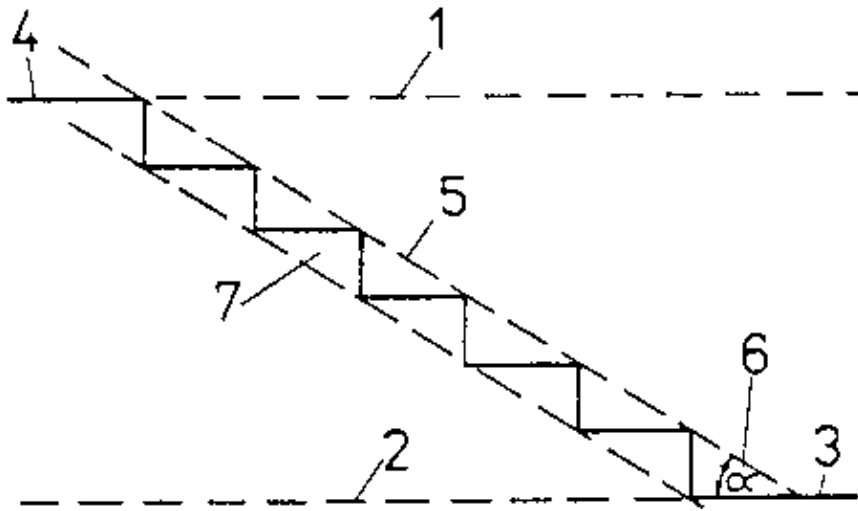**Figure 1 –** Single–branch flight of mortised wooden stairs

Figure 2 – Features of a staircase (set of steps) *1 upper level, 2 lower level, 3 surface – bottom landing, 4 surface – top landing, 5 stair flight line, 6 angle of inclination of the stair flight, 7 stair flight (inclined pan of the stairs)*

A set of steps consists of a bottom stair landing, a top stair landing and the flight of stairs.

The angle of inclination (?) of the flight line results from the ratio of flight height and flight length (see Fig. 10).

Stairs are needed for convenient and safe going from one level to another one. They are also necessary for evacuating people in emergency cases.
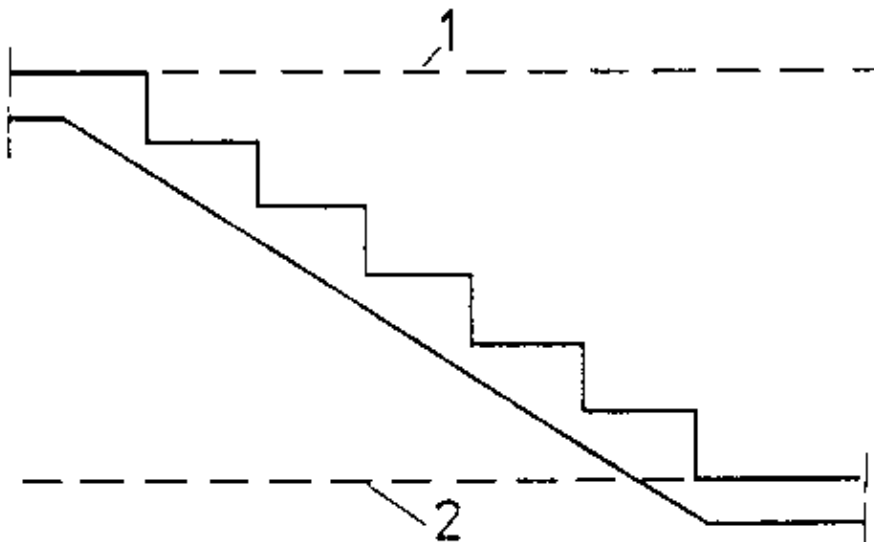
Figure 3 – Representation of the two different levels of a staircase – *1 upper level, 2 lower level*

A wooden staircase consists of the bottom and top stair landings, the two strings (or string boards) and a number of successive steps. Stair railings provide lateral protection against falling down.

Soft wood may be used for the strings.

The steps (treads) must be made of hard wood because they are subject to heavy wear.

The risers are not subject to wear and may be made of soft wood. In the interest of an attractive appearance of the staircase, well–veined hard wood should be used only.

What does the term "stairs" (or "staircase") mean?

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Why should the steps (treads) be made of hard wood?

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2. Types of Straight Wooden Stairs

<u>Wooden Stairs</u>

saddle stairs	inserted stairs (skeleton-step stairs)	mortised stairs
– steps are put on (saddled on) the rise triangles	– steps are slid into the insertion slots from the front	– steps are inserted into the mortised holes
– stairs have no risers	– stairs have no risers	–stairs have risers
(see Fig. 4)	(see Fig. 7)	(see Fig. 8)

Combined Wooden Stairs

wall string mortised steps   outer string saddle steps
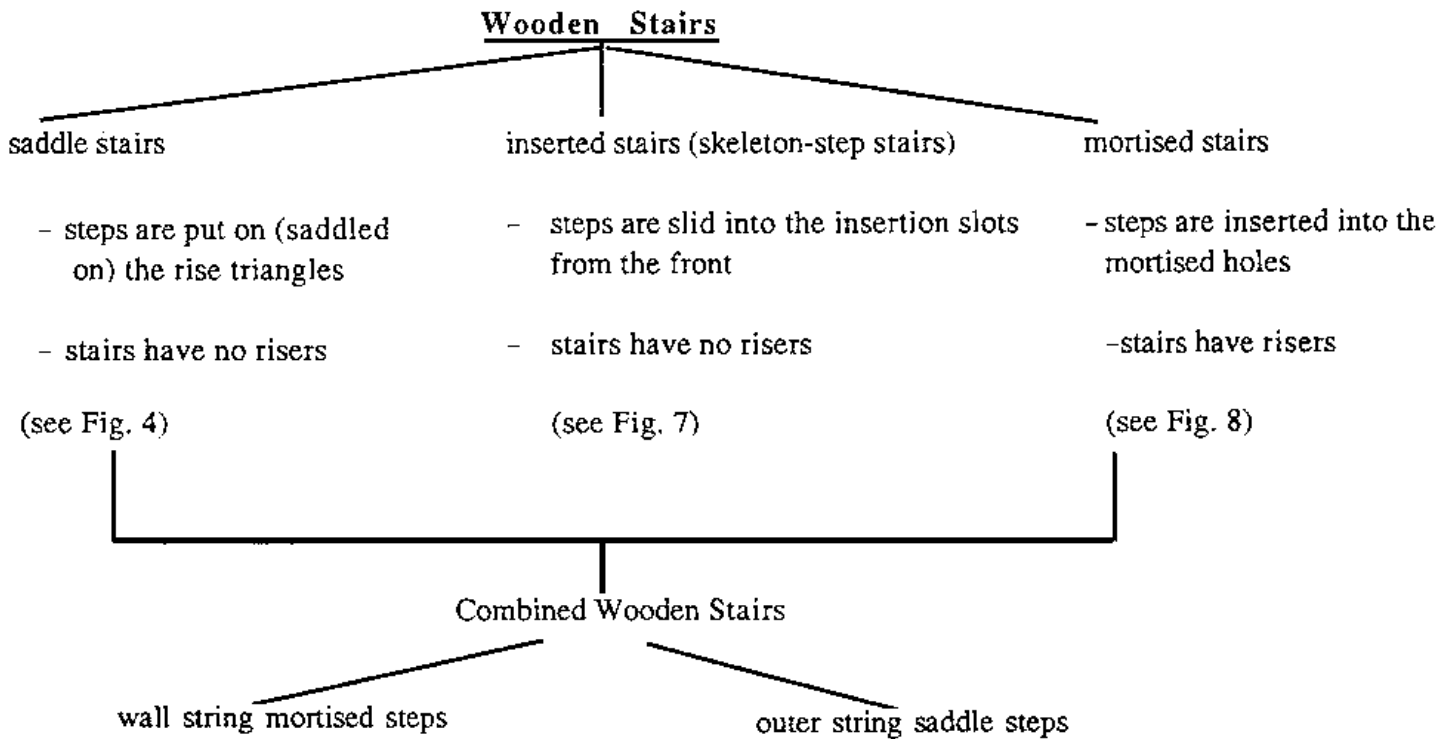
Table 1: (see Fig. 6) Such stairs may be designed with risers or without risers

Saddle stairs

Saddle stairs are staircases where the steps are set on the sawn–out or attached rise triangles or on bearing blocks fitted at the strings.
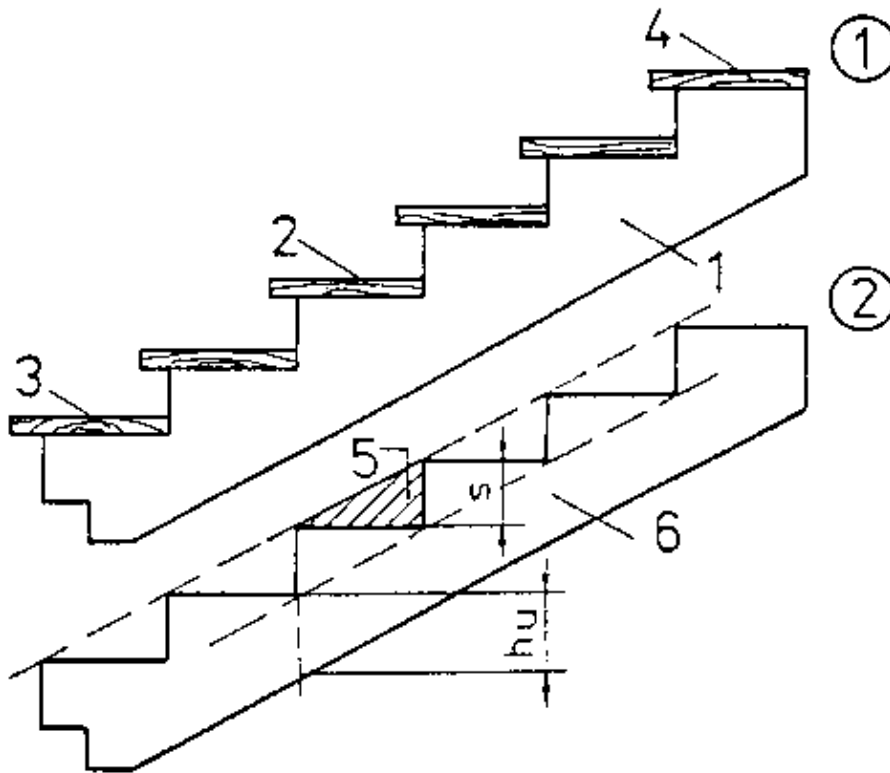
3

Figure 4 – Saddle stairs – (1) sectional view of saddle stairs *1 stair string, 2 step, 3 stair foot (bottom step), 4 stair head (head step)* – (2) sawn–out stair string *s – height of rise,* h_u *– height of string bottom, 5 sawn–out rise triangle, 6 string bottom*

For stairs with sawn–out or attached rise triangles the string bottom must have a sufficient height. The height of the string bottom is calculated by means of the following formula:

$$hu = 40\,mm\left(\frac{s}{W_d} + 2\right) \qquad \text{(Formula 1)}$$

h_u = height of the string bottom

s = height of rise

W_d = string thickness

Table 2:

Perpendicular height (h_u) of the string bottom for wooden saddle stairs

Stair flight width	Stair string thicknes	Perpendicular height of the string bottom
B	W_d	h_u
in mm	in mm	in mm
up to 1200	60	
from 1200 up to 1250	65	
from 1250 up to 1500	70	$h_u = 40\,mm\dfrac{s}{W_d} + 2)$
from 1500 up to 1750	75	
from 1750 up to 2000	80	

Saddle stairs can be designed as pure saddle stairs or as combined saddle stairs. There are three types of pure saddle stairs.
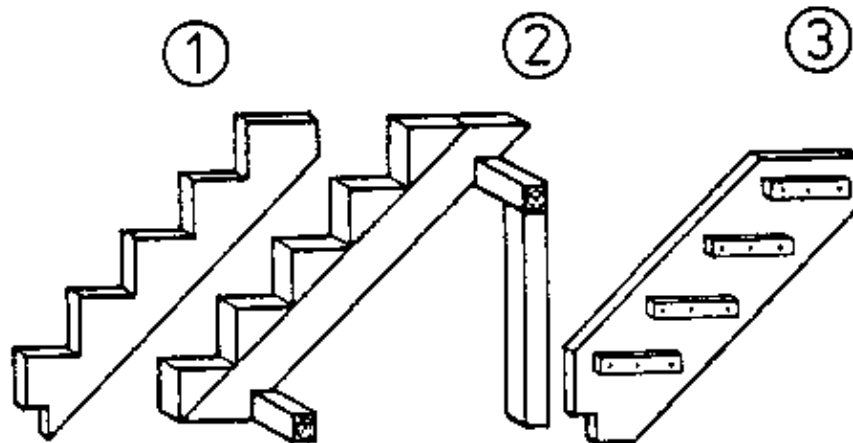

Figure 5 – Types of saddle stairs

(1) stairs with sawn–out rise triangles
(2) stairs with attached rise triangles
(3) stairs with bearing blocks nailed onto the strings

Stairs with attached rise triangles and stairs with bearing blocks fitted at the strings are mainly built as temporary stairs. Such stairs are used temporarily only, such as in the preparation of a building site as access to site accommodations, as access to working platforms, etc.

They are removed and disassembled later. Thus the material can be reclaimed and reused.

When the sawn–out rise triangles of the strings are cut–off from the string bottom, such wood can be reused as posts (see Fig. 4/2).

Similarly the squared timber of stairs with attached rise triangles can be reused.

Combined saddle stairs can be built into apartments or smaller dwelling houses as floor–to–floor staircase.

Such stairs are not removed but remain permanently in place until they are worn out.
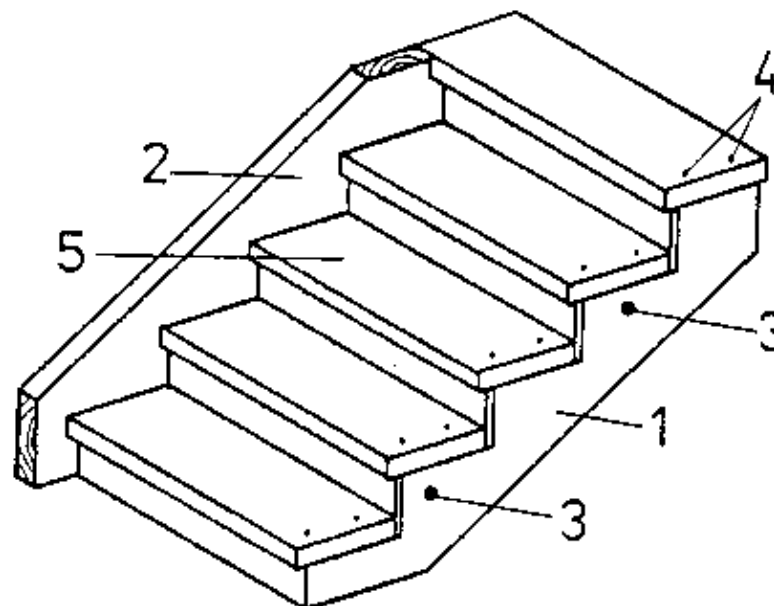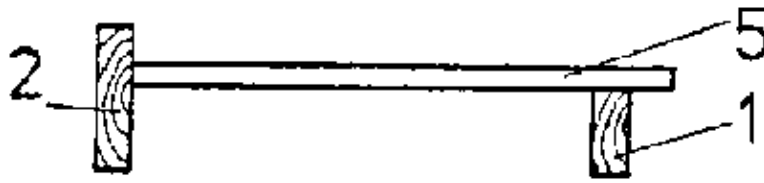

Figure 6 Combined saddle stairs – *1 sawn–out stair string* (*outer string*), *2 mortised stair string* (*wall string*), *3 screw rod with rosette, 4 wood screw* (*countersunk head*), *5 step* (*mortised at left–hand side, saddled on right–hand side*)

5

The steps (treads) are mortised into the wall string and set on the outer string.

Such stairs may also be designed with risers.

The visible end–grained wood of the outer string is to be lagged by veneering.

What are "temporary stairs"?

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Inserted stairs (skeleton–step stairs)

Inserted stairs (or skeleton–step stairs) do not have any risers. Therefore, they should be used as access to ancillary rooms or be built into ancillary rooms only, such as stairs to or in the attics.

The steps (treads) of such stairs are inserted (slid) into the mortised step supports from the front.
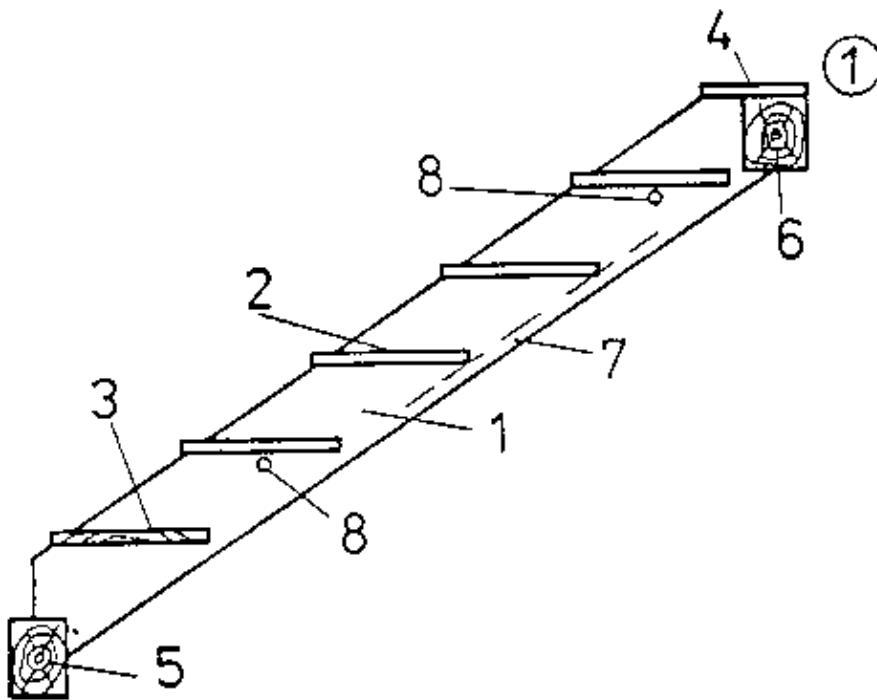

Figure 7 – Inserted stairs (skeleton–step stairs) – (1) sectional view of inserted stairs – *1 stair string, 2 step, 3 stair foot (bottom step), 4 stair head (head step), 5 lower (bottom) stair–apron, 6 upper (top) stair–apron, 7 string bottom, screw rod* – (2) (3) Insertion (sliding–in) of the step into the insertion slot *1 stair string with mortised insertion slots, 2 step, 3 insertion slot, 4 line of inclination of the stair flight. 5 step with facing board to cover the insertion slot, 6 lower (bottom) stair–apron, 7 drilled hole for the screw rod, 8 stair string with arris for insertion, 9 stair string without arris for insertion*

The steps may be designed with or without arris for insertion. In order to cover the mortise, the front of the step can be provided with a facing board (see Fig. 7/2).

The string height depends on the angle of inclination of the flight and can be measured from the drawing floor (Fig. 16).
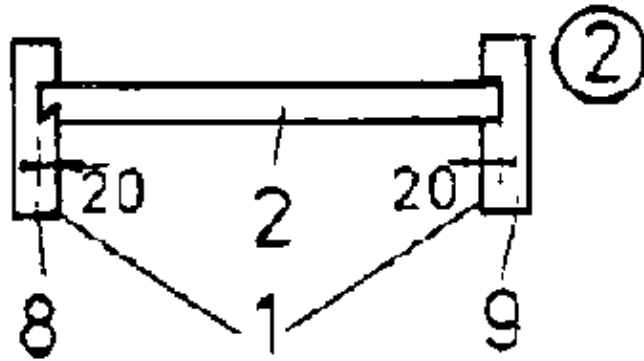
However, it should not be less than 260 mm.

If no arris is applied for insertion, the stair strings must be drawn together by means of screw rods to fix the steps.
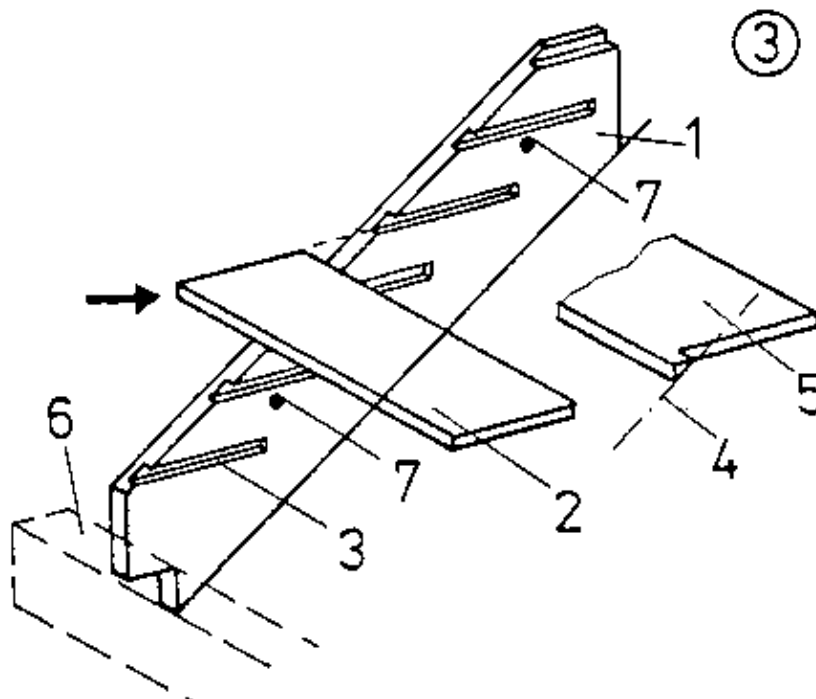
Screw rods are round metal rods with threads at both ends and with nuts.

The nuts at the outer string can be covered by rosettes. Screw rods are also recommended for stairs with arris for insertion.

What are "inserted stairs" (skeleton–step stairs)?

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Mortised stairs

Mortised stairs (stairs with mortised treads) have risers. They are typical floor–to–floor staircases in dwelling houses.

The riser serves a double purpose. It supports the step and prevents deflection of the step under load and it also protects the user of the stairs from objects falling down from other flights upstairs. The string height depends on the angle of inclination of the flight and can be measured from the drawing floor. However it should be at least 260 mm.

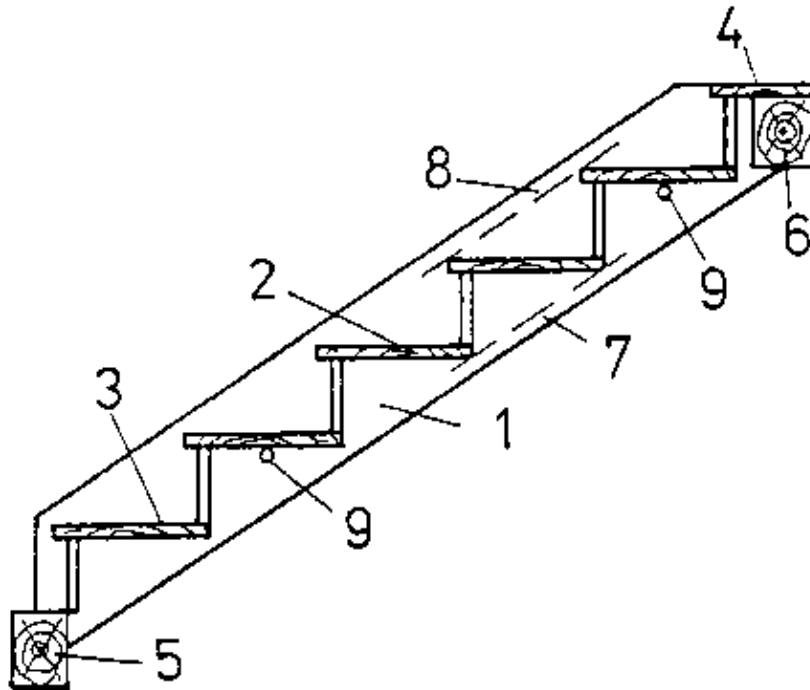The step thickness depends on the flight width.

7

Figure 8 – Sectional view of mortised stairs – *1 stair string,* 2 *step, 3 stair foot* (*bottom step*), *4 stair head* (*head step*), *5 lower* (*bottom*) *stair–apron, 6 upper* (*top*) *stair–apron, 7 string bottom, 8 string top, 9 screw rod*

Table 3:

Step (tread) thickness of solid wood in planed condition for wooden stairs

Stair flight width	Saddle stairs and inserted stairs with a tread width		Mortised stairs
	up to 240 mm	**up to 300 mm**	
	in mm	**in mm**	**in mm**
up to 800	35	32	30
from 800 up to 1000	40	35	30
from 1000 up to 1300	45	40	35
from 1300 up to 1500	50	45	40

The riser thickness should be within 15 to 20 mm. The strings of mortised stairs should be drawn together by at least two screw rods. The nuts in the outer string can be covered by rosettes.

What types of stairs can be built?

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_____

3. Stair components

Tread width

The tread width of a step cannot be chosen at random. It is determined by the average step size of grown–up people.

The average step size to be considered for calculations is 630 mm!

Any new staircase to be built, which is not tied to fixed points like stair–aprons, is calculated to the step size formula.
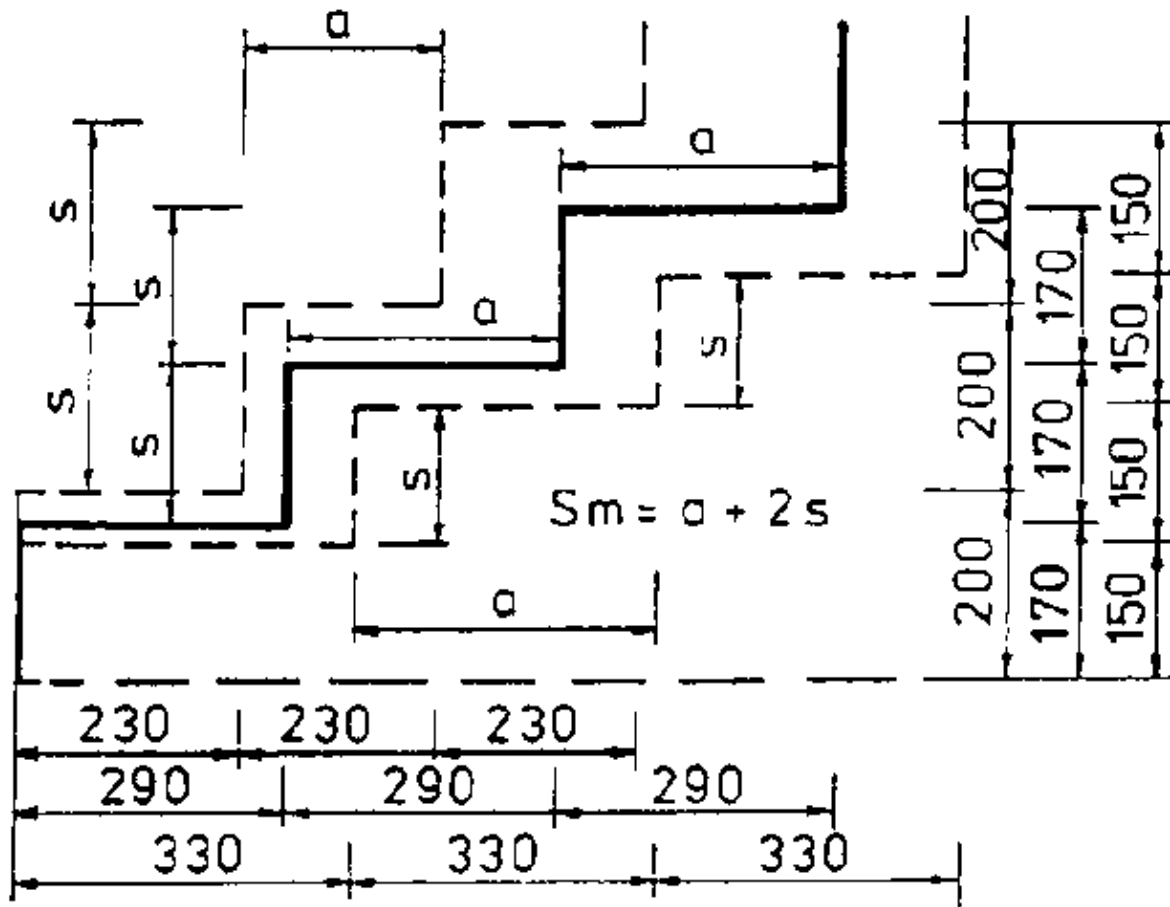
Sm = a + 2s

Sm = step size   (Formula 2)

Figure 9 – Representation of the dependence of the height of rise and of the tread width on the step size – **a** tread width, **s** height of rise, **Sm** step size

Since the tread width depends, to a great extent, on the height of rise, the step size of 630 mm can be taken care of. Thus the step size may vary between 615 mm and 645 mm. Stairs built in this ratio of rise and tread are easy to step on.

Height of rise

The height of rise is the vertical distance between the surfaces of the steps (treads).

The height of rise cannot be chosen at random.

For floor–to–floor staircases in dwelling houses it should be between 165 mm and 190 mm.

The height of rise takes priority for the determination of the ratio of rise and tread because the head steps of the flights must be flush with (have the same height as) the surfaces of the stair landings and the heights of rise within one flight must be of the same size.

The height of rise is calculated by means of the following formula:

$$s = \frac{Lh}{n_s}$$

Lh = flight height   (Formula 3)

n_s = number of rises

In order to calculate the height of rise for a flight, the number of rises must be known first. The number of rises can be determined by assuming any height of rise between 165 mm and 190 mm and completing the formula by it.

$$n_s = \frac{Lh}{s_g}$$

(Formula 4)

sg = height of rise chosen (assumed)

If the result is a decimal fraction, it must be rounded off to bring it up or down to an integer number.

When rounding down, the height of rise will become greater than the one assumed!
When rounding up, the height of rise will become smaller than the one assumed!

Such rounded–off figure is applied to the formula (3) to get the height of rise for the staircase.

The ideal height of rise is 170 mm!

For stairs in ancillary rooms the height of rise may be up to 220 mm.

Ratio of rise and tread

The ratio of rise and tread is expressed by formula (5).

$$m = \frac{a}{s}$$

m = ratio of rise and tread

a = tread

s = height of rise

The ideal ratio of rise and tread is:
$$m = \frac{290}{170}$$

Any staircase must be built to a ratio of rise and tread to be determined in advance.

The height of rise takes priority for the determination of the ratio of rise and tread.

Even if drawings are available for stairs to be built, you should not rely on such drawings only.

Generally, all dimensions for the manufacture of a staircase should be taken from the stairwell and be compared with the drawing.

In most cases, the dimensions taken from the stairwell differ from the dimensions in the drawing. Therefore, the ratio of rise and tread is to be calculated anew for each staircase.

The dimensions taken from the stairwell are binding for the calculation of the ratio of rise and tread!

What is the meaning of "ratio of rise and tread" of a staircase?

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Flight line of stairs

The flight line is an imaginary line running over the front edges of the steps in the centre of the stair flight. In the plan view it is represented by an arrow showing the flight direction of the stairs (see Fig. 11).

> The ratio of rise and tread is determined at the flight line shown in the plan view.

Flight length of stairs

The flight line shown in the plan view corresponds to the real length of the stair flight.

> The flight length of stairs is the horizontal distance between the front edge of the bottom step and the front edge of the head step.

The stair flight is the inclined part of the stairs and consists of a number of treads of equal width.
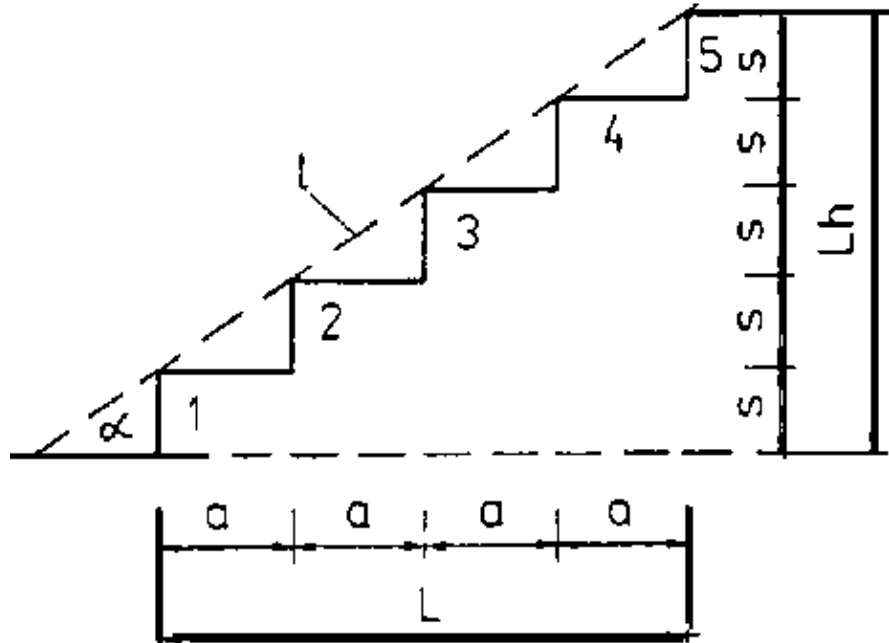

Figure 10 – Connection between stair flight length and stair flight height – **a** tread width, s height of rise, 1 stair flight line, – **L** stair flight length, **Lh** stair/light height, ? angle of inclination of the stair flight 1 – 4 in "L " direction is the number of treads 1 – 5 in "Lh" direction is the number of rises
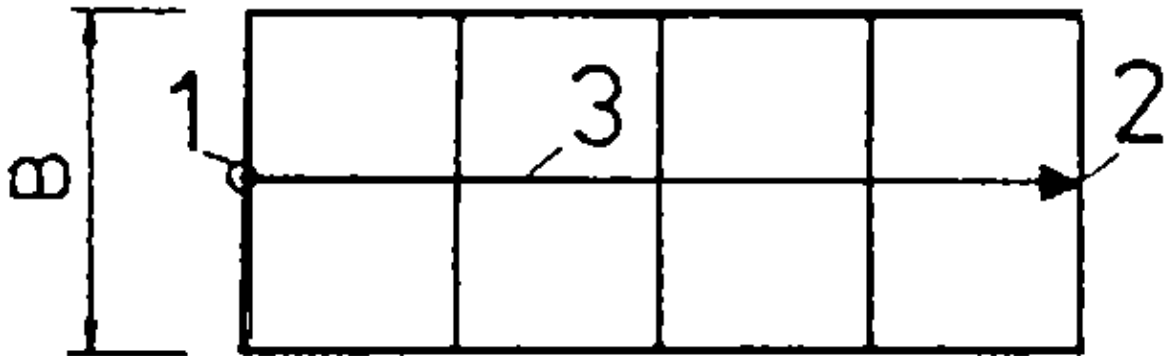

Figure 11 – Layout (plan view) of the stair flight *1 stair foot* (*bottom step*) *at the stair flight line, 2 stair head* (*head step*) *at the stair flight line, 3 stair flight line, **B** stair flight width*

The flight length is calculated to the formula:

$L = n_a \cdot a$

L = flight length of stairs   (Formula 6)

n_a = number of treads

One flight of stairs should consist of not more than 15 treads. If more than 15 treads are required for a staircase, a landing should be included.

More than 15 treads in one flight of stairs would require much physical effort of the user of such stairs. If the tread width is required for the calculation of the ratio of rise and tread, formula (6) is to be conversed to give the tread width as under:

$$a = \frac{L}{n_a}$$

This formula is required when the flight length is limited by built–in stair–aprons (see Fig. 12).

Flight height of stairs

The flight height of stairs consists of a number of heights of rise of equal size (see Fig. 10).

The flight height of stairs is the vertical distance between the surfaces of the two landings.

In this respect it is important that the distance between the surfaces of the finished floor is to be measured. That means, the construction of the floor must be known!

The flight height of stairs decides how many rises are to be included in a flight of stairs because the height of rise cannot be chosen at random.

The flight height is calculated to the formula:

$Lh = n_s \cdot s$ (Formula 8)

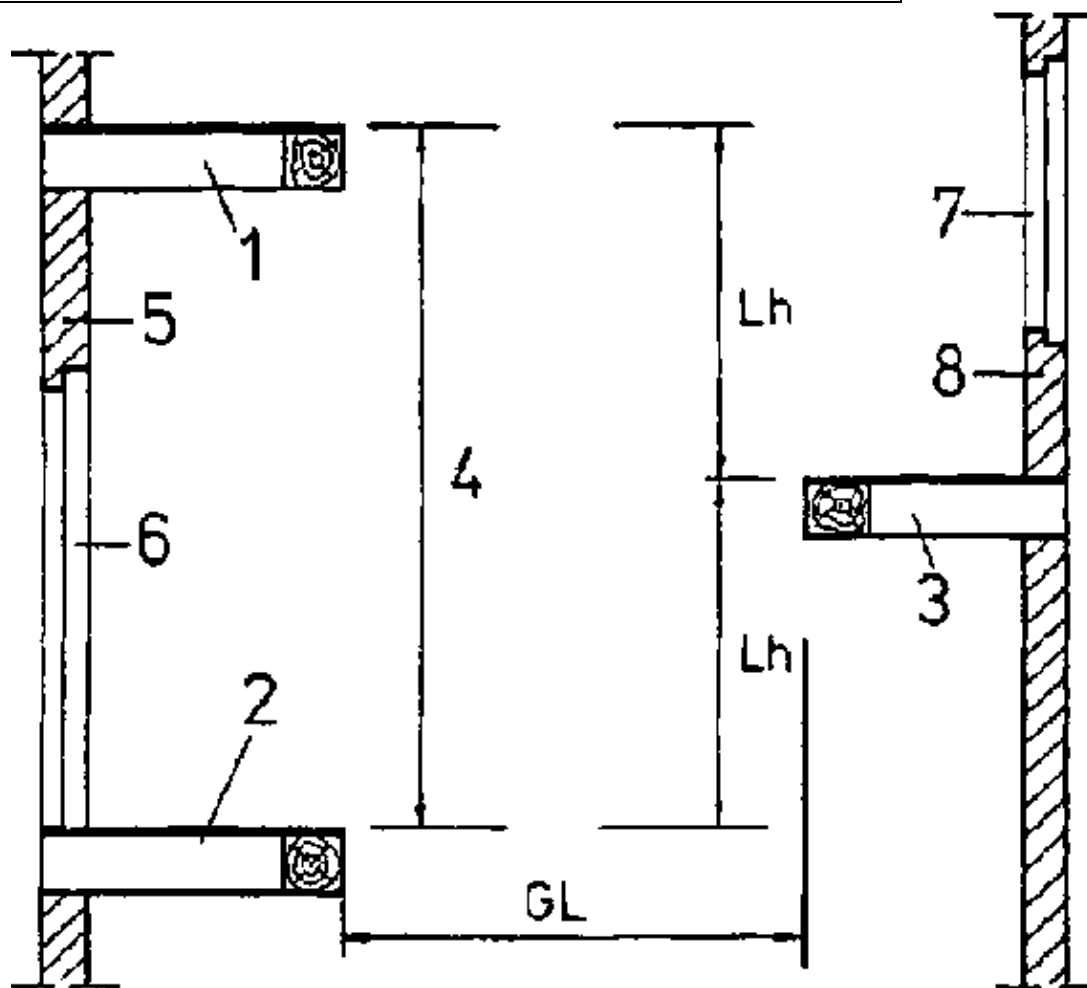| The flight height of stairs is riot in any case equal to the height between floors. |
| --- |

Figure 12 – Connection between floor–to–floor height (height between floors) and the stair flight height – *1 main top landing, 2 main bottom landing, 3 half–landing, 4 floor–to–floor height, 5 staircase (stairwell) wall with access to flat, 6 access to flat (door), 7 staircase window, 8 staircase (stairwell) wall (mostly outer wall),*

The height between floors is the vertical distance between the surfaces of the main landings! In stairmaking it is important to know that each flight of stairs always has one rise more than treads!

$$n_s = n_a + 1 \quad \text{(Formula 9)}$$

What is the flight line of stairs important for in stairmaking?

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What is the "flight length of stairs"?

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What is the "flight height of stairs"?

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Landings

Stair landings are resting places for people who, for health or age reasons, have difficulties in climbing stairs. Without landings the flight of stairs would not be accessible!

The length of main landings must correspond to the flight width. Half–landings must have a minimum length of three times the tread width.
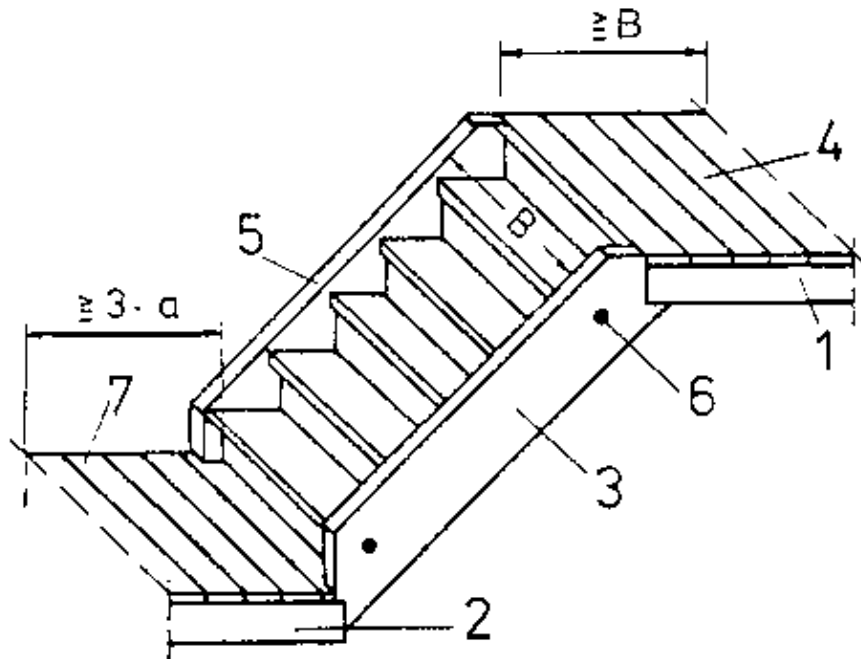

Figure 13 – Representation of the lengths of the main landing and half–landing – *1 main landing, half–landing, 3 outer string, 4 surface – main landing (surface – flooring), 5 wall string, 6 rosette, 7 surface half–landing (surface flooring), B stair flight width*

A stair landing need not always be clearly visible, the half–landing for example. It may pass into the floor ceiling with no noticeable transition point. With wooden stairs, the landings support the flight of stairs. The bottom landing must resist and distribute horizontal and vertical forces, the top landing horizontal forces only.
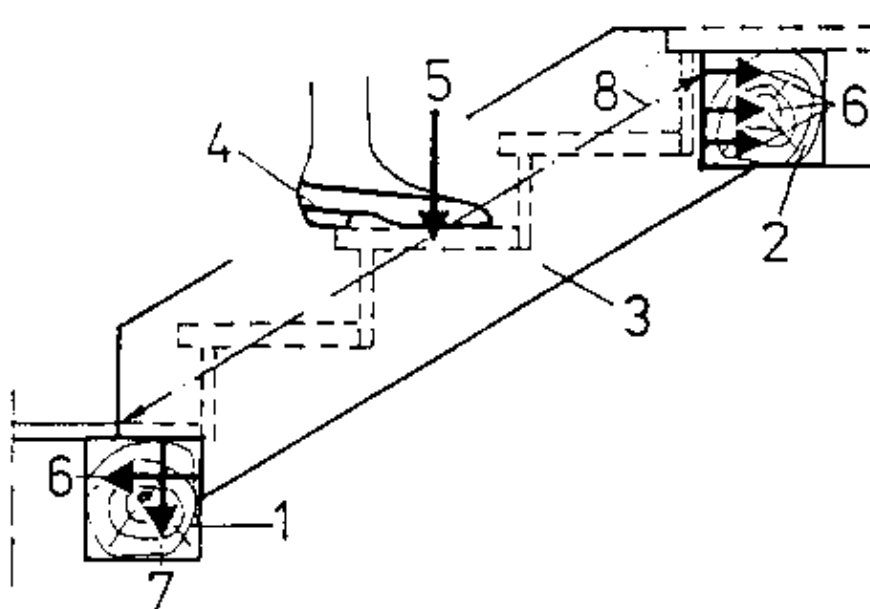
Figure 14 – Distribution of forces in the bottom and top landings – *1 lower stair–apron, 2 upper stair–apron, 3 stair string, 4 load on the stairs by user, 5 acting force by user, 6 force acting horizontally, 7 force acting vertically, 8 force acting diagonally between the two landings*

Stairwell

The stairwell is the space intended for building–in the staircase.
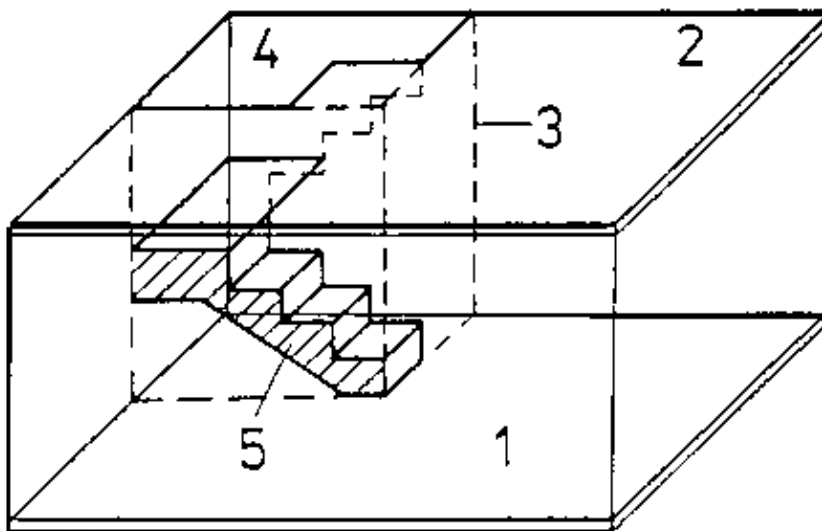

Figure 15 – Representation of the stairwell – *1 lower floor–ceiling, 2 upper floor–ceiling, 3 stairwell, 4 opening in the upper floor–ceiling, 5 stairs with half–landing to be built in*

It is limited in length by the existing opening in the upper floor–ceiling and in the height by the surfaces of the floor ceilings.

The width depends on the type of stairs to be built in. The height between floors decides on the type of stairs to be built in.

The dimensions for the stairs to be built are to be taken from the stairwell and to be compared with the existing drawing.

The stairwell height is always based on the surface of the finished floors!

In order to compare the dimensions taken with the drawing, a hand–sketch is to be drawn and completed by the dimensions taken.

> In the case of mortised stairs, 40 mm are to be deducted from the stairwell length to prevent the necessary riser from contacting the stair–apron!

The stair strings only must contact the stair–apron (see Fig. 16).

What does the term "stairwell" mean?

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Drawing floor

In order to build a straight wooden staircase, only the top and bottom connections to landings need to be drawn (scale 1: 1) on the drawing floor.

It is not necessary to take into account the measured flight length and flight height.

The required angle of inclination of the flight is obtained by drawing (scale 1:1) two treads and two heights of rise at the top stair–apron.
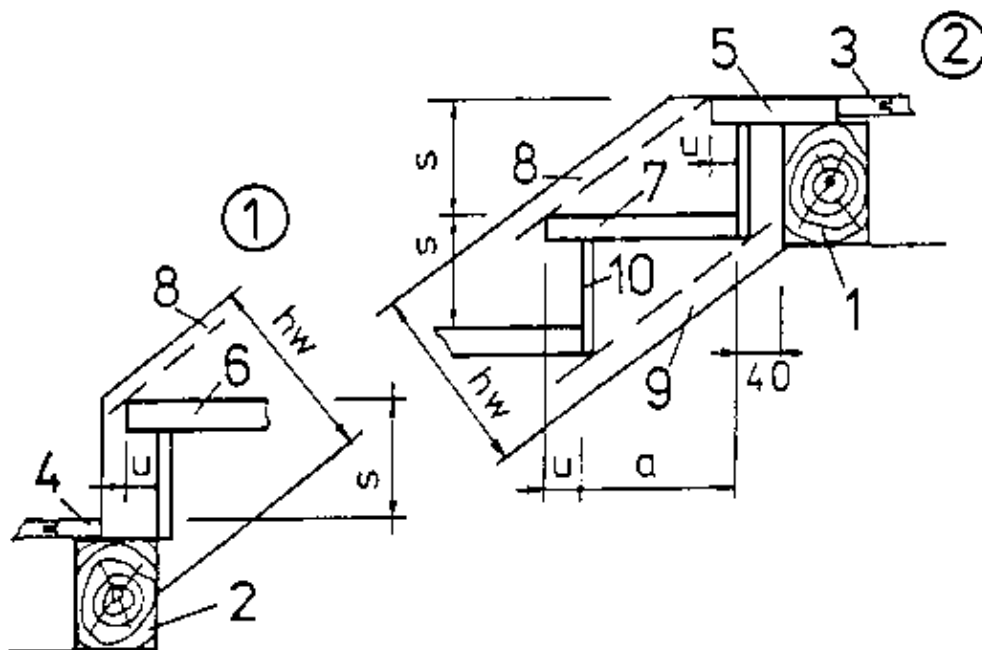

Figure 16 – Drawing of the top and bottom string connections at the stair–aprons – (1) bottom connection (2) top connection – *1 lower (bottom) stair–apron, 1 upper (top) stair–apron, 3 floor construction of the top landing, 4 floor construction of the bottom landing, 5 stair head (head step), 6 stair foot (bottom step), 7 step, 8 string top, 9 string bottom, 10 riser, – **a** tread width, **s** height of rise, **u** false tread, h_w string height*

The angle of inclination can be laid off to the bottom connection by means of a bevel protractor.

A flat, clean plate is used as drawing floor.

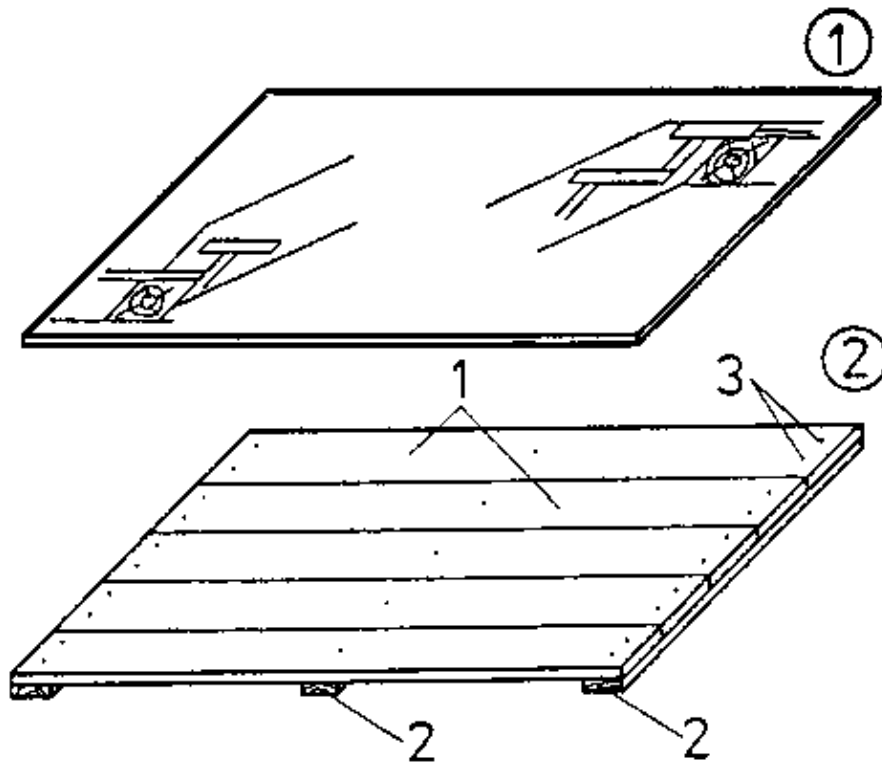It is also possible to use clean boards nailed onto supporting strips.

Figure 17 – Representation of a drawing floor – (1) flat, clean plate (2) drawing floor made from boards – *1 boards, 2 supporting strings, 3 nails*

Stair strings

The stair strings carry the steps in 20 mm deep mortises. The string height can be measured from the drawing floor (see Fig. 16).

The string length can be determined by means of the approximation formula

$$L_w = (n_s + 0.5)\, c \hspace{4cm} \text{(Formula 10)}$$

L_w = length of the posts for the stair string
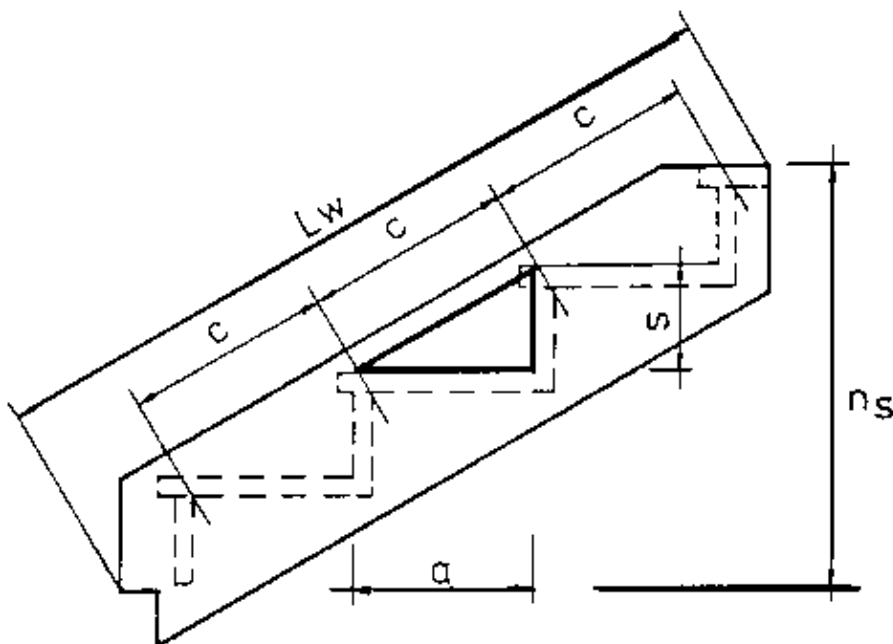
c = size between the front edges of the steps.

Figure 18 – Sketch for determining the stair string length – *a tread width, s height of rise, n_s number of rises, L_w length of posts for the stair string, c length at a rise triangle*

The size "c" can be measured from the drawing floor. The thickness of the string should be at least 50 mm. It is recommended to plane the posts for the stair string on four sides prior to scribing, making sure that they are in parallel. The dimensional tolerances in thickness and height may be ± 1 mm.

Steps

The steps must all be cut to the same length (B + 2 • 20 mm).

"B" is the clear width of the stair flight (see Fig. 13). They must all have the same length to be uniformly fixed (clamped) when the stair strings are drawn together by the screw rods.

If some steps are not fixed (clamped) by drawing together, they will squeak when stepped on.

The steps are surfaced on one small side and one wide side and then thicknessed.

After that the width is scribe–marked. For width scribing it is important that the width of the steps must have the size of the tread width (go width) plus false tread.

For sawing–out of the steps, 2 mm are to be added and will be removed by planing after sawing–out (see
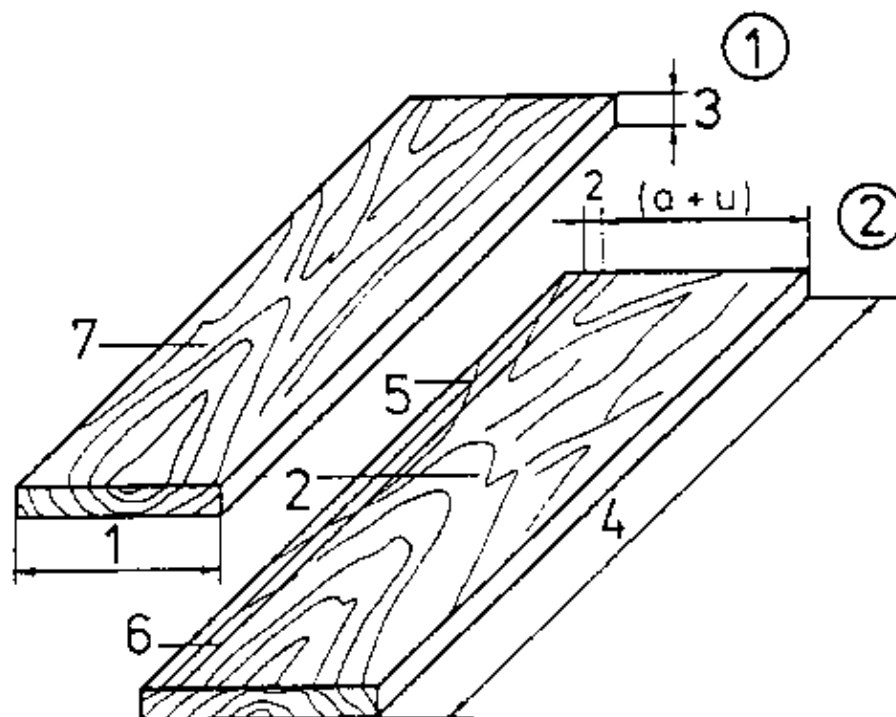

Figure 19 – Connection between rough–step size and finished–step size – (1) rough step (2) finished and scribe–marked step – **a** tread width from the calculation, **u** false tread, – 1 *wide side of the step, 2 left side of the step, 3 small side of the step, 4 length of the step, 5 scribed line for sawing to width of step, 6 scribed line of exact width of step, 7 right side of the step*

When preparing the steps it is to be considered that the left side of the wood is to be stepped on!

How deep should the steps be mortised into the stair string?
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_____

Risers

The risers are to be cut 4 mm shorter than the steps. They must not be clamped by drawing together of the stair strings. The risers must have a slight cove upwards of approx. 2 mm to provide good support to the steps in the flight line when being stepped on. For preparing and planing of the risers the same working steps are required as for the steps.

Stair railing

17

The railing protects the user of the stairs from falling down at the side. It consists of the bottom post, the head post and the hand–rail.
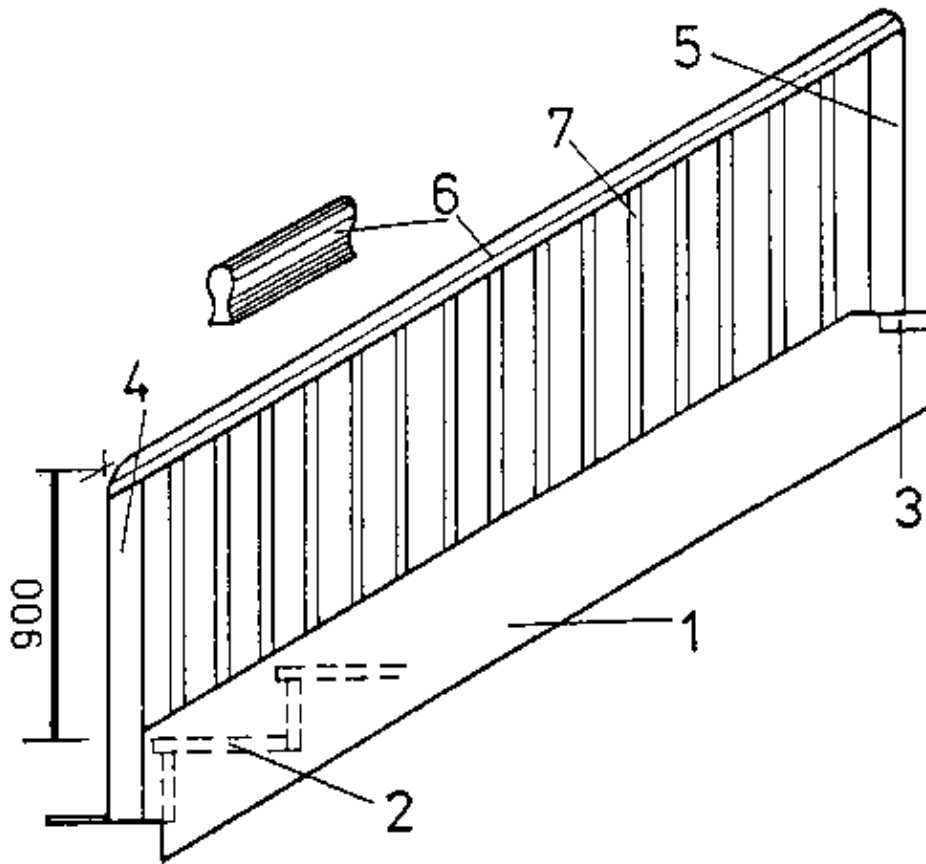

Figure 20 – Stair railing with vertical railing bars – *1 outer string, 2 bottom step, 3 head step, 4 bottom post, 5 head post, 6 hand–rail, 7 vertical railing bar*

Protection between the hand–rail and the outer string can be achieved by unprofiled or profiled vertical railing bars. The railing bars are mortised into the hand–rail. At the bottom end, the railing bars can be mortised directly into the outer string. But it is also possible to use a baseboard for the railing bars to be mortised into. The tenon in the railing bar is spot–faced to avoid back–mortising in the hand–rail, outer string or baseboard.
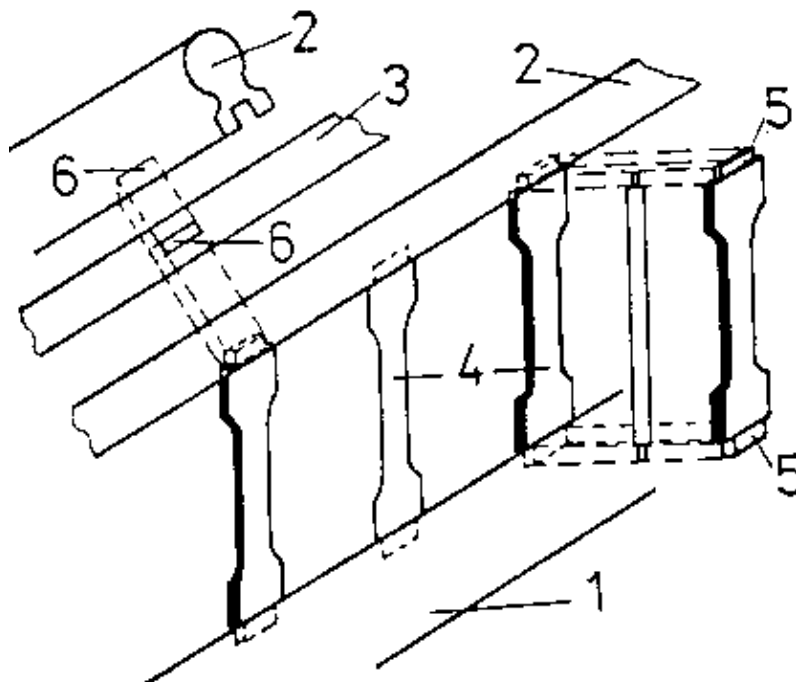

Figure 21 – Representation of the mortise–and–tenon joints of the railing bars – *1 outer string, 2 hand–rail, 3 underside of the handrail, 4 railing bar (profiled), 5 tenon of the railing bar, 6 mortise in the hand–rail*

The hand–rail is to be designed so as to permit easy gripping of it and convenient sliding on it.
Side–protection at the outer string can also be achieved by bars which are in parallel with the hand–rail.
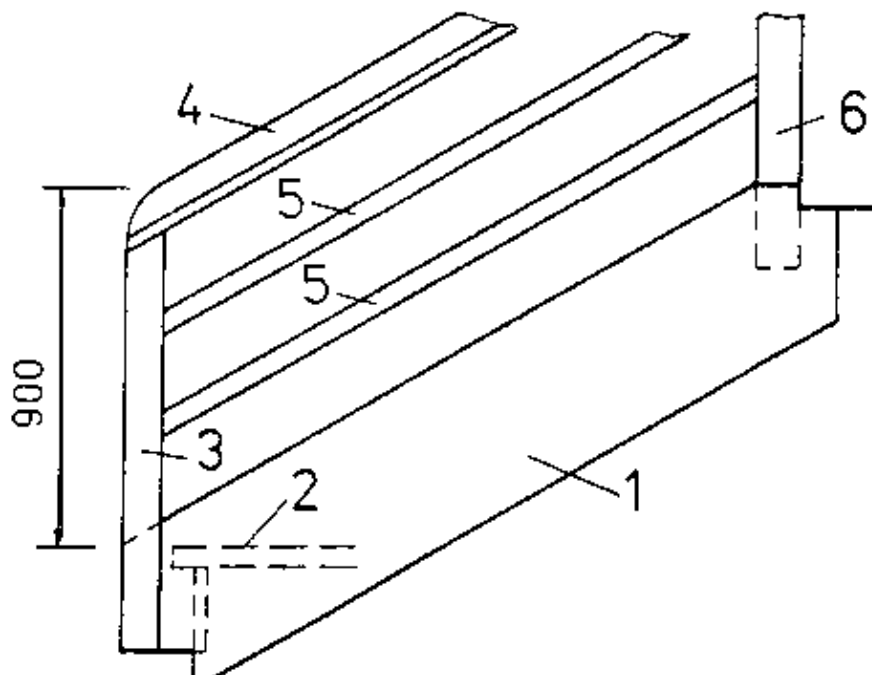
Figure 22 – Stair railing with parallel bars – *1 outer string, 2 bottom stepp, 3 bottom post, 4 handrail, 5 railing bars, 6 head post*

The distance between the railing bars is to be chosen so that children cannot slip through the bars.

The bottom and head posts can be connected with the outer string by a simple lap joint.

Figure 23 – Lap joint between railing post and outer string – *1 outer string, 2 railing post, 3 bottom step, 4 machine screw, 5 lap joint*

For better stability of the railing posts, they can also be connected with the outer string by a slit–and–tongue–joint.

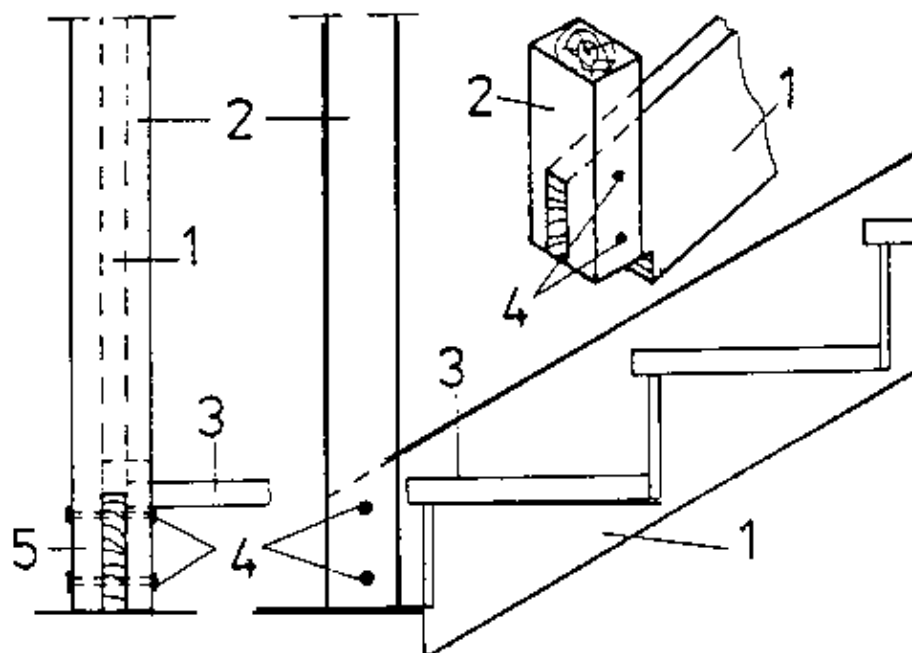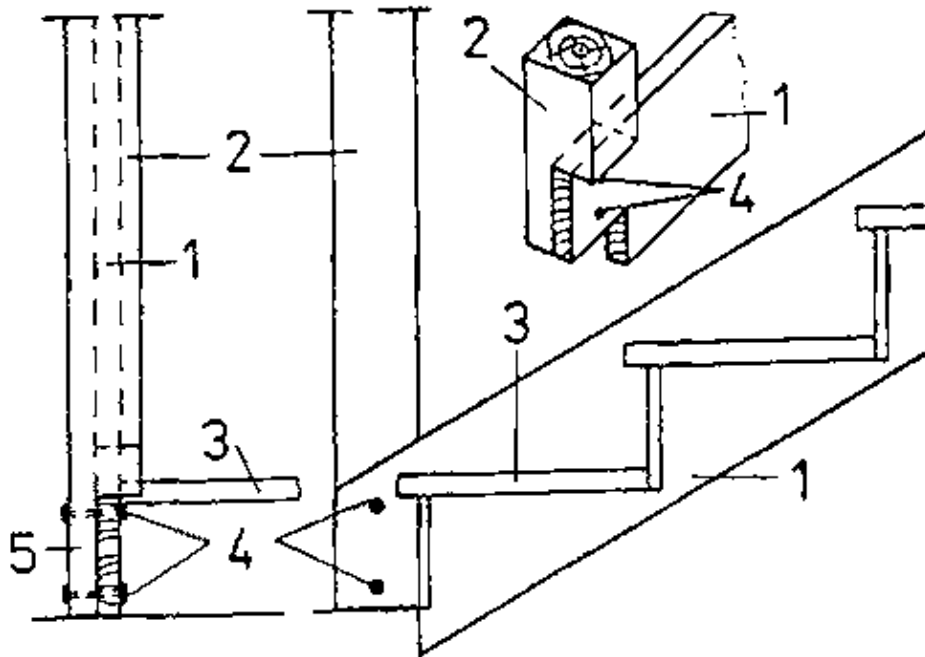**Figure 24 –** Slit–and–tongue joint between railing post and outer string – *1 outer string, 2 railing post, 3 bottom step, 4 machine screw, 5 slit–and–tongue joint*

The railing posts can be glued or screwed to the outer string. The screw heads can be covered by rosettes.

What is the purpose of stair railings?

_____
_____
_____

4. Taking off Dimensions at the Stairwell

Two different types of dimensions are taken off at the stairwell: layout dimensions (plan view) or height dimensions. Wooden staircases may also be built in between solid ceilings. In that case, the surface of the bare ceiling is decisive instead of the surface of the stair–apron (see Fig. 28).

Taking off layout dimensions

The size of the existing or planned opening for the staircase is transferred from the upper floor–ceiling by plumbing.

The plumb points are marked on the lower floor–ceiling and then connected by means of a straightedge (straight, parallel, planed board of 20 – 30 mm thickness, 140 mm width and 2000 – 3000 mm length). A marking–out drawing is drawn.
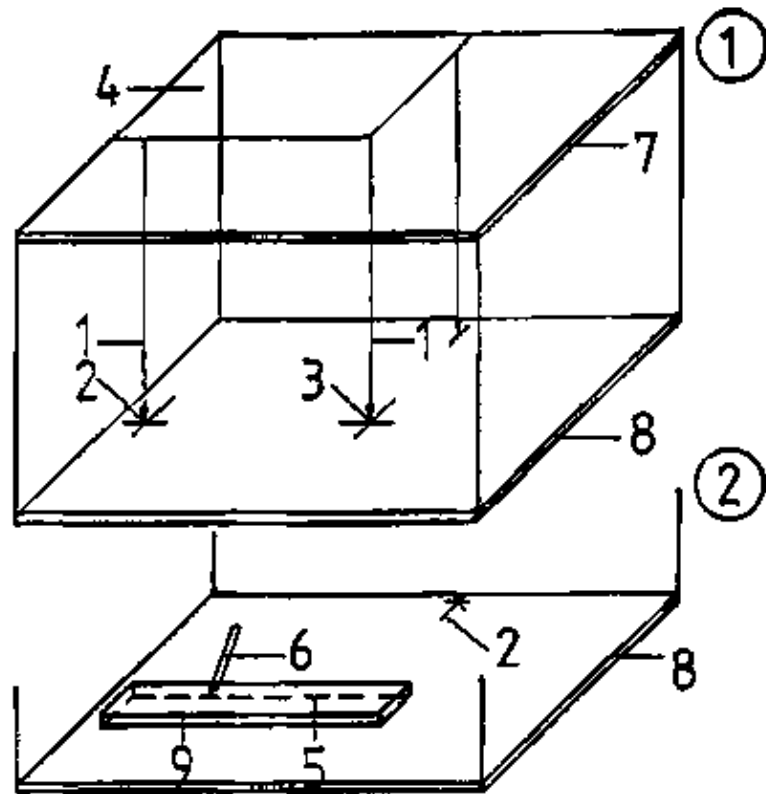
Figure 25 – (1) Transferring of dimensions to the lower floor–ceiling (2) Connecting of marked points with the straightedge – *1 plumb cord, 2 marked point, 3 plumb body, 4 opening in the upper floor–ceiling, 5 applied straightedge, 6 pencil, 7 upper floor–ceiling, 8 lower floor–ceiling, 9 straightedge*

The squareness of the stairwell is checked on the lower floor–ceiling. A self–made builder's square, joined by means of the proportional numbers 3:4:5 and nailed, is used for this purpose.
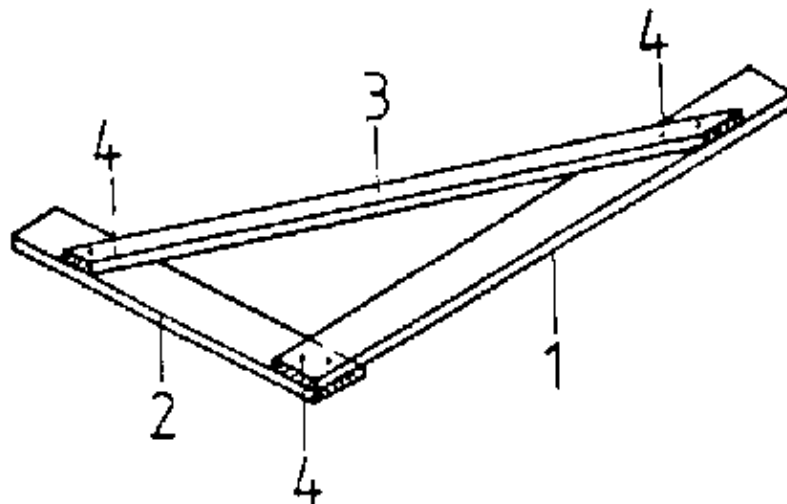
Figure 26 – A builder's square – *1 longer, straight strip for true alignment, 2 shorter, straight strip for true alignment, 3 strip for stiffening (bracing) the two straight strips, 4 nail*

All dimensions taken off are written into a hand–sketch.

Checking of squareness

The angle between the stair flight range and the range at the stair head in the main landing or half–landing is checked. If the two ranges are not square with each other, the right angle is prescribed.

Figure 27 – (1) Checking of squareness of the stairwell – *1 builder's square,* 2 *applying the square to the stair flight range, 3 border of the upper floor–ceiling, 4 squareness with the stair flight range, 5 squareness of the wall corner* – (2) Determination of the size of the stairwell 2 *stair flight range, 4 right* (*square*) *angle with the stair flight range,* **GB** stairwell width, **GL** stairwell length

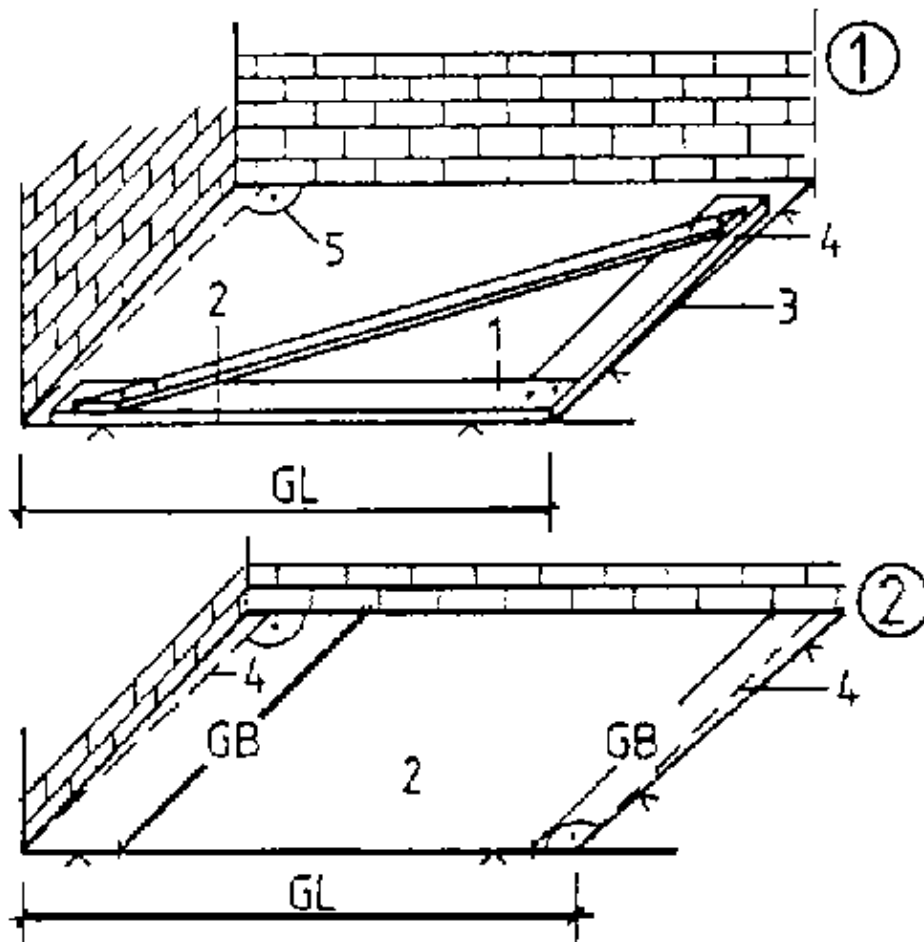Prescribing of the right angle is based on the stair flight range and the smallest size of the stairwell length is written into the hand–sketch.

When the finished staircase is built in, the difference can be made–up (padded with wood) at the stair apron.

Taking off height dimensions at the stairwell

In this connection it is important to know whether the height dimensions are to be taken off at stairwells with or without half–landing. The height dimensions take priority for the calculation of the ratio of rise and tread because the staircase to be manufactured is to be built in between the landings with finished floor with a height of rise of s = 200 mm. This means that the height dimensions in the stairwell are not in any case equal to the dimensions for the stair flight height.
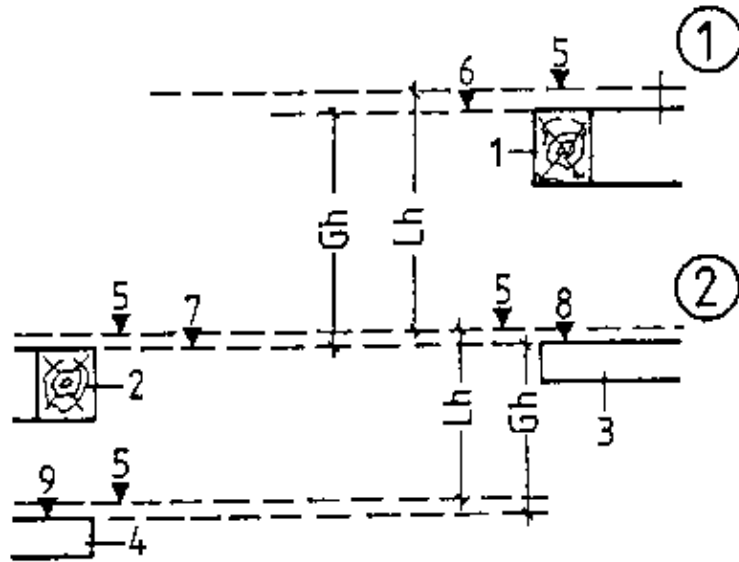
Figure 28 – Connection between stairwell height and stair flight height – (1) with wood joist ceiling (2) with solid ceiling – *1 upper stair–apron, 2 lower stair–apron, 3 upper solid ceiling, 4 lower solid ceiling, 5 surface of finished floor, 6 surface of upper stair–apron, 7 surface of lower stair–apron. 8 surface of upper bare ceiling* (*solid ceiling*)*, 9 surface of lower bare ceiling –* **GH** *stairwell height,* **Lh** *stair flight height*

> The staircase must be built in between the landings with finished floor. Therefore the stairmaker must know the floor construction of the two landings.

The size for the stair flight height results from the following consideration:

$$Lh = Gh - d_1 + d_2 \qquad\qquad\qquad \text{(Formula 11)}$$

Gh = stairwell height between two landings of different levels

d_1 = floor thickness of the bottom landing

d_2 = floor thickness of the top landing

Taking off height dimensions without half–landing

The perpendicular height between the surfaces of the stair–aprons or bare ceiling at the head and foot of the stairs to be built in is measured. The stair flight height is then determined applying formula 11.
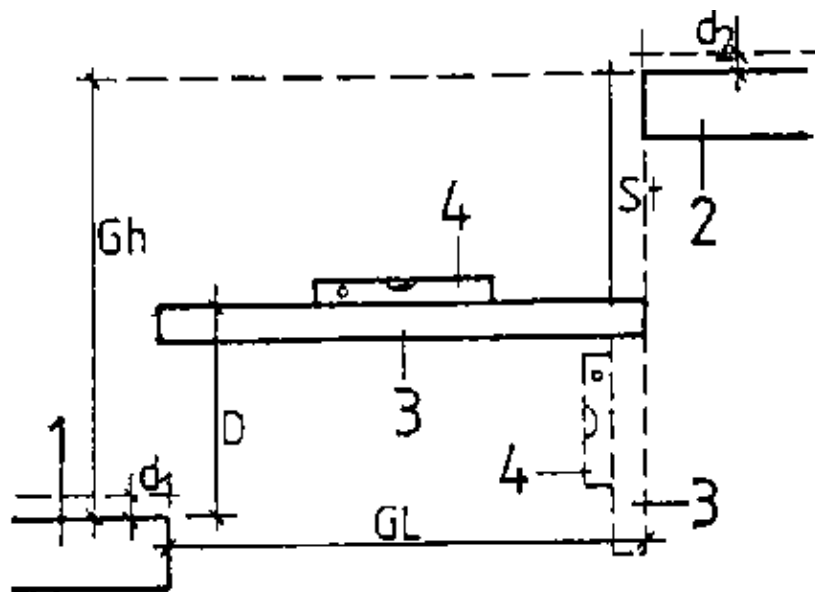

Figure 29 – Taking off height dimensions without half–landing – *1 bottom landing, 2 top landing, 3 straightedge, 4 water level, –* **d₁** *floor thickness of bottom landing,* **d₂** *floor thickness of top landing* **Gh** *stairwell height,* **GL** *stairwell length,* **St** *gauge size,* **D** *difference size*

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The stair flight height thus determined is used for the calculation of the ratio of rise and tread.

Taking off height dimensions with half–landing

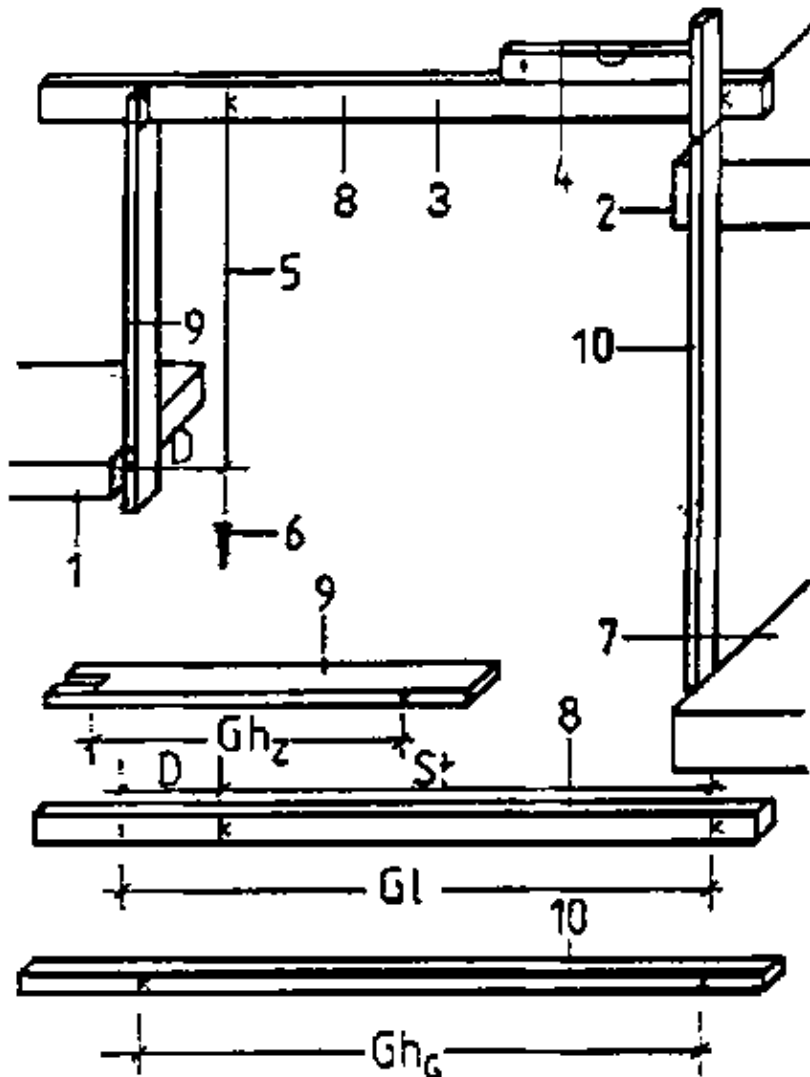Together with the height measurement, the length for the stair flights to be built in is determined.

Figure 30 – Taking off height dimensions with half–landing – *1 bottom landing {half–landing, 2 top landing (main landing) (upper floor–ceiling), 3 straightedge, 4 water level, 5 plumb cord, 6 plumb body, 7 bottom landing (main landing) (lower floor–ceiling), 8 straightedge serving as measuring batten at the same time, 9 batten to support the straightedge and serving as measuring batten at the same time, 10 measuring batten between the two floor–ceilings – D difference size, GH_Z stairwell height at half–landing, Gh_G stairwell height between the floor–ceilings, GL stairwell length, gauge size*

Sequence of operations:

– The plumb cord is fixed to the straightedge.

– The straightedge is put on the top apron.

The end, which the plumb cord is fixed to, is supported by a batten. The batten is held perpendicularly at the half–landing by a second person.

– A water level is put onto the straightedge and levelled by raising or lowering the batten at the half–landing.

– When the straightedge is exactly horizontal, the batten is pressed to the half–landing and the height marking is scribed.

– When the pendulum movement of the hanging plumb has stopped, the gauge size between the plumb cord and the front edge of the stair–apron is measured. At the same time the front edge of the top landing is scribed to the straightedge.

The two sizes, the gauge size and the size on the straightedge between the plumb cord and the front edge of the top landing, are the length of the stairwell.

– Measuring of the height of the stairwell between the two main landings. (Use a batten!) The scribed sizes on the battens 8, 9, 10 in Figure 30 can be measured with a folding rule!

– Checking whether the height of the half–landing (height with finished floor) will fit into the calculated ratio of rise and tread.

> The half–landing with its finished floor must be located at a height of $n_s \cdot s$!

If this is not the case, the half–landing must be removed and built in again at the necessary height. If this is not done, the two stair flights within one storey will have a different ratio of rise and tread!

> A different ratio of rise and tread within stairs with two apposed branches of flights (180 degrees turn) and landing must be avoided, otherwise climbing of such stairs is not safe!

The batten used for supporting the straightedge must be slotted on top to prevent the straightedge from slipping off.

Drawing the hand–sketch

A hand–sketch is to be drawn on a sheet of paper which need not be true to scale.
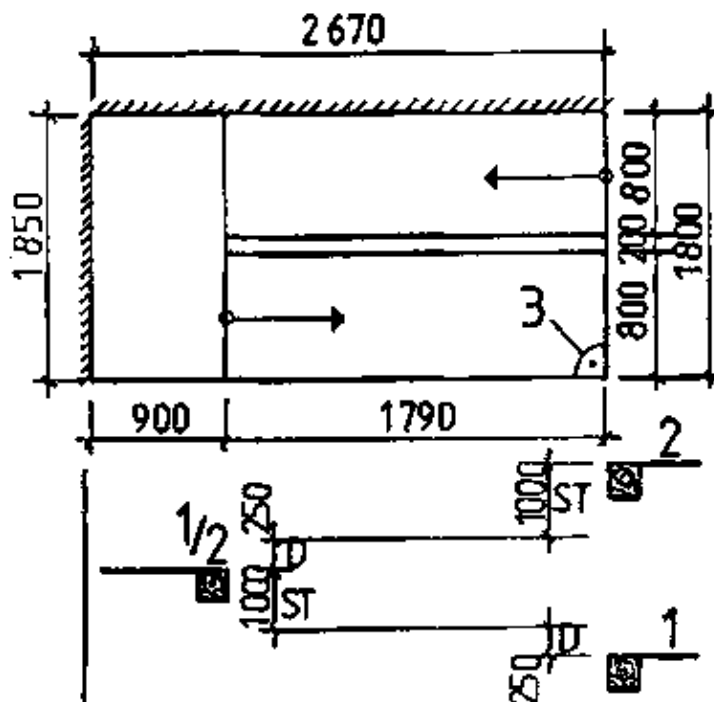
Figure 31 – Hand–sketch with stairwell dimensions written into it – *1 lower stair–apron, 2 upper stair–apron, 3 determined right angle, – **D** difference size, **St** gauge size*

All dimensions taken off are to be written into such sketch. In the plan view length and width of the stairwell and in the elevation the height dimensions of the stairwell are to be shown.

On the basis of such sketch, the sizes for the stairs to be built will be determined and the ratio of rise and tread calculated.

Why must the dimensions of the drawing be compared with the dimensions of the stairwell?

_____
_____
_____

5. Calculations for Stairmaking

Example 1:

A staircase of saddle stairs with a flight width of 1250 mm is to be built in. What perpendicular height must the string bottom have when the height of rise is 190 mm?

Required: h_u

Known: s = 190 mm

              W_d = 65 mm (Table 2)

Formula:
$$h_u = 40\,\text{mm}\left(\frac{s}{W_d} + 2\right)$$
(Formula 1)

Calculation:
$$h_u = 40\,\text{mm}\left(\frac{190\,\text{mm}}{65\,\text{mm}} + 2\right)$$
h_u = 169.9 mm

h_u = 200 mm chosen

The string bottom must have a perpendicular height of 200 mm.

Example 2:

A staircase has a tread width of 288 mm and a height of rise of 171 mm. What is the ratio of rise and tread of this staircase?

Required: m

Known: a = 288 mm

              s = 171 mm

Formula:
$$m = \frac{a}{s}$$
(Formula 5)

Calculation: (Don't work out, just delete the unit of measurement!)
$$m = \frac{288\,\text{mm}}{171\,\text{mm}}$$

$$m = \frac{288}{171}$$

The ratio of rise and tread of the stairs is $\frac{288}{171}$

Example 3:

A tread width of 286 mm and a height of rise of 172 mm have been measured at inserted stairs. What is the step size for climbing such stairs?

Required: Sm

Known: a = 286 mm

             s = 172 mm

Formula: Sm = a + 2s   (Formula 2)

Calculation: Sm = 286 mm + 2 • 172 mm   Sm = 630 mm

The step size is 630 mm.

Example 4:

A vertical distance of 1750 mm has be measured between two landings. The stairs to be built in shall have a height of rise of 170 mm.

How many rises will such stair flight have?

Required: n_s

Known: Lh = 1750 mm

             s_g = 170 mm

Formula: $$n_s = \frac{Lh}{s_g}$$ (Formula 4)

Calculation: $$n_s = \frac{1750\,mm}{170\,mm} = 10.29$$ n_s = 11

The stair flight will have 11 rises.

Example 5:

For mortised stairs with 10 rises the stair flight height is 1680 mm. What is the height of rise for such stairs?

Required: s

Known: Lh = 1680 mm

             n_s = 10

Formula: $$s = \frac{Lh}{n_s}$$ (Formula 3)

Calculation: $$s = \frac{1680}{10}\,mm$$ s = 168 mm

The height of rise of such stairs is 168 mm.

Example 6:

A stair flight has 12 treads. The tread width is 283 mm. What is the length of such stair flight?

Required: L

Known: n_a = 12

             a = 283 mm

Formula: L = n_a • a   (Formula 6)

Calculation: L = 12 • 283 mm   L = 3396 mm

The stair flight length is 3396 mm.

Example 7:

A stair flight length of 3124 mm is available for mortised wooden stairs. The stairs shall have 11 treads. What is the tread width of the stair steps?

Required: a

Known: $L = 3124$ mm

$n_a = 11$

Formula: $a = \dfrac{L}{n_a}$ (Formula 7)

Calculation: $a = \dfrac{3124\,\text{mm}}{11}$ $a = 284$ mm

The tread width of the stair steps must be 284 mm.

Example 8:

What is the stair flight height of stairs having 8 rises with a height of rise of 175 mm?

Required: a

Known: $n_s = 8$

$s = 175$ mm

Formula: $Lh = n_s \cdot s$ (Formula 8)

Calculation: $Lh = 8 \cdot 175$ mm $Lh = 1400$ mm

The stair flight height is 1400 mm.

Example 9:

A stair flight height of 1215 mm has been measured at the stairwell. The stairs to be built in shall be climbable with a step size of 630 mm.

What is the ratio of rise and tread for climbing such stair flight?

Required: m

Known: $Sm = 630$ mm

$Lh = 1215$ mm

$s_g = 190$ mm (Formula 5)

Formula: $m = a/s$

$a = Sm - 2s$

$s = \dfrac{Lh}{s_g}$

Calculation: $n_s = \dfrac{1215mm}{190} = 6.3$ $n_s = 7$

$n_s = \dfrac{1215mm}{7}$ $s = 173.5$ mm

$a = 630$ mm $- 2 \cdot 173.5$ mm $a = 283$ mm

$m = \dfrac{283mm}{173.5mm}$ $m = \dfrac{283}{173.5}$

The ratio of rise and tread of the flight is $\dfrac{283}{173.5}$

Exercise 1

Mortised stairs shall be calculated to the step size. A stair flight height of 1344 mm has been measured.

a) How many treads must be available?
b) What is the tread width of the stairs?
c) What is the consequent ratio of rise and tread of such stairs?

a) Required: n_a

Known: $n_s = \dfrac{Lh}{s_g}$

Lh = 1344 mm

s_g = 180 mm

Formula: $n_a = n_s - 1$

Calculation: $n_a =$

b) Required: a

Known: Sm = 630 mm

$s = \dfrac{Lh}{n_s}$

Lh = 1344 mm

$n_s = 8$

Formula: $a = sm - 2\ s$

Calculation: a
        =

c) Required: m

Known: a = 294 mm

s = 168 mm

Formula: $m = \dfrac{a}{s}$

Calculation: m =

Exercise 2

Saddle stairs shall be built in with a stair flight width of 1300 mm and a height of rise of 170 mm. What height must the string bottom have?

Required: h_u

Known: s = 170 mm

              W_d = 70 mm (Table 2)

Formula:

$$hu = 40\,mm\left(\frac{s}{W_d} + 2\right)$$

Calculation: h_u chosen = mm

Exercise 3

A single–flight staircase has 15 treads with a ratio of rise and tread of 278/176.

What length does this stair flight have?

Required: L $L = n_a \bullet a$

Known: n_a = 15

              a = 278 mm

Formula: $L = n_a \bullet a$

Calculation: L = mm

Exercise 4

A floor–to–floor height of 2656 mm has been measured at the stairwell. A straight staircase with two opposed branches of flights (180 degrees turn) and landing shall be built in. The length of landing is 800 mm. The height of rise shall not exceed 172 mm. The two stair flights shall have the same length.

a) How many rises will one stair flight have?
b) What length must the stairwell have if the stairs are to be built to the step size?

a) Required: ns
Known:
Formula:
Calculation: ns = _____

b) Required: GL
Known:
Formula:
Calculation: GL =_____ mm

Exercise 5

A staircase with inserted stairs has 8 treads with a tread width of 290 mm. What is the stair flight height of such stairs?

Required:
Known:
Formula:
Calculation: L = _____mm

6. Assembly of the Stair Components

Assembly of the stair flight

Single–branch flights of wooden stairs are normally assembled in the workshop and transported to the stairwell as a complete unit.

The assembly of flights of saddle stairs is relatively simple because the steps (treads) are screwed onto the sawn–out stair strings. Accuracy to size is an important criterion in screwing on the steps.

The screws should be surface–treated or be made of nonferrous heavy metal so as to avoid rusting and mean appearance when the steps are cleaned by water.

Saddle stairs assembled in the workshop are secured against displacement during transportation by means of a diagonal strip.
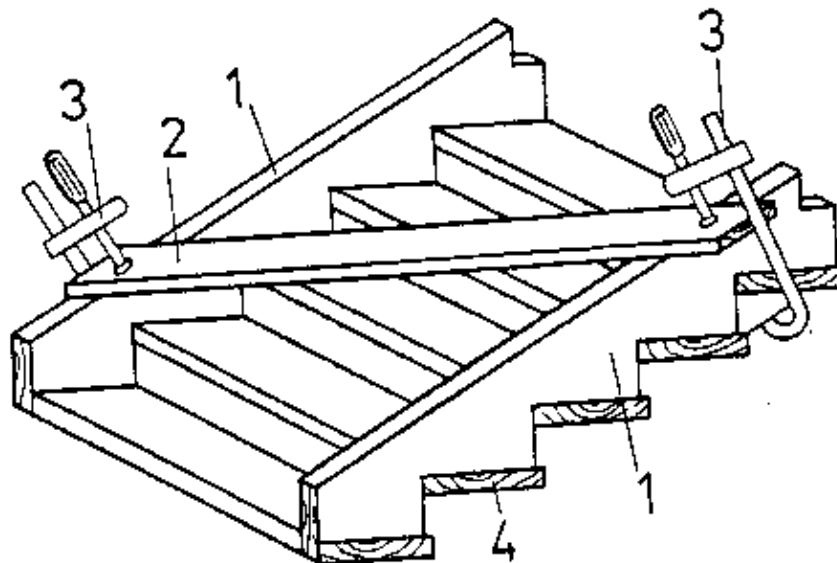

Figure 32 – Stair flight stiffened with diagonal strip (saddle stairs –underside view) – *1 sawn–out stair string, 2 diagonal strip, 3 screw clamp, 4 left side of step*

Screw clamps or ferrules are used for fixing the diagonal strip. To prevent marks in the wood, the lower surface of the string bottom is padded by wooden pads and the steps are padded by wedges having the shape of the rise triangles.

In the case of inserted stairs without arris for insertion of the steps, the stair foot and stair head may be inserted in the mortise (insertion slot) and the stair string be slightly drawn together with the screw rods.

To avoid displacement of the stair strings during assembly, a square–cut board with a length equal to the clear width of the stair flight is clamped between the stair strings. Such board must have a sufficient width and be clamped immediately in the area of the screw rods. This will prevent the stair strings from being drawn together too much.
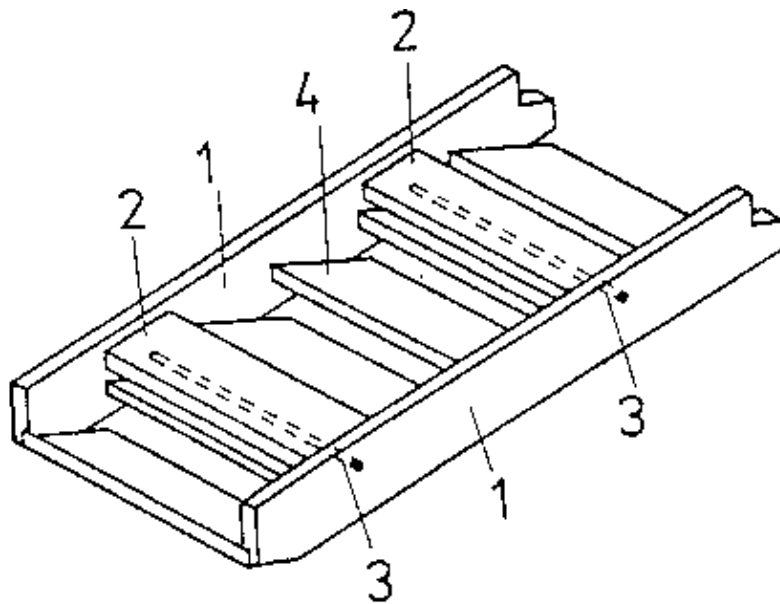
Figure 33 – Stair flight stiffened with square–cut board (inserted stairs – underside view) – *1 stair string, 2 square–cut board for stiffening, 3 drawn–in screw rod, 4 inserted step*

The remaining steps are slid into the insertion slots from the front (see Fig. 7/2). The steps must tightly fit in the insertion slots. If necessary, a hammer may be used for beating in.

Be careful: Use a wooden pad when beating with the hammer to avoid beating marks.

In the case of inserted stairs with arris for insertion of the steps, the steps are inserted, one after the other, into the insertion slots until half of the tread width. Then the steps are, one by one, beaten in cm by cm. A wooden pad is to be used so as not to leave beating marks.

The procedure with mortised stairs is as follows:

– Wooden pads of equal thickness are placed on a flat workshop floor at 500 mm intervals for putting–on the stairs strings.

– The two stair strings are put on the wooden pads flush with each other and with the mortised holes for holding the steps and risers showing upward.
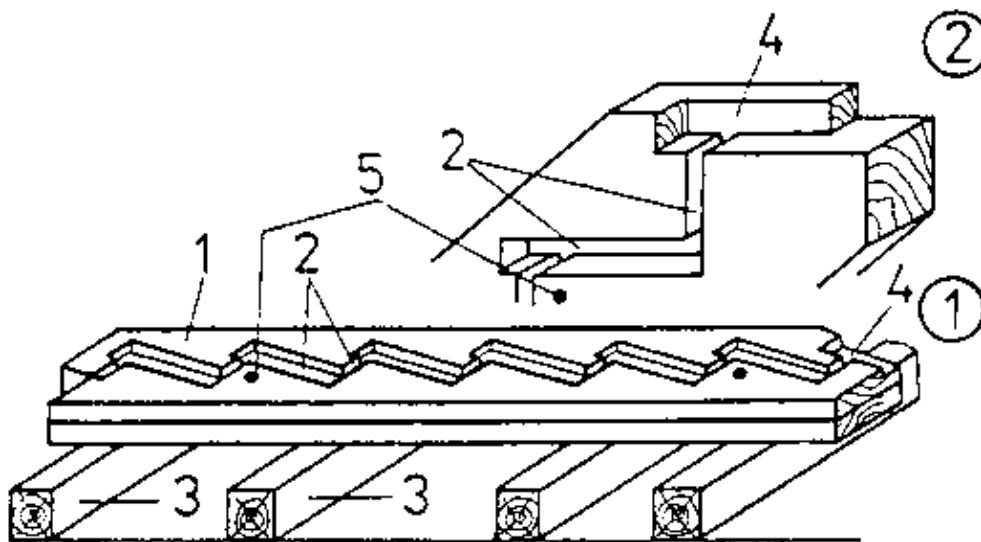

Figure 34 – (1) mortised stair strings put on flush with each other (2) magnified view of the top part of the stair string – *1 stair string, 2 mortised hole for step and riser, 3 wooden pads, 4 accommodation for the head step, 5 drilled hole for the screw rod*

– Under the second and last but one steps, in the centre of the stair string, the holes for the screw rods are scribe–marked and drilled vertically into the stair string with a diameter corresponding to the diameter of the screw rods.

– The outer string remains on the wooden pads. The screw rods are put through the drilled holes and the washers and nuts are attached between the workshop floor and the outer string.

– The steps are inserted, one by one, into the mortised holes for holding the steps and risers.
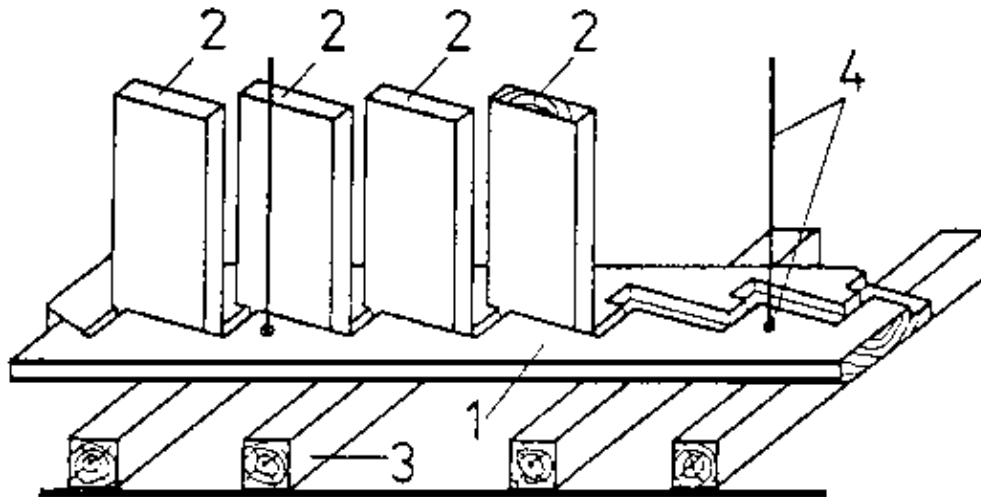

Figure 35 – Insertion of the steps into the mortised holes – *1 stair string, 2 step, 3 wooden pad, 4 screw rod*

– A board is put on the inserted steps and the steps are beaten in by a beating tool until the bottom of the hole.
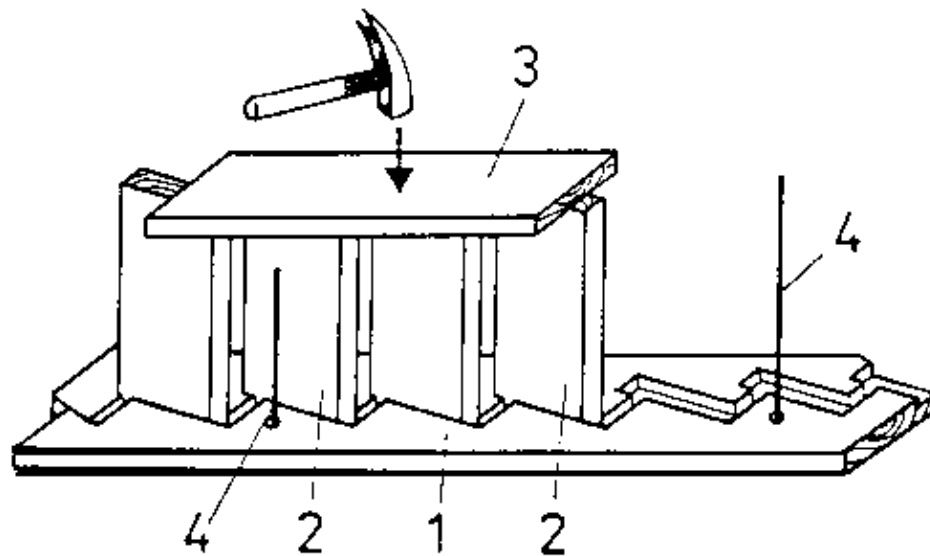

Figure 36 – Beating–in of the steps – *1 stair string, 2 step, 3 wooden pad (to avoid bearing marks), 4 screw rod*

– The risers are inserted and, if necessary, beaten–in.

A wooden pad is to be used for beating in. When beating in it is to be made sure that the risers sit 2 mm deeper on top than the steps.

– The wall string is placed on top and the steps and risers are put into the holes (not fully inserted).

Figure 37 – Placing the stair string on top of the steps and risers beaten in – *1 stair string, 2 step, 3 mortised hole for step, 4 step, 5 mortised hole for riser, 6 drilled hole for screw rod, 7 left side of step (go side), screw rod*

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– The screw rods are passed through the drilled holes in the wall string, the washers are attached and the nuts slightly screwed on.

– A post–piece is put on the wall string to beat the wall string tightly in.

– When all steps and risers are beaten into the mortised holes, the nuts are finally tightened and the stair flight width is checked.

– Any excessive thread of the screw rods is sawn off.

– The rosettes are screwed on.

– The stair strings, steps and risers are sanded with abrasive paper to remove any scribe–marks of pencils and to make the stairs look clean.

Building in of the stairs

First the assembled stair flight is put on the bottom stair–apron with the carved foot provided at the bottom and then it is slowly inclined towards the top apron until it contacts it.

It is to be made sure that the stair strings uniformly contact the stair aprons to avoid displacement of the stair flight. If necessary, the strings are to be recut or packed.

List of symbole and technical terms used in stairmaking

s = tread width

B = staircase width (width of stairs)

c = length between the front edges of the step surfaces, measured in the stair inclination

d_1 = floor thickness of the bottom landing

d_2 = floor thickness of the top landing

GL = stairwell length

h_u = height of the perpendicular string bottom

h_w = string height

L = flight length

Lh = flight height

l = flight line

L_w = length of the posts for the string

m = ratio of rise and tread

n_a = number of treads

n_s = number of rises

Sm = step size

s = height of rise (treads)

s_g = height of rise chosen (assumed)

u = false tread

W_d = string thickness