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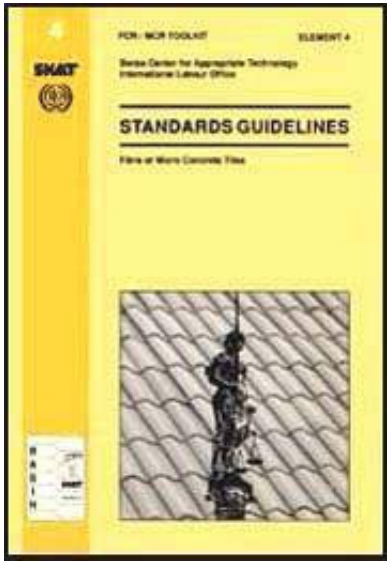

Standards Guidelines - Fibre or Micro Concrete Tiles (SKAT, 1992, 49 p.)

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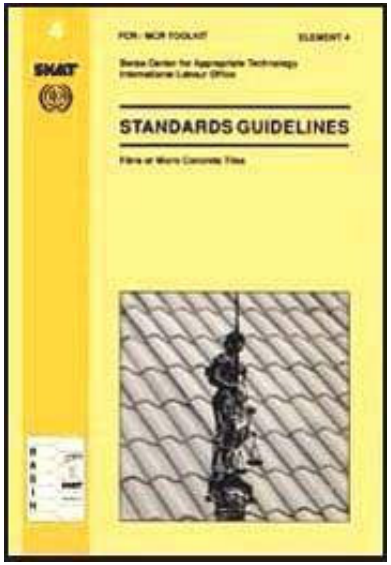

Standards Guidelines - Fibre or Micro Concrete Tiles (SKAT, 1992, 49 p.)

- standards document
- Annex A. - Quality tests recommended by RAS
- Annex B. - Common standards for:
- Annex C. - References and recommended further reading
- Annex D. - Abbreviations

Fibre or Micro Concrete Tiles

FCR / MCR TOOLKIT

Swiss Center for Appropriate Technology International Labour Office


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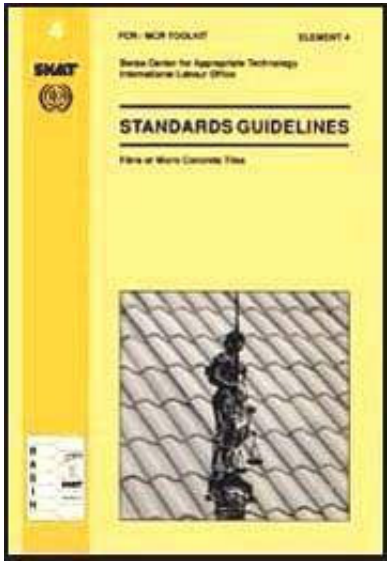

Standards Guidelines - Fibre or Micro Concrete Tiles (SKAT, 1992, 49 p.)

Annex D. - Abbreviations

ASTM	American Society for Testing Materials
BS	British Standard
DIN	Deutsche Industrie - Norm
FCR	Fibre Concrete Roofing
ILO	International Labour Office
INSTEAD	Information Service on Technological Alternatives for Development
Intep	Integrale Planung Energie - Umwelt - Architektur
ISO	International Standard

ITW	Intermediate Technology Workshop
KS	Kenyan Standard
MBS	Malawien Bureau of Standards
MCR	Micro Concrete Roofing
NBS	National Bureau of Standards
NS	National Standard
PFA	Pulverised fuel ash
RAS	Roofing Advisory Service
SC	Sub-committee
SDC	Swiss Development Cooperation
SKAT	Swiss Center for Approriate Technology
TC	Technical Committee
WG	Working Group

The standardisation of FCR/MCR products constitutes the last step in the development of the technology. A standardisation of the product would cut out low quality producers or force them to improve their production.

These guidelines aim at helping official institutions, which issue quality standards for construction materials and building regulations on a national level, to design their own standards for FCR/MCR products which are valid for their specific country, taking into consideration the requirements and characteristics of the local context.

The guidelines also help architects, engineers, building control institutions and contractors to execute their own tests, in the event that national standards are not available or in case the quality of the product is questioned.

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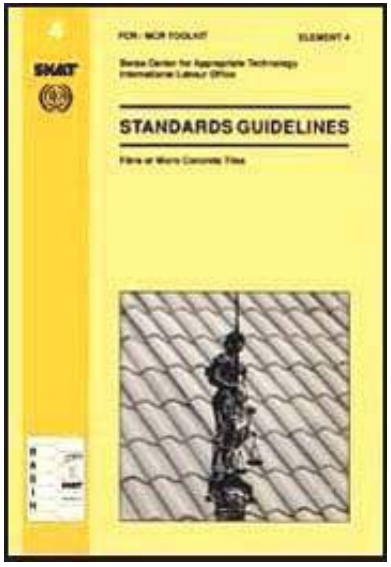

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Guidelines for Government officials, standards institutions and engineers/ architects to define quality standards for FCR/MCR - products.

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operation (SDC)

FCR / MCR TOOLKIT- DIAGRAM:

NATIONAL CENTER KIT

1 National Center Guide
2 Feasibility Study Guide
3 Guide for Trainers
4 Standards Guidelines
5 FCR / MCR, a comparison
6 Constraints in Dissemination of FCR/MCR Technology
7 Equipment Standards

PROMOTION KIT

10 FCR/MCR Basics
11 Case Reports
12 Product Information

13 Promotion Material

PRODUCER KIT

Technical Part

20 Workshop and Equipment
21 Production Management Guide
22 Production Guide
23 Quality Control Guidelines
24 Roof Design Guide

Economic Part

30 Basic Financial and Administration Management
31 Advanced Financial and Administration Management
32 Marketing Guide

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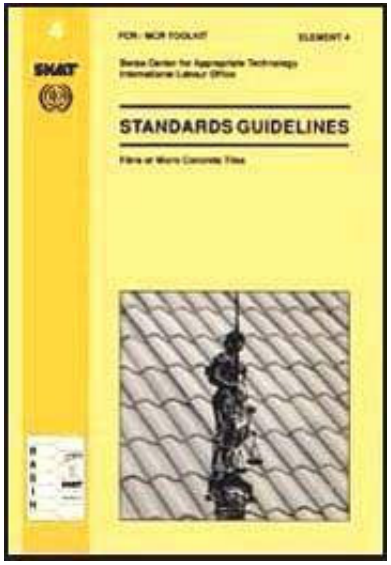

- **implement anational FCR/MCR standard**
- **4. Content of a national standards document**
- **Annex A. - Quality tests recommended by RAS**
- **Annex B. - Common standards for:**
- **Annex C. - References and recommended further reading**
- **Annex D. - Abbreviations**

1. Preface

The history of FCR/MCR

The FCR/MCR-technology was developed in the 1970s

based upon generations of experience of concrete tiles and asbestos cement sheets. During the 1980s it has found applications in many countries all over the world. Today the technology is at a mature stage and the experience of the technology has shown that it offers a reliable roofing material that can compete with most of the conventional roofing materials.

The roles of BASIN, SKAT and ILO

BASIN

BASIN (Building Advisory Service and Information Network) is a coordinated network of experienced international professionals, set up to provide qualified advice and information in the field of building materials and construction technologies.

The activities of BASIN are divided between four leading European, nonprofit appropriate technology organizations (GTZ/GATE Germany, ITDG England, SKAT Switzerland, CRATerre France), each of which covers a separate specialized subject area, in order to provide more qualified expertiese with greater efficiency.

SKAT

SKAT is an information and documentation center and a consultancy group engaged in promoting and implementing Appropriate Technology for partner counties world-wide.

Among the BASIN partners, SKAT is specialised in roofing, and in this field is especially familiar with the FCR/MCR technology. Within BASIN, SKAT established the Roofing Advisory Service (RAS). With the

commitment to facilitate the promotion and dissemination of the FCR/MCR roofing technology, SKAT/RAS is producing the "FCR/MCR Toolkit" series of which this "Standards Guidelines" is one element.

ILO

A programme for the development, the promotion and the application of appropriate building technologies suitable for low-cost construction is currently implemented by the Micro-enterprise and Informal Sector Section of the ILO Entrepreneurship and Management Development Branch.

The objective of this programme is to minimize construction cost, maximize the use of locally available raw materials, and generate productive employment. It aims also at developing small and micro-enterprises in

this sector of activities and demonstrating commercial viability of these micro-enter prises. This programme makes use of an innovative approach whereby some of the activities are carried out within on-going technical cooperation projects for the development of small and micro-enterprises, executed by the ILO or other agencies (e.g. UNDP, multi-bilateral projects, bilateral projects). Various means of action are used by this programme: research and development, dissemination of technological information, advisory services to governments and implementation of technical assistance projects.

Technical reports are prepared on the basis of field activities carried out by this programme in a number of African and Asian countries. These reports concern the establishment of pilot and/or commercial production units of building materials, surveys of the building

materials sector in selected countries, results of research end development activities, and so on. Manuals are also published on specific topics such as the small-scale production of building materials providing technical and economic information of interest to small and micro-enterprises.

Network of specialists

A world-wide network of specialists and of specialised institutions provides technical support to new and already established producers of FCR/MCR. This helps to ensure reliability and quality of the products in this growing market.

This FCR/MCR network of specialists is coordinated by the Roofing Advisory Service (RAS) of SKAT.

The FCR-MCR Toolkit

The guidelines in hand are part of the FCR/MCR Toolkit. This kit imparts the entire know-how that is required in the field of the FCR/MCR-technology, covering the technical aspects as well as the economic, organizational, management and marketing aspects. The toolkit-diagram shows the structure of its contents.

The kit is now (1991) at its development stage. Many elements are already available, other elements exist in a draft version or at least in outline.

Contact address

This literature, as well as further information, is available from:
Roofing Advisory Service

Tigerbergstrasse 2
c/o SKAT
CH-9000 St. Gallen, Switzerland
Tel 071/30 25 85

and

ILO
INSTEAD
Route des Morillions 4
CH-121 1 Geneve

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JPM. Parry, ITW, UK
Fred Jan Twigt, consultant, Netherlands

Material from the following National Standards Bureaux has been used:

Philippines Bureau of Product Standards
British Standards
Kenyan Standards
Malawi Standards


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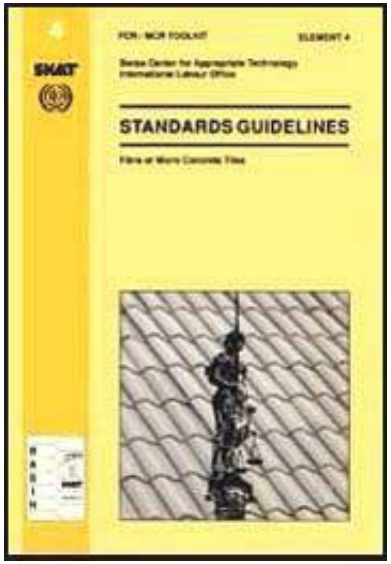
Standards Guidelines - Fibre or Micro Concrete Tiles (SKAT, 1992,



49 p.)

- ***(introduction...)***
- **Acknowledgements**
- **1. Preface**
- **2. Introduction**
- **3. How to design and implement anational FCR/MCR standard**
- **4. Content of a national standards document**
- **Annex A. - Quality tests recommended by RAS**
- **Annex B. - Common standards for:**
- **Annex C. - References and**

recommended further reading

Annex D: Abbreviations

2. Introduction

What are FCR and MCR

FCR (Fibre Concrete Roofing) is a new roof covering technology. It consists of concrete tiles made of cement mortar mixed with a small amount of natural or synthetic fibre.

In the case of MCR (Micro Concrete Roofing) fine aggregate is used instead of fibre.

For further basic information please refer to "The Basics of Concrete Roofing Elements".

The advantages of FCR and MCR

The technology provides an inexpensive and reliable roof cladding and suits especially the needs of developing countries. The main advantages are:

- **The raw materials are available locally and thus foreign exchange is saved.**

- **The appropriate technology that is involved allows for decentralised and small scale production.**

- **The technology involves little investment.**

- **The production is labour intensive rather than capital-intensive, thus it creates jobs.**

- **During sun radiation, compared to metal sheeting, rooms covered with FCR/MCR remain cooler because of better thermal insulation and ventilation.**

- **During rain, compared to metal sheeting, FCR/MCR produces much less noise.**

- **The product is environmentally well adapted.**

- **The technology is easy to learn.**

The drawbacks of FCR/MCR

The durability of FCR/MCR is basically as good as for ordinary concrete tiles, which have shown service lives exceeding 50 years. However, it may happen that the strength of tiles is lower in comparison with modern tiles and AC sheets. This mainly occurs when the production unit is too small and therefore unable to ensure a constant level of quality control or when standards for FCR/MCR tiles are not existing.

Why are National Standards important?

When a product is newly introduced in a country it must be reliable for the users. Also, potential users of the product should be convinced that a product is of good quality and this should be guaranteed.

In the case of FCR/MCR, the clear advantages of the technology will help the product to penetrate the market on a large scale. However, officially recognised quality standards are required to achieve this goal, because building control institutions usually depend on such standards to be in a position to certify the use of a product.

Quality standards will encourage decision makers, be it the house owners, the architects, contractors and engineers, or the project planners, to recommend and specify FCR/MCR as roofing material. They can guarantee for quality, safety and durability based on

official recognition and legislation. This is specially important in governmental projects (schools, health centers, public housing schemes), where the respective institutions are obliged to respect building regulations.

The lack of standards is hence a potential inhibiting factor to the widespread adoption of this advantageous technology. Issuing National Standards for FCR/MCR would, therefore, contribute substantially to spreading its use.

Objectives of these Guidelines

The standardisation of FCR/MCR products constitutes the last step in the development of the technology. A standardisation of the product would cut out low quality producers or force them to improve their production.

Often the respective official bodies would be willing to issue such standards but are not in a position to do so because the required basic data are not available or not internationally and scientifically assured.

These guidelines aim at closing this information gap. They help official institutions, which issue quality standards for construction materials and building regulations on a national level, to design their own standards for FCR/MCR products which are valid for their specific country, taking into consideration the requirements and characteristics of the local context.

The guidelines also help architects, engineers, building control institutions and contractors to execute their own tests, in the event that national standards are not available or in case the quality of the product is questioned.

The methods described in these guidelines can also help to persuade customers and clients.

What you will find in these Guidelines:

Chapter 3 describes the main steps that are required when designing and implementing a National FCR/MCR Standard.

In chapter 4 the structure of such a standards document is proposed. It provides also sample text which helps to formulate a standards document. These texts are partly compiled from various existing standards and partly the content of the technical recommendations by RAS, and will have to be adapted, taking into consideration local conditions.

In the annex you find a description of the testing

methods that are required to guarantee quality, safety and durability of the product, as well as information about common standards of dimensions and shape, fittings and fixing devices.

Basic data and limitation

These data are based on scientific laboratory research and long standing practical experiences over the last ten years by international technology specialists. However, the figures may vary from place to place depending on the raw material properties and other local factors. The experience in a particular country will provide the exact data that are to be applied.

What you will NOT find in these Guidelines:

The guidelines are not designed for newcomers who are

interested in the technology in general. For basic information we suggest that the following booklet should be obtained: "The Basics of Concrete Roofing Elements".

It is also not designed for producers who want to start or improve production and business. For them the various elements of the FCR/ MCR Toolkit are available, containing technical information on raw material specifications, description of production processes and equipment, as well as information on business questions such as marketing, financial and administration management.

Comments

Comments and feedback information are welcome and will help to further improve these guidelines and with it

the technology. They may be sent to SKAT or ILO.

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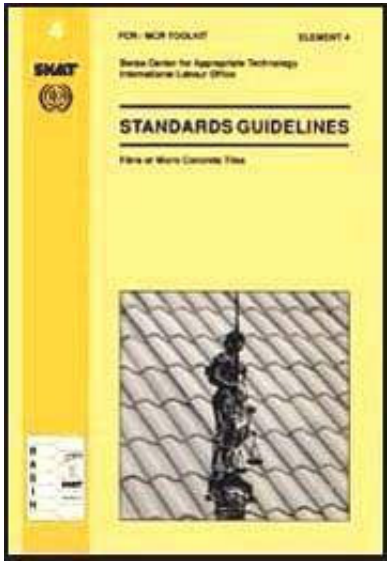

- **Standards Guidelines - Fibre or Micro Concrete Tiles (SKAT, 1992, 49 p.)**
  - **3. How to design and implement anational FCR/MCR standard**
    - **3.1 The limits of existing standards**
    - **3.2 Design methodology**
    - **3.3 Size and shape**
    - **3.4 Implementation**

Standards Guidelines - Fibre or Micro Concrete Tiles (SKAT, 1992, 49 p.)

3. How to design and implement anational FCR/MCR standard

3.1 The limits of existing standards

In many industrial countries standards exist for building materials where one may find a specific standard for a product more or less similar to FCR/MCR tiles. In developing countries there is a temptation to design new standards as a replica of existing ones used in industrial countries. The danger is that the local characteristic is neglected, although the technical and socio-economic context differs much between industrial and developing countries. Even between the various developing countries there exist vast differences.

For example, the quality and availability of both the raw materials and labour, the production methods and construction techniques may not be sufficiently considered. The resulting standards would then involve very rigid technical specifications that would not be appropriate in the local context. For this reason producers would not reach the required quality level. This would involve the risk that the quality of the product could be compromised by the producers and the users.

Therefore, it is not possible to design one standard that is valid all over the world. It is unavoidable that each country issues its own National Standard for FCR/MCR.

3.2 Design methodology

A National Bureau of Standards (NBS) may have its own

way to develop standards for the various construction materials, which can possibly be adapted and used in the case of FCR/MCR as well. However, in situations where such a policy is not well established, it is advisable to think over and systematize the approach, and to coordinate it with internationally accepted procedures of standards writing.

Recommended method

A recommended approach is the so called "Technical Committee Method". It is applicable for the various building materials including FCR/MCR.

The NBS forms a Technical committee (TC); if necessary subcommittees (SC) and working groups (WG) are likewise formed to expedite the work of the TC. So that a resultant standard is meaningful and realistic in the

light of a dynamic environment, the TC, SCs, and WGs include representatives of the NBS, manufacturers, consumers, academe, professionals and other government agencies as members.

The method involves the following steps:
(The text is mainly adopted from the Bureau of Product Standards of the Philippines.)

Step I:

Establishing a program

After the NBS receives requests or proposals from interested parties to develop a standard for a specific subject, it draws a program of work on standardization taking into account the needs and interests of industry, trade, consumers, academe, professionals and

government. Other factors include:

- **the state of the art, including the latest developments in science and technology as well as developments regarding the products design and materials,**
- **availability of resources in the country such as technology, production processes and materials,**
- **public health and safety,**
- **national economic development objectives.**

Step II:

First draft

Based on research that also examine existing international standards and in consultation with sectors

concerned, the NBS prepares a draft of a standard. It is submitted to the TC for intensive deliberation. Once a consensus on vital issues is attained a committee draft is issued by the TC.

Step III:

Promulgation

The committee draft is forwarded and circulated through the Director of the NBS to all parties or sectors concerned for comments and suggestions. Recipients of the committee draft include all potential users of the standard envisaged.

Step IV:

Evaluation of comments

After the lapse of the commentary period, all comments on the committee draft are evaluated by NBS technical staff and presented to the TC for consideration.

Step V:

Draft for public review

After due deliberation and incorporation of all the modifications necessary, another draft is prepared by the TC and is presented to a general public hearing within concerned parties, including the practitioners inside and outside the country, for further comments and suggestions.

Step VI:

Final version

Finally, after due consideration and evaluation, the final draft standard is prepared and submitted to the concerned authority (Standards Board, or Secretary of Trade and Industry etc.) for approval and promulgation as a national standard. Because of the possibility of rejection, a two way flow of communication at all stages between the technical committee and this authority would be advantageous.

Step VII:

Publication

The national standard is then edited and published in the official gazette or newspapers of general circulation.

3.3 Size and shape

Standards development includes also the definition of

precise size and shape of the product. This should be based on a consensus sought during multisectoral deliberations including intensive dialogues with the private sector in order to find the most practical and market-oriented product design for the country. Also internationally applied standards should be considered and incorporated whenever possible.

New developments

The specifications rayed down in a National Standard will represent the status at the time when written. However, it should also be open to new developments, whereby such new products should pass all the tests as well.

3.4 Implementation

In order to achieve uniform and reliable quality of the product in a particular country, and at the same time to gain the confidence of the customers, standards should be implemented with rigourous systems, established to check all the FCR/MCR material producers.

The standards shall be the basis for

- **the establishment and definition of certification schemes.**
- **general use, that is during production testing and selling of the products,**
- **the formulation of tender documents and buying contracts.**

Proposed certification method

The NBS shall operate a certification system under which a license to use the National Standards (NS) Mark is awarded to a manufacturer that consistently complies with the prescribed standard for his product. The license to affix the NS Mark on a product is issued only after the applicant passes the NBS strict factory evaluation and product testing requirements.

In the evaluation of an application for the use of the NS Mark, the NBS shall conduct a thorough evaluation of the manufacturer's resources; these include production, inspection and testing facilities, quality control systems and procedures, skills of supervisory and non-supervisory quality assurance personnel, and other resources that would enable the manufacturer to consistently comply with a standard. During evaluation, the NBS shall offer, whenever necessary, technical advisory services to the manufacturer for the

improvement of the latter's production and quality control operations.

Thus, when the NS-Mark is found on a product, it shall signify that this product is of good quality, safe and reliable to use.

The NS-Mark should contain the following information:

- **Name of the manufacturer**
- **Trade mark or other means of identification**
- **Number of this standard**
- **Date of production**

Upon request a certificate that the products comply with the requirements of this standard should be supplied.

Product testing and laboratory accreditation

To support the NS Certification Mark system and the research requirements of standards development, the NBS shall operate a testing laboratory, either its own or by contracting a private laboratory.

In addition, the NBS shall run a laboratory accreditation program. Testing institutions, public or private, shall be accredited on the strength of their competence, integrity and willingness to work closely with NBS in meeting product testing requirements.

Promotion

To promote the standards, a concerted effort should be made by all institutions involved in the technology.

- **Training**

A secure method to introduce the standards and make them effective is to incorporate them in the training courses at different levels. Training manuals and curicula should be accordingly adapted.

- **Publicity**

Articles in professional newspapers as well as handouts, radio talks and video films, distributed through suitable channels are other important ways to disseminate the standards.

- **Field days**

The organization of field days, perhaps in combination with professional meetings or exhibitions with public shows, may be another means to pass the information to the target audience.

Institutional support

The NBS shall bring about that the concerned authorities amend the National building regulations and other regulatory instruments in order to take FCR/MCR roofing into account, so that it becomes possible to enforce the standards.

City and town councils should be urged to modify their building regulations by inserting the use of FCR/MCR roofing into the bye-laws.

This could be promoted by conducting guided tours for local authorities in order to familiarize them with FCR/MCR and its current developments.


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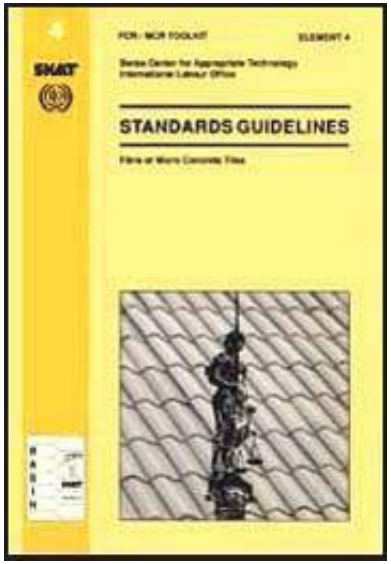

Standards Guidelines - Fibre or Micro Concrete Tiles (SKAT, 1992, 49 p.)

4. Content of a national standards document

4.1 Structure

Although each country should design its own standard, not every country's authorities have to start from scratch. For obvious reasons it is advisable to base new standards on the work and experience that has already been achieved in other countries.

The content of a National Standard should be based on a combination of local and foreign data, research and testing results, so that standards confirm internationally as much as possible. Wherever the local characteristics allow it, technical data applied in a country should comply with data applied elsewhere.

The technical data and testing methods

The data which should be included in a standard must ensure that a product fulfils all requirements for a reliable roof, namely sufficient static strength,

watertightness, correct dimensions and reliable fixing device. Therefore it is recommended to test the following properties:

- **Transverse strength (Bending test)**
- **Permeability (Watertightness test)**
- **Surface quality (Pores and cracks test)**
- **Dimensions (Size and shape test)**
- **Nib strength (Nib tensile test)**

These tests may be made according to the Quality Control Guidelines (FCR/MCR toolkit, element 23). The relevant sections of this manual are attached in Annex A.

These methods are not difficult and basically designed for the use in the workshops of the producers, and shall serve as an example. The laboratory equipment

available to a particular NBS would possibly permit more scientific testing methods. In this case the standards shall be designed accordingly.

The structure of the standards document

If standards authorities in different countries apply a similarly structured document, exchange of information between countries will be much easier. It helps to design a document that is complete and that no important aspect is overlooked.

Therefore, the following structure is recommended:

1 Foreword

2 Scope

3 Definitions

4 Raw materials
4.1 Cement
4.2 Sand and aggregate
4.3 Water
4.4 Admixtures
4.5 Pigments
4.6 Fibres
4.7 Materials for fixing

5 Manufacturing

6 Size and shape

7 Fixing devices
7.1 Nailing
7.2 Nibs
7.3 Fixing wires

8 Freedom from defects

9 Physical requirements

9.1 Transverse strength
9.2 Bearing capacity of the nib
9.3 Permeability
9.4 Water absorption

10 Marking

11 Sampling

12 Compliance

13 Fittings

Annexes

Description of the testing methods
Size and shape of the products, fittings and fixing devices
List of equipment required for testing

4.2 Text and data

Hereafter the text of a possible Standards Document is given, structured as recommended above. It may serve as a sample. It contains the data as recommended by RAS and is complemented with sequences from the following existing standards:

- **BS 473,550:1990 British Standard and Specification for Concrete roofing tiles and fittings**

- **KS 02-749 Kenyan draft standard specification for sisal concrete roofing tiles**

- **MBS 161:1988 Malawi Standard, Cement Roofing Products-Specifications**

The first column gives the recommended text and data, and the second column an alternative version. To each heading the two versions are given side by side. Comparing the two columns helps to find the right formulation for a particular situation.

PLEASE WIDEN YOUR TEXT WINDOW FOR OPTIMAL VIEWING

No Title	Data recommended by RAS	Optional text
1 Foreword	This Standard has been prepared under the authority of.....	The standard specifies the quality of Fibre Concrete Roofing tiles(FCR) and Micro

		Concrete Roofing tiles (MCR) from the point of view of strength, impermeability and durability.
	In this standard, the suitable or desirable properties of rooting fibre concrete and micro concrete tiles (and semi sheets) are enumerated so as to cover the various types of products presently being produced.	
	In the formulation of	

	this standard, reference to the following standards have been acknowledged with thanks.....	
	The following organisations/persons were represented on the Committee:.....	
	It should be noted that all sizes given are typical and that this Standard does not inhibit the manufacture of other sizes.	

	The standard specifies the quality of the tiles as a unit from the point of view of strength, impermeability and durability. Experience has shown that tiles complying with the permeability requirements are resistant to frost.	
	The design of the tile in relation to the exclusion of rain and snow depends also upon the pitch of the roof, the lap of the	

	tiles, and the locality and exposure. The recommendations of manufacturers and of other standards (.....) should be followed in this connection.	
	Compliance with this Standard does not of itself confer immunity from legal obligations.	
2 Scope	This Standard specifies the minimum-standard for the raw materials,	

	manufacture, dimensions and other physical properties of FCR/MCR tiles, semi sheets and fittings. The recommendations of the manufacturer of the products and of national codes of practice for tiling of roofs and fixing against wind uplift should be consulted in conjunction with the standard. (BS 5534, BS 8000: part 6:1990)		

		Reference
		This standard makes reference to the following publications
	NOTE. The titles of the publications referred to in this standard are listed in the Annex.	
3 Definitions	For the purpose of this standard the following definitions shall apply:	Acceptable. Acceptable to the Bureau of Standards.
	Acceptable:	
	Acceptable to the purchaser but in	

	relation to the standardization mark acceptable to the Bureau of Standards.	
	Defective:	
	A tile that fails in one or more respects to comply with the appropriate requirements of the Standard.	
	Stated length/width:	
	The length / width that is the manufacturer's equivalent specified to be the appropriate	

	length/ width.	
	Face of the tile:	
	The upper face of the tile when fixed on the roof (see fig.)	
	Back of the tile:	
	The lower face of the tile when fixed on the roof (see fig. .....)	
	Acceptable. Acceptable to the Bureau of Standards.	
	Fibre Types:	
	The standards cover manufacture of FC tiles made with	

	various fibres. Examples: coir, kenaf, polypropylene, sisal, coconut husk, stem fibre (jute etc.).	
	Batch. The quantity of products made using the same mix of cement, sand and fibres	Batch:
	Fittings. Fittings are components with particular shapes which are fitted to tiles or semi sheets to complete the roofing at the verge,	Any quantity of tiles or one size and same material type, pattern and dimensions from one manufacture, submitted

	ridge and eaves.	
	Pitch. The distance between two adjacent crests of a tile or semi sheet.	at any one time for inspection and testing.
	Product. A tile, sheet or fitting that complies with this standard.	
4 Raw materials	The raw materials to be used for manufacturing cement roofing products shall be free from deleterious materials liable to cause ultimate	

	deterioration in the quality of the products. The raw materials shall comply with the following requirements.	
4.1 Cement	The cement used in the manufacture of the tiles, shall be ordinary Portland cement. The quality should measure up to the standards required for normal concrete and masonry work and	The cement used in the manufacture of the products shall comply with the require meets of BS 12 or BS 6688. Where pulverized fuel ash (PFA) is used with cement complying with the require meets of BS 1 2, it shall comply with

	comply with B.S., ASTM or DIN or National codes for portland cement, blended cements etc. (strength, setting time, fineness, SO3 content, soundness).	the requirements of BS 3892: Part 1.
	In some cases the use of pozzolanic binders may be taken into consideration.	Any other cementitious materials may be used that will produce a product complying with the requirements of this standard.
4.2 Sand and aggregate	For FCR tile production only sand is used. If the tiles are produced without	The aggregate shall be clean and of silicious or similar char- acteristics. The grading of

	fibre (MCR) a special defined content of fine aggregate is added.	aggregate shall comply with the requirements of fine aggregate specified in National code .....for concrete (BS882)
	Sand and aggregate should be well graded and clean, free of organic material.	
	Clay and silt content: The clay and silt content may not exceed 4 %.	The manufacturer shall satisfy himself as to the suitability of the aggregate before using it in his production.
	In no case may a	

	particle of aggregate be bigger than the product thickness minus 1 mm.	
4.3 Water	Water shold be clean, standard potable water and be free from matter harmful to concrete.	Water should be clean and free from matter harmful to the cement reactions.
4.4 Admixtures	Normal concrete additives such as accelerators, waterproofers and plasticisers may be used as required.	Any chemical admixtures used in the concrete shall not have adverse effects on the quality and appearance of the tiles produced.
4.5 Pigments	Any color applied	All pigments and

	shall not contain material that is deleterious to the productand shall not contain any toxic material (Drinking water collected from roofs 1).	admixtures complying with the requirements of standards ... and which are proven to be non toxic after cast into the cement matrix (BS 1014:1975/1985, BS 5075: Part 1-3 and BS 4887: Part 1-2) may be used.
	The color may be added to the mix during production or applied as pains. In either case it has to be mineral based (silicates) and not	

	synthetic (plastic, Latex etc).	
4.6 Fibres	The fibres should be clean, not contain loose particles, soft pith etc., liberate matters harmful to the cement reactions, and should be well separated.	
	The average length of individual fibres shall not exceed 20 mm.	
4.7 Materials for fixing	For fixing, a material of the following shall be used:	Materials for fixing shall be durable and be able to carry loads of at least 300 Newton (N).
	• Galvanised steel	

	• Galvanised steel wire of diameter at least 0.9 mm. • Copper wire (or other non-ferrous wire of a metal that is compatible with concrete) or diameter at least 1.22 mm. • Stainless steel wire of diameter at least 0.9 mm. • String of a material that does not rot (nylon etc.)	
	The wire should be flexible enough to be	

	twisted by hand without breaking. No organic strings of jute, hemp and the like shall be accepted.	
5 Manufacturing	Cement roofing products shall be manufactured from a homogenuous mixture of the raw materials.	
6 Size and shape	The deviations shall be tested as described in the Quality Control Guidelines and shall	The sizes of the tiles shall stay within the following tolerances:

	not exceed the following tolerances: Tolerance in length ± 3 mm in width ± 3 mm in profile ± 3 mm In thickness ± 0.5 mm in squareness ± 3 mm	
	The sizes of tiles are typically as detailed in the Annex	
7 Fixing devices	The tiles are fixed to the battens by a nib with a wire loop or tie wire.	
	Normal tiles are fixed	

	at one point only, special tiles (eg. at verge, ridge and eaves) may have more fixing points.	
7.1 Nailing	Direct nailing through holes in the tile or in the nib is not allowed because there is a risk of damage in the form of hair cracks during nailing that reduces the durability.	Inclusion of nail holes shall be optional with pantiles. Nail holes shall be of an accept able diameter and shall be so positioned that the distance between their centres and a line joining the bases of the batten lugs is not less than 10 mm and not more than 16 mm. Plain

		tiles shall have two nail holes, the centre of each being not less than 25 mm and not more than 45 mm from the adjacent side of the tile, interlocking type tiles shall have at least one nail hole positioned approximately on the longitudinal centreline of the tile.
7.2 Nibs	The nib shall be designed according to Annex.....	Lugs
		Lugs shall be of one of the following types:

	The dimensions shall be the following: Length min 25mm Width min 15mm Height min 15mm	a) A concrete lug (on the under side of the tile, having a hole of diameter at least 3 mm through the lug. The distance between the other surface of the lug and the adjacent periphery of the hole shall be at least 6 mm. b) A non-ferrous metal lug which is compatible with concrete, firmly cast into the underside of the tile, and having a hole diameter at least 3 mm through the lug. The distance between

		the outer edge of the lug and the periphery of the hole shall be at least 3 mm.
7.3 Fixing wires	Fixirg-wires shall be firmly cast into the bottom of the nib and shall have sufficient length: • in case of wire loop to allow nail fixing to the batten • in case of tie wires to allow tie around a 50x50 mm batten.	
8 Freedom from defects	The products shall be true in shape and	The products shall be true in shape and the

	free from visible defects which may impair the appearance or serviceability of the products. The surfaces of the products shall be of uniform texture and smooth on the side in- tended to be exposed to weather. The edges shall be square, clean and straight. The product shall not have any holes and no visible cracks	surface shall not have pores deeper than 2 mm or larger in diameter than5 mm. Visible cracks may not be deeper than 2 mm nor longer than 5 mm.

	longer than 5 mm. The surface shall not have any pores deeper than 2 mm or larger in diameter than 5 mm.	
9 Physical requirements		
9.1 Transverse strength	The product shall be of sufficient transverse strength. When tested in the manner described in the Quality Control Guidelines (see also Annex .....) a 250 mm wide tile shall	When tested in the manner described in the Annex the average breaking load (obtained from three tiles, in wet condition by storing them for at least 24 hours in water) should not be less than:

	bear the following loads (tested when tiles are dry): A 6 mm thick product should bear 30 kg weight. An 8 mm thick product should bear 50 kg weight. A 10 mm thick product should bear 80 kg weight.	for 6mm thick tile 250 N for 8 mm thick tile 400 N for 10 mm thick tile 650 N
		The load should be applied at an uniform speed not exceeding 6500 N/min.
9.2 Bearing	When tested in the	When tested in the

capacity of the nib	manner as described in the Quality Control Guidelines (see also Annex ....) the fixing wire and the nib shall bear a weight of 20 kg.	manner as described in the Quality Control Guidelines (see also Annex .....) the fixing wire and the nib shall bear a weight of 200 N.
9.3 Permeability	When tested in the manner as described in the Quality Control Guidelines (see also Annex ....) the underside of the product shall be free from water drips. Eventual signs of damp shall not cover more than 50 % of	The product shall pass the test described in BS 473, 550:1990 (test roof on which water is sprinkled for 2 hours).

	the total area covered with water.	
9.4 Water absorption	When the tiles are tested in accordance with the average percentage of water absorption shall be not more than 10 percent.	
10 Marking	The product shall be marked legibly and indelibly to identify • the manufacturer • trade mark, or other means of identification • the standard and	NOTE. Use of the Mark is governed by the rules and pro- visions of the Bureau of Stan cards Certification Marking Scheme.

	certification applied • the date of production NOTE. If requested, a certificate that the products comply with the requirements of this standard should be supplied.	
11 Sampling	•Selection of sample A belch of 2000 or part thereof ready for use shall be selected to the satisfaction of all parties. Ten tiles shall be selected at random from the	Samples of cement roofing products shall be taken atrandom from stocks aged four weeks or more from the date of manufacture. The sample shall consist of 5 tiles per batch of 1000

	batch. •Identification and protection of samples Each sample of products shall be marked so as to identify the batch from which it was selected. The sample shall be reasonably protected from extreme conditions of temperature, relative humidity and wind exposure until they are tested. Independent tests It independent tests	tiles or part thereof.

	are required the samples shall be taken before or immediately after delivery. The tests shall be carried out in accordance with this standard.	
12 Compliance	A tile shall comply with this standard if it meets all the requirements of the standards. It the tiles fail to satisfy the test requirements, the whole of the batch from which they were	

	selected shall be deemed not to comply with this Standard.	
13 Fittings	Fittings shall be of similar quality, color and texture to the tiles with which they are laid. The nominal dimensions and the corresponding tolerances of the cement roofing fittings shall be as given in Annex	

Grading for FCR:	
Maximum grain size	2 - 3 mm

Maximum grain size	2 - 3 mm
Component above 2 mm	0 - 10 %
Component 0.5 - 2 mm	35 - 75 %
component below 0.5 mm	25 - 55 %

Grading for MCR			
Prod. thickness	6 mm	8 mm	10 mm
Max. grin size 4 mm	5.5 mm	7 mm	
Comp. above 2 mm	25-45%	30-50%	35-55%
Comp. 0.5-2 mm	20-50%	15-40%	15-40%
Comp. below 0.5mm	15-45%	15-40%	15-40%


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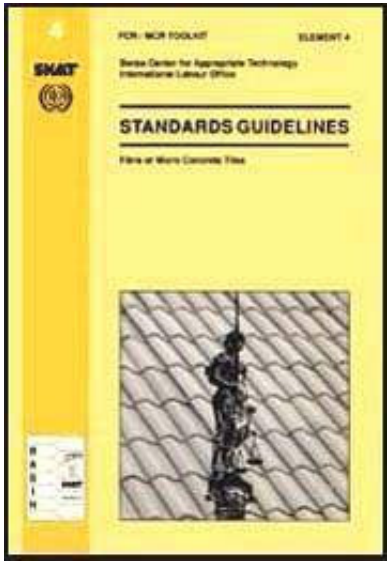


- **Standards Guidelines - Fibre or Micro Concrete Tiles (SKAT, 1992, 49 p.)**
  - **Annex A. - Quality tests recommended by RAS**
    - **Size and shape test**
    - **Bending test**
    - **Nib tensile test**
    - **Watertightness test**

Standards Guidelines - Fibre or Micro Concrete Tiles (SKAT, 1992, 49 p.)

Annex A. - Quality tests recommended by RAS

Size and shape test

Why this test

Only the correct size and shape of all tiles ensures a proper fixing on the roof. Poorly fixed tiles easily crack under load and wind driven water may enter the roof.

Tiles that are not square will not fit properly and the overlap will not be sufficient.

Tiles that are too thin will leak and are not strong enough.

How

Check that the tile has the right dimensions, shape and profile.

Profile:
Compare the tile with a standard mould. If a plastic

mould is used then it must be adequately supported to prevent flexing.

Squareness:
Test on a standard mould that the edges of the tile are parallel with the mould.

Thickness at the edges:
Check if the thickness of the upper part of the tile (a) differs from the thickness of the lower part of the tile (b). Check on both ends of the tile.

Thickness in the middle:
Check also the thickness of the tile in its centre, by breaking the tile.

Tolerance:

Tolerance in length ± 3 mm

Tolerance in width ± 3 mm
Tolerance in profile ± 3 mm
Tolerance in thickness ± 0.5 mm
Tolerance in squareness ± 3 mm

Bending test

Why this test

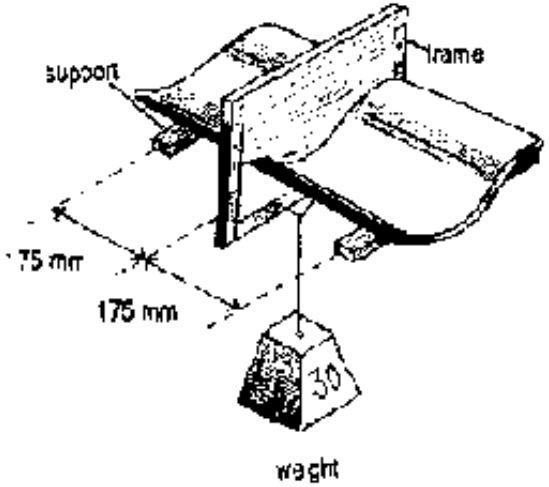
The test ensures that the load bearing capacity is sufficient.

How

The tile shall be dry when tested.

The tile is supported by bat tens of the same timber as used in the actual roof structure, at a distance of 350 mm. In the centre between the support a weight is

placed over a plank fitting exactly to the profile of the tile. Put a 5 mm thick rubber between the plank and the tile for even distribution of the load.



Figure

The test is more accurate when wet tiles are tested, after they have been immersed in water for 24 hours. Then the corresponding load is reduced by about 15 %.

If a flexular testing machine is available, this test could be adopted by accomplishing the bearers with wooden frame. The load should be applied at a uniform rate not exceeding 6500 N/min.

Result

The tile, when tested dry, must not break under the following loads:

A 6 mm thick product should bear	30 kg weight
An 8 mm thick product should bear	50 kg weight
A 10 mm thick product should bear	80 kg weight

The load always refers to a width of 250 mm, i. e. the width of a normal tile.

Nib tensile test

Why this test

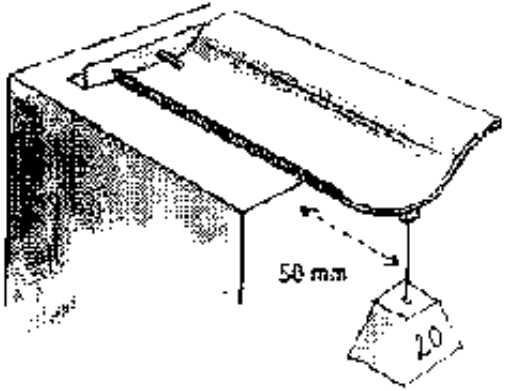
A firm connection of the nib to the tile and of the wire to the nib is essential for a safe roof.

How

**The product shall be tested by carefully suspending a 20 kg weight from the loop of the nib,
without introducing dynamic loads. Let the load stay for 1 minute.**

Result

The nib and loop must bear a weight of 20 kg without cracking.



Figure

Watertightness test

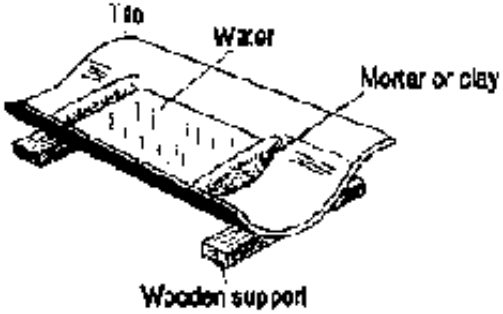
How

Construct two small weirs to allow water to stand in a pool, using wet mortar or clay. Put the tile on supports away from the weirs. Carefully fill with water.

Note:The test works only if the atmosphere is humid

(minimum 70 % relative humidity). In a warm and dry climate eventual seepage dries immediately, so that it cannot be observed.

During the dry season the test has to be done in a high-humidity chamber or by covering the test set-up with a plastic sheet.



Figure

Result

If after 24 hours there is no free water (drips) on the

underside of the product, it has passed. There may be signs of damp, but this area should not exceed 50 % of the total tile area.

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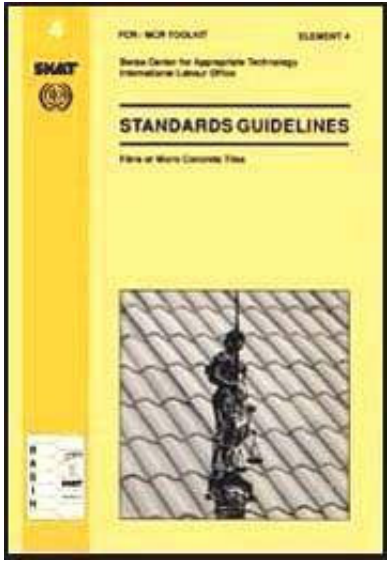


- **Standards Guidelines - Fibre or Micro Concrete Tiles (SKAT, 1992, 49 p.)**
  - **Annex B. - Common standards for:**
    - **Dimensions and shape**
    - **Fittings**
    - **Fixing devices**

Standards Guidelines - Fibre or Micro Concrete Tiles (SKAT, 1992, 49 p.)

Annex B. - Common standards for:

Dimensions and shape

The tiles are produced in various dimensions and shapes.

- **Sheets**

In the early stages of the development of the technology, sheets of 1 m² or more were produced. This product had many disadvantages and is not commonly used anymore.

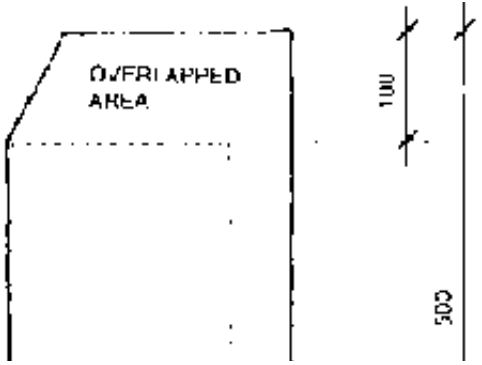
- **Semi sheets**

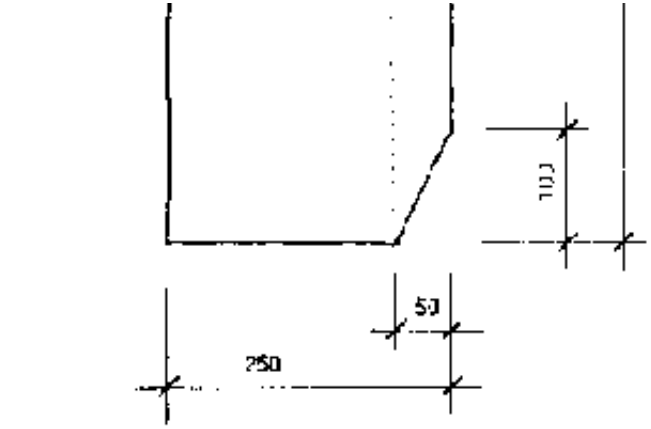
A medium size (600 x 600 mm), called "Semi Sheet", is widely used, especially by producers that use equipment

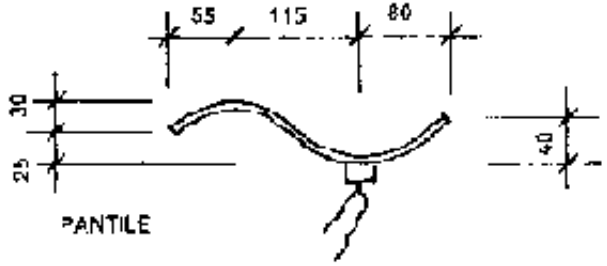
from J.P.M. Parry & Associates Ltd.

- **Pantiles and Roman tiles The most common products are, however, the "Pantile" and the "Roman Tile". The shape and dimensions, as introduced by J.P.M Parry & Associates Ltd. (see illustration below), have been widely accepted as common standard.**

The tests and figures presented in these Guidelines refer to the Pantile and Roman Tile. They may be analogously applied to other products as well.




50
250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115
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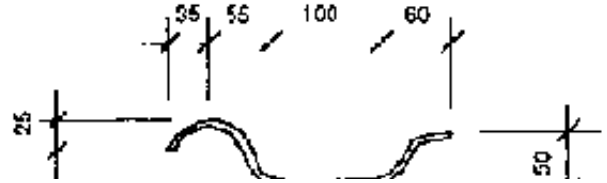
30
25
40
PANTILE

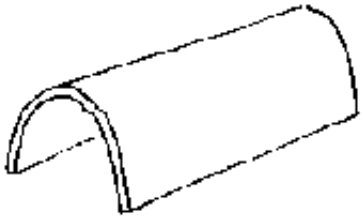

35
55
100
60
25
50

Figure

Fittings

The most important fitting is the ridge tile. Two types are commonly used, the angular ridge tile and the hog-back ridge tile.

ANGULAR RIDGE TILE



HOG-BACK RIDGE TILE

Figure

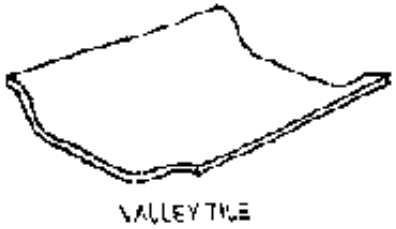
For tripped roofs the Bonnet hip tile or the angular hip tile are used.

BONNET HIP TILE

ANGULAR HIP TILE

Figure

For L-shape buildings a roof with a valley may be required. Here the valley tile can be used.



Figure

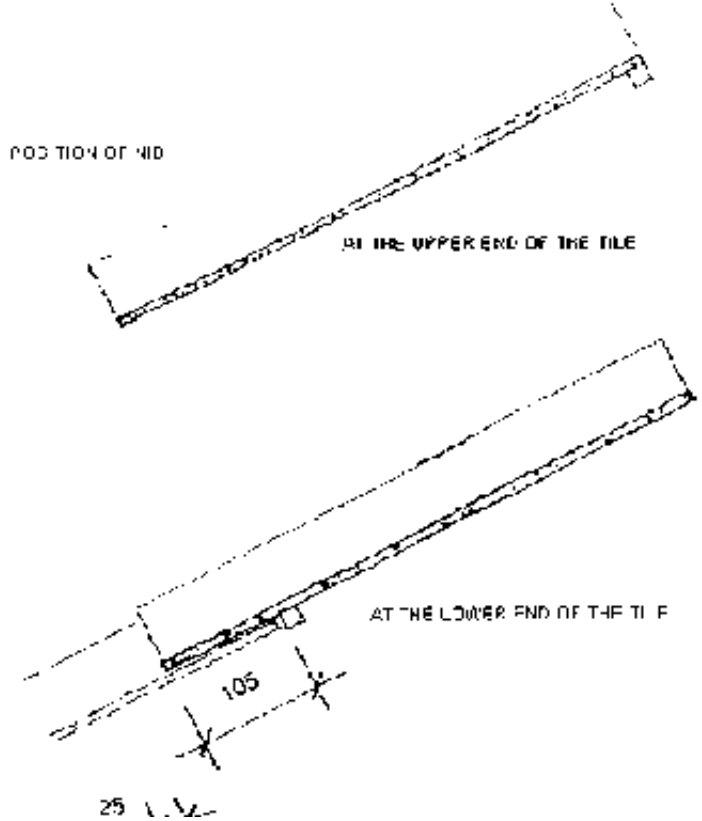
Fixing devices

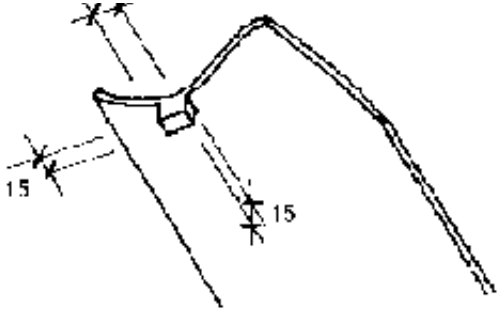
The tiles are fixed to the battens by a nib with a wire loop or tie wire.

Normal tiles are fixed at one point only, special tiles (ea. at verge, ridge and eaves) may have more fixing points. In hurrican prone areas all tiles should have two fixing points.

Direct nailing through holes in the tile or in the nib is not recommended because there is a risk of damage in

the form of hair cracks during nailing that reduces durability.





DIMENSION OF NIB

Figure

Nib dimensions

Length	min 25 mm
Width	min 15 mm
Height	min 15 mm

Fixing wires shall be firmly cast into the bottom of the nib and shall have sufficient length

- **in case of wire loop to allow nail fixing to the batten .**

- **in case of tie wires to allow tie around a 50 x 50 mm batten. The wire should be flexible enough to be twisted by hand without breaking.**

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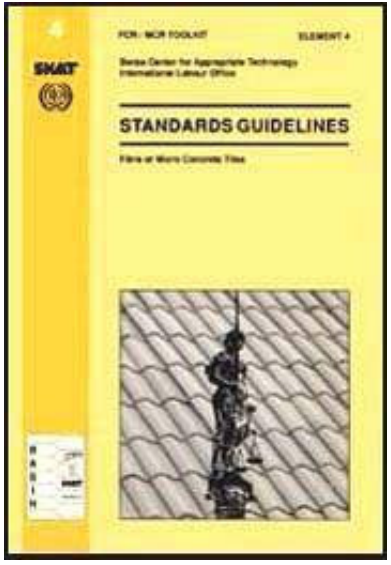

Standards Guidelines - Fibre or Micro Concrete Tiles (SKAT, 1992, 49 p.)

- ***(introduction...)***
- **Acknowledgements**
- **1. Preface**
- **2. Introduction**
- **3. How to design and implement anational FCR/MCR**

Annex C. - References and recommended further reading

(E) = English; (F) = French; (S) = Spanish

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References to Existing Standards and Regulations

DIN 7470 Artificial stones
Subtitles of interest:
DIN 274 Teil 1 04.72

Asbestos-cement corrugated roof slabs; dimensions, requirements, testing.

DIN 274 Teil 2 04.72
Asbestos-cement corrugated roof slabs; application for roof covering.

DIN 274 Teil 3 12.76
Asbestos-cement sheets; asbestos-cement roof slabs, dimensions, requirements.

DIN 274 Teil 4 08.78
Asbestos-cement sheets; flat asbestos-cement boards, dimensions, requirements, tests.

DIN 274T1, 2, 4EErl BE 1981 10.08.81
Implementing regulations on the introduction of technical building regulations - asbestos cement

building slabs (see ABI BE 1, No 54).

DIN 274T1, 2EErl. HA 28.06.72
Technical building regulations; asbestos cement sheetings (DIN 274 parts 1 and 2; issue 4.72) (see Amtl Anz HA, 1972, No 182).

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Construction supervision; technical building regulations; DIN parts 1 and 2, corrugated roof slabs of asbestos cement and requirements on plain panels of asbestos cement (see ND MBI, 1972, No 27).

DIN 274T1, 2EErl NW 05.07.72
DIN; corrugated sheets of asbestos cement (see MBI NW, 1972, No 91).

DIN 7480 Earth. Clay. Cob. Stoneware. Ceramic

materials

Subtitles of interest:

DIN 456 08.76
Burnt-clay roofing tiles; requirements, testing, control.

E DIN 456 A1 12.89
Burnt-clay roofing tiles; requirements, testing, quality control; amendment 1.

DIN 1115 05.87
Concrete roofing tiles; requirements, testing, inspection.

DIN 52251 Teil 2 04.87
Indirect methods of determining the frost resistance of roofing tiles; determination of water absorption.

DIN 52251 Teil 3 04.87

Indirect methods of determining the frost resistance of roofing tiles; determination of coefficient of impregnation.

DIN 52251 Teil 5 04.87
Indirect methods of determining the frost resistance of roofing tiles; determination of drying shrinkage and firing shrinkage.

DIN 52253 Beiblatt 1 12.89
Test methods for the determination of the frost resistance, burnt clay roofing tiles, fair faced clay bricks and clinker bricks; information.

DIN 52253 Teil 1 12.88
Testing the frost resistance of roofing tiles; freeze-thaw test with upper side freezing after sprinkling with water.

DIN 52253 Teil 2 12.86
Testing the frost resistance of roofing tiles; freeze-thaw test with freezing on all sides after impregnation with water under wacuum.

DIN 7483 Roofs. Roofing. Roof construction
Subtitles of interest:

ZVDH Asbestzement 01.74
Rules for asbestos cement coverings.

ZVDH Dachziegel, Dachsteine 05.84
Rules for roof coverings with roof tiles and roof stones.

ZVDH Schiefer 07.77
Rules for slate coverings.

ASTM

C 406 (04.08)
Roofing slate.

C 459 (04.05)
Sampling/testing asbestos-cement flat sheets/roofing and siding shingles/clapboards, methods.

C 460 (04.05)
Asbestos-cement, def of terms.

C 220 (04.05)
Flat asbestos-cement sheets. spec.

C 221 (04.05)
Corrugated asbestos-cement sheets, spec.

C 222 (04.05)
Aspestos-cement roofing shingles, spec.
D 3880 (04.05, 08,03)

Asbestos-fiber strength unit (for reinforcing asbestos-cement products), test.

D 3752 (04.05, 08.03)
Strength imparted by asbestos to a cement matrix, test.

C 666 (04.02)
Resistance of concrete to rapid freezing/thawing, test.

C672 (04.02)
Scaling resistance, when exposed to deicing chemicals.

C 947 (04.05)
Flexural properties of thin-section glass-fiber-reinforced concrete, using simple beam with third-point loading, test.

C 948 (04.05)
Dry and wet bulk density/water absorption/apparent

porosity of thin sections of glass fiber reinforced concrete, test.

C 1018 (04.02)
Flexural toughness/first-crack strength of fiber-reinforced concrete, using beam with third-point loading, test.

French codes

DTU 40.23
Couverture en tulles plates de terre cuite (edition octobre 1982). - 23 p. (DTU P 31-204).

DTU 40.24
Couvertures en tulles en beton a glissement et a emboitement longitudinal (edition octobre 1982) - 27 p (DTU P 31-205).

DTU 40.25
Couverture en tulles plates en beton. - 21 p. (DTU P 31-206).
Tuiles en beton a glissement a emboitement longitudinal (E) - 11 p. (NF P 31 -311).
Couverture - tuiles plates en beton (E) - 12 p. (NF P 31-312).

DTU 40.31
Couverture en plaques ondulees d'amiante-ciment. - 16 p (DTU P 33-201).

DTU 40.12
Couverture en ardoises d'amiante-ciment. - 33 p. (DTU P 33-202).
Couverture arniante-ciment - Plaques ondulees et accessoires en amiante-ciment. - 15 p. (NF P 33-301).
Ardoises et accessoires en amiante-ciment pour

couverture et bardage (E) - 8 p. (NF P 33-302). Couverture amiante-ciment - Plaques ondulees en amiante-ciment a resistance amelioree - Resistance a la traversee d'un corps mou de grandes dimensions specification - essai (E). - 12 p. (NF 33-303).

British Standards BSI

BS 402: Part 1.1990
Specification for plain tiles and fittings.

BS 473, 550:1990
Specification for concrete roofing tiles and fittings.

BS 680: Part 2: 1971
Specification for roofing slates. Metric units.

BS 690: Part 2:1981

Specification for asbestos-cement and cellulose-asbestos-cement flat sheets.

BS 690: Part 3:1973 (1989)
Corrugated sheets

BS 690: Part 4: 1974
Slates.

BS 690: Part 5: 1975
Lining sheets and panels.

BS 690: Part 6:1976
Fittings for use with corrugated sheets.

BS 4624: 1981
Methods of test for asbestos-cement building products.

BS 4764: 1986

Specification for powder cement paints.

BS 5247: Part 14:1975
Corrugated asbestos-cement.

BS 5534: Part 1:1990
Code of practice for slating and tiling. Design.

BS 5534: Part 2:1986
Design charts for fixing roof slating and tiling against wind uplift.

BS 6432: 1984 (1990)
Methods for determining properties of glass fibre reinforced cement material.

BS 8000: Part 6:1990
Code of practice for slating and tiling of roofs and claddings.

ISO International Standard

ISO 393-5: 1987 (E)
Asbestos-cement products - Part 5: Short corrugated and asymmetrical section sheets and fittings for roofing.

ISO 9000:1987(E)
Guidelines for Selection & Use, Quality Management & Assurance Standards.

ISO 9001:1987(E)
Quality Systems, Model for Quality Assurance in Design Development, Production, Installation and Servicing.

ISO 9002:1987(E)
Quality Systems, Model for Quality Assurance in Production & Installation

ISO 9003: 1987(E)

Quality Systems, Model for Quality Assurance in Final Inspection and Test.

ISO 9004:1987(E) Guidelines, Quality Management and Quality System Elements.

Kenyan Standard

KS02-749
Draft Kenyan Standard Specification for Fibre Concrete Roofing Tiles.

Malawian Standard

MBS 161:1988
Cement Roofing Products-Specification