KZN Human Settlements

uMnyango wezokuhlaliswa kwabantu

ISIFUNDAZWE SAKWAZULU-NATALI

TRADITIONAL/ INDIGENOUS HOUSING TECHNOLOGY

DRAFT RESEARCH REPORT

OCTOBER 2009

PRODUCED BY PRODUCT DEVELOPMENT COMPONENT

LIST OF FIGURES

ABBREVIATIONS

BESA:	Bitumen Emulsion Stabilized Adobe
CSIR:	Centre for Scientific and Industrial Research
NHBRC:	National Home Builders Registration Council
SABS:	South African Bureau of Standards

beyond providing basic shelter to achieving the broader vision of sustainable human settlements that are spatially and socially inclusive, well-designed and developed in an environmentally efficient way. The plan introduces a number of mechanisms which would assist in the creation of sustainable human settlements one of which relates to enhancing the housing product. The mechanism identifies the need to develop more appropriate settlement designs and housing products and to ensure appropriate housing quality in both the urban and rural environments. Within the rural context, there is a need to make housing interventions more effective, to enhance the traditional technologies and indigenous knowledge which are being used to construct housing in rural areas and to improve shelter, services and tenure where these are priorities for the people living there. In this regard the Department would need to investigate measures and incentives to enhance housing design and promote and alternative technologies, including support and protection of indigenous knowledge systems.

1.2 Purpose of the Study

The purpose of the study is to identify technologies which are/can be utilized in the rural areas, when subsidies are allocated, so as maintain the social structure and cultural integrity of these communities.

1.3 Project Methodology

The project was undertaken utilizing mainly secondary research (literature review) and some primary research (interviews).

2. RURAL HOUSING TYPOLOGIES

Traditional architecture acknowledges the importance of indigenous knowledge in the built environment. The design of houses takes account of the individuals' needs, lifestyle, culture and traditions and is closely linked to the social processes of rural society. The construction process is not merely seen as the provision of shelter but an opportunity to work as a group so as to bring the houses in line with the community norms in terms of construction and aesthetics. This has also helped in passing down the construction process from generation to generation.

Two main types of technologies have been utilized in rural dwellings over the years viz. grass and wattle and daub. The earlier structures underwent a form of evolution through various stages to their present form of appearance. In addition, some forms of indigenous technologies have also been incorporated into current housing technologies and has been certified by the Agrèment Board (Hydraform [Annexure A] and BESA [Annexure B]).

The influence of the diverse cultures in South Africa is still present in the housing structures built over generations. The rural landscape in South Africa reflects the various cultures through the architectural forms and material utilized in the construction of houses. The advantage of this is the ability of structures to blend in with the environment. This presents an opportunity to learn how these individuals apply and utilize alternative technologies in the construction of houses and settlements in the rural areas.

The research report presents an overview of the evolution of technologies used in the rural setup and includes information relating to both uncertified and accredited structures.

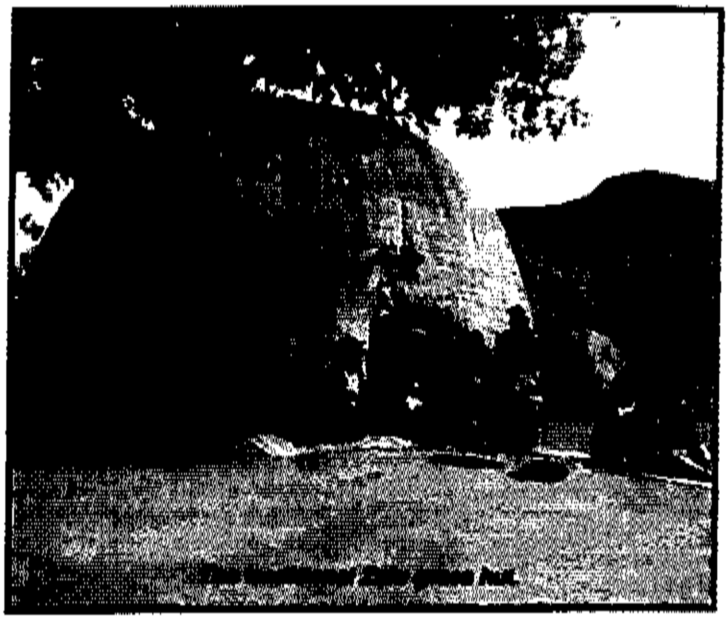

Figure 1: Beehive Hut

The framework is then thatched over either by grass thatching sown onto the sapling frame or grass matting covering the thatch and sewn onto the frame. In this structure the walls form the roof and vice versa. There was no foundation to the structure (timber framed posts were planted directly into the ground). The floor was either made of clay or cow dung as a traditional polish.

Figure 2: Construction of Beehive Hut

The beehive was then modified and became known/described as a beehive dome on a cylinder. The drum/cylinder is built up by an internal structure of pole uprights which are joined by a basket weave of saplings onto which the dome framework is secured. After thatching, clay or daga is plastered to varying

2.1.1.2 Wattle and Daub

Many traditional structures in KwaZulu-Natal are still constructed using this technology. The sapling framework of the beehive has been replaced by a wattle timber framework. Saplings are then run horizontally along the timber framework, both internally and externally, completing a wall structure with infill panels. The panels are then filled with a variety of material including brush, reeds, timber posts, rubble, clay, stone etc. The inside and outside walls are then plastered with daga. (Figure 4 & 5)

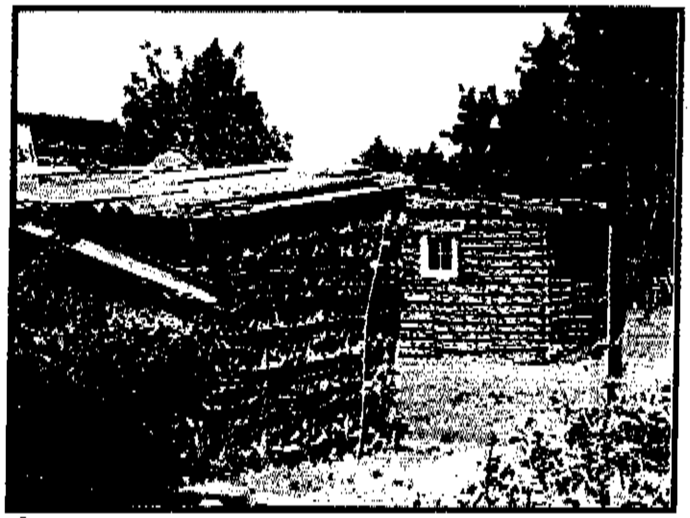

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Figure 4: Wattle and Daub Structure

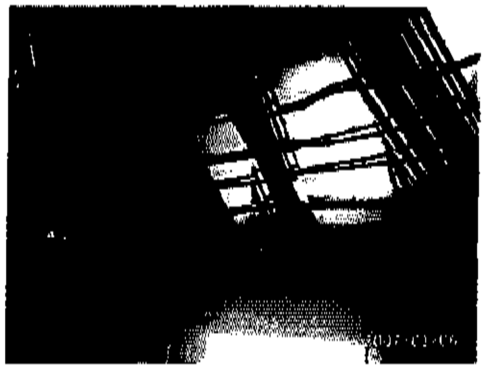
The roof is constructed in the following way viz. timber beams are supported on the main wall timber posts and are brought to a central apex point. The roof is then constructed utilizing either thatch, iron sheeting and in some cases a combination of both materials are used. (Figure 6)

The dwelling does not have a foundation. The timber framed posts were planted directly into the ground. Ventilation into the structure is via. the doorway and windows. The following gives an indication of the advantages and disadvantages of these dwellings:

<u>Advantages:</u>

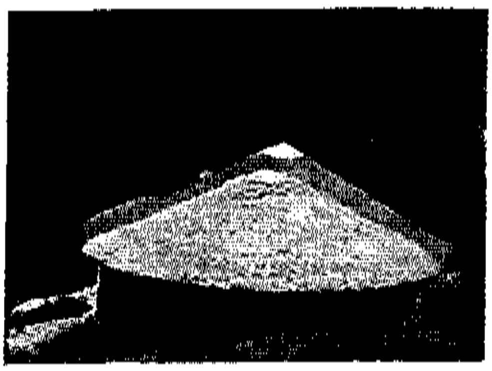
- Easy to construct.
- Availability of material

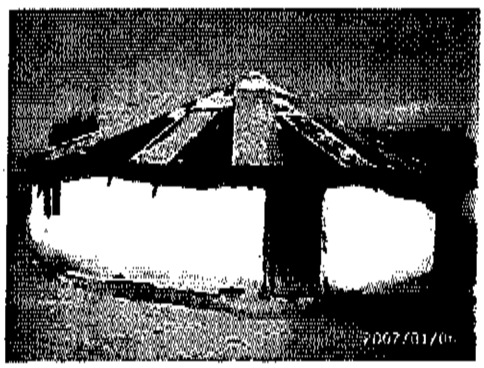
Figure 6: Construction of Wattle and Daub Roof

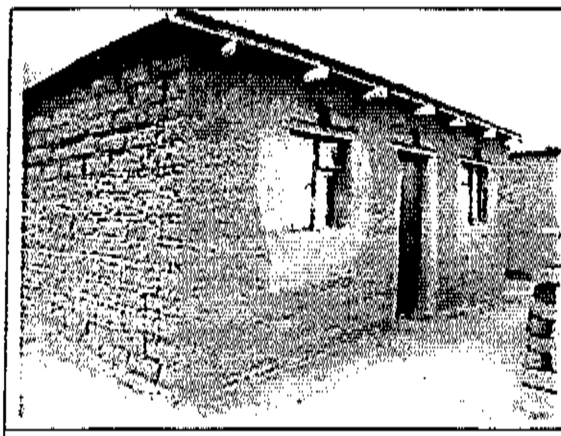


Roof Construction:

Timber beams are supported on the main wall timber posts and are brought to a central apex point.







Completed structure can be rectangular or round. Blocks are cement together in rows. The roof is tied downs 3 to 4 rows down. Where possible, the weather facing wall is plastered with cement. This increases the durability, and reduces maintenance. Cow dung and or cement flooring is a common feature.

The following gives an indication of the advantages and disadvantages of these dwellings:

Advantages:

- Thermal properties.
- Acoustics
- Availability of material
- Cost effective

Regulations and Building Standards Act (Act 103 of 1977), and the regulations made in terms of that act. The regulations include mandatory performance requirements that support the objectives of the act which is to ensure the safety and health of persons living or working in any building. The role of NHBRC is to enforce compliance with the National Building Regulation requirements by the home builders in the home building industry.

Agrément SA is an independent organization established by the Minister of Public Works and housed at the CSIR. Their primary business focus is the certification of non-standardized or innovative building products through technical assessments that verify whether the products and systems are fit for purpose. Agrément certifies products where no national standards are applicable and their certification process is performance based. A valid Agrément certificate will comply with the National Building regulations.

2.1.2.2 Certified Products

These products are based on the earth block technology/system. It is based on the premise that earth has been used for thousands of years in the construction of buildings and strong, long lasting structures can be built. The benefits of the system include:

- Utilizing local skills and knowledge of traditional building methods,
- Houses with thick walls are energy efficient – structures are cool in summer and warm in winter, and
- Earth blocks are usually cheaper than conventional bricks/blocks.

The following provides an overview of some of the certified products that utilize traditional/indigenous technology.

The bricks are then cured under plastic sheeting thus requiring very little water (12% moisture) and no burning/baking. This therefore results in very little water being utilized and trees being cut for the baking process. In addition, topsoil is used to cover the excavation pits created and the surrounding landscape is not detrimentally disturbed.

Figure 9: Curing of HydraformBricks

The bricks are considered to have similar, if not better, structural and thermal performance as compared to ordinary baked clay bricks. In addition, the portable nature of the machines means that the bricks can be produced on site thus reducing transport, pollution and the carbon footprint.

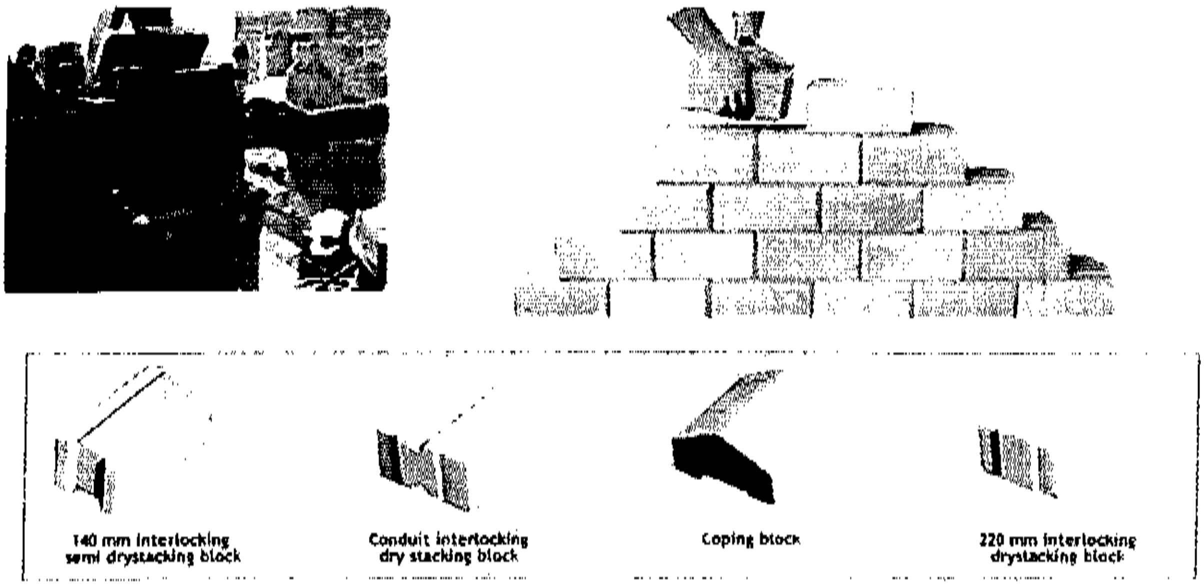


Figure 10: Hydraform Bricks

The system is deemed suitable for rural areas for the following reasons:

- Cost efficiency.
- Only the cement, doors, windows and roofing materials need to be delivered.

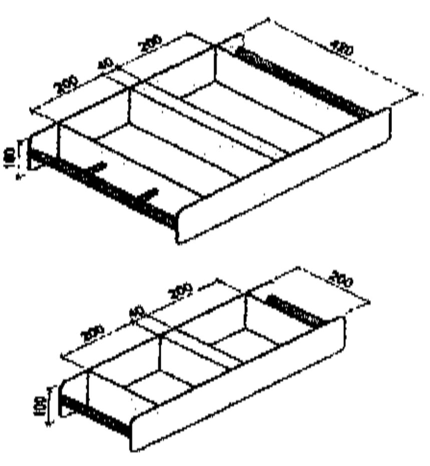


Figure 11: BESA Block Moulds

The mixture is then thrown into steel or wooden block moulds. The moulders use their hands and work the mud into all parts of the mould and work the mixture to remove excess air. The top surface is smoothed off with a straight edge piece of material (wood) the mould is then removed by lifting it straight up. The blocks are then left undisturbed and after 24 hours it may be exposed to the full sun (encouraging the curing process).

The blocks can then be placed on their edge to ensure that the block dries uniformly. No blocks should be used until it is properly dried and at least four weeks old.

See Annexure B for more information relating to the BESA System Agrément Certificate.

Figure 12: BESA Bricks

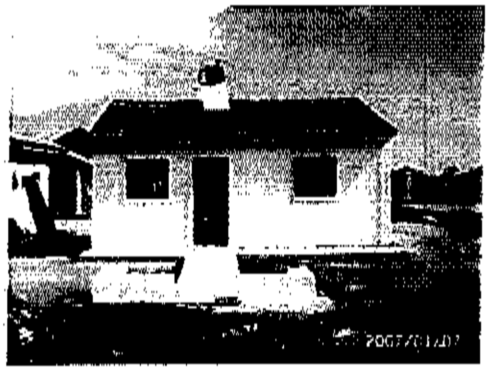


Figure 14: Sandbag House constructed at Eric Molobi Innovation Hub

The advantages of building houses with this system include the following:

- The sandbag wall is extremely strong owing to its thickness and weight.
- Services to the house can be easily incorporated into the sandbag wall as it is built.
- For sites in rural areas construction of such houses can take place even at remote locations without road access. Limited transport required.
- Minimal environmental impact.
- Thermal and acoustic efficiency of buildings.
- Local people can be employed as the construction does not require high skills levels and the building process is easily learnt.

2.1.2.3.2 Unfired Adobe Clay Bricks – Lynedoch Eco-Village, Stellenbosch

The use of earth in construction has been utilized over many years as a result of its versatility and widespread availability and is regarded as one of the oldest building materials. The bricks are manufactured using earth with clay content of between 20-35%, 50-65% sand and 5% straw. An optimum moisture content is required for the mixture to bind and will vary depending on the soil utilized. The

Subsidized House – 140m^2 vs 45m^2

Middle Income Housing

Lynedoch Housing & Technologies

60% less electricity, 45% less water, no sewage, zero solid waste, walking distance to public transport (rail), minimal cement (less CO2), 25% of normal monthly CO2 release

The master copy of this certificate appears on the website http://www.agrement.co.za

Validity

Users of any Agrément certificate should check its status: all currently valid certificates are listed on the website and are designated Active or Inactive.

A registered certificate holder is in possession of a confirmation certificate attesting to his status.

Title:

BESA Building System

Certificate holder:

The certificate holder is any person, company or institution registered as such by Agrément South Africa and who is in possession of a valid numbered certificate of registration relating to the BESA Building System, issued by Agrément South Africa.

Any competent person, company or institution who:

- wishes to build dwellings that are covered by the Housing Consumers Protection Measures Act and buildings that comply with the National Building Regulations,
- is capable of carrying out this work in accordance with the terms and conditions of certification and undertakes to do so,

may apply to Agrément South Africa to be registered as a holder of this open certificate.

Quick guide

This certificate covers the use of the BESA Building System for the erection of single storey buildings in all areas of South Africa for the uses [occupancy classes [SABS 0400 – 1990: Table 1 of Regulation A(20)1)] set out below.

H4 Dwelling houses[detached houses and related outbuildings]

H3 Domestic residences [semi-detached houses, row houses and related outbuildings].

This certificate and Agrément South Africa's assessment apply only to BESA buildings that are designed, manufactured and erected as described and illustrated in this certificate, and where the terms and conditions of certification are applied.

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SABS 0400:1990 *The application of the National Building Regulations*

Contents

Responsibility for compliance with the requirements of this certificate and the quality of the finished building resides with the person or entity claiming such compliance.

Any client, building authority, financial institution, building control officer, etc. who requires that BESA dwellings must comply in all respects with this certificate should bear in mind that only registered holders of the BESA certificate participate in Agrément South Africa's post-certification quality monitoring scheme that checks compliance with the terms and conditions of certification. A certificate holder will possess a valid numbered registration certificate.

Part 2: Assessment

Scope of assessment

This assessment applies to the innovative aspects of the BESA Building System. These aspects have been assessed as an integral part of a building that is composed of innovative and conventional construction. The innovative aspects are:

(a) the method used to identify suitable earth for the system;

(b) the method of stabilising the earth to manufacture adobe building blocks;

(c) the erection of the superstructure walls using adobe building blocks and stabilised earth mortar;

(d) the composite ring beam installed in all superstructure walls;

(e) the use of bitumen emulsion stabilised earth as a bagged or bagged and textured plaster finish.

All other aspects of buildings that are erected in accordance with this certificate are conventional, are subject to the rules of good building practice and must comply with the National Building Regulations.

The conventional aspects of construction are subject to the rules of good building practice (typically as described and illustrated in Agrément South Africa's ***Supplement to certificates*** and in the *Home building manual Parts 1, 2 & 3* issued by the National Home Builders Registration Council), and must comply with the Republic of South Africa's *National Building Regulations*.

Assessment

In the opinion of Agrément South Africa, the BESA Building System as described in this certificate is suitable for the construction of buildings of the types specified (page 1).

The performance in use of buildings erected with the system will be such that they will satisfy:

- the relevant requirements for safety and health prescribed by Agrément South Africa;
- where stated in Table 1, the requirements of the National Building Regulations;
- Agrément South Africa's performance criteria and requirements for durability and habitability.

Agrément South Africa's detailed comments on the assessment are set out in Tables 1, 2 and 3 below. Each aspect of performance was assessed by experts in the field.

National Building Regulations and Building Standards Act 103, 1977 Government Notice No R. 2378, Government Gazette No 12780, Pretoria, South Africa, 12 October 1990.

Compliance with the National Building Regulations

The innovative aspects of the BESA Building System relate to the National Building Regulations as set out in Table 1. Any regulation not specifically referred to is considered to be outside the scope of this certificate and must be applied by the local authority in the normal manner.

Table 2: Habitability

Aspects of performance	Opinion of Agrément South Africa	Explanatory notes
Thermal performance and energy usage	Satisfactory. BESA dwellings without ceilings do not perform as well as the <u>standard brick house</u> [SBH] and energy usage in winter is higher. The performance of dwellings with ceilings is marginally better than that of the SBH. The addition of insulation to the ceiling improves that performance to a level that is comparable with that of a thatch roofed BESA dwelling. Energy usage in winter in BESA dwellings with insulated or uninsulated ceilings, is lower than that required by the standard brick house. That of thatch roofs is also lower.	Agrément South Africa's opinion is based on the calculated likely maximum indoor air temperature in summer in 53 m² BESA dwellings erected in Cape Town, Durban and Johannesburg, and the calculated energy required to maintain an indoor temperature of 16 °C in winter in these dwellings situated in Cape Town and Johannesburg. When assessing the thermal performance of a dwelling, the calculated performance of the subject is compared with that of the standard brick house. This is of similar size, orientation and fenestration as the BESA dwellings and has • external walls of 230 mm thick brickwork and internal walls of 105 mm thick brickwork, • plastered internal wall surfaces, • a concrete floor, • a sheeted roof that is fitted with a ceiling without insulation.
Condensation	Satisfactory. BESA dwellings with conventional roofs that are fitted with ceilings [with or without insulation] and BESA dwellings with thatched roofs may be erected in the <u>Southern Coastal Condensation Problem Area</u> (SCCP Area).	Condensation is generally a problem in the SCCP Area. The assessment of this aspect of performance applies only to dwellings in this area. Regarding the occurrence of condensation on the walls of dwellings, Agrément South Africa requires that the minimum standard of performance be equivalent to that of the standard brick dwelling which is itself not immune to condensation problems.
Acoustic performance	Satisfactory. Agrément South Africa's performance <u>criteria for sound attenuation</u> between adjacent rooms will be met. SABS 0218: Part 1 - 1988 *Acoustical properties of buildings*	Agrément South Africa's opinion is based on a study of airborne sound insulation values of similar systems. This indicated that the sound attenuation values between rooms would be at least: • single BESA block wall [with or without] finishes: 40 dB($D_{nT,w}$). • double BESA block wall [party wall between dwellings]: 46 dB($D_{nT,w}$). A description of the degree of acoustic privacy that can be expected between specific rooms for various degrees of sound insulation together with the minimum in situ airborne sound insulation required between rooms is given in the <u>*Supplement to certificates*</u>. For recommended sound insulation values, reference should be made to SABS 0218: Part 1.
Durability	Satisfactory. Given normal use and adequate and regular maintenance, buildings erected with this system will be durable.	Agrément South Africa's opinion is based on inspection of buildings constructed with bitumen emulsion stabilised earth blocks at Waterloo, KwaZulu-Natal, on knowledge of the materials of construction used and on the development and evaluation work carried out on the system.

Part 3: Technical description

General description

The BESA building system comprises:

- the manufacture of solid stabilised adobe building blocks [BESA blocks];
- the construction of single storey buildings in which the superstructure walls are built of BESA blocks together with stabilised earth mortar. These walls are reinforced at regular intervals with brickforce reinforcement and by a composite ring beam above door and window head height;
- stabilised earth plaster.

All other aspects of the construction of BESA buildings are conventional.

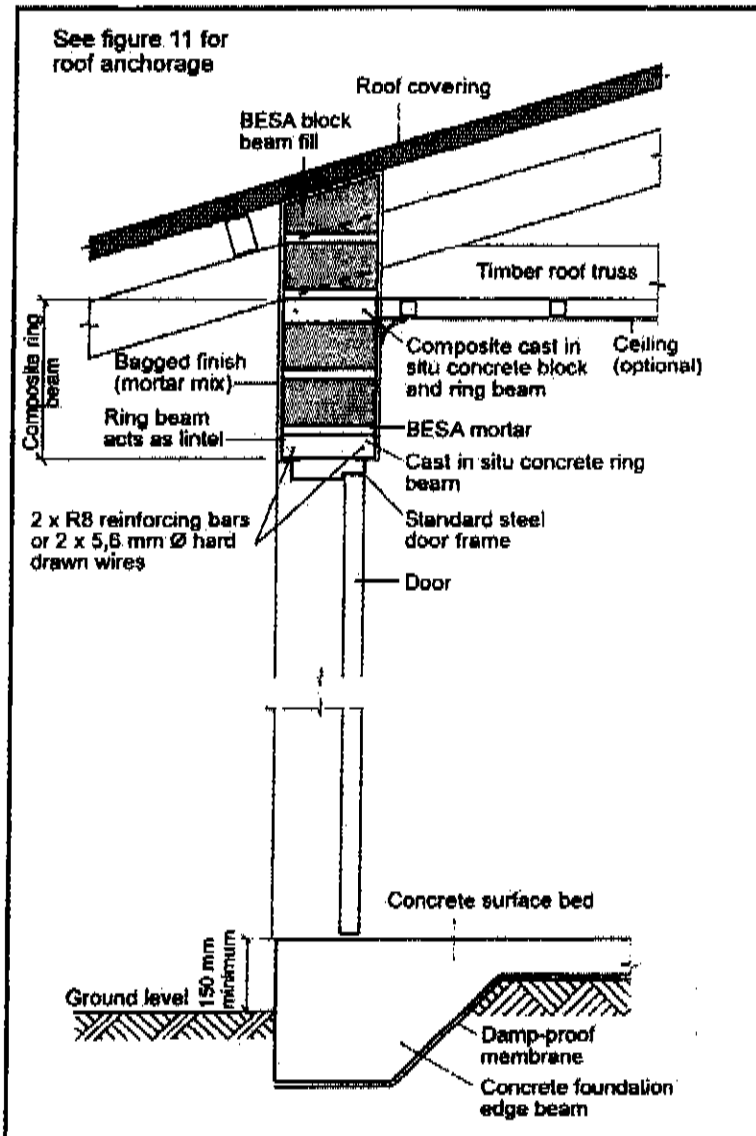


Figure 1: Section through external wall at door

turned on edge without distorting. After an initial 24 hours the blocks may be exposed to full sun to encourage the curing process [in this case the drying process].

If manufactured in the open air, the blocks are protected from rain until at least a week old. When sufficiently strong, the blocks are carried to a stockpile and stacked on edge with spaces between them to allow air circulation. No blocks are used until they are properly dry and at least four weeks old. This period may be extended if the drying process was delayed by cold or wet weather.

BESA mortar and plaster

These are normally mixed by hand. The materials and mix proportions are identical to those of the blocks except in the following respects:

- the polypropylene fibres are omitted,
- where BESA plaster will be applied as a bagged finish, the earth is sieved to remove particles greater than 6 mm.

Design and erection of BESA buildings (Figures 3,4,5, 6 and 8)

Dimensional limitations

BESA single-storey buildings are designed within the dimensional limitations set out below. Unless otherwise stated, all dimensions are measured on the external face of the external wall. [Minimum dimensions are nominal to suit block size and coursing.]

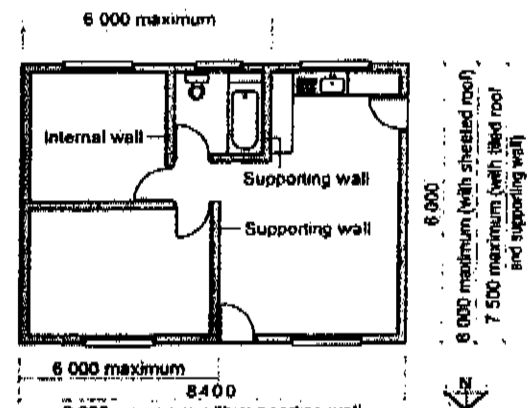


Figure 3: Sample plan for a dwelling showing dimensional limitations (sheeted and tiled roofs)

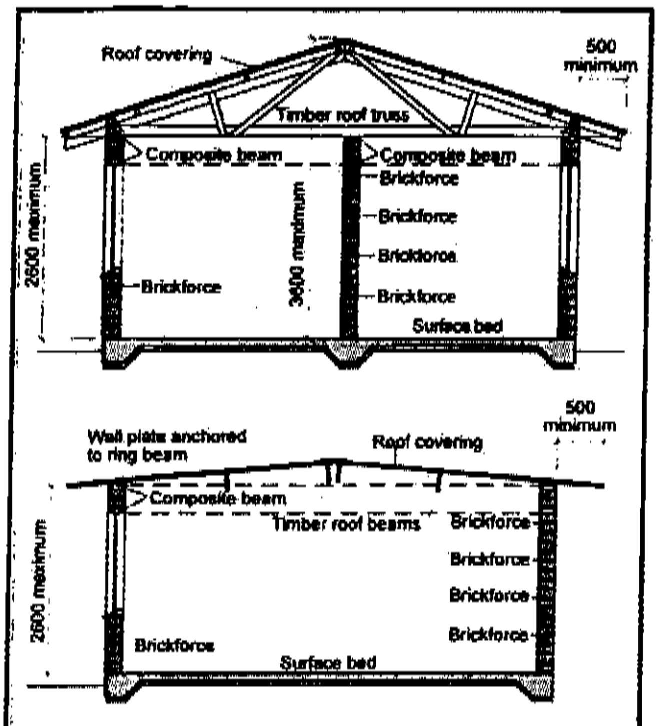


Figure 5: Typical section through BESA dwelling

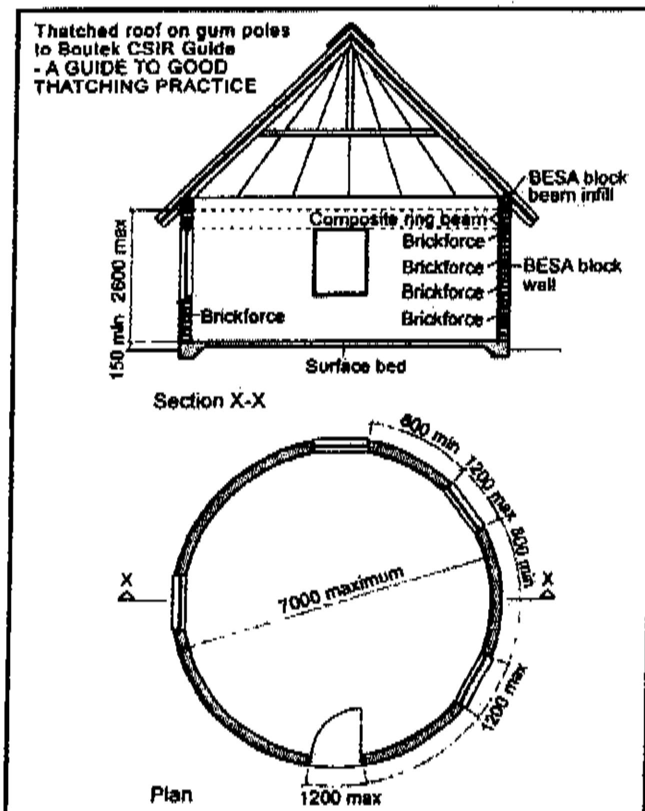


Figure 6: Typical rondavel layout

Rondavels

Maximum plan diameter	7,00 m
Maximum height of external wall from floor level to underside of rafters	2,60 m
Maximum length of opening in an external wall	1,20 m
Minimum length of solid external wall between openings	0,80 m
Minimum roof pitch for thatch roof	45°

Foundations [Figures 5, 6 and 7]

Foundations are conventional. A competent person classifies the site in accordance with the site class designation set out in Table 3 of the South African Institute of Engineering Geologists [SAIEG] publication *Guidelines for urban engineering geological investigations.*

In normal ground conditions (site class designation H or R) foundations consist of either:

- a conventional 75 mm thick cast in situ concrete surface bed with a thickened edge beam,

or

- conventional cast in situ concrete strip foundations [normally 600 mm x 200 mm] under the external walls and any loadbearing internal walls.

In each case local thickening of the floor slab forms foundations for the non-load-bearing internal walls.

In abnormal or problematical ground conditions, the foundations and their reinforcement are designed by a professional engineer and are constructed in accordance with his design.

Foundation walls and backfill [Figures 5 and 7]

Foundation walls are conventional and may be built of brickwork or stonework or of hollow concrete blocks [7 MPa] filled with concrete with a characteristic compressive strength of 10 MPa at 28 days [see Boutek guide page 27]. All the above are built with a cement/sand mortar. The area between the foundation walls is backfilled using selected material, in layers of 100 mm to 150 mm deep.

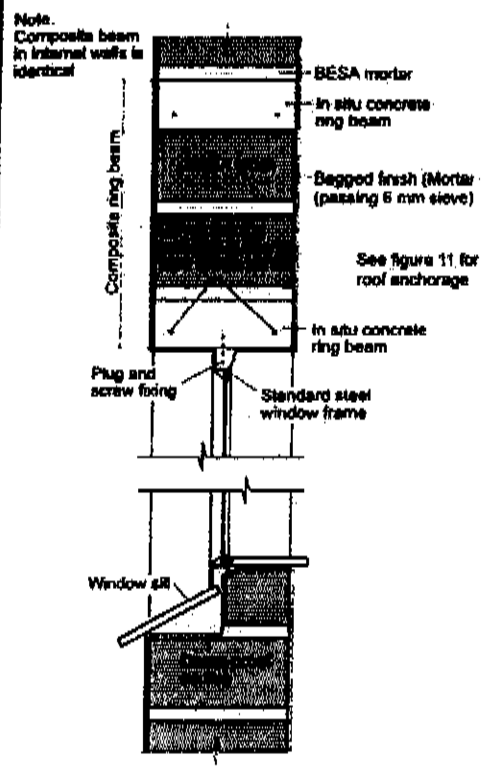


Figure 9:Section through window with ring beam

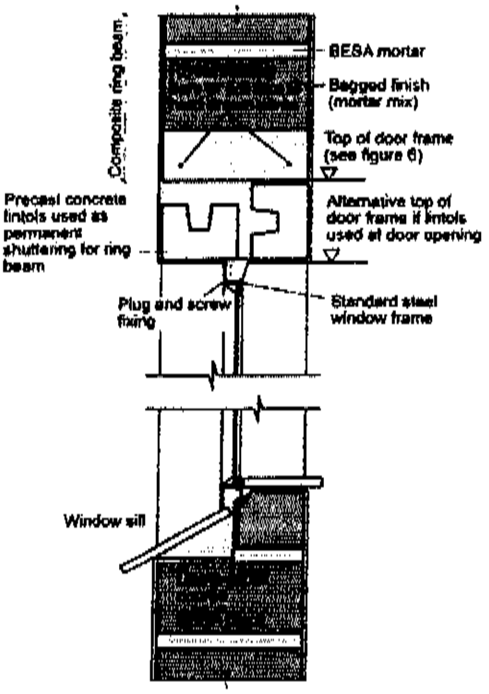


Figure 10: Section through window with precast lintol

The windows are placed in position. The walls are built up to the level of the top of the doorframes, taking care that where fixing lugs are provided to the window and door frames, the lugs are firmly bedded in mortar between the block courses. Where lugs are not provided, the frames are fixed into the blocks [not the mortar] by means of plugs and screws. Alternatively, patented concrete-framed window blocks may be built in place.

All walls are built up together. In general not more than ten courses of blocks are laid in any 24 hours. This is monitored and adjusted on each site depending on the setting characteristics of the BESA mortar.

BESA mortar beds and perpends

The finished thickness of a mortar bed is normally between 15 and 25 mm. Exceptionally it can be up to 30 mm. Care is taken when laying the blocks to maintain a reasonably uniform thickness of mortar bed.

The width of the vertical joints or perpends between the blocks is of a similar thickness and may be varied to accommodate the block sizes. Care is taken that the beds and joints are completely filled with mortar.

Composite ring beam [external walls] [Figures 1, 5, 6, 9, 10, and 11]

At lintel height a continuous ring beam is formed in all external walls. This consists of two cast in situ reinforced concrete beams separated by at least two courses of BESA blocks [see <u>Boutek Guide</u> Pages 36 and 37].
The lower cast in situ beam which is a minimum of 50 mm deep and of 1:2:2 fine- aggregate concrete, is reinforced with two R8 steel reinforcing bars or two 5,6 mm Ø hard drawn wire. At the corners one pair of reinforcing bars is bent through 90° and lapped with the reinforcement in the adjoining wall for a minimum distance of 500 mm. The courses of BESA blocks are laid in BESA mortar on this beam and an identical reinforced concrete beam is cast in situ on top of the final course of blocks to form a continuous composite beam. This forms the wall head of the eaves walls. Beam filling for eaves walls and gable walls are built up to the apex on this beam.

At openings the lower part of the composite beam may be shuttered to act as a lintel or precast concrete lintels may be used as permanent shuttering and the composite beam formed on top of these [see Figures 9 and 10 and the Boutek guide Page 39].

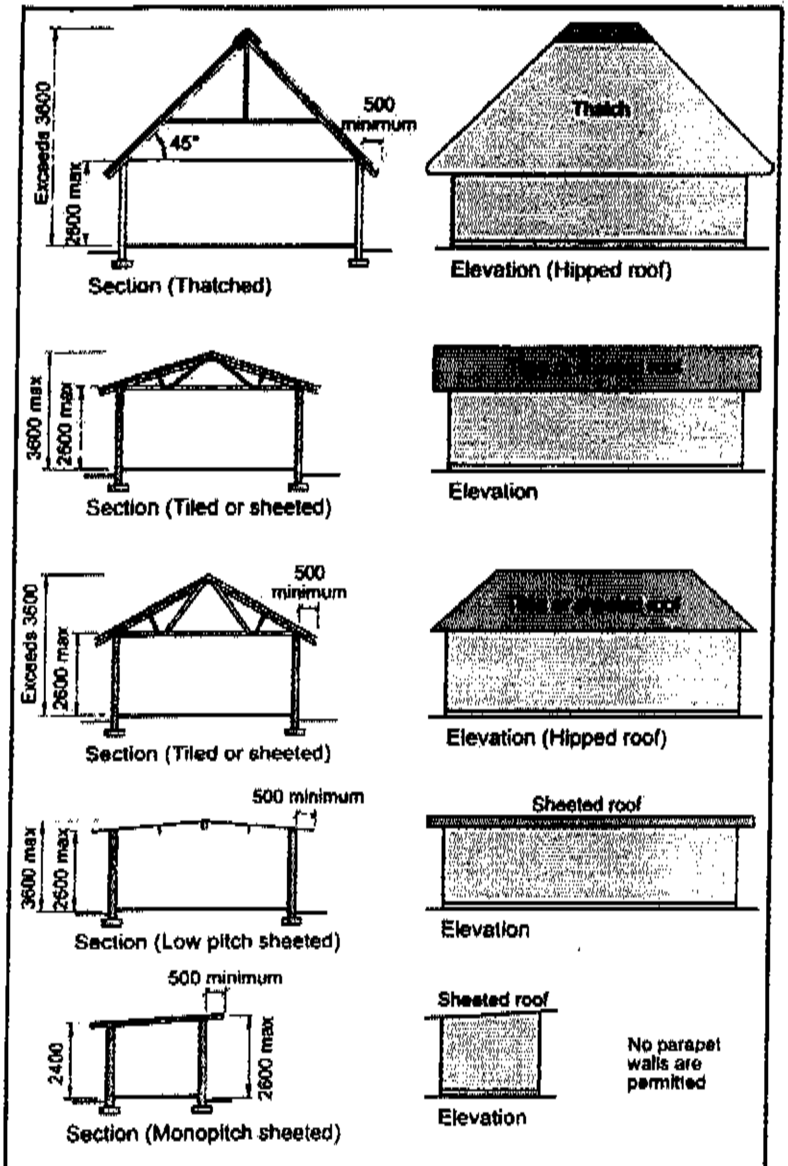


Figure 12: Typical roof shapes

Thatch roofs are constructed in accordance with the CSIR Boutek publication *A guide to good thatching practice.*

Ceilings and insulation [Figure 1]

Thatch roofed buildings are not normally provided with a ceiling. Ceilings are optional in buildings with conventional roof construction except in the case of dwellings that are erected in the SCCP Area.

Ceilings are conventional and consist of either conventional 6,4 mm thick gypsum plasterboard or 6 mm thick FC cellulose sheet, fixed to timber brandering. The brandering is nailed in place between or beneath the tie beams, purlins or rafters. Insulation, where specified, consists of 40 mm thick glassfibre or mineral wool installed above and in close contact with the ceiling.

Services

Conventional services are provided. Electrical conduits are normally cast into the surface bed and taken up the inside of the walls to the power points. Any chasing or cutting of the walls is carried out using disc grinders with masonry cutting blades. The resultant groove or channel is filled flush with BESA mortar.

Wall finishes

Internal and external wall surfaces may be finished in a variety of ways.

(a) The mortar joints are flushed by applying the BESA plaster mix by hand.

(b) A slurry of BESA plaster is hand applied in two applications [work the first application into joints and cracks, allow to dry and shrink then work a second coat into shrinkage cracks. Then finish to the required texture].

(c) As for (a) or (b) with additional texture provided by applying BESA plaster with a Tyrolean render machine.

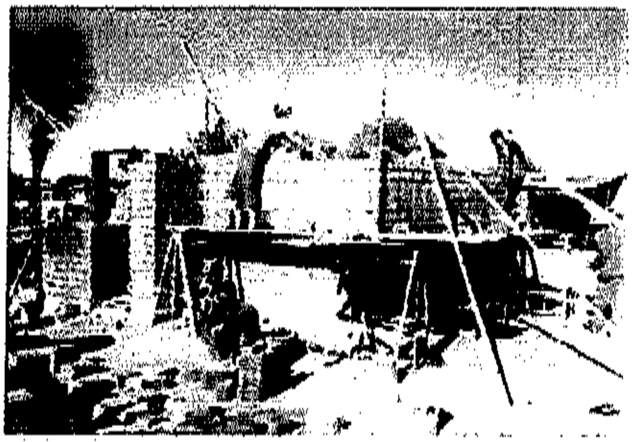
(d) Prime wall surface with a 1:9 mix of *Flexbond* (by Messrs Cemcrete) and water. Use the priming mixture to mix a 1:5

AGREMENT SOUTH AFRICA

CONSTRUCTION PRODUCTS APPROVALS

AGREMENT CERTIFICATE 96/237

Valid until further notice (see fourth paragraph of Preamble on page 1)



Title:
HYDRAFORM BUILDING SYSTEM

Certificate holder:
Hydraform Developments (Pty) Limited
P O Box 17570
SUNWARD PARK
1470
Telephone: (011) 913-1449
Fax: (011) 913-2840

Subject:

The Hydraform Building System consists of:

- conventional cast in situ concrete strip foundations and surface beds or cast in situ concrete surface beds with thickened edge beams and thickenings under internal walls
- a combination of dry-stacked and mortar-bedded 220mm and 110mm thick soil-cement block walls, reinforced where specified
- conventional roof construction which incorporates cross-bracing in the plane of the ceiling when specified dimensional limitations are exceeded
- conventional roof sheeting, clay or concrete roof tiles.

Use:

This certificate covers the use of the building system in all areas of Southern Africa, with certain limitations, for the erection of single storey buildings of the following types:

- non-residential school buildings (A3)
- moderate and low-risk commercial service buildings (B2) and (B3)
- moderate and low-risk industrial buildings (D2) and (D3)
- clinics and other institutional (residential) buildings (E3)
- small shops (F2)
- offices (G1)
- hostels, semi-detached, row houses and detached houses (H2), (H3) and (H4)
- moderate and low-risk storage (J2) and (J3).

COMPLIANCE WITH THE NATIONAL BUILDING REGULATIONS

(For greater detail see Part I, Section 4.3 of this certificate.)

The following Regulations are deemed to be satisfied:

A13(1)*(a) Materials*
B1(1) and B1(2) *Structural design*, if within the limits laid down
H1(1) *Foundations*, on non-problematic soils
K1, K2, K3 and K4 *Walls*
T1(1) *Fire protection*

CONTENTS

PREAMBLE

This certificate is issued by the Board of Agrément South Africa in terms of the powers granted to it by the Minister of Public Works.

This certificate covers only those Hydraform buildings that are erected in accordance with the certificate holder's specification (see Part II) and in which account has been taken of the limitations and conditions mentioned in this certificate. It does not apply to any other building system marketed, manufactured or erected by Hydraform. Users of this construction method should satisfy themselves that the limitations and conditions contained in this certificate are complied with.

The validity of this certificate is subject to continued participation by the certificate holder in Agrément South Africa's post-certification inspection scheme and agreement by the certificate holder to a periodic reappraisal of the system by Agrément South Africa. Such a reappraisal will normally be undertaken at three year intervals to monitor the performance in use of the system, taking into consideration any changes to the system that may have been proposed, and will determine whether the conditions imposed are still justified. Users of this certificate should satisfy themselves that it remains valid by referring to the latest editions of Agrément South Africa's publication *Directory of current certificates* or by contacting Agrément South Africa's offices.

Notices affecting the validity of this certificate will be published in the Government Gazette.

The certificate has been granted after a technical assessment of the innovative aspects of the Hydraform Building System based on:

- a study of drawings and specifications
- inspection of a building under construction
- tests, structural calculations and an assessment of Hydraform's quality management.

The certificate gives uses for which the product is considered satisfactory and indicates precautions which should be taken in its use.

PART I: CERTIFICATION

1 **CERTIFICATE HOLDER**

The certificate holder is Hydraform Developments (Pty) Limited, who markets the building system and manufactures the machines which are used to manufacture the soil-cement blocks. The blocks are manufactured and buildings erected by the certificate holder or by licensees appointed by him. The names of such licensees are registered with Agrément South Africa.

2. **SUBJECT**

The Hydraform Building System consists of:

- conventional foundations and surface beds
- 220 mm thick external walls of soil-cement blocks which are either dry-stacked or laid in horizontal mortar joints which may be reinforced, depending upon their position in the wall
- 110 mm wide semi dry-stacked and reinforced internal walls
- conventional roof construction and covering
- horizontal wind trusses introduced in the plane of the ceiling when structural limitations are exceeded

Competent persons are responsible for the structural design of all Hydraform buildings which fall within the dimensional and other limitations of the system. A professional engineer must be responsible for the structural design should the dimensional and other limitations be exceeded.

3. **USE**

This certificate covers the use of the Hydraform Building System in all areas of Southern Africa for the erection of single storey buildings of the following types

- non-residential school buildings (A3)
- moderate and low-risk commercial service buildings (B2) and (B3)
- moderate and low-risk industrial buildings (D2) and (D3)
- clinics and other institutional (residential) buildings (E3)
- small shops (F2)
- offices G1)
- hostels, row houses, semi-detached and detached houses (H2), (H3) and (H4)
- moderate and low-risk storage (J2) and (J3).

The occupancy class, as defined in Part A, Table 1: *Occupancy of Building Classifications* of the National Building Regulations has been attributed by Agrement South Africa to the types of buildings covered by this certificate and is shown in brackets.

4. **ASSESSMENT**

4.1 **Scope**

This assessment applies to the innovative aspects of the building system as described in Part II of this certificate. It also applies to those conventional aspects of the build-

53 m², 77 m² and 100 m²)[6] with a 75 mm thick concrete surface bed, a total window area not exceeding 15 %, 19,5 % and 19 % respectively of the floor area, oriented true north and situated in the different climatic zones shown in Figure 2 of *Supplement to Certificates*

(c) The thermal performance of dwellings erected in accordance with this system is such that the indoor air temperatures will remain within the upper and lower limits prescribed by Agrément South Africa for dwellings in the different climatic zones.

4.5 **Durability**

Agrément South Africa is of the opinion that with reasonable use and adequate and regular maintenance as recommended by the Certificate Holder (see Part II, Section 5), buildings erected in accordance with this system should be as durable as conventional buildings. This assessment is subject to the requirement that blocks that will be used below damp proof course level, in conditions where they would be subject to high moisture conditions and/or in areas of severe exposure, a cement content of more than 10% by mass of dry soil be used. The precise percentage is to be determined after carrying out appropriate durability tests.

The effects of freezing and thawing of the blocks have not been evaluated as there are few areas in Southern Africa where freezing is of sufficient severity to cause degradation of the blocks. It is therefore recommended that if circumstances arise where the use of the Hydraform blocks is contemplated in areas subject to exceptionally severe frost, their performance under such circumstances be comprehensively evaluated.

Where roofs are to be covered with profiled galvanised sheet steel, particularly in coastal areas[7] and in other areas where the atmosphere is subject to industrial pollution, it is advisable to take the condition of similar roofs in the vicinity into consideration

4.6 **Habitability**

4.6.1 **Acoustic performance**

(a) A description of the degree of acoustic privacy which can be expected between specific rooms for various degrees of sound insulation is given in Section 2 of *Supplement to Certificates.*

(b) Based on the results obtained from sound attenuation tests previously conducted[8] on walls of a similar nature, the sound insulation indices likely to be obtained between adjacent rooms should not be less than 45 dB ($D_{nT,w}$) for 110 mm thick walls and 50 dB ($D_{nT,w}$) for 220 mm thick walls if plastered both sides. In both cases these walls are to be built up to the underside of ceilings or roof cladding.

4.6.2 **Condensation**

(a) Condensation is generally only a problem in Climatic Zones 1 and 2 and in the SCCP Area (see Figures 1 and 2 of *Supplement to Certificates*). The assessment of this aspect of performance is therefore confined to dwellings in these areas.

In the assessment three sizes of single storey dwellings (53 m², 77 m² and 100 m²) of the types specified in Section 4.4.1 are considered. It is assumed that houses of standard layout[9] and fenestration are occupied by four, six or eight people who exhale or generate vapour at the rate of 0,01 g/s per person and that the ventilation rate in such houses in Climatic Zones 1 and 2 is 1,0 air change per hour (if the occupancy rate is increased and/or the ventilation is reduced by blocking off the ventilation openings, the rate of condensation will increase). Houses are presumed to be oriented true north and to have a vapour flue installed in areas where water vapour is generated, such as the bathroom and the kitchen

The provision of window drains which will permit any condensate that forms on the window glass to be collected and led to the outside of the building will reduce the occurrence of condensation on the walls of houses.

(b) The following types of Hydraform buildings will not perform satisfactorily with regard to condensation:

- 53 m², 77 m² and 100 m² buildings without ceilings covered with galvanised steel or fibre cement sheets
- 53 m² buildings with uninsulated ceilings, covered in galvanised steel or fibre cement sheets

Figures 2(a) and 2(b) show graphically the potential for condensation in each size of dwelling constructed with the Hydraform Building System using galvanised steel and fibre cement roof sheeting with uninsulated and insulated ceilings

4.7 **Certificate holder's quality system**

The quality system adopted by the certificate holder will ensure that acceptable production and erection standards are consistently maintained. The quality system is based on recommendations contained in the SABS ISO 9000 Series

5. **CONDITIONS OF CERTIFICATION**

5.1 **Requirements of *Supplement to Certificates* that must be met**

The following requirements listed in *Supplement to Certificates* apply to those aspects of Hydraform Building System buildings that have not been specifically assessed (refer to Section 4.1 above):

Accuracy in buildings: 1.1
Acoustic performance: 2.2.2 and 2.2.3
Behaviour in relation to fire: 3.1
Condensation: 4.1 and 4.2
Durability and serviceability: 5.1 (excluding 5.1.9 and 5.1.14)
Rainwater penetration and damp-proofing: 6.1.1 - 6.1.5 and 6.2

5.2 **Other technical requirements that must be met**

The design and erection requirements listed below highlight details of the innovative aspects of the building system that require special attention.

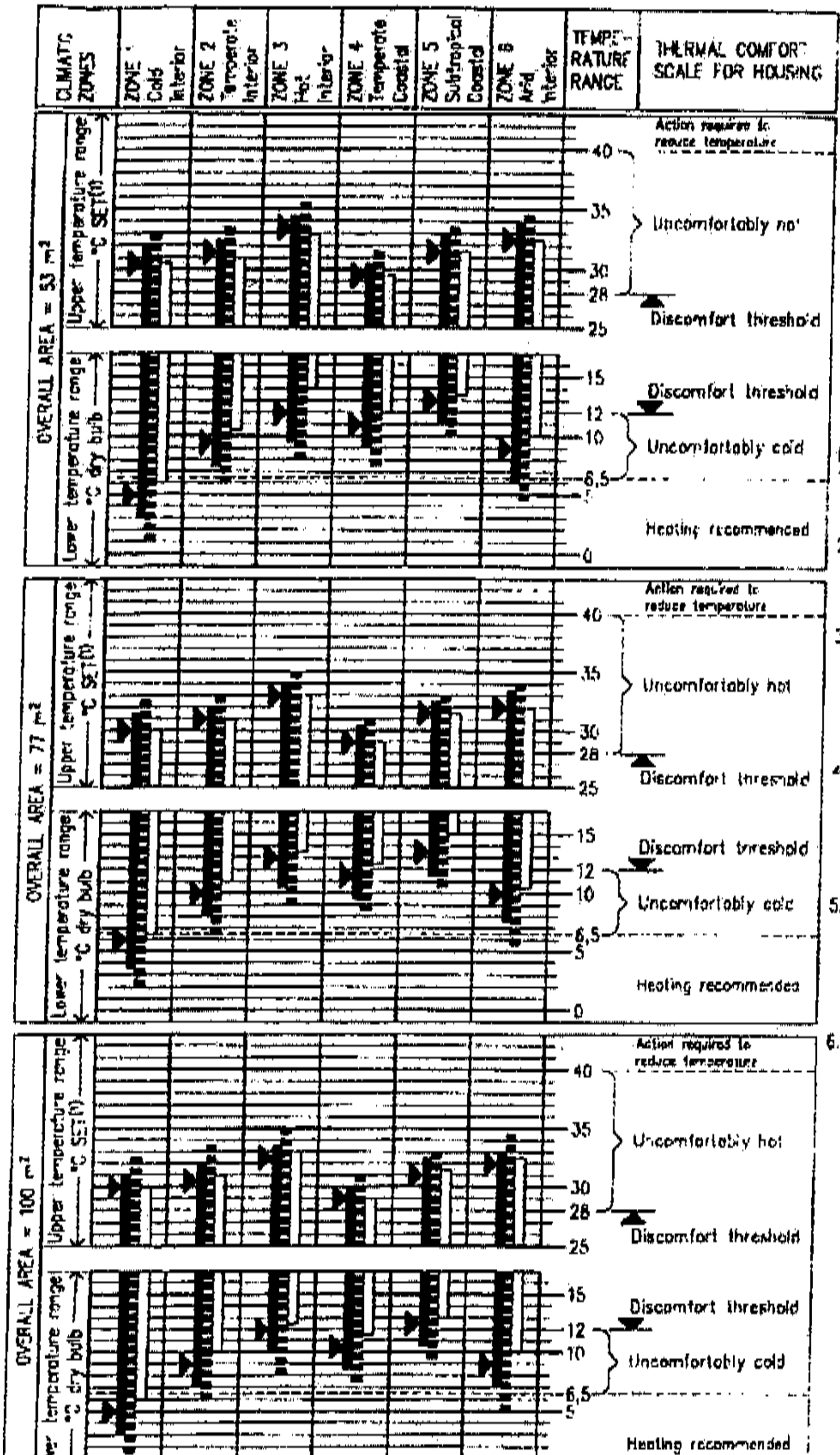
[6] The standardised house designs are described and illustrated in the chapter on thermal performance, in Agrément South Africa's Booklet B1

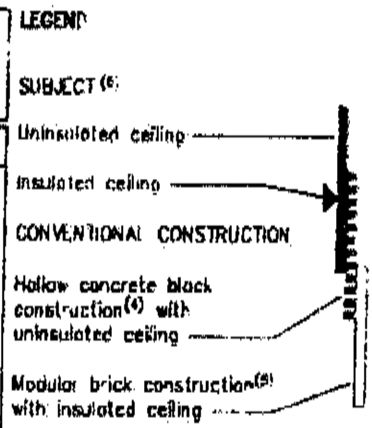
[7] Coastal areas: those areas between the coastline and an imaginary line 30 km inland, parallel with the coastline, or the top of the escarpment or watershed of the first mountain range inland if these areas are less than 30 km from the coastline. The entire area of jurisdiction of any local authority whose area is cut by the line demarcating these coastal areas is taken as falling within the coastal area

[8] Single number quantity for airborne sound insulation ($D_{nT,w}$) in decibels, as defined in SABS 0218, Part I - 1986. (See also *Supplement to certificates*)

[9] The standardised house designs are described and illustrated in the chapter on thermal performance in Booklet B1

CONDITIONS OF CERTIFICATION



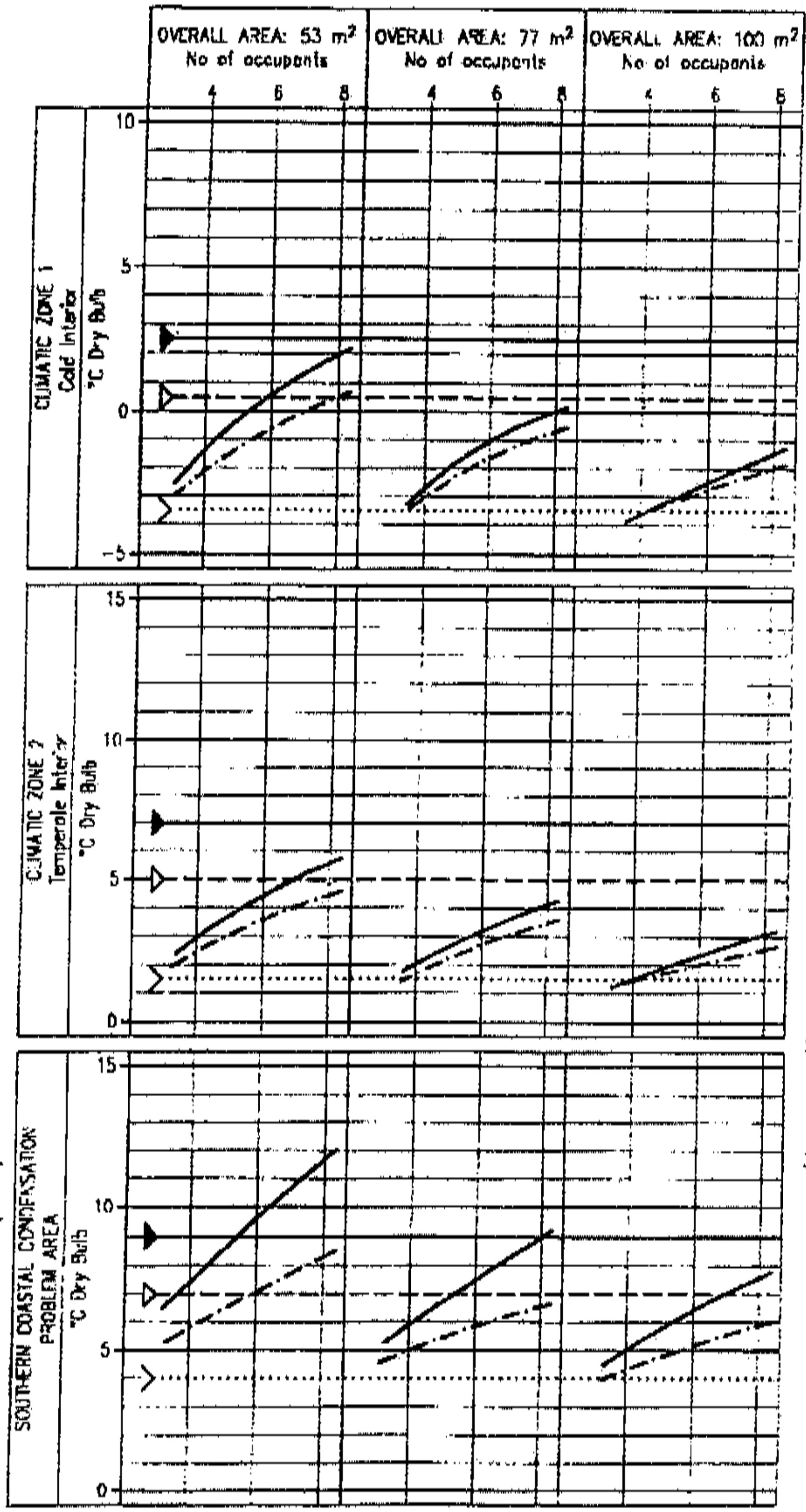


NOTES

1. °C SET: See booklet B1 (1986), Section 8, item 1 for definition.
2. Standard layout, orientation and fenestration: See Booklet B1 (1986), Section 8, item 5.1
3. Floors and roofs: As described in Figures 8(b), 8(c) and 8(d) of Section 8 of Booklet B1 (1986) unless otherwise specified for the subject.
4. Hollow concrete block construction 150 mm thick single skin hollow concrete block external walls bagged on both sides (see Booklet B1 (1986), Section 8, item 5.1)
5. Modular brick construction: 230 mm thick burnt clay brick external cavity walls plastered on the interior (see Booklet B1 (1986), Section 8, item 5.1).
6. Subject: Hydroform Building System with galvanised roof sheeting

FIGURE 1(a)

ESTIMATED INDOOR AIR TEMPERATURE RANGES FOR BUILDINGS OF STANDARD LAYOUT, FENESTRATION AND ORIENTATION(2)



LEGEND

Indoor air dew-point temperatures for houses without window drains[2]

Indoor air dew-point temperatures for houses with window drains

Indoor wall surface temperatures of external walls of houses with insulated ceilings

Indoor wall surface temperatures of external walls of houses with uninsulated ceilings

Indoor wall surface temperatures of external walls of houses without ceilings

NOTES

1. Condensation will be a problem in houses where the indoor air dew-point temperature for a given number of occupants rises above the indoor wall surface temperature.
2. Window drains are devices that convey the water vapour which condenses on the cold inside surfaces of window panes during the night to the outside.
3. The calculated values given are approximate and are based on the assumptions set out in the condensation assessment contained in Part I of this certificate.

AGR74-2A SCALE 1=1 (BLACK)

95/

FIGURE 2(a)

POTENTIAL FOR CONDENSATION IN HYDRAFORM DWELLINGS WITH GALVANISED ROOF SHEETING

1 **GENERAL**

The Hydraform building system utilises soil:cement blocks for the erection of external and internal walls of single storey buildings. Hydraform block making machines are used to produce two types of blocks, one for external walls and the other for internal walls. Blocks of different strength are manufactured for use in different parts of the building. Both types of block are keyed on their upper and lower surfaces and the 220 mm wide block is also keyed at the ends

External walls are built of 220 mm wide blocks, generally between 200 and 240 mm long. To facilitate bonding, shorter blocks (minimum length of 100 mm) can be manufactured. Depending on the position of the block in the wall, it may be dry-stacked or bedded in mortar. No mortar is applied between the vertical faces of these 220 mm wide blocks which butt up against each other whether dry-stacked or bedded in mortar. The horizontal mortar joints are reinforced as specified.

Internal walls are built of 110 mm wide blocks between 200 and 240 mm long, in conventional stretcher bond. The blocks are laid in conventional mortar; however, the mortar in the horizontal joints is limited to the idth of the rebate which occurs along the underside of the block. Horizontal mortar beds are reinforced, as specified.

All walling is single skin construction. The external and internal surface of external walls are plastered and painted. All other wall surfaces are plastered, bagged or given a splatter plaster coat with the exception of the foundation walls which are either unfinished or bagged.

All building requisites such as steel and timber windows, doors and door frames, joinery, roofing and ceiling materials, roof trusses, timber, ironmongery, plumbing materials, paints, etc are purchased from recognised manufacturers and merchants. All services and finishing work (eg electrical installation, drainage and plumbing, flooring, glazing, painting, etc) are carried out either by the certificate holder, his licensees or by firms who specialise in those trades.

The foundations, roof construction (except for horizontal wind bracing where necessary) and roof coverings are conventional.

2. **MANUFACTURE OF HYDRAFORM BLOCKS**

The Hydraform block manufacturing machine is portable and can be moved from site to site.

Suitable soil is identified and mix proportions determined as set out in Part II, Section 3 below.

The pre-determined quantities of soil, water, cement and lime, where necessary, are thoroughly mixed before being placed in the block-making machine. Mixing can be done by hand or by machine, by volume or by mass batching but mass batching is preferable.

Blocks are manufactured to the dimensions shown in Figures 3 and 4. The upper and lower faces of blocks must be straight and true and shall not deviate from a straight edge laid in any direction by more than 0,5 mm. The length of blocks may vary between 100 and 250 mm. The dimensional tolerance on any aspect of the height or width shall be ± 1,0 mm. In addition the upper and lower faces of the blocks must be parallel and the height measured at each end may not differ by more than 1,0 mm.

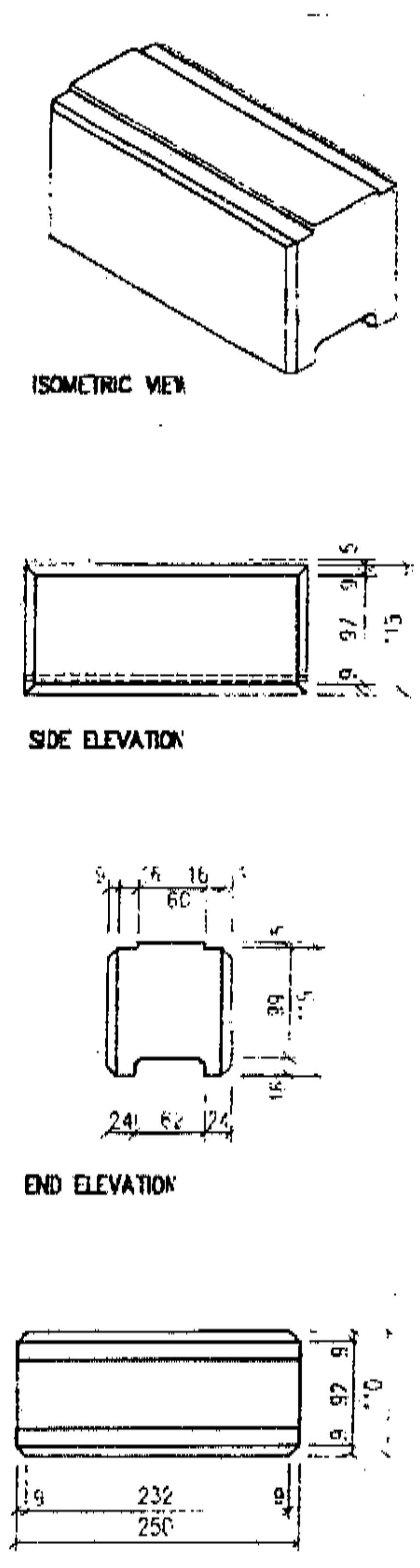


Figure 3: Details of 110 mm Hydraform blocks

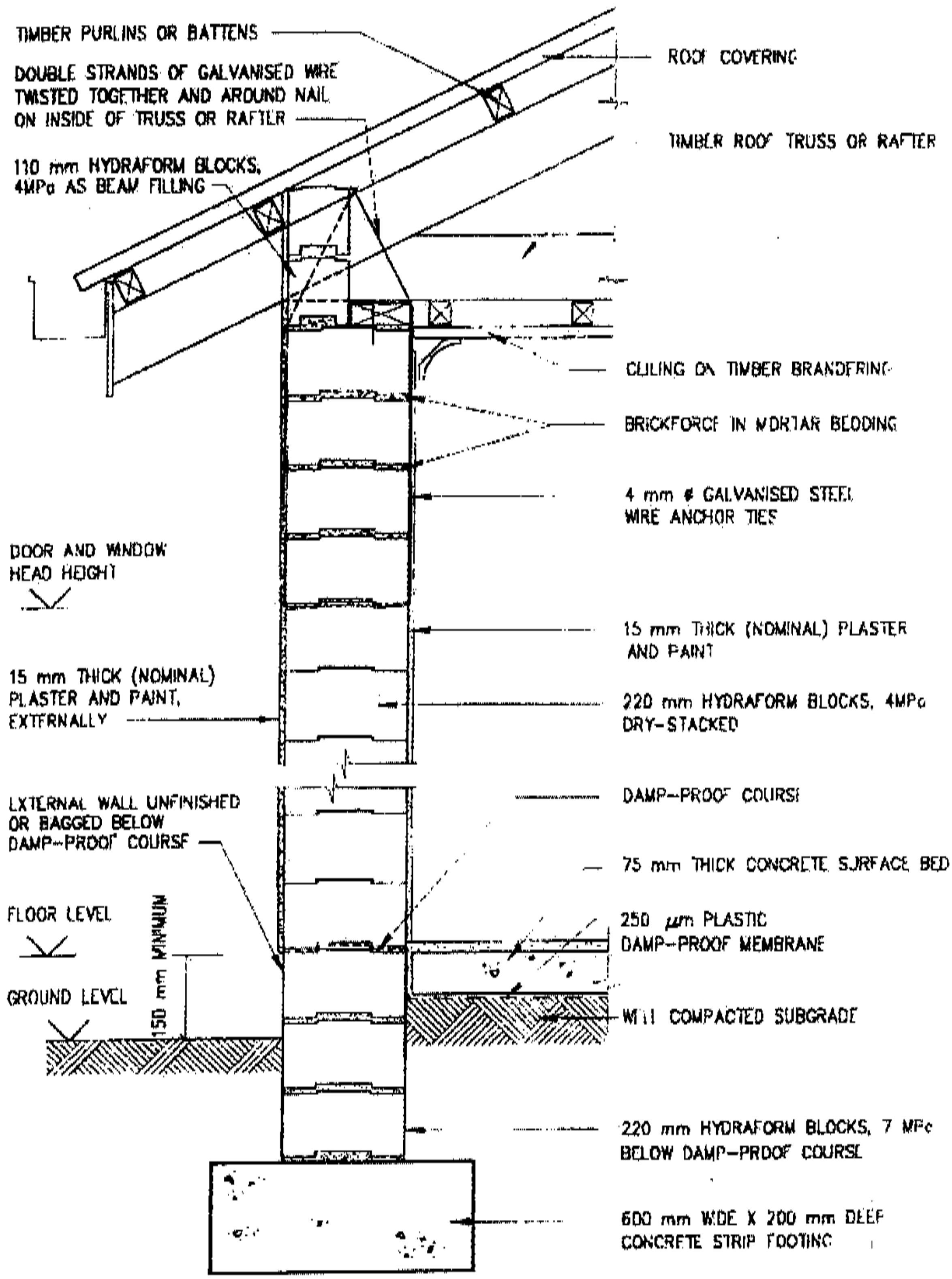


Figure 5: Typical section through external wall showing foundation and roof anchorage details (for alternative foundation details see Figure 7)

ESTIMATED VOLUME BATCHING QUANTITIES FOR INITIAL TRIAL MIXES

Nominal compressive strength	Cement volume	Soil volume	Cement	65 litre wheel barrows
4MPa	1	20	1 pocket	10
7MPa	1	12	1 pocket	6

Portland cement must comply with the requirements of SABS 471.

Portland cement 15 must comply with SABS 831

Portland Blast Furnace Cement must comply with the requirements of SABS 626.

Portland Fly Ash cement must comply with SABS 1466

Lime, where used, must comply with the requirements of SABS 824.

Empirical tests such as the 'Jar', 'Ball' and 'Drop' tests give a quick indication only of material suitability. Other tests carried out by Hydraform which include a test for dimensional accuracy, shear strength, standard penetration and durability tests, will also give an indication of a block's likely performance. These tests, together with laboratory testing in accordance with Hydraform's quality management system, should ensure blocks of an acceptable standard for use as specified

Reference may also be made to *The Properties of Compacted Soil and Soil-cement Mixtures for use in Building* (see appendix).

4 ERECTION

4.1 General

Hydraform buildings are normally planned to conform to the dimensional limitations referred to Part I, Section 5.2.1. The design of buildings that exceed these limitations is the responsibility of a professional engineer.

4.2 Foundations

Foundations are normally cast in situ and of the following types:

- conventional strip footings 250 mm thick x 600 mm wide
- surface beds with thickened edges and thickenings under internal walls.

Concrete used in foundations shall have a minimum 28 day strength of 15 MPa.

When doubt exists regarding ground conditions or when buildings are designed by a professional engineer, the foundations are designed in accordance with SABS 0161 to meet the requirements of the individual project.

4.3 Foundation walls and surface bed

In all cases foundation walls are constructed of 220 mm wide blocks with a minimum nominal compressive strength of 7 MPa at 28 days. All blockwork below the damp-proof course and the first course above the damp-proof course or foundation slab level is bedded in a 1 cement : 6 sand mortar bed. Mortar joints above foundation level include brickforce (see Figure 5). Foundation walls which intersect are cross-bonded only at corners.

A continuous damp-proof membrane, such as polyethylene sheet that complies with SABS 952, at least 0.25 mm thick, is provided under all surface beds and

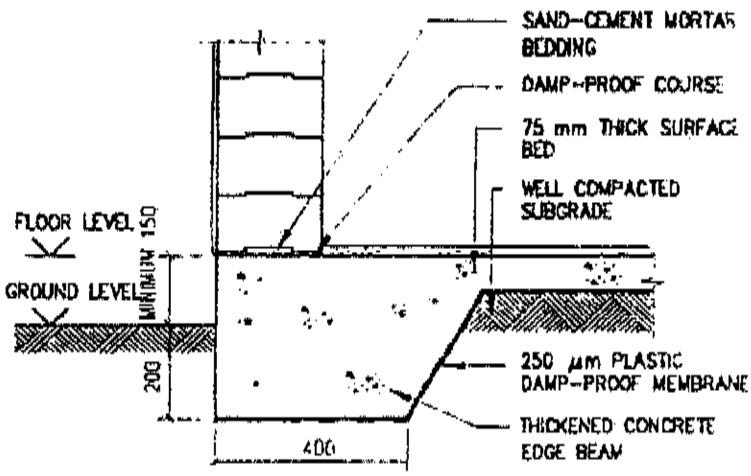


Figure 7: Alternative external wall foundation detail

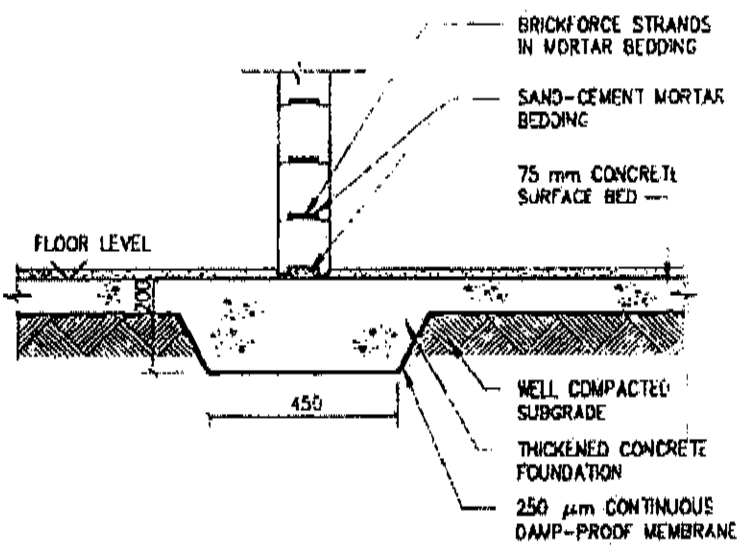


Figure 8: Alternative internal wall foundation detail

The blocks in the top course of gable walls are cut to rake. Internal raking walls that are required to be taken up to the underside of the roof covering materials, are treated in the same way as gable walls.

4.6 Division and occupancy separating walls with regard to fire regulations

Where required by SABS 0400, occupancy division and separating walls are provided. These walls are either 110 or 220 mm wide Hydraform walls for non-loadbearing or loadbearing applications respectively. In both cases walls are plastered on both faces.

4.7 Roofs

Roof structures are conventional and consist of timber trusses supported on 114 mm x 38 mm timber wall plates on the ring beams. These trusses in turn support light weight sheeted roofs (galvanised steel or FC) or concrete tiles. For certain types of structures, where dimensional limitations are exceeded, horizontal wind trusses are u-

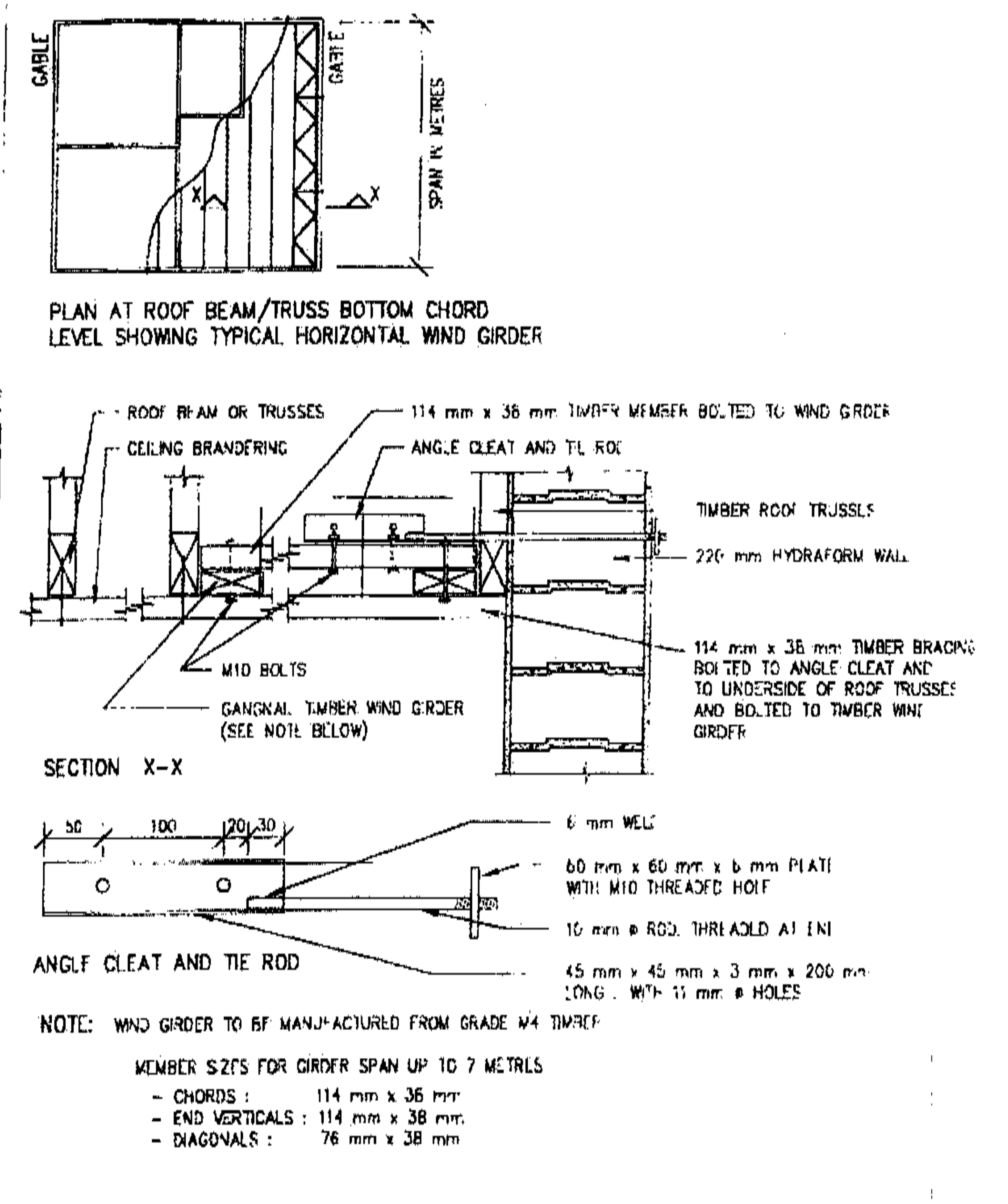


Figure 12: Horizontal wind girder detail

APPENDIX

SABS DOCUMENTS REFERRED TO IN THIS CERTIFICATE

Standard specifications

SABS 471:1971 *Portland cement (ordinary, rapid-hardening, and sulphate resisting)*
SABS 831:1971 *Portland cement 15*
SABS 626:1971 *Portland blast furnace cement*
SABS 1466:1988 *Portland fly ash cement*
SABS 824:1967 *Lime for soil stabilisation*
SABS 952:1985 *Polyolefin film for damp-proofing and waterproofing in buildings*
SABS 634:1972 *Emulsion paints for exterior use*

Codes of practice

SABS 0218:Parts I & II:1988 *Acoustical properties of buildings*
SABS ISO 9000 Series *Quality management systems*
SABS 0161:1980 *The design of foundations for buildings*
SABS 0400:1990 *The application of the National Building Regulations*

References

Webb, Celliers and Stutterheim. *The Properties of compacted soil and soil-cement mixtures for use in buildings.* National Building Research Institute, CSIR, Pretoria, March 1950.