CLAY BRICK TECHNICAL GUIDE

3rd Edition 2015 Revised

The Claybrick Association

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The Clay Brick Association of South Africa

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REFERENCES AND RECOMMENDED READING

The Clay Brick Association of South Africa
Clay Brick Laying Made Easy

FW Kraukamp:
1. Bricklaying & Plastering Theory (N1&2)
2. Bricklaying is easy.

BDA UK:
The BDA Guide to Successful Brickwork.

Brick Institute of America:
Pocket Guide to Brick Construction.

Cement & Concrete Institute (RSA):
Various pamphlets on concrete, mortar, plaster and construction detailing.

National Home Builders Registration Council:
Home Building Manual Parts 1, 2 & 3.

FS Croft: FSC Consulting Engineers:
Chapter 5: Structural masonry with clay brick

CT Dickinson – Consultant:
The Clay Brick Association of South Africa

H Harris – Consultant:
The Clay Brick Association of South Africa

Lessons for South Africa from global trends in environmental labelling of buildings and construction products

FOREWORD

The Clay Brick Association of South Africa is proud to bring you the completely revised and revamped version of its well-received Clay Brick Technical Guide. The publication has not only undergone a full visual overhaul with a new look and feel and completely new illustrations, it has also undergone a complete revision of all its technical content.

With the complete revision of the SABS and its SANS codes, which included the new SANS 10400, we as the CBA felt it time to bring our technical guide up to speed with the new standards and in turn ensure it is the most up to date publication in regarding best practices for masonry walling. Taking a lot of its cues from SANS 10400 – Part K, the publication covers the need to know aspects of clay masonry from manufacture of clay units to accommodation of movement and standards for structural masonry, all in the pages of this handy guide.

One of the corner stones (no pun intended) of the Clay Brick Association is to preserve and uphold technical excellence within the clay brick industry, whether it be through the numerous technical projects we are involved in and promoting or through producing technical publications such as this.

Upholding the great name of clay brick as one of the earth's most sound and versatile building materials will always remain our passion.

We have also included three new chapters on sustainability, energy efficiency standards, thermal comfort and the role clay brick has to play in complying within the eco space. Whether you are and experienced clay mason, brick manufacturer or trainer, this publication offers invaluable professional insight into clay masonry.

Jonathan Prior

Executive Director
Clay Brick Association of South Africa

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CHAPTER 1

CLAY BRICK MANUFACTURE

CLAY BRICK MANUFACTURE

Brick Manufacture

Bricks made by shaping a plastic mass of clay and water, which is then hardened by drying and firing, are among the oldest and most enduring of mankind's building materials. Until comparatively recent times the clay was dug, the bricks were made and the kilns set or drawn by manual labour with the help of animal power. About 100 years ago, the first effective machines for brick production appeared, and the trend towards mechanisation of clay winning, making and handling operations has continued at an increasing pace to this present day.

Clay brick is the simplest and most ancient of all building materials. Few other fabricated building units have enjoyed such widespread and continuous popularity. This enduring public acceptance is based on the unique combination of properties offered by clay brick to the owner and builder. This single material can be used to enclose a structure with a decorative, load-bearing wall, which is exceptionally durable and, if properly constructed in the first place, requires practically no maintenance.

Because of the versatility of the raw material, which can readily be moulded into a variety of shapes and sizes, and the flexibility that this gives to design and construction, building with clay brick has remained cost-effective, at initial use and in the long term.

Secondary clay materials are compounds of alumina, silica with minor amounts of lime, magnesia, soda or potash. Iron compounds, usually the oxides, hydroxides or carbonates are nearly always present as impurities in brick clays, and they account for most of the array of colours found in the finished product. Clays containing up to 3% of iron oxide give white to cream or buff colours, which change to pinks and reds as the iron oxide content rises to between 8-10%. By adding manganese dioxide in proportions from 1-4%, a range of grey and brown colours can be produced.

More important than their chemical composition are the facts that:

- When mixed with water, the clay minerals give a plastic mass that can be shaped by pressure to form a brick;
- At economically practical temperatures ranging between 1000°C to 1200°C, the clay particles can be fused into a cohesive mass of great compressive strength;
- Controlled evaporation of the free water surrounding the particles in plastic clay minimises excessive shrinkage and defects in the structure of the brick.

Modern brick manufacture involves high speed processing at extrusion rates of up to 25000 bricks per hour. Solid bricks of the size traditional in South Africa (222 x 106 x 73mm) weigh 3kg to 3,3kg. Therefore, 1000 finished bricks weigh approximately 3,3 tonnes. In the wet state before firing, the clay is heavier. For every 1000 bricks at least 4 tonnes of material must be dried, fired to a temperature of 1000°C to 1200°C (depending on the clay used) and cooled down.

The Manufacturing Process

Winning

Heavy earth-moving equipment such as bulldozers, scrapers and mechanical shovels are used to extract the clay and shales.

Crushing and Blending

After being transported from the pit by truck or endless conveyor, the materials are stockpiled to enable blending of the various types of clay.

The clays are fed separately by hopper or conveyor to the primary crushers - in South Africa rolls or hammer mills are commonly used. These reduce the particle size down to 3-5mm or less. The mixing of clays follows, to impart the desired properties, such as colour and strength.

Grinding

Conveyors carry the mixed clay away for secondary crushing, which is usually done by means of a pan mill. The pan mill has two heavy steel wheels on an axle that is connected to a central vertical spindle around which they rotate, crushing the clay against the base of the pan.

The base is perforated to allow the crushed material to fall through. This process, when done with dry clay, shatters the brittle particles into smaller pieces. When the pan mill is used with wet clay, the plastic material is squeezed through the perforations and then falls between high-speed rollers which complete the grinding process.

Screening - Dry Processing

Before being shaped, the clay is screened and oversize pieces are returned to the pan mill for further crushing.

Shaping

Bricks are hand formed, pressed or extruded into their final shape. The method used to shape the bricks affects their final appearance and texture, and sets certain limitations on the handling methods employed during manufacture.

Extruded Bricks (Most common method in South Africa)

Clay with 18-23% water content is forced by an auger into a horizontal cone-shaped tube that tapers down to the die. Two compaction stages are commonly incorporated, with a vacuum chamber between them to remove any air in the clay that would reduce the strength of the end product.

The extruded clay column is cut into brick-sized pieces by an arrangement of wires. Extruded bricks, although often smooth, may be mechanically patterned or textured. Most bricks of this type have anything from 3-12 perforations, and by increasing the surface area, the required drying, firing, and cooling times are reduced. Any internal stresses are relieved by the perforations which also prevent distortion of the bricks during firing.

Drying of Bricks

In the brick-making process, the clay is refined and water is added in order to mould the brick. Before the bricks can be fired, they must be properly dried: the moisture content has to be reduced to less than 5% by mass for the clamp kiln.

In South Africa, there is adequate sun for the drying operation and most clamp kiln brick makers make full use of this free source of energy by placing the bricks on open hacklines. This operation has the disadvantage that it may make the process time-consuming, especially in the rainy season.

To reduce the drying cycle, brick makers have introduced some mechanical means of drying. The two most common methods are tunnel or chamber driers. The energy (heat) for the drying is produced in a supplementary coal heater or recycled off the kiln and the heated air is fed into the driers. These methods work as follows:

Tunnel Driers:

The bricks are produced and then off-set on flat rail trolleys or kiln cars. The cars are pushed through the tunnel. This operation can take up to 40-50 hours, from wet green to dry.

Chamber Driers:

Patented chamber driers are large rooms where bricks are packed onto pallets. The chambers may have a capacity of 50 000 to 60 000 bricks, Hot air is fed into the chamber. Drying time is between 48 -60 hours much quicker than the 14-21days needed for solar drying,

Firing

Bricks are fired at temperatures between 1000°C and 1200°C, depending on the type of clay. Light coloured clays usually require higher firing temperatures than dark coloured ones. Of the many known types of ceramic kilns, four types were used in South Africa, namely; the Down Draught kiln, the Hoffman-type Transverse Arch kiln (TVA), the Tunnel kiln and the Clamp kiln, However, the Down Draught type of kilns have since been discontinued because of their uneconomical firing procedures in terms of labour, coal, etc.

Down-draught Kilns:

Consist of a rectangular space with a barrel-vaulted roof and a slotted or perforated floor open to flues below. Green bricks (40 000 to 100 000 at a time) are stacked in the kiln. Fires are lit in fireboxes along the sides and the hot gases fire up to the curved roof, down through the bricks and from there to the chimney stack. Fires are fuelled by coal, gas or oil. When the desired temperature has been reached, the temperature is maintained for a specific period and the fires are then allowed to die. The kiln cools down, the fired bricks are removed and another batch of green bricks is placed in the kiln for firing.

TVA Kilns:

Firing in the TVA kiln is continuous. Each day green bricks are placed in cleared chambers in front of the fire, and the fired bricks are removed from behind it, with two or three adjacent wickets being kept open for this purpose. When a chamber is full, the wicket is bricked up and fuel (coal, oil or gas) is fed in among the bricks through holes in the crown or roof of the kiln.

The fire is made to move forward by “taking on” a row of fire holes at the front and dropping a row at the back, every 2 to 4 hours in an average sized kiln. In this way the fire moves right around the kiln every 10 to 14 days. The hot gases from the firing zone are drawn forward by exhaust fans to preheat and dry out the green bricks, while the fired bricks are cooled down by the flow of air passing from the open wickets behind the firing zone.

Tunnel Kilns:

The tunnel kiln is also a continuous kiln, but the fire is stationary while the bricks move past it on kiln cars. As in the TVA kiln, the unfired bricks are preheated by the spent combustion gases. After the fire, heat released by the cooling bricks may be drawn off for use in the associated driers. With this interchange of heat, the tunnel kiln uses less fuel than the intermittent type of down-draught kiln.

Tunnel kilns have several other advantages. For example, cars can be loaded and unloaded in the open factory, and always at the same loading points, so that handling problems are simplified; and tile kiln car acts as a conveyor belt so the bricks are fired as they pass through the firing zone.

Clamp Kilns:

In clamp kilns, some fuel is placed into the body of each brick. The bricks are packed into a pyramid-shaped formation. The clamp has a layer of coal, equivalent to two courses of bricks packed at the bottom. This layer (scintle) is set alight. It ignites the fuel in the base layer of bricks and progressively, the fuel in each brick ignites in the clamp kiln.

Clamp kiln firing can take up to three weeks and although the bricks may have finished burning in that time, it could take longer before they are cool enough to be sorted. Temperatures can be as high as 1400°C in the centre of the clamp.

Vertical Shaft Brick Kilns (VSBK)

Dry bricks are packed in layers into the top of a vertical refractory lined cylinder of 1,5m to 2,0m in diameter. The vertical cylinder of bricks are supported on a movable steel grid at the bottom exit end of the cylinder.

As layers of fired bricks are periodically drawn away, further layers of dry bricks then enter the “hot zone” about halfway down the vertical shaft. Bricks are progressively lowered down the cylinder in a continuous process.

All the heat in the firing zone is derived from fuel added to the brick body, generally finely crushed coal.

Delivery

Mechanical handling of bricks is a familiar sight in South Africa. In pack systems, signode strapped packs of ±500 bricks are arranged in a suitable stack and bound together by bands or plastic wraps. The packs are lifted by forklift or crane truck. Handling on site may be by hoist or brick barrows.

Conclusion

Modern clay brick making is a capital intensive ceramic process that requires long-term planning sensitive to the cyclical nature of the building and construction industries.

NOTES

CHAPTER 2

THE LANGUAGE OF BRICKS

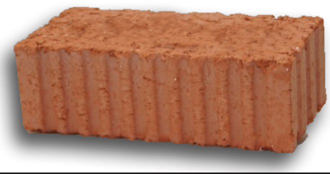
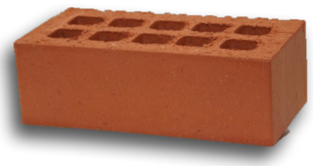
THE LANGUAGE OF BRICKS

Introduction

When referring to walls the National Building Regulations and other South African National Standards refer to a masonry unit without differentiating between a brick and a block; of importance though is whether the masonry unit is solid or hollow. However, SANS 227:2007 the South African National Standard for the manufacturing of burnt clay masonry units classifies a brick as a masonry unit satisfying any of the following dimensions, i.e. a length not more than 300 mm, a width not more than 130 mm and a height not more than 120 mm. A masonry unit falling outside these dimensions is a block.

Classification of bricks

SANS 227:2007 and SANS 1 575:2007 the South African National Standard for burnt clay paving units give the following classification:

Code	Name	Picture	Description
FBX	**FACE BRICK EXTRA**		Clay bricks that are selected or produced for their durability and high degree of uniformity of size, shape and colour
NFP	**NON-FACING PLASTERED**		Clay bricks suitable for general building work that is to be plastered
FBS	**FACE BRICK STANDARD**		Clay bricks that are selected or produced for their durability and uniformity of size and shape
NFX	**NON-FACING EXTRA**		Clay bricks suitable for use, plastered or unplastered, for general building work below damp-proof course or under damp conditions or below ground level where durability rather than aesthetics is the criterion for selection
FBA	**FACE BRICK AESTHETIC**		Clay bricks that are selected or produced for their durability and aesthetic effect deriving from non-uniformity of size, shape, or colour
E	**ENGINEERING UNITS**		Any class masonry unit produced for structural or load-bearing purposes in face or non-face work, where the manufacturer supplies clay bricks to an agreed compressive strength. An engineering unit is designated by the addition of the letter E followed by a number equal to the nominal compressive strength in megapascals, e.g. FBSE21
PA	**CLAY PAVERS**		Clay pavers that are selected or produced for their durability and for a high degree of uniformity in size and shape, and that have dimensions such that the ratio of work size length to work size width is approximately 1:1;2:1 or 3:1.
PB	**CLAY PAVERS**		Clay pavers that are selected or produced for their durability and for their uniformity in size and shape.

NOTE: *Pictures depicted are for example only and may differ in size, shape and colour to actual products supplied.*

CHAPTER 3

PRODUCT SPECIFICATION AND PHYSICAL PROPERTIES

PRODUCT SPECIFICATION AND PHYSICAL PROPERTIES

Overall Dimensions and Tolerance

The most commonly used and manufactured brick size is the 'Imperial Brick'. It is 222mm (long) x 106mm (wide) x 73mm (high) with a mass of between 2,4kg and 3,3kg, depending on the materials used, the degree of vitrification and the perforations provided.

Table 3.1 - Tolerance on work sizes

Tolerance on Work Sizes			
Class of Unit	Tolerance (mm)		
	Length	Width	Height
	Individual Units		
FBX	±5	±3	±3
FBS	±7	±4	±4
FBA, NFP, NFX	-	-	-
	Average 32 Units		
FBX	±2.5	±1.5	±1.5
FBS	±3.5	±2	±2
FBA	-	-	-
NFP, NFX	±3.5	±2	±2

Other sizes of bricks and blocks are made by individual manufacturers in various dimensions. Some of the more common sizes available are seen in the table at the bottom of this page.

Warpage and Tolerance

Measured Across the Length or across Diagonal Corners:

FBX Products : Individual units not to exceed 5mm; in not more than three units shall the warpage exceed 3mm

FBS & Engineering: Individual not to exceed 5mm

FBA & NFP: No requirement

Brick Compressive Strength

A wide range of bricks are available in this country. Bricks vary in compressive strength due to the differing qualities of raw material used and the method of firing. The compressive strengths can range from 7 MPa for NFP, to greater than 50MPa for Face Brick Extra and Engineering products. Standard testing is carried out on a sample of 12, to prescribed procedures. Most, if not all, local manufacturers are able to produce clay bricks to specified compressive strengths.

Modern methods of manufacture are used to produce bricks of consistent quality, but given that bricks are made from naturally occurring materials, the compressive strength of individual bricks in a given batch inevitably varies.

Note: The compressive strength of clay bricks is not always indicative of their durability. Clay products for special applications can be provided to specific tolerances and strengths.

Efflorescence

Efflorescence is the crystallisation of soluble salts on or near the surface of brickwork that results from the evaporation of water carrying salts through or from the brickwork. Efflorescence can be no more than an unsightly deposit on newly laid brickwork that soon disappears or it can be serious, causing unsightly permanent discolouration or even the failure of plaster, paintwork or face finishes.

This is often caused by poor waterproofing or detailing. SANS 227 - Burnt Clay Masonry Units: Table 4 ,describes degrees of efflorescence and the limits of efflorescence caused by salts in the clay bricks during manufacturing.

The degrees of efflorescence are as follows:

Nil: No perceptible deposit of salts

Slight : A very thin, slightly noticeable deposit of salts occurring on the edges of a unit only

Moderate: A deposit heavier than slight, but that has not caused powdering or flaking of the surface

Heavy: A thick deposit of salts covering a large area that has not caused powdering or flaking to the surface

Serious: A deposit of salts that has caused powdering or flaking of the surface.

When units are tested in accordance with SANS 227 the numbers that exhibit efflorescence shall not exceed the limits given in Table 3.2, for special or normal grade, appropriate to the class of the units.

Combinations of Brick Dimensions (mm)										
Length	222	222	222	222	220	190	190	290	290	390
Width	90	40	90	140	110	90	106	90	150	190
Height	73	73	114	114	73	90	90	90	190	90

Table 3.2 Degree of Efflorescence

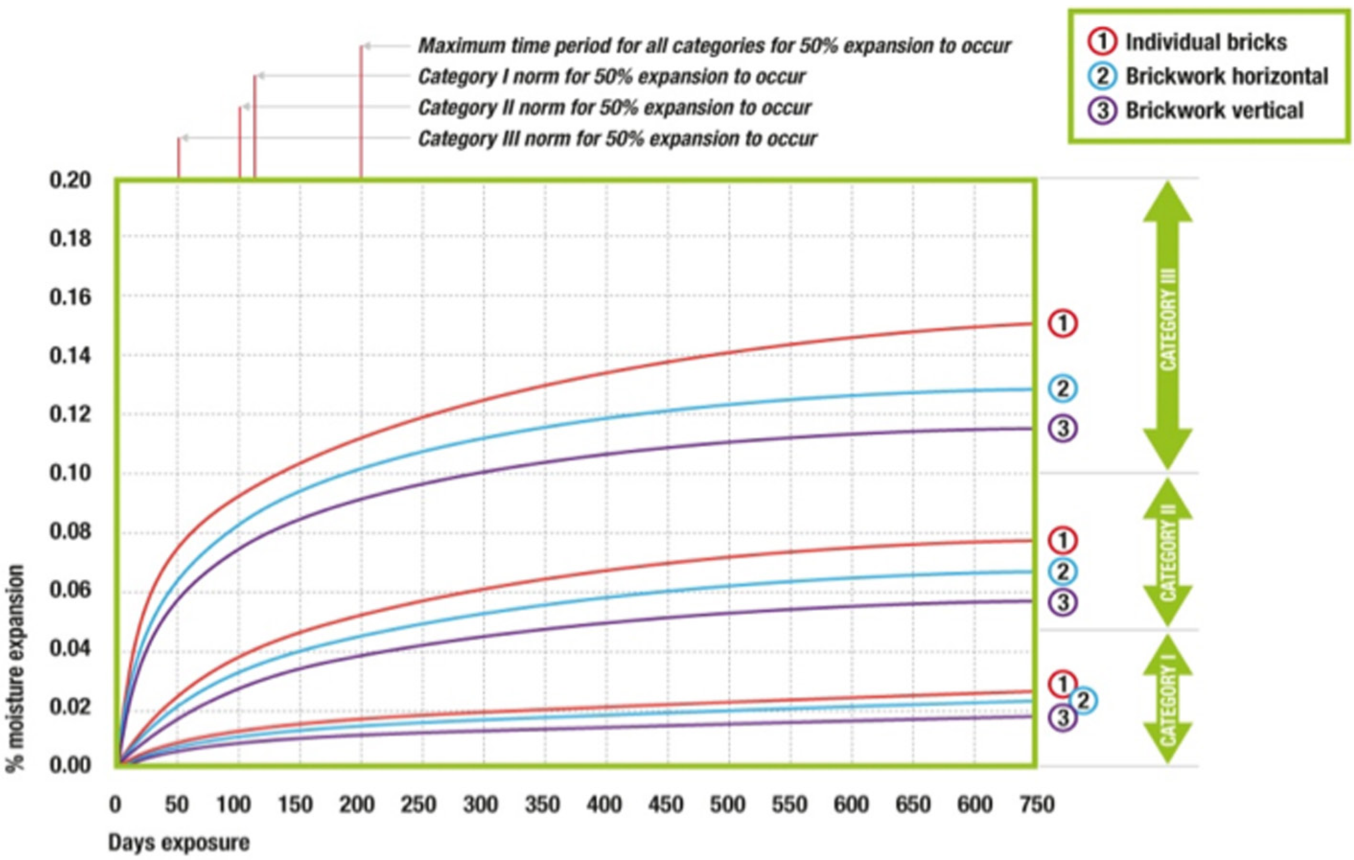
Degree of Efflorescence				
Grade	Class of Unit	Number of Units that Exhibit Efflorescence		
		Degree of Efflorescence		
		Slight	Moderate	Heavy
Special	FBS	20	-	-
	FBX	20	-	-
	FBA	20	-	-
	NFP	10	10	-
	NFX	10	10	-
Normal	FBS	10	10	-
	FBX	10	10	-
	FBA	10	10	-
	NFP	-	10	10
	NFX	-	10	10

Irreversible Moisture Expansion

Water absorption, water-soluble salts and moisture expansion values are best agreed upon between the supplier and the purchaser.

Burnt clay masonry units, in general, shall have an irreversible moisture expansion of not more than 0,20% and, in faced applications, a demonstrated satisfactory performance with respect to durability, unless it can be reasonably demonstrated by other means that the units are fit for purpose. This expansion, which is characteristic of all porous ceramic products, commences once the unit starts absorbing moisture from the atmosphere - hence the term moisture expansion. Moisture expansion must be considered when designing and constructing a brick structure. See Figure 3.1.

Burnt clay masonry units undergo an irreversible moisture expansion, which occurs as a result of the absorption of moisture from the atmosphere after firing.



3.1 - Typical rates of irreversible moisture expansion in brickwork

NOTE

- There is no difference in the expansion of perforated and solid bricks. Bricks stored in air expand in the same manner as bricks cooled from the kiln in a drier.
- There are no cost-effective ways of accelerating the irreversible moisture expansion of ceramic materials.
- The rate of expansion decreases steadily with the passage of time.

Other Properties

Durability: Selection Criteria

The best indicator of a product's durability performance in any application is at least 5 years' satisfactory performance in the application concerned.

A single global value of compressive strength alone is not an adequate criterion for a product's likely durability in an exposed application. The present minimum requirement for facing of 17MPa average compressive strength fails to cater for the requirements of varying exposure zones

Currently, a direct determination of durability does not exist in the form of a proven accelerated weathering test or some other performance-based evaluation, although a programme of research and of measuring the performance of products is ongoing.

Durability is the ability of a material to withstand the combined effects of the weathering agents of moisture, soluble salts, frost and thermal changes.

Exposure is the severity of these weathering actions, varying from mild to severe, and depending on both regional geographic conditions, and micro-climatic conditions with regard to the building's height and the material's position within the building.

Parapets and copings, for example, are clearly subject to more severe exposure conditions than face brickwork protected by overhanging eaves. Internal face brickwork is not subject to the same degree of exposure as external, unrendered brickwork. This section is primarily concerned with the selection of clay bricks for external face brick applications.

The use of facings and non-facings selected for durability in an area geographically close to the factory manufacturing the bricks poses few problems. The local knowledge of the exposure conditions and of the performance of the bricks concerned, which is generally available from the brick manufacturer, specifier and/or building contractor, will ensure that only products suited for their intended purpose will be used.

It is when bricks are specified by an architect or client far from the location of the manufacturer, with the building undertaken by a contractor who is not familiar with the properties and performance of the particular brick concerned, that the risk of a brick being used that is not suited to a particular application is increased.

Exposure Zones

In parts of Southern Africa, where the climate and peculiar local conditions combine to produce a harsh environment, certain types of face bricks used externally may suffer from weathering.

Broadly, experience and Masonry Walling has shown that Southern Africa may be grouped into four exposure zones.

Recommended Exposure Zones for Facings

Certain facing bricks may not be suited to external exposure in Zones 3 and 4. The recommended exposure zone to which each product is suited should be indicated by the manufacturer. In several instances, a special selection of clay facings from a factory can provide a product with enhanced durability and performance suited to more severe exposure applications.

Recommended Specifying and Ordering Procedure

To assist the industry in supplying the client with the correct type of brick for any application, it is recommended that the type of brick required for the application should be clearly stated or specified in bills of quantities or on architectural drawings and the expected exposure zone should be identified.

Initial Rate of Absorption

SANS 10164: Part 1. The South African Standard for the structural use of masonry, Part 1: Unreinforced masonry walling covers laying of structural units. The bond between brick and mortar is largely influenced by the demand of the brick to absorb water by suction and the ability of the mortar to retain the water necessary for the hydration of cement.

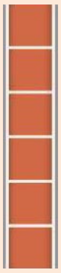
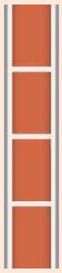
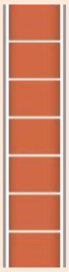
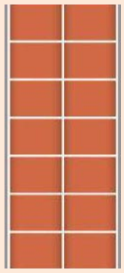
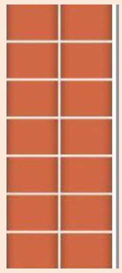
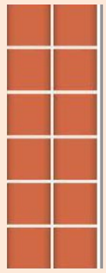
Table 3.3: Exposure zones

Zone 1 Protected	All inland areas more than 30 km from the coastline.
Zone 2 Moderate	The 30 km zone along the coast, but excluding the sea spray zone.
Zone 3 Severe	The sea spray zone such as the seaward sides of Durban Bluff and other exposed coastal headland areas, i.e, the 15km coastal zone from Mtunzini northwards to the Mozambique border, including Richards Bay; and the coastal belt of Namibia.
Zone 4 Very Severe	Areas such as Walvis Bay where moisture from the sea mist and high ground water tables, soluble sulphates in the soil, and/or rapid temperature changes combine to create the most severe exposure and weathering conditions; and industrial areas where high acid or alkaline discharges occur.

Structural units of clay with an initial rate of absorption exceeding 1,8kg/m².min should be moistened prior to laying to reduce the rate to between 0,7 and 1,8kg/m².min.

Fire Resistance

Fire resistance rating is a measure of the length of time a walling element will resist a fully developed fire. Failure occurs in an element when its resistance is overcome in a defined way. Firstly, if it collapses or its structural ability is Impaired, it is said to have failed at the time of collapse. Secondly, a wall can fail if it develops cracks and fissures through which hot gas or flame can pass and, thirdly, an element can fail if the temperature on the side away from the fire exceeds a certain level. Values of fire resistance of typical clay brick walls are given in Figure 3.2.

UNIT	BRICK	CLAY BRICK MAXI	FBA/NFP CLAY BRICK	NFP CLAY BRICK	FBA/NFP CLAY BRICK	FBA/NFP CLAY BRICK	FBA CLAY BRICK	FBA/NFP CLAY BRICK
PLASTER	12mm Cement Plaster both sides	12mm Cement Plaster both sides	None	12mm Cement Plaster both sides	12mm Cement Plaster both sides	12mm Cement/ Plaster inside only	None	12mm Cement Plaster inside only
								
THICKNESS	106	90	106	140	222	222	222	222
ACOUSTIC INSULATION	44db	43db	44db	45db	49db	49db	47db	48db
FIRE RATING* Structural and Non-structural *indicative figures only	30 min 60 min	30 min 60 min	30 min 60 min	30 min 60 min	120 min 240 min	120 min 240 min	120 min 240 min	120 min 240 min

3.2 - Fire resistance and acoustic insulation values for clay brick walls

Acoustic Insulation

Acoustic insulation, measured in decibels (dB), is the ability of a wall to resist the transmission of airborne sound. The measurement is based on a logarithmic scale and is not linear, which implies that halving or doubling of the insulation value would be represented by a 6dB change.

As mass is the best defence against noise penetration, the heavier walling products will generally perform better. Values of acoustic insulation of typical clay brick walls are given in Figure 2.

Thermal Properties

The thermal properties of a wall are related to its ability to transmit or resist the movement of heat and to its capacity to store thermal energy.

Thermal Transmittance

Thermal transmittance, (U-value) is measured in Watts (W) per square metre (m²) per degree Celsius, W/m² ⁰C, as the rate of heat flow through an element, e.g. a wall. The lower the U-value, the better the insulation properties of the wall: it has a greater resistance to the flow of heat.

The U value not only takes into account the resistance offered by the wall, but also the outside and inside surface resistance. Since the U- value notionally provides a measure of the heat flow through a wall, it is the figure used to compare the performance of different constructions and to make energy-use calculations.

Thermal Capacity

Thermal capacity is measured in Joules (J) per square metre (m²) per degree Celsius, J/m² °C, and is a measure of the degree of heat that can be stored by a wall. Clay brick walls with their high thermal capacity have the ability to store heat during the day and release this heat at night. In climatic regions where there are high temperatures during the day and low temperatures at night, this results in thermally comfortable dwellings with a reduction in energy consumption to cool or heat the buildings.

The SANS 10400-XA and the SANS 204 Regulations are an attempt made by government to regulate energy use and encourage energy efficiency in building. Clay brick walls where applicable comply with these requirements.

NOTES

CHAPTER 4

ACCOMMODATION OF MOVEMENT

ACCOMMODATION OF MOVEMENT

Overall Movement

All buildings are subjected to varying degrees of dimensional change after being built. Many factors affect movement, such as the temperature and moisture changes of the surrounding atmosphere, the characteristics of the masonry and mortar, the degree of restraint imposed by foundations, roof trusses and suspended slabs, and the imposed loads on the walls.

In general, it is simpler to adopt empirical rules rather than to try and estimate movement in a building from first principles. SANS 10249: Masonry Walling has a section on movement in masonry.

Thermal Movement

An increase in the temperature of a wall will induce expansion. The degree of movement is equal to the temperature range multiplied by the appropriate coefficient of thermal movements overcoming restraint in the wall itself (see Table 4.1). A decrease in temperature will result in the shortening of the wall that may induce cracks. However, the movement that actually occurs within a wall after construction depends not only on the range of temperatures, but also on the initial temperatures of the units as laid, their moisture content and the degree of restraint. To determine the effective free movement that could occur, therefore, some estimation of the initial temperature and temperature range has to be made. The effective free movement that is calculated should still be modified to allow for the effects of restraints.

Table 4.1 : Linear thermal movement of masonry units and mortar

LINEAR THERMAL MOVEMENT OF MASONRY UNITS AND MOTAR		
Material	Coefficient of linear thermal movement C x 10^{-6}	Movement per 10m of wall for 50ºC temperature change (mm)
Burnt masonry units (see note 1)	4 - 8	2 - 4
Concrete masonry units (see note 2)	7 - 14	3,5 - 7
Mortars	11 - 13	5,5 – 6,5
Note: 1.Thermal movement of burnt clay masonry units depends on the clay mixture and its firing 2.Thermal movement of concrete masonry units depends on type of aggregate and mix of proportions		

Irreversible Moisture Expansion Movement

The continuing expansion of bricks justifies earlier recommendations to avoid problems in buildings. Building problems caused by the expansion of bricks can be avoided by using a lean mortar mix that can accommodate at least some of the expansion, avoiding designs such as short offsets in long runs of brickwork and by incorporating adequate movement joints.

SANS 10249 refers to an accepted categorization of clay masonry units according to average moisture expansion for the 96 h standard steam test, i.e. category I is < 0,05 %, Category II is 0,5 to 0,10 % and category III being 0,10 to 0,20 %.

Moisture Content Movement

Burnt clay units exhibit little movement with changes in moisture content. Movement is normally not more than 1mm in every 10m of length and rarely more than 2mm in every 10m of length. This movement is reversible.

Movement in Adjoining Structures

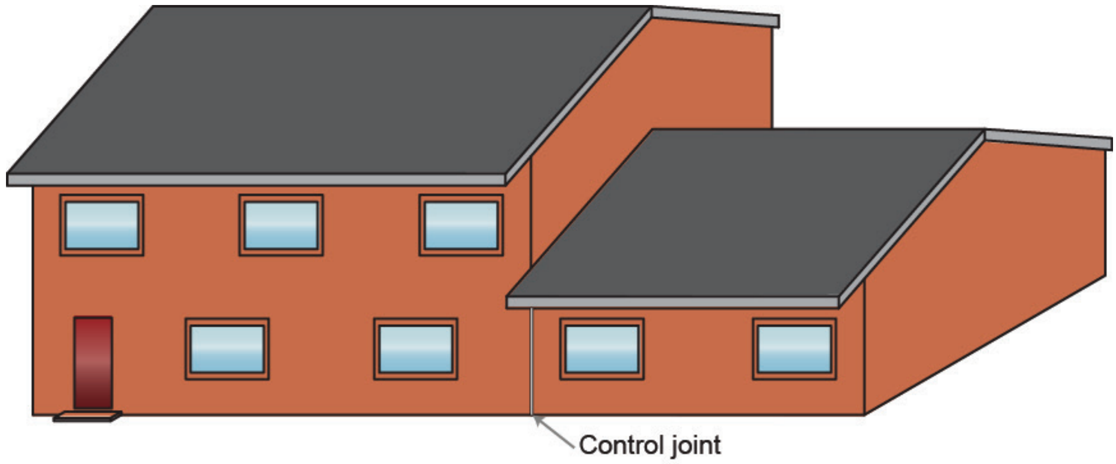
Structural movement in adjoining concrete or steel structures can cause distress. Distress can occur in either supported or enclosed brickwork, and call arise from elastic and creep deformation and deflection under stress, and from shrinkage in the case of reinforced concrete components.

Problems can arise when elements supporting masonry walls, such as foundations and suspended concrete floor and roof slabs, deflect and impose unanticipated stresses on the brickwork. Infill brickwork panels in reinforced concrete framed buildings can be stressed because of the shortening of the concrete columns due to elastic and creep stresses and shrinkage of the concrete (normal 1,2 to 1,5mm/m for shortening of columns). Thus, the top of infill panels must be separated from the structural member above by a gap of between 5 and 12mm.

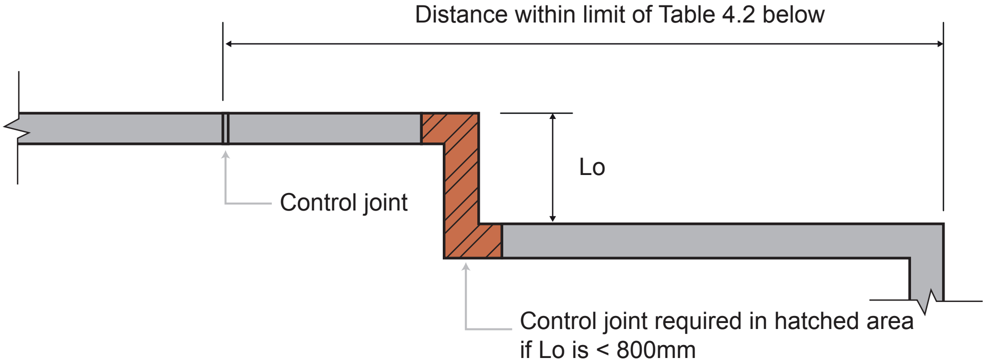
Provision of Control Joints

Movement in masonry can be accommodated by designing the masonry so that it is separated into discrete panels through the provision of control (movement) joints that reduce stress build-up. The design and positioning of control joints should accommodate movements but should not impair the stability of the wall or any of its functions such as impermeabilty, sound insulation and fire-resistance.

Figures 4.1, 4.2 and 4.3 show the position of control joints in buildings and free-standing walls.



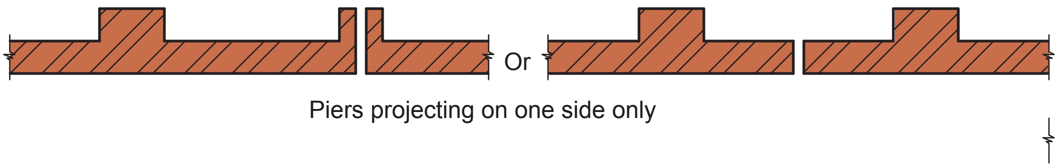
4.1 - Location of control joints in buildings



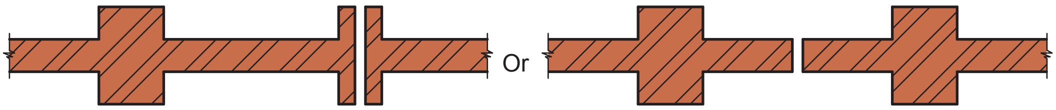
4.2 - Position of control joints at set backs

Table 4.2: Maximum Vertical Control Joint Spacing in Walls

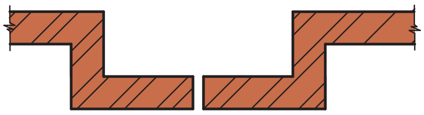
MAXIMUM VERTICAL CONTROL JOINT SPACING IN WALLS			
Unit type	Moisture expansion (%)	Appropriate spacing of vertical joints 10-12mm wide	
		Free standing wall (m)	Housing units (m)
Unreinforced			
Burnt clay	<0,05	16	18
	0,05 - 1,0	10	14
	0,10- 0,20	6	10
Masonry with bed joint reinforcement			
Burnt clay	<0,05	16	18
	0,05 - 1,0	12	16
	0,10- 0,20	8	12



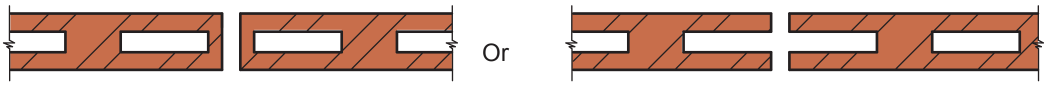
Piers projecting on one side only



Piers projecting on both side



Z-shaped



Diaphragm

4.3 - Location of control joints in free-standing walls

Table 4.3 - Free-standing walls (solid units)

FREE STANDING WALLS (SOLID UNITS)			
Nominal wall thickness (T) mm	Maximum height (H) m	Nominal dimensions of piers (overall depth x width) mm	Maximum pier spacing (centre - centre) m
No Piers			
90	0,8		
110	1,0		
140	1,3		
Z-shaped			
90	1,8	390 x 90	1,2
90	2,0	490 x 90	1,4
110	1,6	330 x 110	1,5
110	2,1	440 x 110	1,5
140	2,2	440 x 140	2,0
140	2,5	590 x 140	2,5
Piers projecting on side			
90	1,4	290 x 290	1,4
90	1,5	390 x 290	1,6
90	1,7	490 x 290	1,6
110	1,5	330 x 330	1,8
110	1,5	440 x 330	1,8
110	1,9	550 x 330	2,0
140	1,7	440 x 440	2,2
140	1,8	590 x 390	2,5

Table 4.3 (continued) - Free-standing walls (solid units)

FREE STANDING WALLS (SOLID UNITS)			
Nominal wall thickness (T) mm	Maximum height (H) m	Nominal dimensions of piers (overall depth x width) mm	Maximum pier spacing (centre - centre) m
Piers projecting on side			
90	1,5	490 x 290	1,4
110	1,6	550 x 330	1,8
140	1,6	440 x 440	2,2
Diaphragm walls			
90		290 x 190	1,4
90		390 x 190	1,4
110		330 x 220	1,6

Note:
1. No earth to be retained by walls
2. Piers to extend to top of wall without any reduction in size
3. Walls to terminate in a pier or a return

NOTES

CHAPTER 4

NOTES

CHAPTER 5

STRUCTURAL MASONRY WITH CLAY BRICK

STRUCTURAL MASONRY WITH CLAY BRICK

Background

The National Building Regulations are generally functional in nature, i.e. they do not prescribe how a building should be constructed, but rather stipulate the qualitative performance requirements that the building design or construction of the building must satisfy. To facilitate the use and application of the National Building Regulations the functional regulations are supported by a set of deemed-to-satisfy rules which are published in SANS 10400, The Application of the National Building Regulations – Part K: Walls. The deemed-to-satisfy provisions describe design and construction methods, materials and solutions, which if applied, will ensure that the building so designed and constructed will satisfy the functional requirements of the regulations.

SANS 10400-Part K: Walls provides deemed-to-satisfy or empirical rules to satisfy the National Building Regulations. Any masonry structure of a wall of such structure that falls outside the scope of SANS 10400-K is subject to a rational design to provide structural integrity, stability and serviceability; this is carried out using South African National Standards, such as the loading and structural masonry standards, i.e. SANS 10160 and 10164, Parts 1 and 2 respectively (soon to be superseded by Eurocode 6).

In addition to the aforementioned there are also technical requirements published by the National Home Builders Registration Council (NHBRC) in terms of the Housing Consumer Protection Measures Act.

The Clay Masonry Manual summarizes key aspects of the deemed-to-satisfy rules in SANS 10400-Part K with the understanding that these documents shall be consulted.

Empirical Design of masonry walls (SANS 10400-K)

Introduction

SANS 10400-K is a comprehensive standard that inter alia outlines aspect of permissible wall panel sizes for single and double storey dwellings and framed buildings, foundation and freestanding walls (boundary, retaining, balustrade and parapet), define and detail lateral support to walls, detail control, movement and articulation joints and various fixing details, arches, anchoring details of roofs and provide information on lintels. Salient features of SANS 10400-K will be summarized to illustrate the use of the deem-to-satisfy rules.

Although reference has been made to “brick” in earlier chapters it is important to note that SANS 10400-K does not refer to a brick or a block but to solid or hollow masonry units. Except for the section on control joints no reference is made to the type of masonry material, i.e. clay or concrete.

Building Limitations (Clause 4.2.1)

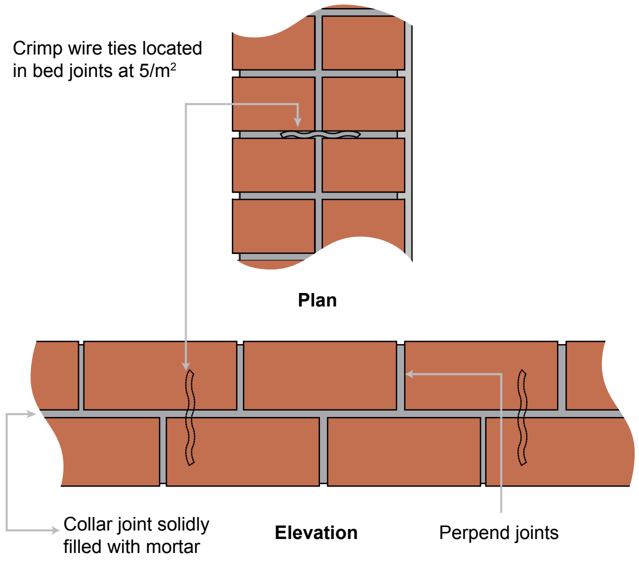
The provisions hereafter apply only to masonry walls in dwelling units, dwelling houses, educational buildings, hospitals, hotels and other institutional occupancies and general offices where the imposed floor load does not exceed 3,0 kN/m^2 that are not exposed to severe wind loadings arising from crests of steep hills, ridges and escarpments, in:

a) single storey buildings or the upper storey of double storey buildings where:

- the foundations for masonry walls satisfy the requirements of SANS 10400-H: Application of the National Building Regulations – Part H: Foundations and the supporting members satisfy the requirements of SANS 10400-B: Structural Design;
- the span of roof trusses or rafters (or both) between supporting walls does not exceed:
  - 6,0 m in respect of a single leaf wall with a thickness less than 110 mm;
  - 8,0 m in respect of 140 mm, or greater, single leaf walls and all cavity and collar jointed walls. A collar jointed wall comprises parallel single leaf walls with the space between them not exceeding 25 mm, filled solidly with mortar and tied together with wall ties know as crimp ties (see figure 6)
- the nominal height of masonry above the top of openings is not less than 0,4 m;
- the average compressive strength of hollow and solid masonry units is not less than 3,0 MPa and 4,0 MPa, respectively;
- Class II mortar satisfying the requirements of SANS 2001-CM1, Construction standards – Part: CM1: Masonry walling, is used;
- the mass of the roof covering in roofs other than concrete slabs does not exceed 80 kg/m^2;
- the span of the concrete roof slabs between supporting walls does not exceed 6,0 m;
- concrete roof slabs are not thicker than 255 mm if of solid construction, or the equivalent mass if of voided construction;
- foundation walls are not thinner than the walls which they support; and
- the height of foundation walls does not exceed 1,5 m,

b) the lower storey in a double storey building where the requirements listed in a) are still relevant but the average compressive strength of the hollow and solid masonry units are not less than 7,0 MPa and 10 MPa respectively; the following requirements are also applicable:

- the height measured from the ground floor to the top of an external gable does not exceed 8,0 m;
- the storey height measured from floor to wall plate level or to the underside of the first floor does not exceed 3,0 m;
- the walls supporting floor elements are of cavity construction or have a nominal thickness of not less than 140 mm.



5.1 - Collar-jointed walls

c) infill panels in concrete and steel framed buildings of four storeys or less where:

- the average compressive strength of hollow and solid masonry units is not less than 3,0 MPa and 5,0 MPa respectively;
- Class II mortar (as previously) is used;
- the walls are either of a cavity construction or have a nominal thickness of not less than 140 mm; and
- the nominal height of masonry above openings is not less than 0,4 m; and the storey height measured from floor to soffit of the floor above does not exceed 3,3m.

d) freestanding, retaining, parapet and balustrade walls where:

- the average compressive strength of hollow and solid masonry units is not less than 3,0 MPa and 5,0 MPa respectively; and
- Class II mortar is used.

Limitations of masonry walling in single and double storey buildings (Clause 4.2.2)

Masonry wall panels in single and double storey buildings shall have dimensions not longer than that derived from Figure 4 in SANS 10400-K, reproduced here as Figure 5.3. Six tables summarizes the maximum lengths of openings and the minimum distances between the face of supports and openings and between successive openings in accordance with the provisions of detailed figures.

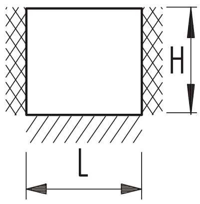
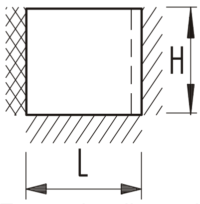
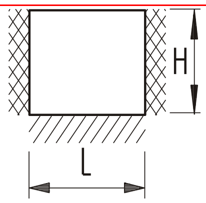
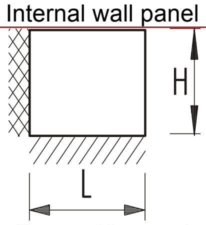
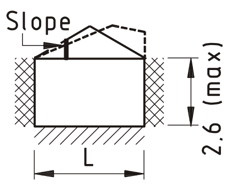
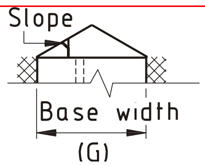
Summary of limitations

Figure 5.2 gives a summary of the detailed wall panel configurations with various support conditions as reproduced in Figure 5.3. 220 collar jointed and 110 single leaf wall types horizontally supported and with vertical supports (excluding vertical butt joints) shall have wall panel sizes as indicated in Figure 5.2; Figure 5.3 below in conjunction with SANS 10400-K shall be consulted for other wall configurations with nominal wall thicknesses and other types of support conditions. Panels incorporating full height doors shall be treated as being supported on the one side only.

Support conditions	Description	Summary
  	Horizontal support Vertical support (cross wall or return) Vertical tied butt control joint providing lateral stability	• External wall panel: A 220 collar jointed wall supported on both sides made up of solid units can be built to a maximum length (L) and height (H) of 9,0m and 4,6m respectively with openings in excess of 15 % • Internal wall panel: A 110 single leaf wall supported on both sides made up of solid units can be built to maximum length (L) and height (H) of 5,5m and 3,6m respectively with or without openings. • A 220 collar jointed external gable wall with a symmetrical 26º slope supported on both sides can have a maximum base width (G) of 80 m • The maximum dimension for a 220 collar jointed internal and external wall panels supported on one side only (or with a door on the one side) can be built to maximum length (L) and height (H) of 3,1m and 3,6m respectively

5.2 - Summary of wall panel sizes in single and double storey buildings

SANS 10400-K limitations

Wall configuration	Table	Commentary
 External wall panel	Table 1 in SANS 10400-K is reproduced as Table 6 hereafter. Maximum dimensions for external unreinforced wall panels supported on both sides are given.	Applicable to panels which don't incorporate gable ends. Wall panel sizes are sensitive to panel openings. Two categories of opening are provided for: - less than 15 % of wall area - greater than 15 % of wall area *Figure 5.2 refers: A 220 collar jointed wall panel made up of solid units can be built to a maximum length (L) and height (H) of 9,0m and 4,6m respectively with openings in excess of 15 %*
 External wall panel	Table 2 in SANS 10400-K dimensions for external unreinforced wall panels supported on both sides incorporating a tied control/articulation joint. Refer to SANS 10400-K	Applicable to panels which don't incorporate gable ends. Wall panel sizes arehttp://www.hikethelycian.com/ sensitive to panel openings. Two categories of opening are provided for: - less than 15 % of wall area - greater than 15 % of wall area *Figure 5.2 refers: A 220 collar jointed wall panel made up of solid units with openings in excess of 15 % units can be built to L = 8,5m and H = 4,6m*
 Internal wall panel	Table 3 in SANS 10400-K gives the maximum dimensions for internal unreinforced wall panels supported on both sides with or without openings. Refer to SANS 10400-K	Wall panel size is not governed by openings. *A 110 single leaf wall panel made up of solid units can be built to L = 5,5m and H = 3,6m*
 External/Internal panel supported	Table 4 in SANS 10400-K gives the maximum dimensions for internal and external unreinforced wall panels supported on one side only. Refer to SANS 10400-K	Panels which incorporate full height doors are treated as walls supported on one side only with openings. Wall panel is sensitive to openings (no size of opening is specified). *A 110 single leaf wall panel made up of solid units can be built to L = 5,5m and H = 3,6m*
	Table 5 in SANS 10400-K gives the maximum length of external unreinforced wall panel 2,6 m (max.) high supporting a freestanding (isosoles) gable triangle or portion thereof. Refer to SANS 10400-K	Applicable to panels which incorporate gable ends or portion thereof which have a panel height not exceeding 2,6m. Wall panel is sensitive to panel openings. Triangular portion of gable above eaves level needs to comply with the provisions of table 6 in SANS 10400-K. Internal walls with gables (fire walls) are to be designed in accordance with the provisions of table 1 (no openings). *The maximum L of a 110 and 220 thick wall panel made up of solid units supporting a gable wall with a 26º slope is limited to 3,5 & 8,0 m respectively*
	Table 6 in SANS 10400-K gives the maximum base width (G) of external triangular unreinforced gable end. Refer to SANS 10400-K	The base width (G) must be reduced by the length of any openings within the gable. *The maximum G of a 110 and 220 thick gable wall made up of solid units supporting a 26º slope is limited to 5,5 & 8,0 m respectively*

5.3 - Table selection chart for the determination of wall panel sizes in single and double storey buildings

Table 5.1 - Maximum dimensions for external masonry wall panels supported on both sides

1	2	3				4				5			
Nominal wall thickness mm	***Wall type***	**Panel A no openings**				**Panel B openings ≤ 15 % wall area**				***Panel C* openings > 15 % wall area**			
		L m	**H** m	**L** m	**H** m	**L** m	**H** m	**L** m	**H** m	**L** m	**H** m	**L** m	**H** m
Solid units													
90	single leaf	3,2	2,4	2,8	3,4	2,7	2,4	2,5	3,4	2,7	2,4	2,3	3,4
90-90	cavity	5,5	2,7	5,5	3,9	5,5	2,7	5,0	3,9	5,5	2,4	4,5	3,9
110	single leaf	4,5	2,7	4,0	3,6	4,0	2,7	3,5	3,6	3,5	2,7	3,0	3,6
110-110	cavity	7,0	3,3	6,0	4,4	7,0	2,4	5,5	4,4	6,5	2,4	5,0	4,4
140	single leaf	7,0	3,3	6,0	4,3	6,5	2,4	5,2	4,3	6,0	2,7	5,0	4,3
190	collar jointed	8,0	4,6	8,0	4,6	8,0	4,6	8,0	4,6	8,0	4,0	7,5	4,6
220	collar jointed	9,0	4,6	9,0	4,6	9,0	4,6	9,0	4,6	9,0	4,6	9,0	4,6
Hollow units													
90	single leaf	2,8	2,4	2,5	3,4	-	-	-	-	-	-	-	-
90-90	cavity	5,0	2,7	4,5	3,9	4,5	2,4	4,0	3,9	4,0	2,7	3,5	3,9
110	single leaf	3,5	2,4	3,3	3,6	3,0	2,4	2,8	3,6	3,0	2,4	2,8	3,6
110-110	cavity	6,0	2,4	5,0	4,2	5,0	2,4	4,2	4,2	4,5	2,7	4,2	4,2
140	single leaf	5,5	2,4	4,5	4,2	4,5	2,7	4,0	4,2	4,2	2,4	3,7	4,2
190	single leaf	7,5	2,7	6,0	4,4	6,5	2,4	5,0	4,6	6,0	2,7	4,8	4,4

Note:

1. Two alternative panel sizes (L x H) are provided in respect of each panel type; the left hand column for each panel type provides dimensions for the maximum length (L) and the right hand column the corresponding maximum height dimension (H). Linear interpolation is permitted between these two sets of panel dimensions but not between wall types.
2. The values tabulated in respect of solid units may be used for corresponding walls of hollow unit construction provided that the following reinforcement is provided:
   a) Truss type brickforce having main wires of not less than 3,55 mm diameter built into courses at vertical centres not exceeding 400 mm; and
   b) Either two 5,6 mm diameter rods in 90 mm and 110 mm single leaf and cavity walls in the bed joint immediately above window level, or a single Y8 bar in a bond block in 140 mm and 190 mm single leaf walls at this same level, such reinforcements extending across the entire length of the panel and into the supports.
3. Where collar joints in collar jointed walls are not fully mortared, such walls shall be treated as cavity walls.
4. Panels incorporating full height doors or doors with fanlights are to be treated as panels supported on one side only.

Limitations of infill masonry panels in framed buildings (Clause 4.2.3)

Infill masonry wall panels in framed buildings of four storeys and less are sized in a similar manner as those in the previous section and shall have dimensions not longer than those contained in Table 3 or Figure 10 of SANS 10400-K or derived from Tables 9 to 15 in the Standard. Panel sizes are subject to the maximum lengths of openings and the minimum distances between the face of supports and openings and between successive openings. Vertical supports, which are provided by means of intersecting masonry walls are similar as before (See Figure 5.2), whilst infill masonry wall panels shall be connected to reinforced concrete columns and slab soffits. All joints shall be filled with elasto-plastic sealants to accommodate movement.

Summary of limitations

Figure 5.5 gives a summary of the order of magnitude of wall panel configurations with various support conditions; panels incorporating full height doors shall be treated as being supported on the one side only. Jointed and 110 single leaf wall types horizontally supported and with vertical supports (excluding vertical butt joints) shall have wall panel sizes as indicated in Figure 5.2; Figure 5.3 below in conjunction with SANS 10400-K shall be consulted for other nominal wall thicknesses and other types of support conditions.

Summary

- A 220 collar jointed external wall panel wall supported on both sides made up of solid units can be built to a maximum length (L) and height (H) of 9,0m and 3,3m respectively with openings in excess of 15 %
- As the support conditions become less effective, i.e. if provided with a tied joint on one side the same wall becomes smaller, i.e. and can be built to a maximum length (L) and height (H) of 9,0m (or 8,0m) and 2,4m (or 3,3) respectively
- If provided with a tied joint on both sides the same wall becomes even smaller, i.e. and can be built to a maximum length (L) and height (H) of 7,0m (or 5,5m) and 2,4m (or 3,3) respectively
- If provided with a tied joint on both sides the same wall becomes even smaller, i.e. and can be built to a maximum length (L) and height (H) of 7,0m (or 5,5m) and 2,4m (or 3,3) respectively

5.5 - Summary of wall panel sizes in framed buildings

5.2.5.1 Free-standing boundary and garden walls (Clause 4.2.4.2)

Where any free-standing wall is a masonry wall the thickness and pier size of such a wall shall conform to the relevant values given in Table 5.2; such walls retain no earth, have piers extending to the top of the wall without any reduction in size, terminate in a pier or a return a have solidly filled cores in all piers where units are hollow. No horizontal damp proof course shall be provided in free-standing boundary and garden walls.

Table 5.2 - Free-standing walls (solid units)

1	2	3	4
Nominal wall thickness (T) mm	**Maximum height (H) m**	**Nominal dimensions of piers (overall depth x width (D X W) mm**	**Maximum pier spacing (centre to centre; S) m**
No piers			
90	0,8	-	-
110	1,0	-	-
140	1,3	-	-
190	1,5	-	-
220	1,8	-	-
290	2,2	-	-
Z shaped			
90	1,8	390x90	1,2
90	2,0	490x90	1,4
110	1,6	330x110	1,5
110	2,1	440x110	1,5
140	2,2	440x140	2,0
140	2,5	590x140	2,5
190	2,1	390x190	2,5
190	2,5	490x190	3,0
220	2,4	440x220	3,0
220	2,8	550x220	4,0
Piers projecting on one side			
90	1,4	290x290	1,4
90	1,5	390x290	1,6
90	1,7	490x290	1,6
110	1,5	330x330	1,8
110	1,5	440x330	1,8
110	1,9	550x330	2,0
140	1,7	440x440	2,2
140	1,8	590x390	2,5
190	2,0	590x390	2,8
220	2,3	660x440	3,2
Piers projecting on both sides			
90	1,5	490x290	1,4
110	1,6	550x330	1,8
140	1,6	440x440	2,2
190	1,8	590x390	2,8
220	2,1	660x440	3,2
Diaphragm walls			
90	2,1	290x190	1,4
90	2,7	390x190	1,4
110	2,6	330x220	1,6

NOTE:
D = total depth of pier plus wall thickness; W = width of pier; S = centreline spacing of piers.

CHAPTER 5

Free-standing parapet and balustrade walls (Clause 4.2.5)

Free-standing balustrade and parapet walls of solid units shall have a thickness of not less than the height of the wall above the base divided by 5 or 4,5 if no dpc is present and if dpc is present at the base respectively.

Balustrades and parapet walls made up of solid units that have returns which continue for a distance of at least 0,75 metres from the external face of such walls or are fixed to columns at centres not exceeding 3,5 metres, shall have a thickness of not less than 110.

Free-standing retaining walls (Clause 4.2.4.1)

Free-standing retaining walls shall be designed and constructed so that:

a) the height of fill retained by free-standing retaining walls does not exceed the values given in Table 5.5;
b) piers, where required in terms of Table 5.5, project on the opposite side of the wall to the fill that is being retained;
c) control joints are located at intervals not exceeding 10m;
d) no surcharge of fill is placed within a distance equal to the height of the amount of fill being retained; and
e) sub-soil drainage is provided behind the wall by providing weepholes formed by building into the wall, 50 mm diameter plastic pipes, with the non-exposed end covered with geofabric, at a height not exceeding 300 mm above the lower ground level, at centres not exceeding 1,5 metres.
f) No horizontal damp proof course shall be provided.

Table 5.3 - Retaining walls (solid units)

1	2	3	4	5
Nominal wall thickness (T) mm	**Wall Types**	**Maximum height retained (h) without piers m**	**Nominal pier dimension (D) mm**	**Maximum pier spacing m**
Solid units				
140	Single leaf	1,3	600 x 300	1,8
190	Collar jointed	1,3	600 x 300	2,5
190	Collar jointed	1,6	800 x 400	2,6
220	Collar jointed	1,7	660 x 330	3,0
220	Collar jointed	1,8	880 x 440	3,1
290	Collar jointed	1,0	-	-
330	Collar jointed	1,2	-	-

Foundation walls (Clause 4.2.2.6)

Foundation walls shall not exceed 1,5 m in height and be of a thickness not less than the wall it supports. The cores in hollow units and cavities in cavity walls shall be filled with grade 10; infill concrete. The height of fill retained behind a masonry foundation wall shall not exceed the values given in Table 5.6; the height being the difference in ground level between the soffit of the surface bed and the external ground level

1	2	3
Nominal wall thickness mm	**Wall type**	**Maximum difference in ground levels - mm**
90 and 110	single leaf	200
140	single leaf	400
190	single leaf / collar jointed	600
220	collar jointed	700
90-90	cavity	700
110-110	cavity	1000
290	collar jointed	1000
330	collar jointed	1200

Empirical Rules for Foundations (SANS 10400-H)

Empiricla rules apply to buildings not exceeding two storeys in height and with loadings not exceeding those detailed in building limitations for empirical design, except in cases where the founding material consists of a problem soil, i.e. heavy soil or shrinkable clay or a soil with collapsible fabric.

These rules include that:

- Walls are to be placed centrally on foundations.
- Concrete should have a compressive strength of at least 10MPa.
- Any continuous strip foundation shall have a thickness of not less than 200mm.
- The minimum width any continuous strip foundation shall not be less than 600mm for a wall supporting a roof covered with concrete tiles, clay tiles or thatch; 400mm for a wall supporting a roof covered with metal or fibre-cement sheets or metal roof tiles.

SABS 0161: The design of foundations for buildings contains recommendations with regard to site investigations and inspections, materials, design considerations, earthworks and excavations, and foundation types.

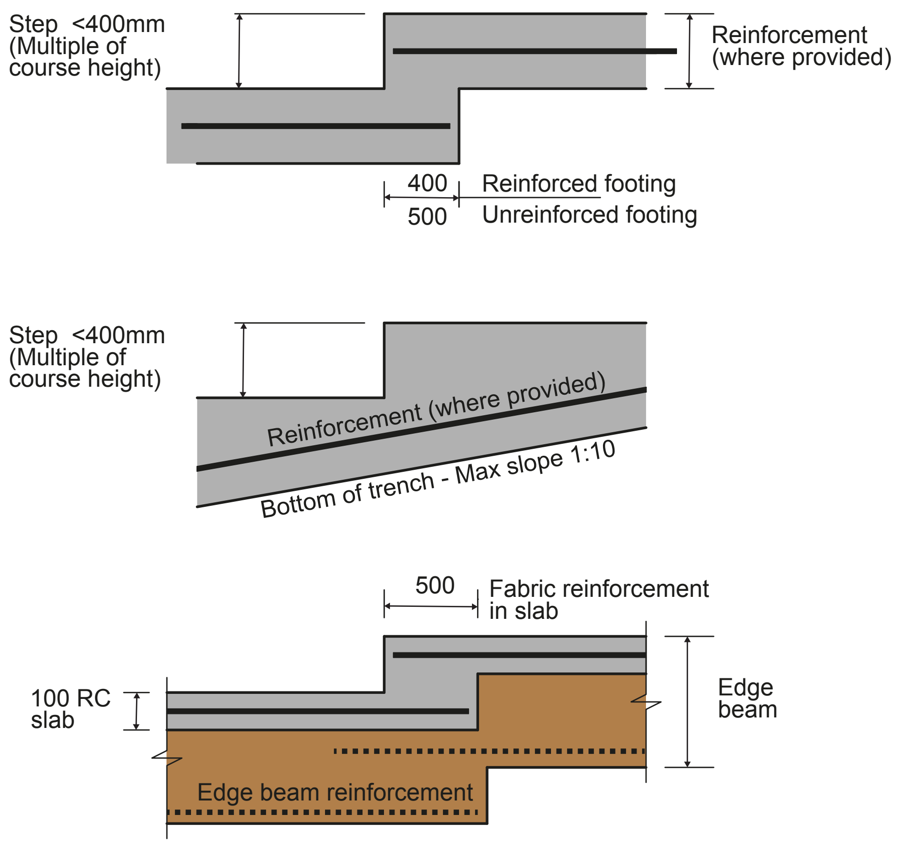
Foundation Preparation

- Top soil containing grass roots must be removed from the area where unreinforced or reinforced slabs are to rest. Loose or disturbed ground must be compacted.
- The accuracy of the setting out shall be achieved through positive control measures: their relative location to site boundaries and adjacent structures shall be verified. Regular checks on the trench widths trench lengths and the length of diagonals across external corners must be carried out.
- On sloping ground, foundation trenches for strip footings may be stepped so that the required foundation depth is attained as shown in Figure 5.3.
- Sites of receive 'slab-on-the-ground foundations' shall be levelled. All necessary filling shall comply with the requirements of compaction provided below. The bases of edge beams shall be sloped not more than 1:10. Steps in slabs in excess of 400mm shall only be permissible if approved by a competent person.
- Steps in foundations shall not be provided within 1,0m from corners.
- Excavations shall be deepened locally to remove soft spots where necessary. Hard spots shall be removed wherever practicable. Where soft spots / isolated boulders do not exceed 1 500mm in diameter, unreinforced strips foundations may be centrally reinforced with two No Y12 bars externally a distance of not less than 1 500mm beyond the face of such soft spots as shown in Figure 5.2.
- Excavations should be prodded with a 10-12mm diameter bar prior to the casting of concrete. Uniform penetration should be obtained. Where this is not the case the soft spots (where penetration is greater than in the surrounding areas), should be dealt with as shown in Figure 5.2.

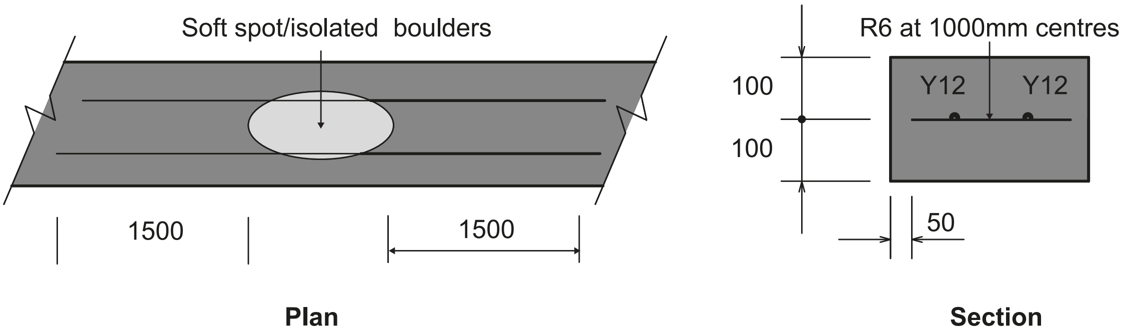
Excessive foundation excavations shall be avoided.

Any fill upon which edge beams of 'slab-on-the-ground' foundations and strip footings are to be founded, shall be placed under the supervision of a competent person or shall be deepened to be founded on in situ material. The controlled fill shall continue past the edge of the foundation and at least 1 000mm shall be retained or battered beyond this point by a slope not steeper than 1 : 2 (vertical : horizontal).

- Trenches shall be kept free of surface water.
- Where the bottom part of foundations has dried out excessively due to exposure or has softened due to rain or ground water, the excavation shall be re-bottomed prior to concreting.



5.6 - Methods for stepping strip footings and slab-on-the-ground foundations



5.7 - Reinforcement in strip footings at soft spots/isolated boulders

Minimum width of Strip Foundations in Single Storey Structures – SABS 0161: Part 4, Section 2, Table 2

Table 5.5: Minimum width of strip foundations

Founding Material Type	Tile / Sheeted Roof		Reinforced Concrete Roof	
	Internal Wall (mm)	External Wall (mm)	Internal Wall (mm)	External Wall (mm)
Rock	400	400	400	400
Soil	400	500	600	750

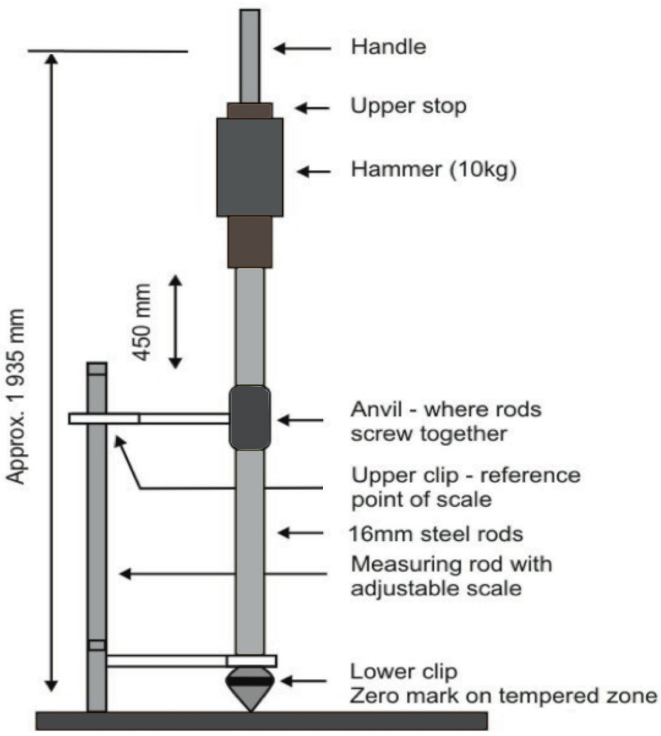
NOTE:

Internal walls upon which reinforced concrete roofs do not bear may have a foundation width of 400mm

Compaction

The maximum height of fill beneath floor slabs and 'slab-on-the-ground' foundations, measured at the lowest point shall not exceed 400mm unless certified by a competent person. Fill shall be moistened prior to compaction so that a handful squeezed in the hand is firm but does not show signs of moisture. Fill shall be placed in un-compacted layers not exceeding 100mm in respect of hand compaction or 150mm in respect of compaction by mechanical means.

Each un-compacted layer shall be well compacted before additional fill material is added. Compaction in excess of 3 blows of a dynamic cone penetrometer (See figure 10) is required to penetrate 100mm of the fill provided that fills do not comprise more than 10% gravel of size less than 10mm and contain no isolated boulders.



5.8 - Dynamic cone penetrometer

CHAPTER 5

Minimum thickness of foundation walls (SABS 0400 Table 4 – Part KK9)

- The height of any foundation wall not acting as a retaining wall shall not exceed 1,5m.
- Where a difference in ground level, including backfill exists between the two foundation walls such difference shall not exceed 1,0m.
- No foundation wall shall have a thickness less than the relevant value given in Table 5.3; provided that such thickness shall not be less than:
  - The thickness of the wall carried by such foundation wall; or
  - If it is the wall carried by the foundation wall, the sum of the thicknesses of the leaves of such a cavity wall.

Table 5.6 - Minimum thickness of foundation walls

Type of foundation wall	Acting as a retaining wall			Not acting as a retaining wall			
	Difference in ground level (mm)			Height (mm)			
	Less than 500	500 to 750	750 to 1000	Less than 300	300 to 500	500 to 1000	1000 to 1500
Single Leaf Brick							
External	140	190	230	140	140	140	190
Internal	-	190	230	90	140	140	190
Single Leaf hollow block (cavities filled with concrete)							
External	140	190	230	140	140	140	190
Internal	140	190	230	90	140	140	190
Cavity Wall							
External (cavity filled to 150mm below damp-proof course level)	190	190	230	190	190	190	190

Rain Penetration Requirements (SABS 10400:Part K:Section 4.5:Annexure C)

The resistance of external walls to rain penetration shall be in accordance with Table 5.7 when tested in accordance with the requirements of Annexure C, SANS 10400: Part K.

Category 1 Building

Building which:
a) Is designated as of class A3, A4, F2, G1, H2, H3 or H4 occupancy (See regulation A20 in SANS 10400-A),
b) Has no basements,
c) Has a maximum length of 6,0m between intersecting walls or members providing lateral support, and
d) Has a floor area that does not exceed 80m^2

Table 5.7 – Rain penetration acceptance criteria

Building Category	Acceptance criteria when tested in accordance with the requirements of Annexure C
Category 1	Moisture which penetrates the wall of insufficient intensity to run down the wall onto the floor of the house.
Other than category 1	No damp patches are visible on the inside of the wall.

Stainless steel (Grade 816) ties shall be used in the following areas:

- Sea spray zones; and
- Tidal and splash zones.

Coastal areas are situated between the coastline and an imaginary line 30km inland, parallel with the coastline, or the top of the escarpment or watershed of the first mountain range inland, if these are less than 30km 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.

Mortar

Four types of building mortar are detailed in SABS specifications (SABS 0164-1 and SABS 0249):

- Common cement: sand
- Common cement: lime; sand
- Common cement: sand plus mortar plasticiser
- Masonry cement: sand.

Table 5.8 - Proportions of mortar

Mortar class	Common Cement (kg)	Lime (Litres)	Sand (measured loose and damp) (Litres Max.)	Masonry Cement; Sand or Common Cement, Sand with Mortar, Plasticiser	
				kg	Litres Max
I	50	0-10	130	50	100
II	50	0-40	200	50	170
III	50	0-80	300	50	200

Mix Proportions

The approximate limiting proportions of these mortars are detailed in Table 5.8.

Class II mortar is the general purpose mortar for all brickwork. Concrete wheelbarrows have 65 litres and a sand volume of 200 litres is achieved by using three wheelbarrows of sand. The addition of lime is optional. A maximum of 40 litres is permitted per 50 kg unit of common cement.

A competent person is required to design mixes for mortars that use materials or mix proportions other than those described above.

Cement

Cements for use in mortar shall be common cements complying with SABS E 197-1, and masonry cements complying with SABS ENV 413-1.

Cement Designation	Strength Glade
CEM I	42,5N
CEM II A-L	32,5N or higher
CEM II A-M	42,5N
CEM II A-S	32,5N or higher
CEM II A-V	32,5N or higher
CEM II B-S	32,5N or higher
CEM II BV	32,5N or higher
CEM III	32,5N or higher

Lime

The use of Lime in mortar mixes is optional. Lime imparts the properties of plasticity and water retention to mortar. The latter property is important as it prevents mortar drying out, resulting in the incomplete hydration of the common cement.

Lime used in mortar is hydrated lime (commercial bedding lime) and not quicklime or agricultural lime. Lime gives the best results when used with coarse sands. Lime with clayey sands can make tile mortar over-cohesive and difficult to use. Lime should not be used with masonry cement.

Sand

Sand for mortar should comply with SABS 1090 and must be well graded from 5mm downwards in accordance with Table 5.8

In the assessment of mortar sands grading is only one factor to be considered, with shape, surface area character of fines and average particle size of the sand also being important. A simple practical field test that includes these factors is the cement and concrete institute test.

Provided that the choice of sand yields a smooth, plastic and cohesive mix, its quality, based on "water demand" can be determined by the following test. Quantities used should be weighed on a kitchen scale that is accurate, and tile test should be carried out on a smooth impervious surface. It is also important that the sample used is fairly representative of the bulk supply.

Size of square apertures (mm)	Percentage by mass passing	
	Fine aggregate Plaster	Fine aggregate Mortar
4,750	100	100
2,360	90-100	90-100
1,180	70-100	70-100
0,600	40-90	40-100
0,300	5,65	5,85
0,150	0-20	0-35
0,075	0-7,5	0-12,5

Procedure:

- Dry out a wheelbarrow full of sand to be tested.
- Weigh 5kg cement and 25kg of dry sand.
- Measure 5 litres, 1 litre and 1,5 litres water into separate containers.
- Mix the cement and sand until the colour is uniform.
- In succession, mix in each of the volumes of water (5 litres, 1 litre and 1,5 litres) until the mix reaches a consistency suitable for plastering.

Then:

- If 5 litres is enough -the sand is of "good" quality
- If 5 litres + 1 litre is enough -the sand is of "average" quality
- If 5 litres + 1 litre + 1,5 litres is enough -the sand is "poor"
- If more than 7.5 litres is needed -the sand is "very poor"'
- A "good " or "average" sand should be used for mortar in walling below the damp-proof course".

Mortar Plasticisers

Mortar plasticisers exercise a desirable effect on the workability and plasticity of the mortar in which they are used. Generally, the admixtures have no effect on setting time (they do not accelerate or retard the mortar setting) but may cause air-entrainment.

The use of mortar plasticisers is optional. Their effectiveness varies with the quality of sand, the composition of the cement, its fineness, the water-cement ratio, temperature of the mortar, volume of plasticiser and other factors, such as site conditions.

Pigments

Pigments may be used to colour mortar, with the dosage depending on the specific colour required. The recommended limit on mineral oxide content is 7% of common cement content. Pigmented mortar with face brickwork can change the appearance of a building dramatically.

Ready-Mixed Mortar

Ready-mixed mortar with an extended board life has been successfully used over a number of years. Ready-mixed mortar has advantages of convenient need on site as it is delivered at a consistency ready for use. Usually it is delivered in ready-mix trucks or containers. It is stored in containers on site in a "protective manner" that minimises loss due to evaporation and protects the mortar from freezing in cold weather. No other materials or admixtures are added on the site.

The mortar contains a regulator, which is a retarding type admixture that controls the initial hydration period of the cement. This allows the mortar to remain plastic and workable for a period, generally between 24 and 36 hours, but sometimes as long as 72 hours. At any time during this period when the mortar is used, suction by the masonry units will occur and initial set takes place in a normal manner. The early strength that develops is satisfactory for the walls to be constructed at a normal rate and the mortar will retain enough water to ensure long-term strength development.

NOTES

CHAPTER 6

CLEANING OF CLAY BRICKWORK

CLEANING OF CLAY BRICKWORK

Prevention is better than cure: Cover face brickwork during building or renovating operations to prevent mortar and paint stains.

General Precautions

Staining can mar the appearance of brickwork, but incorrect cleaning techniques can cause permanent damage. Consequently, any proposed method of cleaning should be tried out in a small unobtrusive area and left for at least a week to judge the results before the whole job is tackled. The techniques given here are intended for do-it-yourself work in removing relatively small areas of staining. A specialist contractor should be engaged for cleaning large areas of brickwork.

It is preferable to use wooden scrapers and stiff fibre brushes to avoid damaging the bricks but where chemicals are to be used, the brickwork should be thoroughly wetted with clean water to prevent it absorbing the chemicals, and rinsed thoroughly with clean water afterwards. Adjacent features such as metal windows and the area at the foot of the wall should be protected from splashing of the chemicals.

Many of the chemicals recommended are caustic, acidic or poisonous, so care should be taken and protective clothing and goggles should be worn. Volatile solvents should only be used indoors under conditions of good ventilation. It is essential to identify the type of stain or deposit before any cleaning operations are undertaken.

Preparation

Remember to thoroughly wet the brickwork with clean water before applying any chemical, and wash down with clean water afterwards. Bricklaying should be managed carefully to prevent unsightly staining from mortar.

Mortar and Mortar Smear

Where possible, remove larger pieces with a scraper, then wash, down with a dilute solution of a proprietary acid cleaner. The manufacturer's instructions must be strictly followed.

- Wet the brickwork thoroughly with water.
- Remove mortar with a proprietary acid cleaner.
- Remove any residual acid in the brickwork by washing down with water.
- When removing mortar smear from brickwork that has a potential to exhibit vanadium staining, the following final procedure is then recommended:
- Treat the brickwork with a 15 to 20% solution of Potassium Hydroxide to prevent the recurrence of the vanadium stain.

Lime and Lime Bloom

Follow treatment recommended for 'Mortar and Mortar Smear'.

In older brickwork lime staining originating from the reinforced concrete structure can be particularly difficult to remove. It is important to stop the flow of moisture through the structure to overcome the problem.

NOTE

Light coloured face bricks are particularly susceptible to severe staining if too harsh an acid is used -please consult your brick manufacturer or the Clay Brick Association.

Vanadium

Wash down with a 20% solution of Potassium Hydroxide. Do not wash the wall with clean water afterwards (Hydrochloric acid should never be used on vanadium stains since it 'fixes' them and turns them brown.

Efflorescence (white Crystals or White Furry Deposit)

This usually disappears rapidly from new brickwork by the action of wind and rain. Brushing or sponging down the wall at times of maximum efflorescence will also help, the salts brushed off should not be allowed to accumulate at the base of tile wall, otherwise they may be carried back into the brickwork by subsequent rain.

Lichens and Mosses

These can be killed with a solution of Copper Sulphate (1 kg to 10 litres of water) or a proprietary weed killer. Vegetable growth is generally indicative of damp brickwork and will usually reappear if this basic cause is not cured, (Green staining which does not respond to this treatment is probably due to Vanadium salts from within the bricks.) Boiling water or steam is very effective in cleaning mosses.

Running Water

Water running regularly down the surface of brickwork produces pattern staining and this can usually be removed by scrubbing after wetting with a high pressure mist spray of cold water. If this is not effective, the treatment recommended for mortar should be followed. Moisture movement concentrates salts and is the main cause of all staining.

Various Oils

Sponge with white spirit, carbon tetrachloride or trichloroethylene, Good ventilation is essential if volatile solvents are used indoors.

Paint

Apply commercial paint remover or a solution of trisodium phosphate (1 part to 5 parts of water by mass), allow the paint to soften, and remove with a scraper. Wash the wall with soapy water and finally rinse with clean water.

Rust or Iron

Wash down with a solution of oxalic acid (1 part to 10 parts of water by mass). (Brown staining which does not respond to this treatment, particularly at the junction of the brick and mortar, is probably due to manganese).

Manganese (Dark Brown)

Brush the stain with a solution of 1 part acetic acid and 1 part hydrogen peroxide in 6 parts of water.

Timber (Brown or Grey)

These stains are due to water spreading tannin or resin from the timber across the bricks and mortar. Normally they can be removed by scrubbing with a 1:40 solution of oxalic acid in hot water.

Smoke and Soot

Scrub with a household detergent. The more stubborn patches can be removed from the brick pores using trichloroethylene, although good ventilation is needed if this is used indoors.

Tar

Except where bricks are liable to surface damage, remove excess tar with a scraper, then scrub with water and an emulsifying detergent. If necessary, finally sponge with paraffin. Do not wet brickwork with water first.

Large Projects -Multi-Storeyed Buildings

Sandblasting is not recommended as a solution although it has been used in special instances overseas. High pressure cleaning is suitable if well managed by experienced contractors and with agreement and pre-planning between the architect, contractor, sub-contractor and brick manufacturer.

- Hand labour should be used to remove large mortar particles.
- Cleaning should only start about seven days after the building is complete when the mortar is set.
- Metal, glass wood surfaces, etc. should be appropriately masked.
- Cleaning should commence at the top of the building working downwards.
- The walls should be saturated with clean water before chemicals are applied.
- Choice of application pressures and chemicals are critical to the operation.

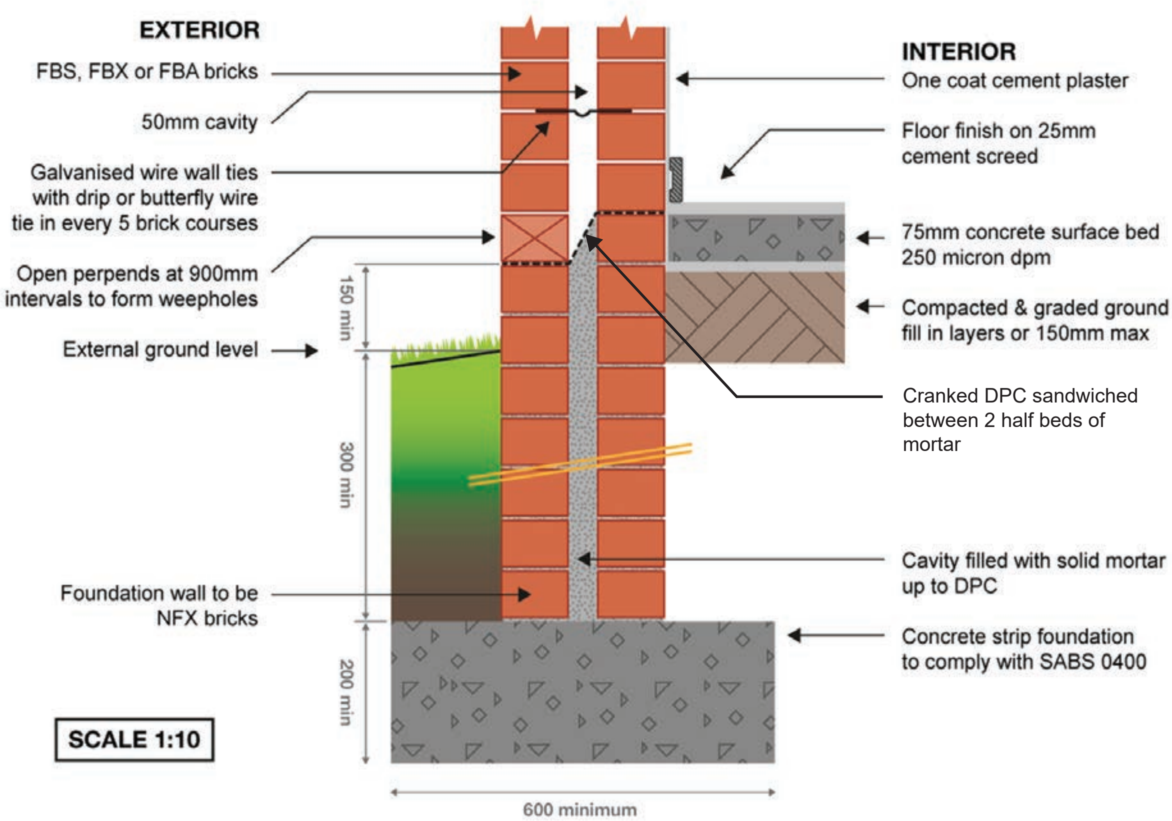
NOTES

CHAPTER 7

CONSTRUCTION DETAILS

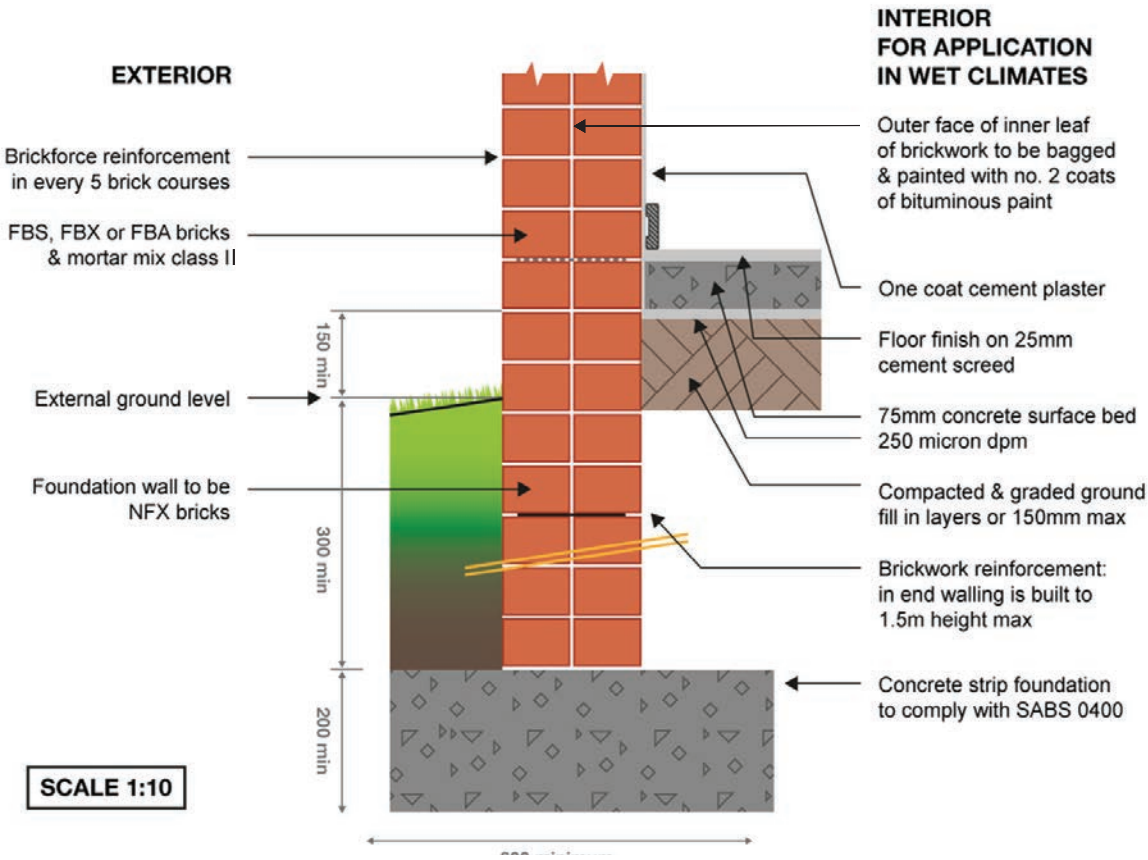
CONSTRUCTION DETAILS

Drawings depicting details of damp proof courses, weepholes, lintels, roof ties to walls, etc. are supplemented by specifications used to translate designs into physical reality. Detailing is therefore an important link between good design and quality construction. The construction details that follow are examples of sound acceptable practice

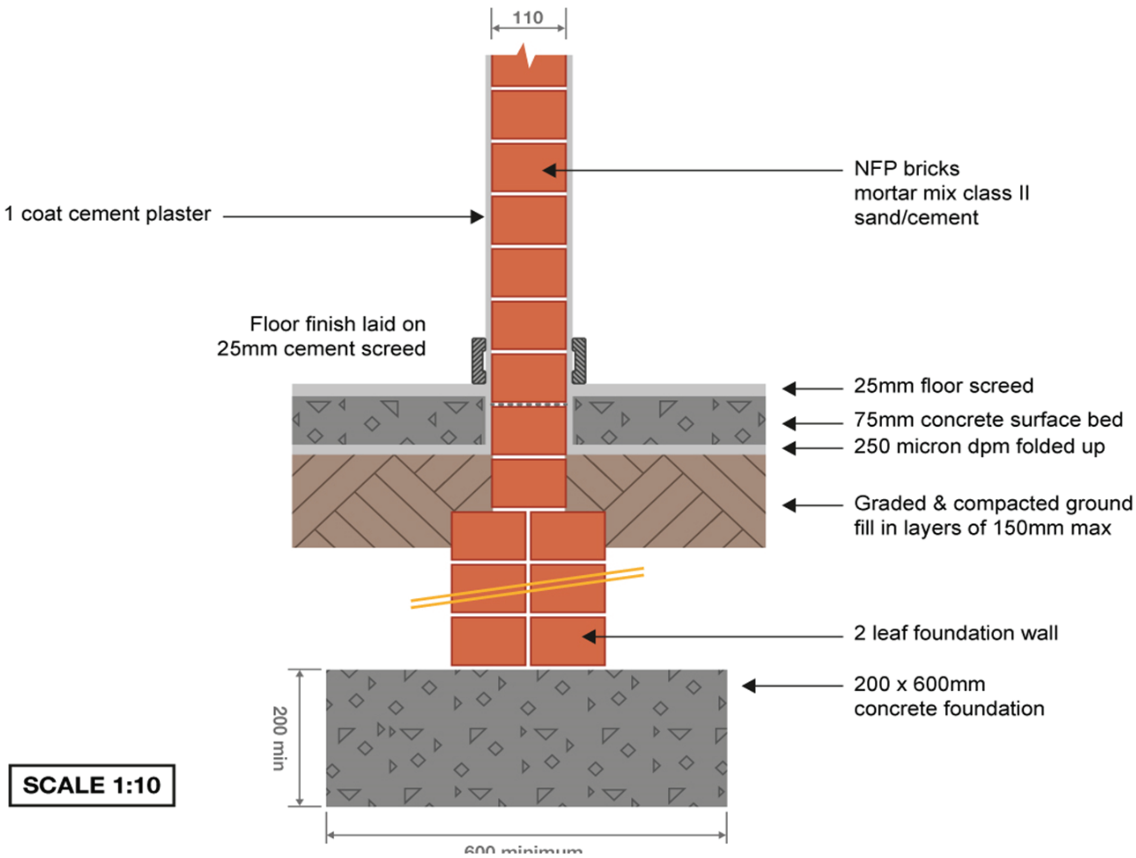


7.1 - External facebrick cavity wall and surface bed junction

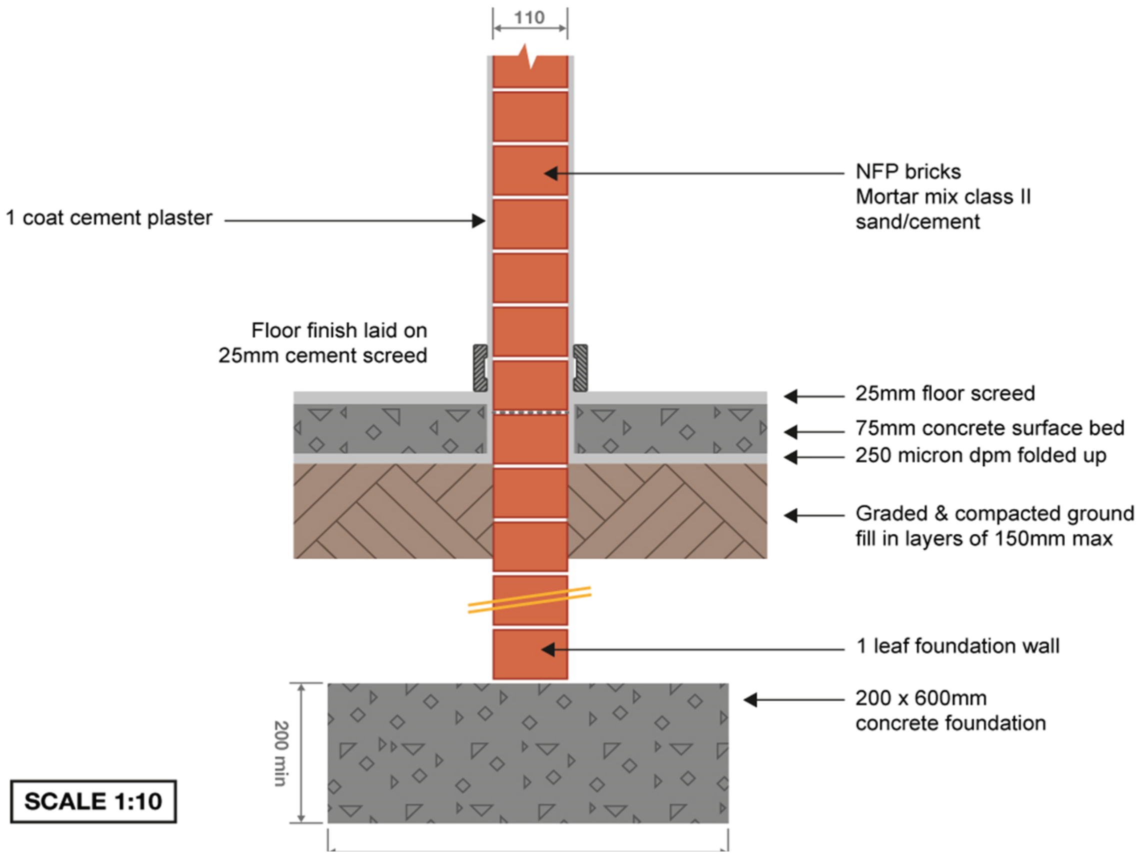
NOTES



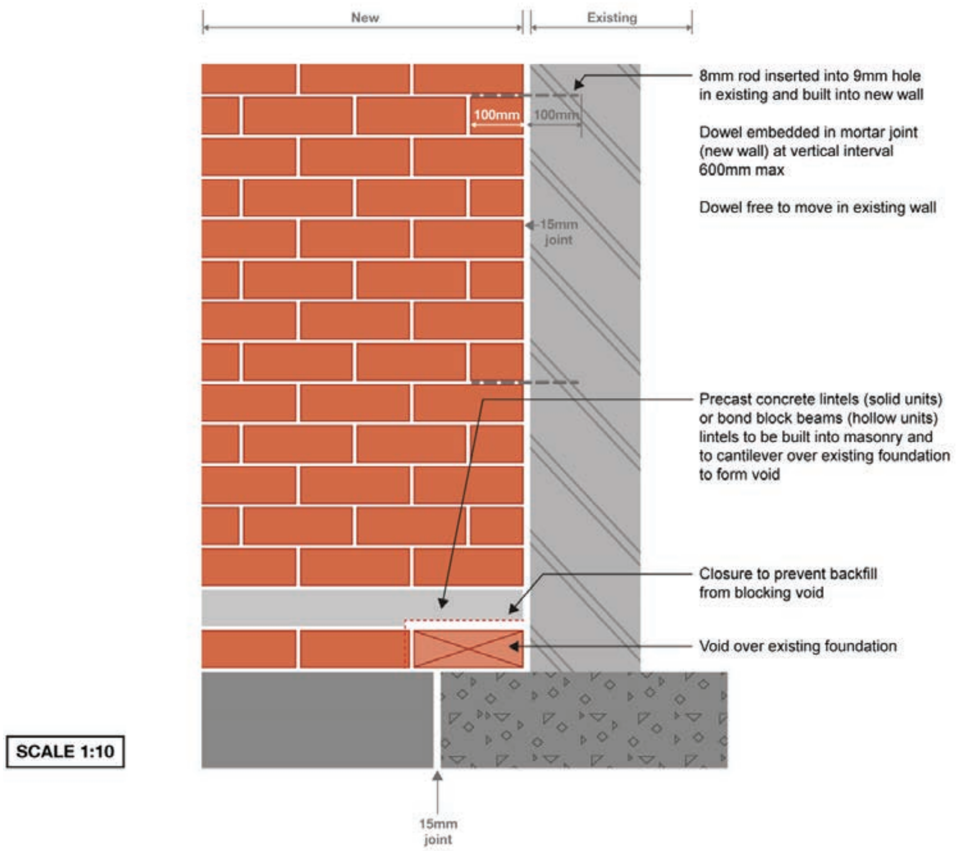
7.2 - External facebrick solid wall and surface bed junction



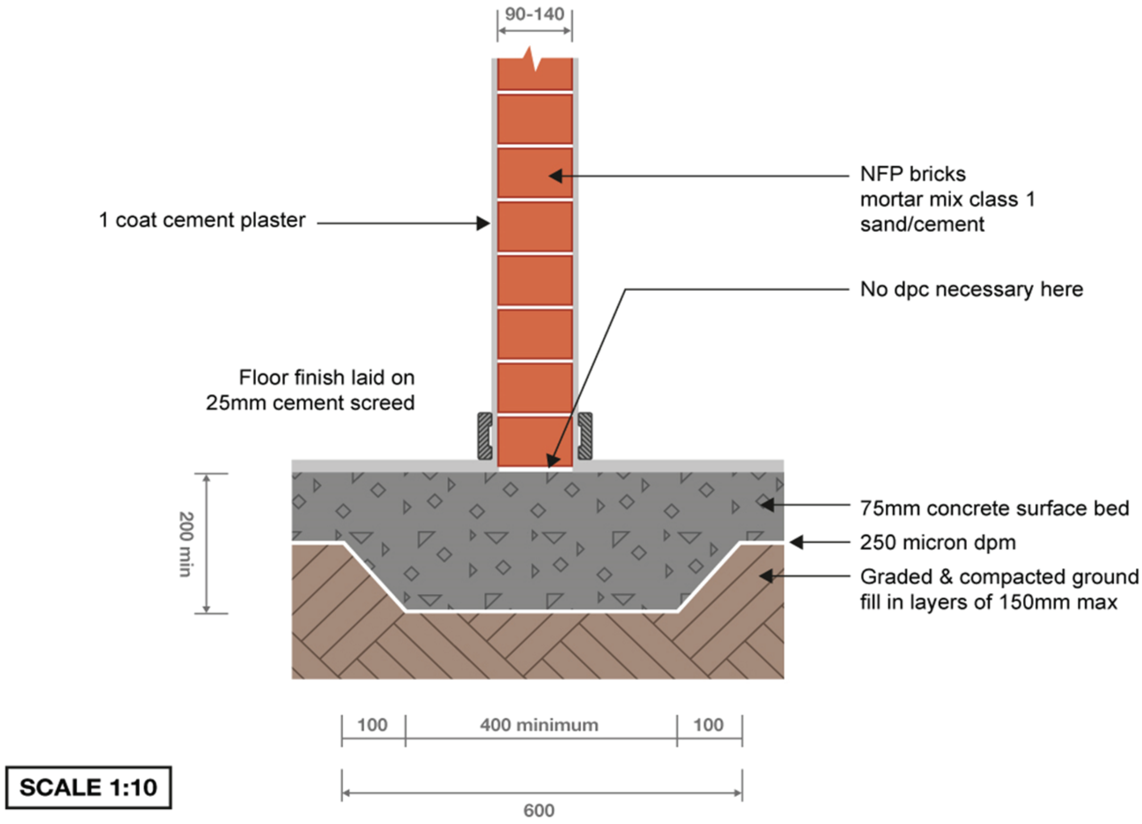
7.3 - Internal footing (75mm - 1000mm in height)



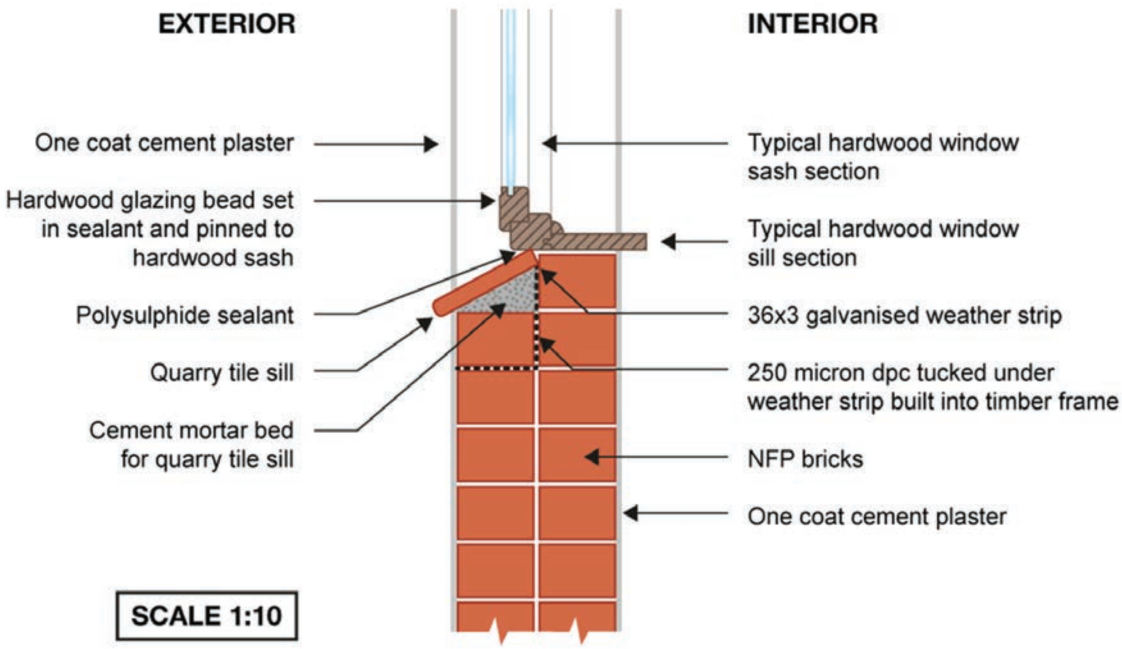
7.4 - Internal footing (300mm in height)



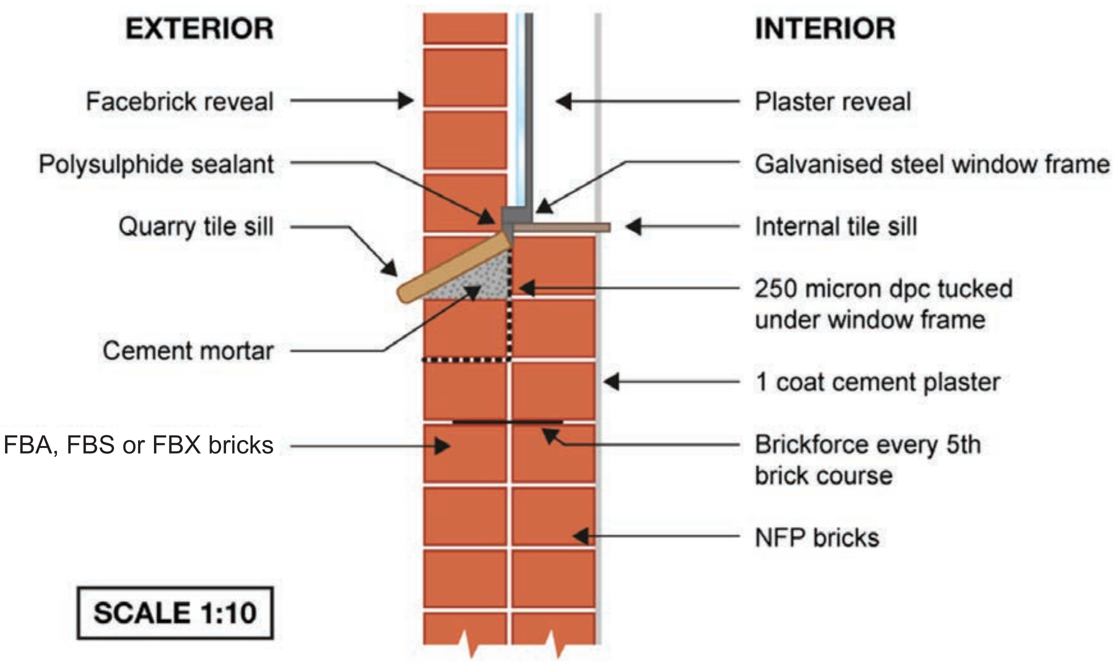
7.5 - New wall joined to an existing wall



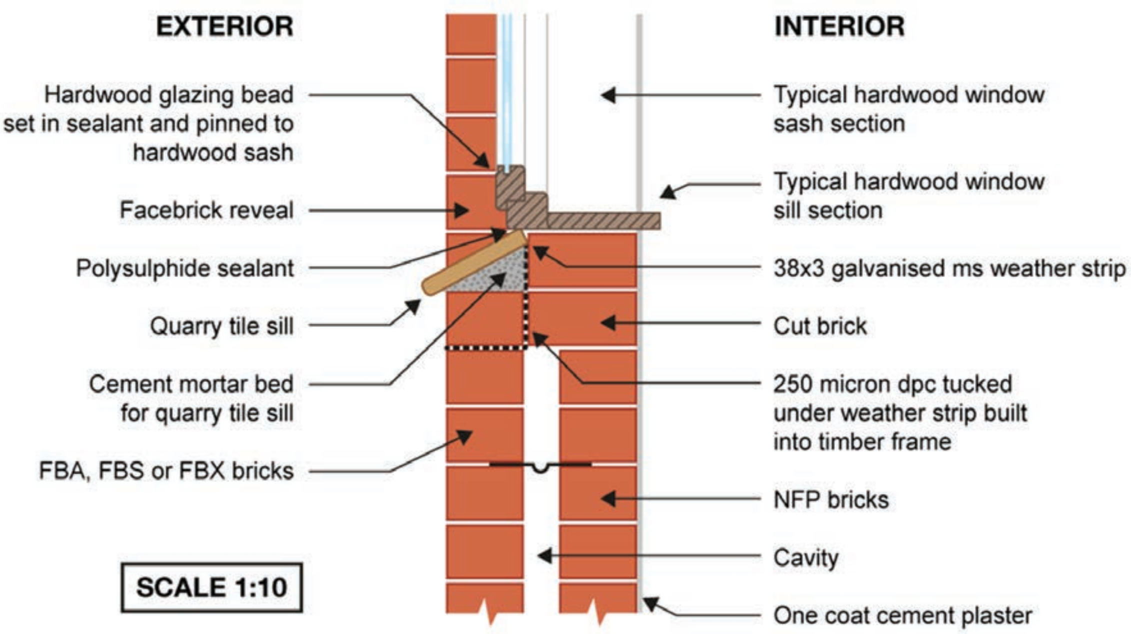
7.6 - Internal footing (thickened surface bed foundation)



7.7 - Typical detail of a hardwood window (sill level in a brick wall)

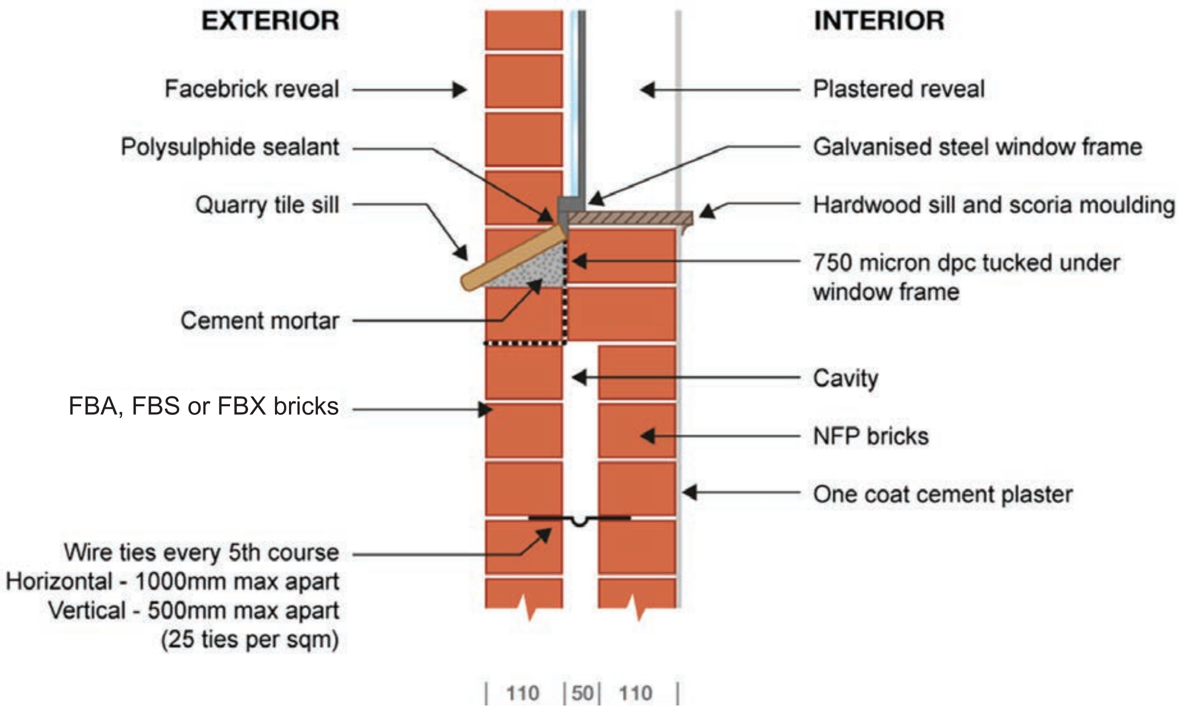


7.8 - Facebrick externally with quarry tile sill for brick wall

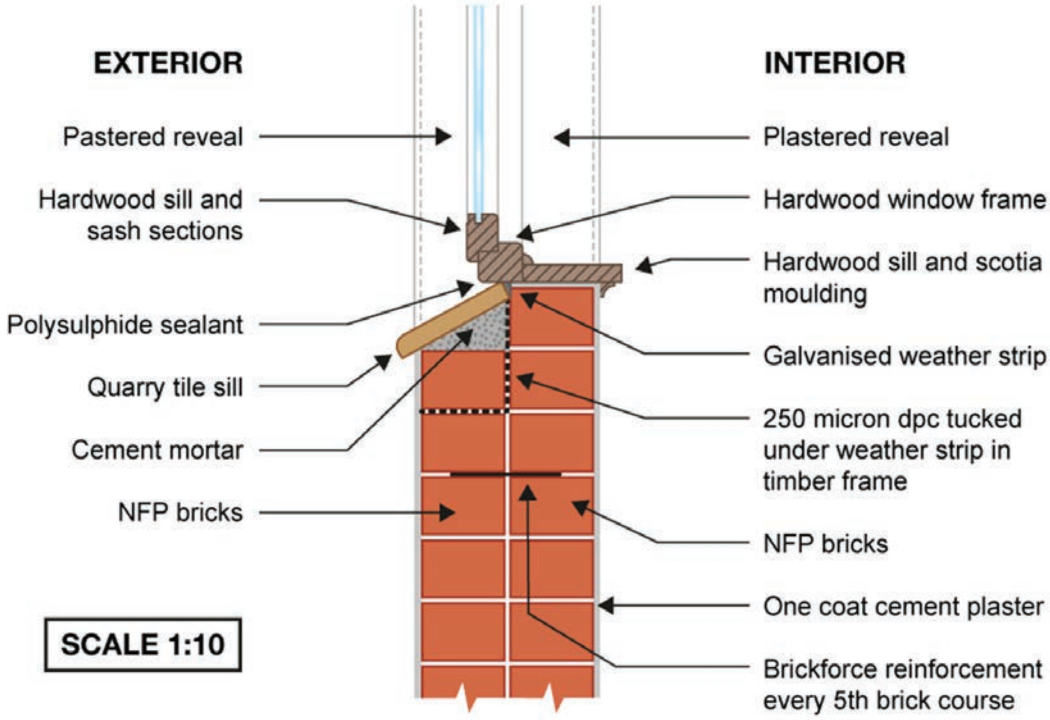


7.9 - Facebrick externally with timber window frame and quarry tile sill for cavity wall

CHAPTER 7

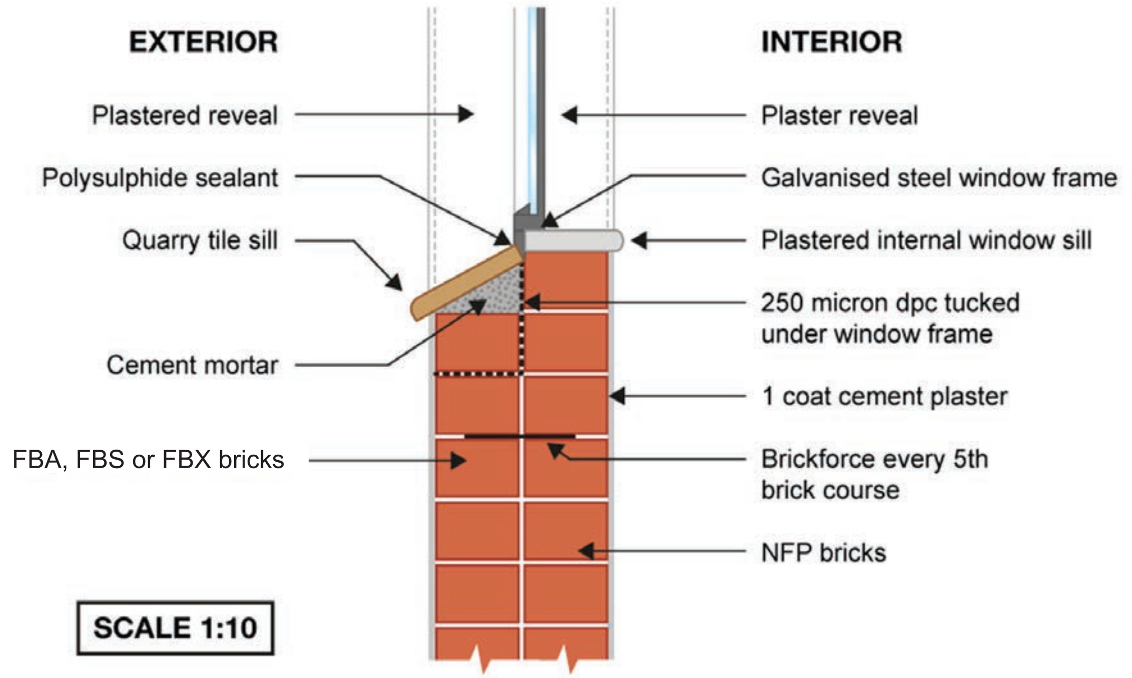


7.10 - Facebrick externally steel window frame and quarry tile sill for cavity wall

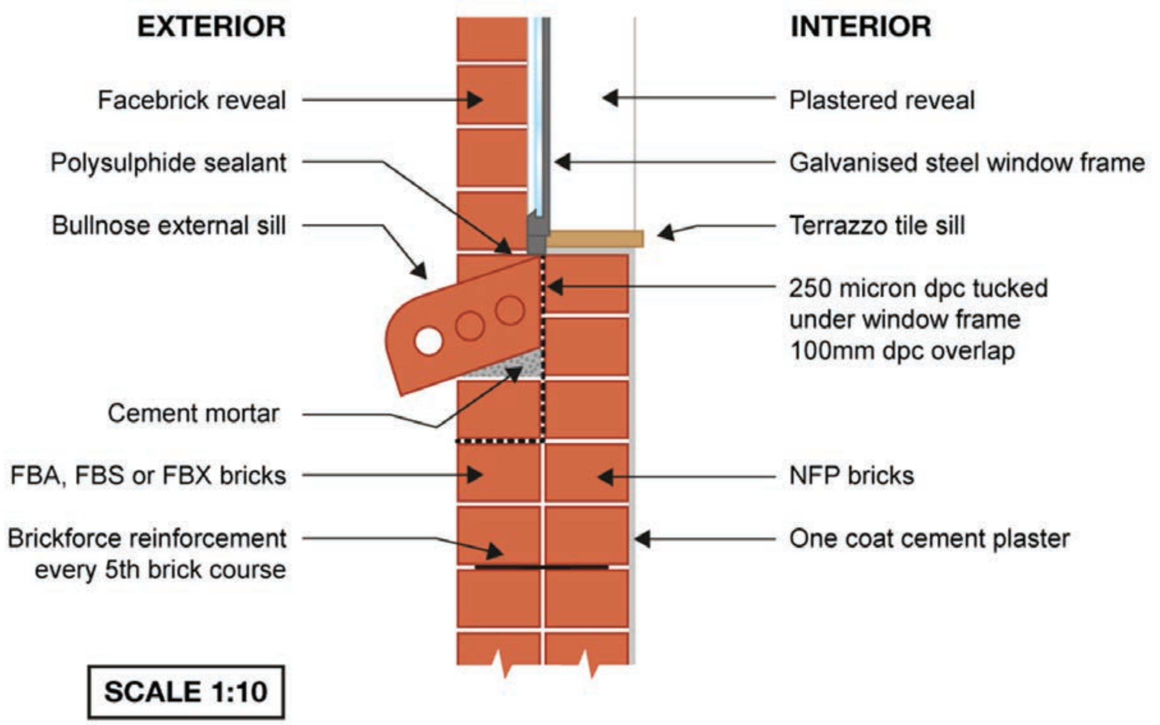


7.11 - External brick wall with quarry tile window sill (hardwood window)

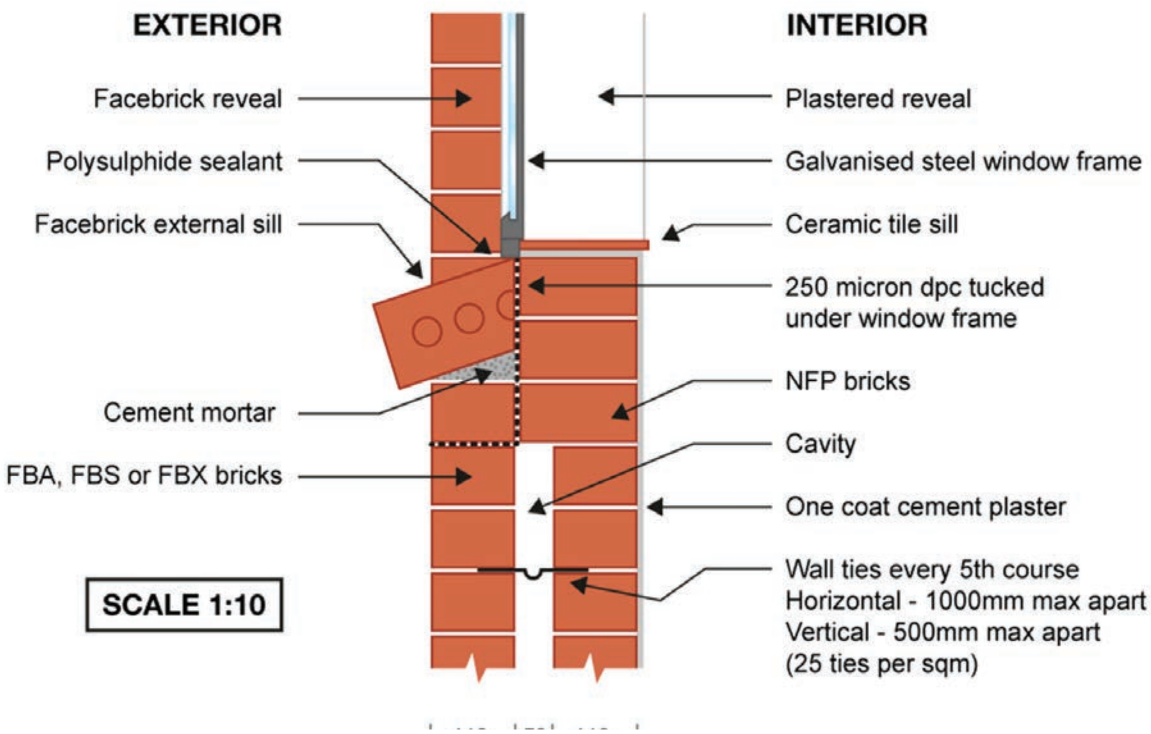
CHAPTER 7



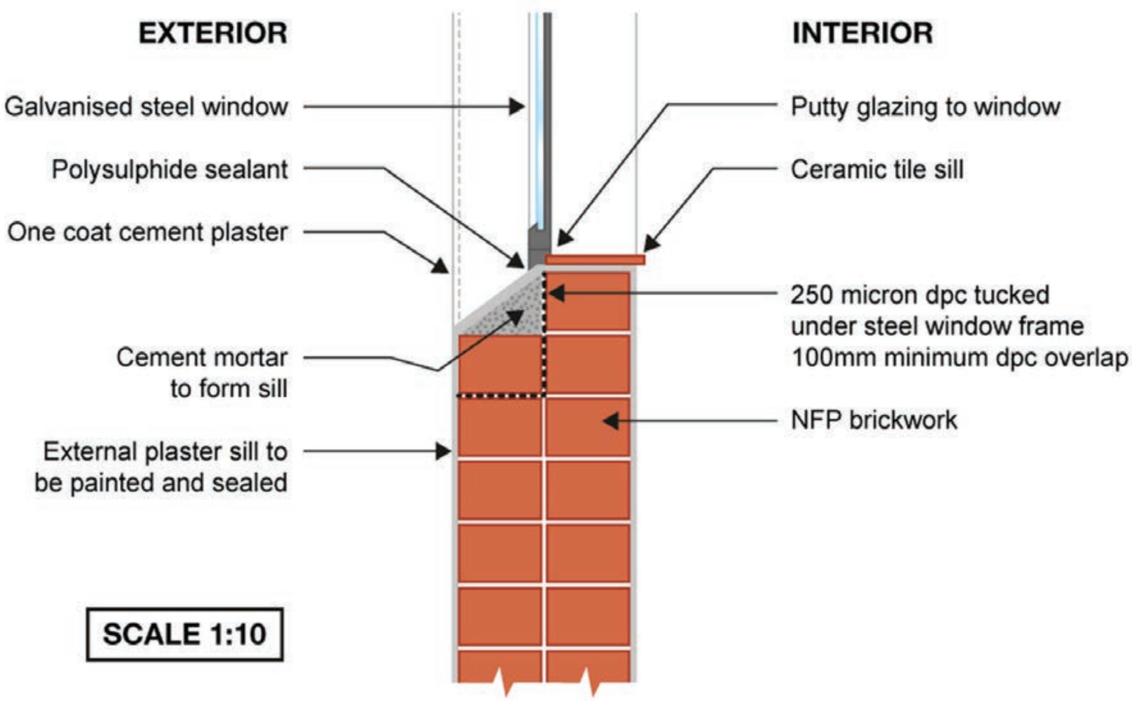
7.12 - External facebrick wall with quarry tile window sill (steel window)



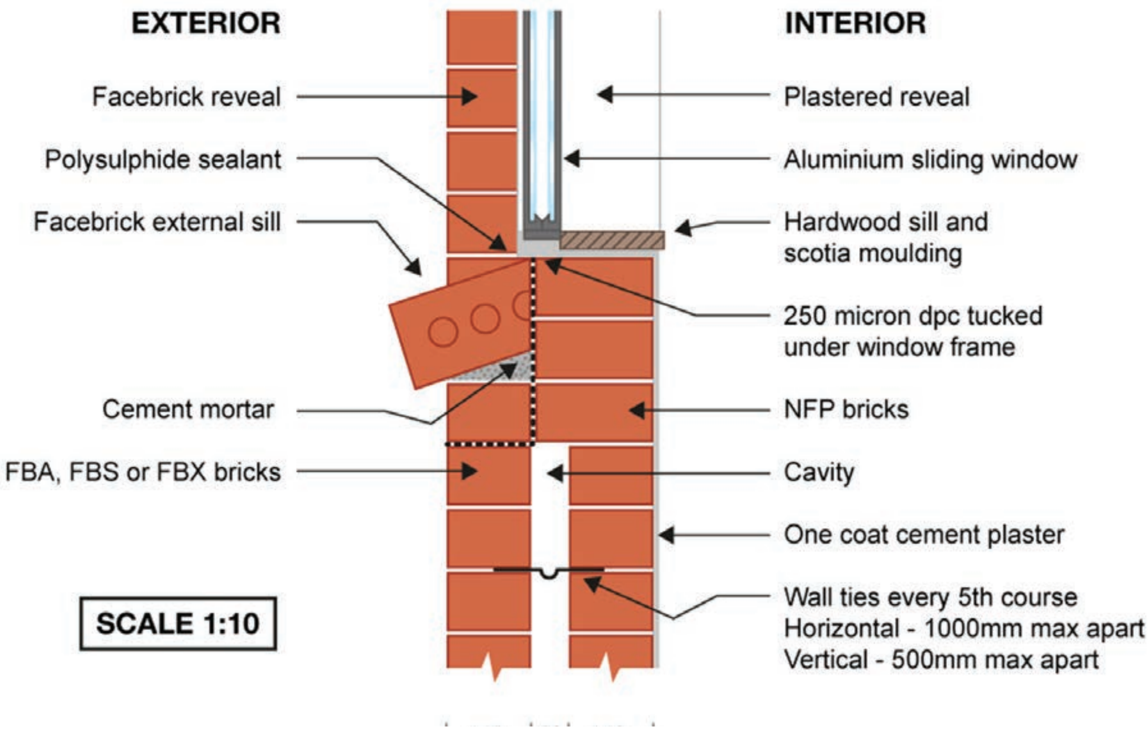
7.13 - Facebrick with bullnose sill externally for brick wall (steel window)



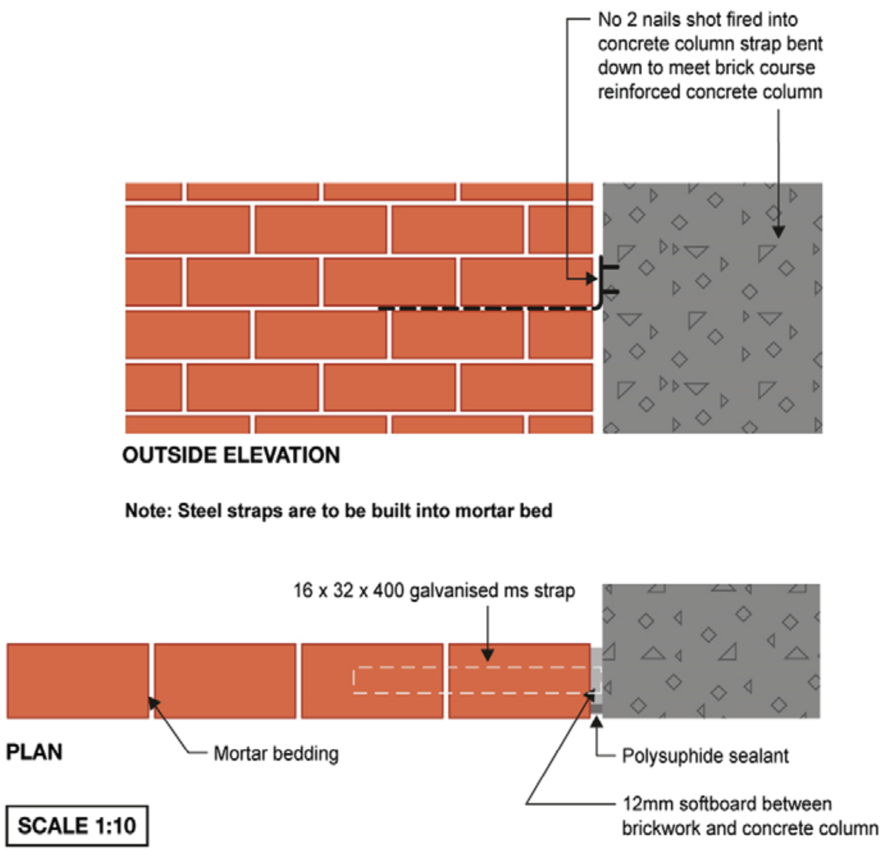
7.14 - Facebrick with bullnose sill externally for cavity wall (steel window)



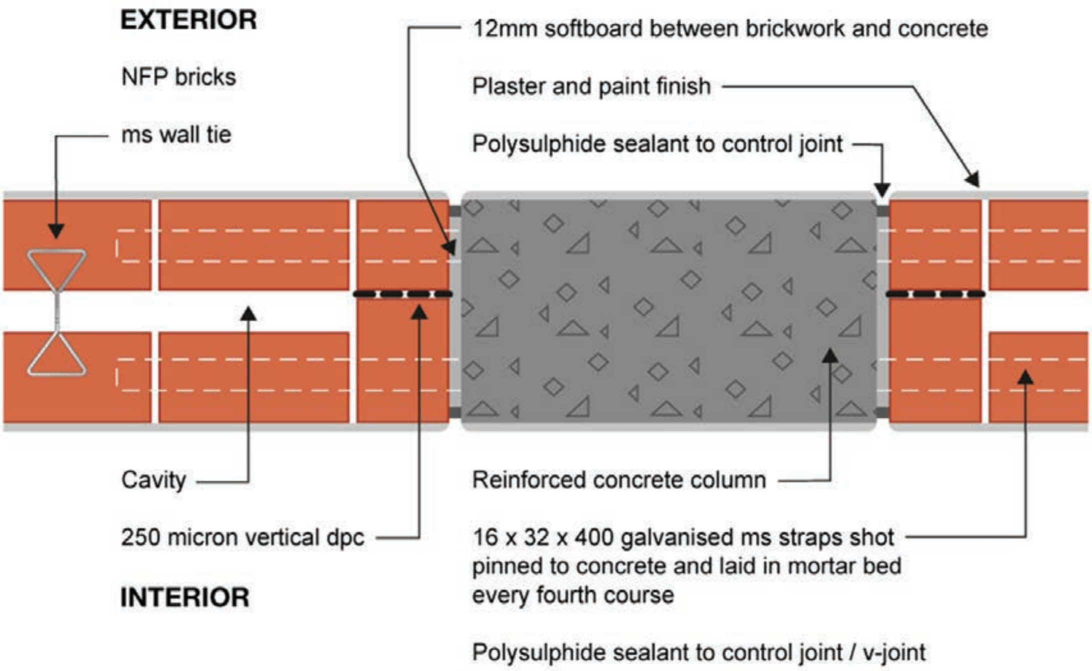
7.15 - Steel window with plaster external sill in brick wall



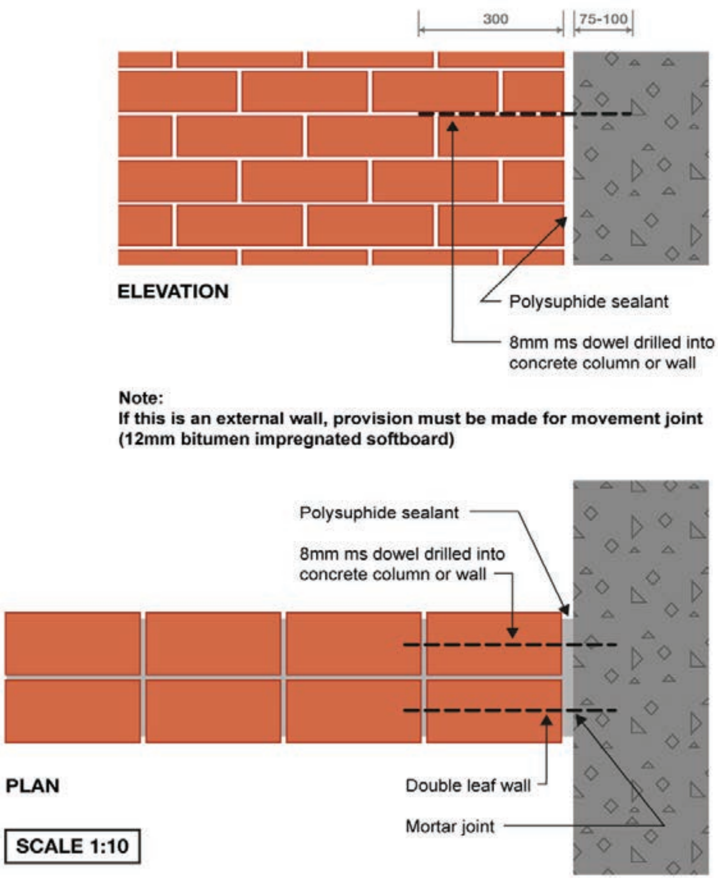
7.16 - Facebrick with brick sill externally for cavity wall Sliding aluminium window



7.17 - External cavity wall construction at junction with R.C. balcony slab

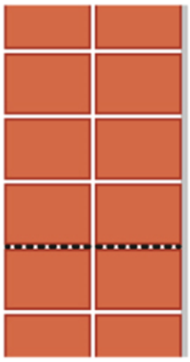


7.18 - Typical R.C column / brick cavity wall junction with vertical joints



7.19 - Section of brick wall joined to concrete column

CHAPTER 7



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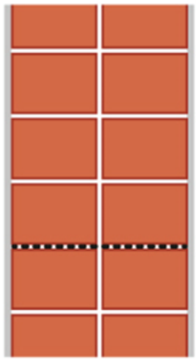

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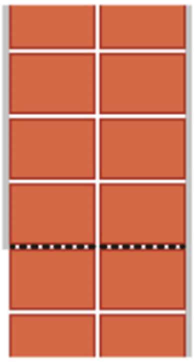

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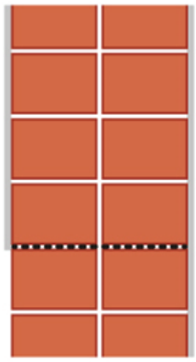

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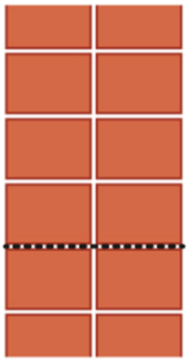

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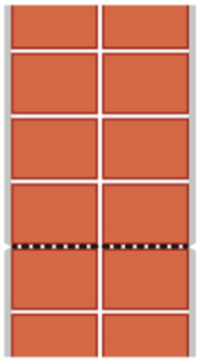

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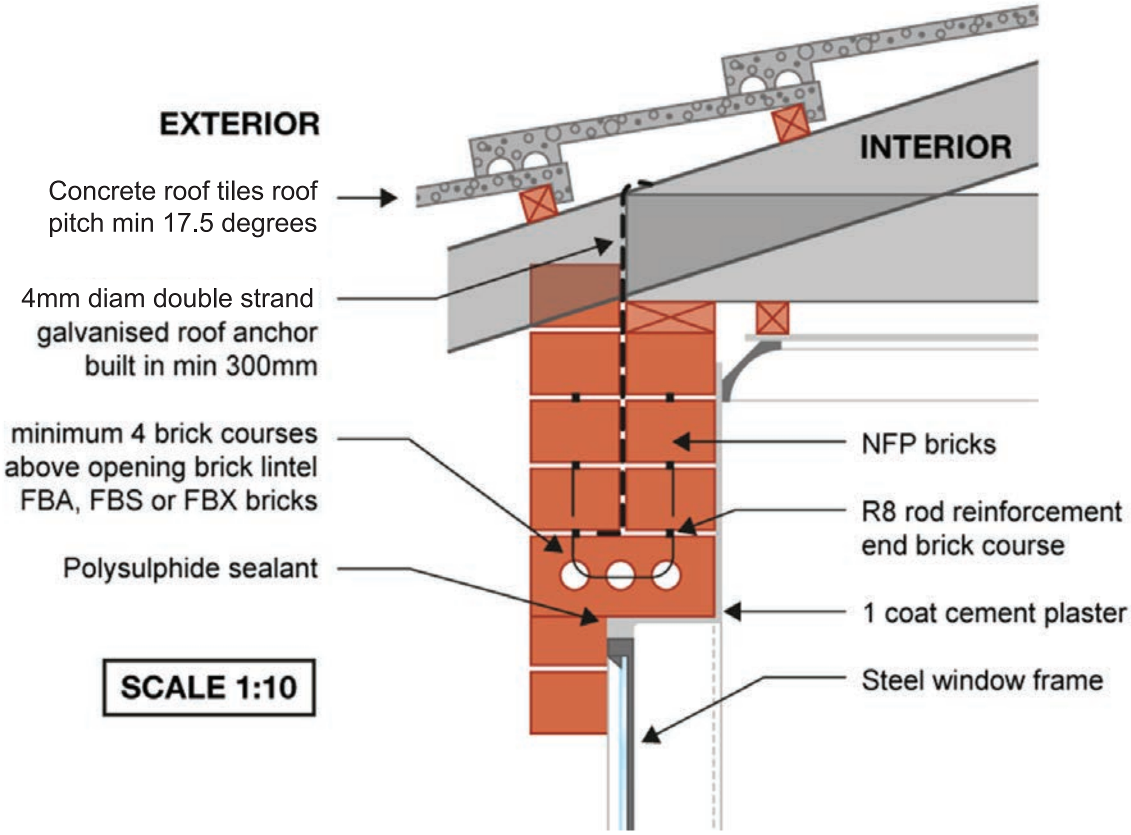
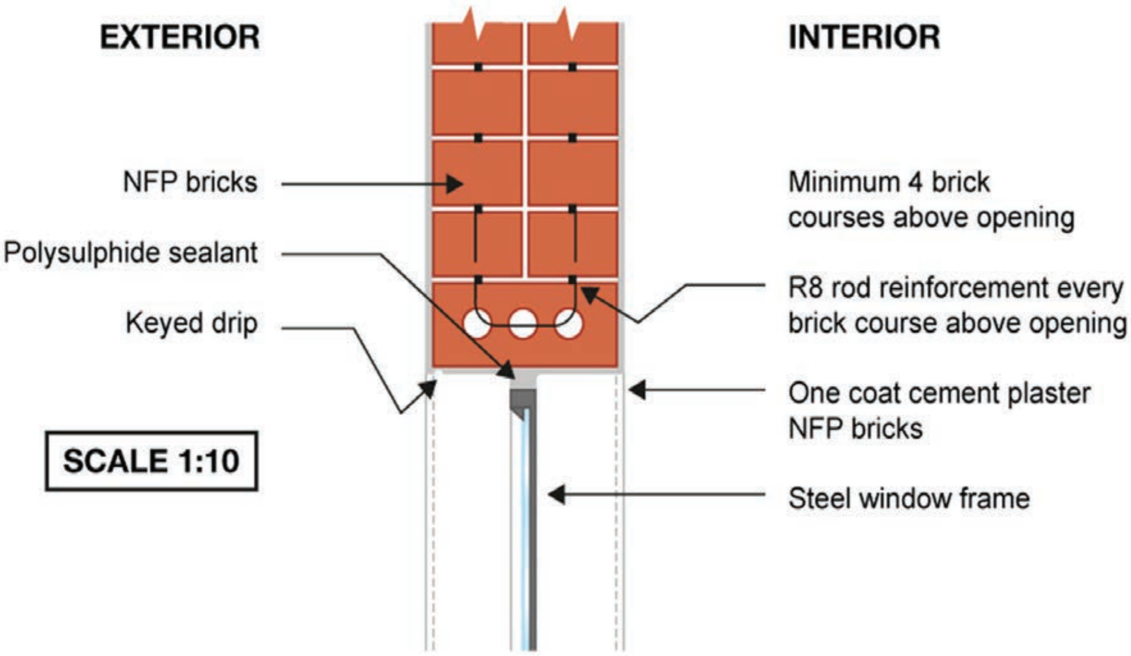
SCALE 1:10

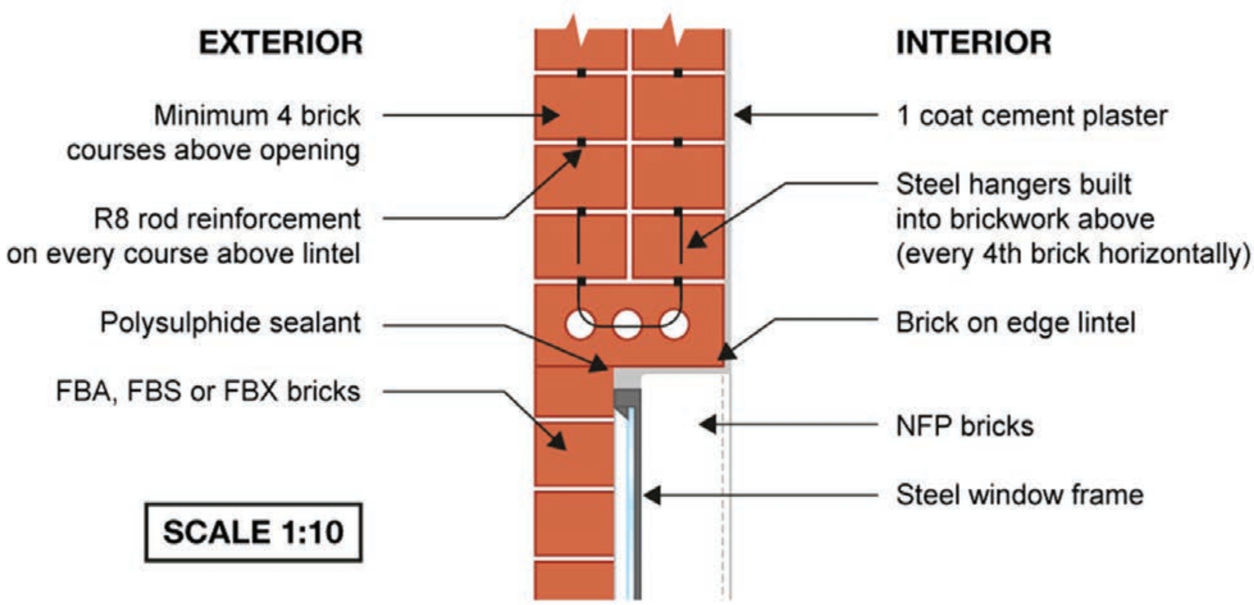
7.20 - Placement of DPC in two leaf brick wall



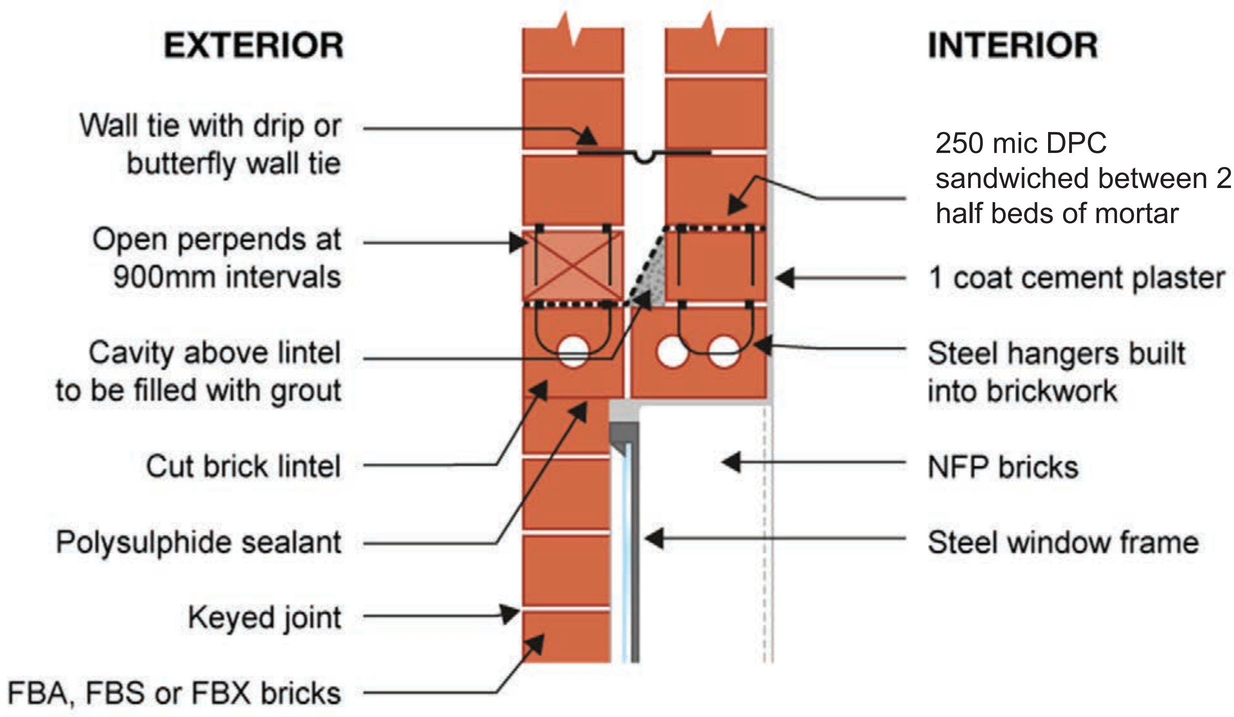
7.21 - Brick lintel for facebrick external wall (steel window)



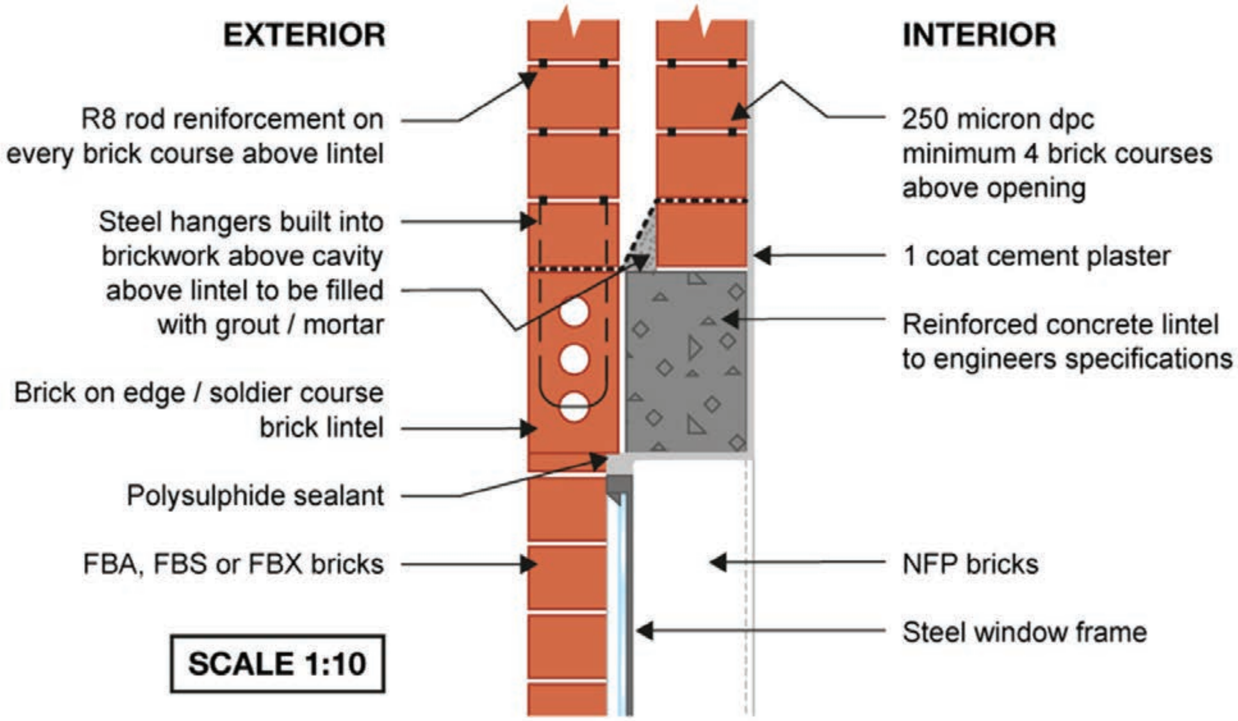
7.22 - Brick lintel for an external plaster finished brick wall



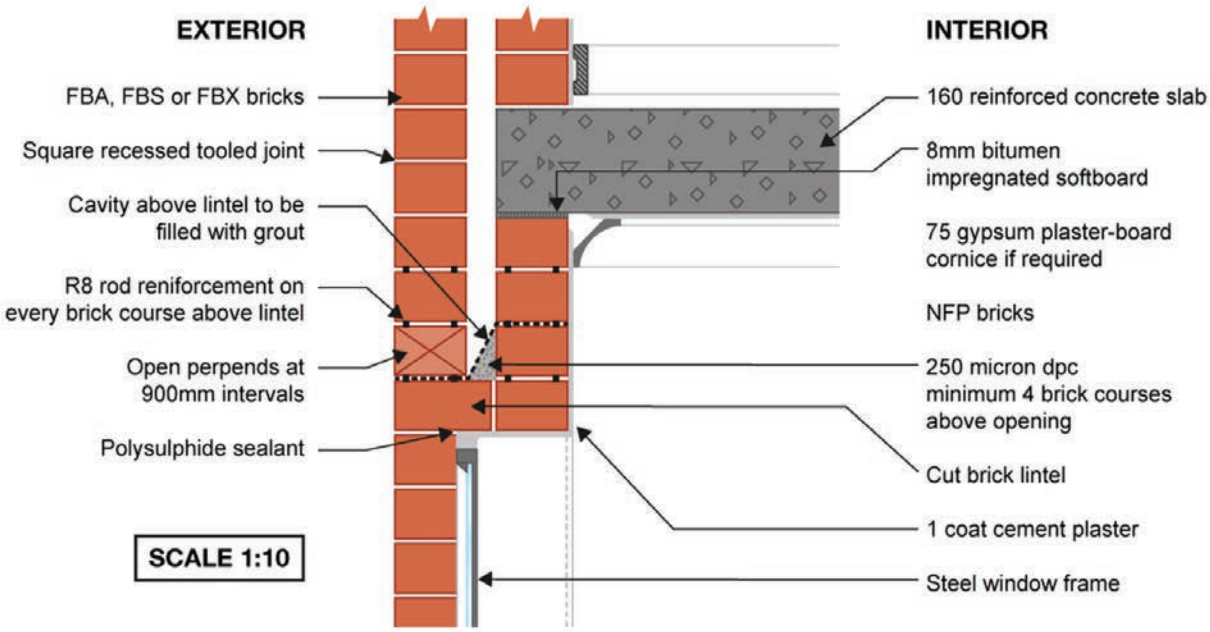
7.23 - Brick lintel for an external facebrick wall



7.24 - Brick lintel for an external cavity wall

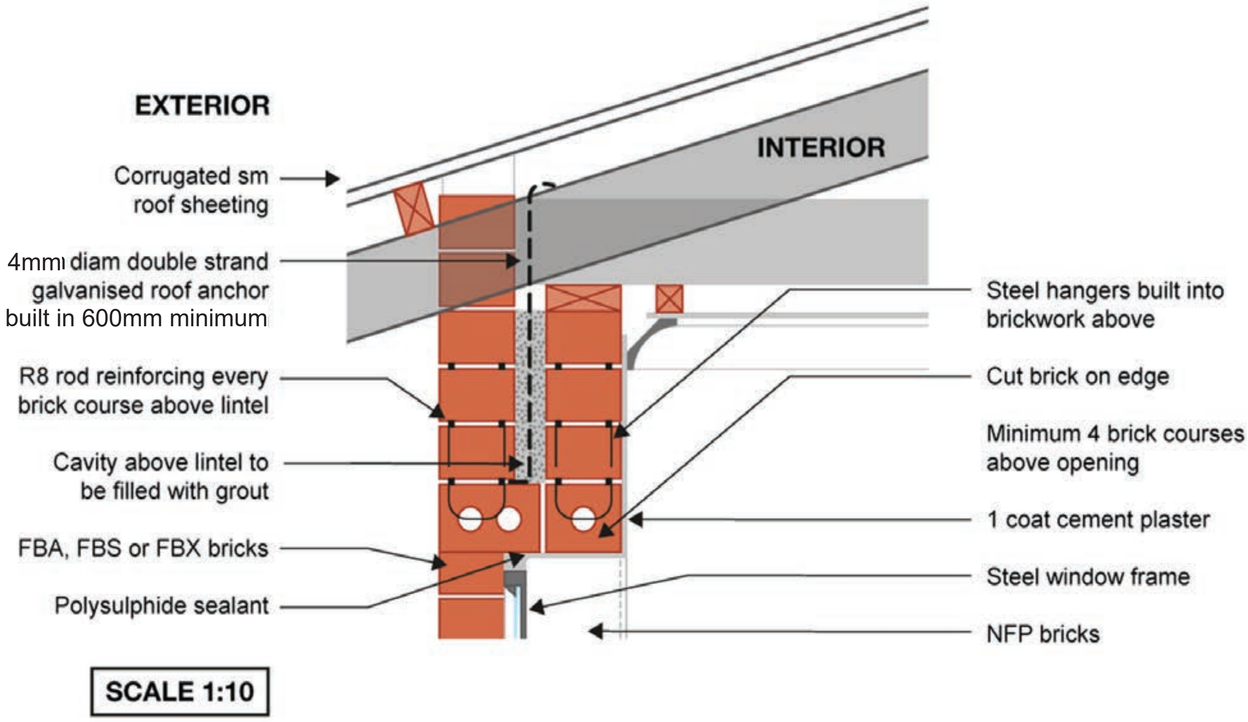


7.25 - Brick on edge (soldier course) lintel for cavity wall

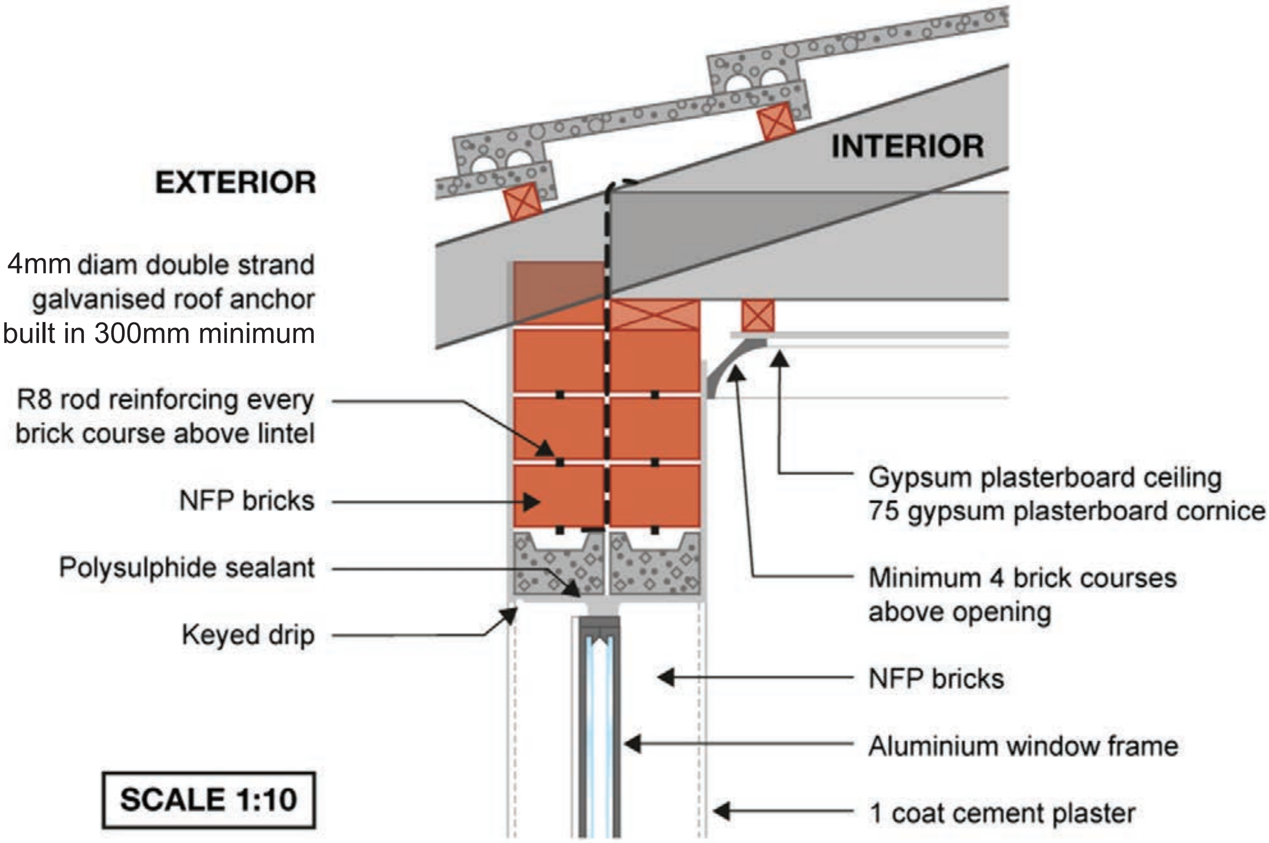


Note: This detail is suitable for a multi-story building where there is no protection from rain to the area above the window

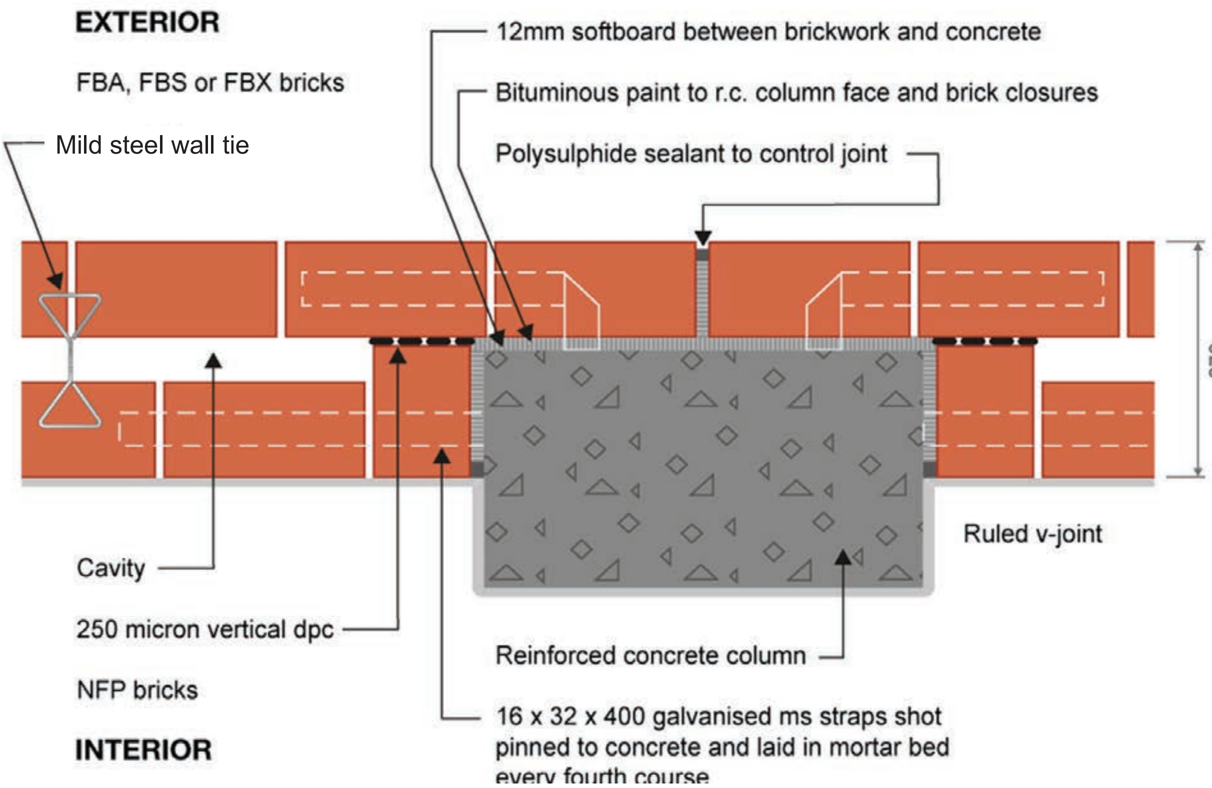
7.26 - Brick lintel for facebrick external wall (steel window)



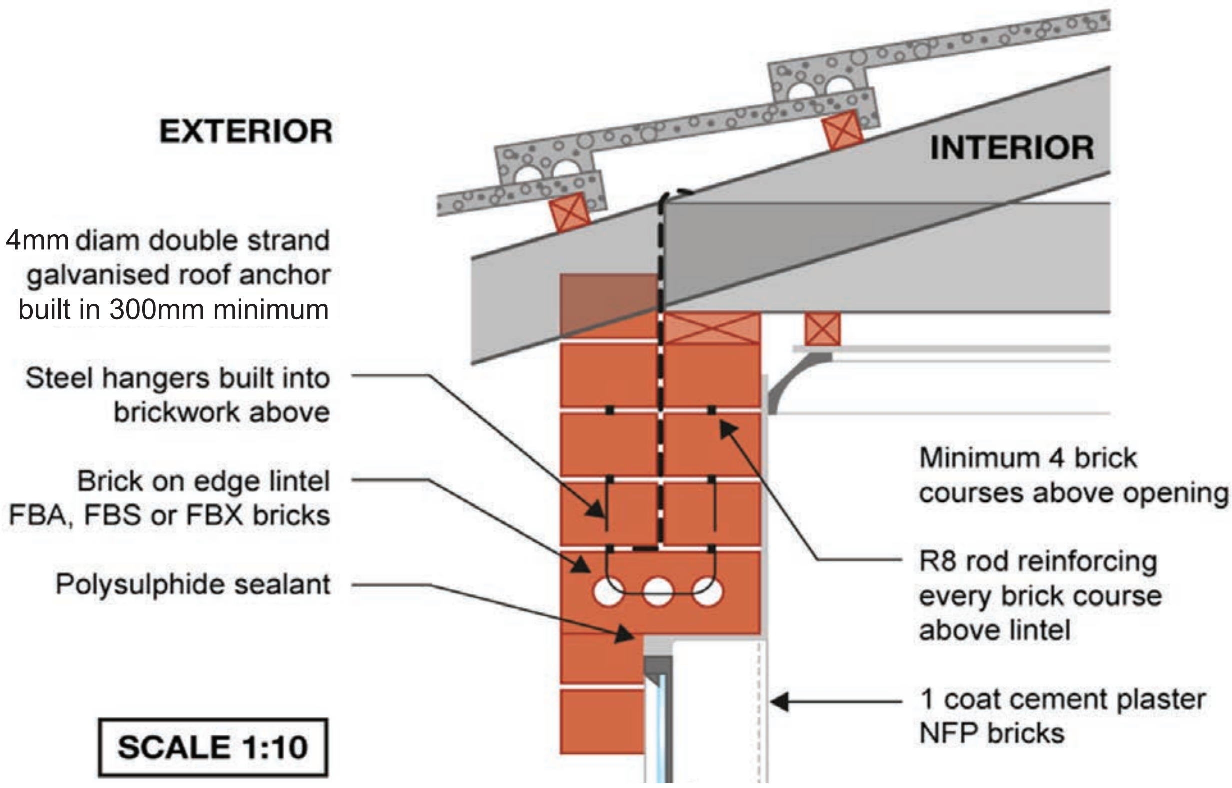
7.27 - Brick lintel for facebrick external wall (steel window)



7.28 - Double precast concrete lintel for plastered external brick wall (aluminium window)



7.29 - Typical R.C column / brick cavity wall junction with vertical joints



7.30 - Brick on edge lintel for facebrick external wall (steel window)

NOTES

CHAPTER 8

SUSTAINABILITY AND RELEVANCE OF CARBON EMISSIONS

SUSTAINABILITY AND RELEVANCE OF CARBON EMISSIONS

Concepts of Sustainability

The accepted definition of Sustainable Development is 'Development which meets the needs of the present without compromising the ability of future generations to need meet their own needs'.
The simultaneous pursuit of economic prosperity, environmental neutrality and social equity is the much recognised the triple bottom line for businesses, governments and society in general.

Firstly, Environmental Sustainability is the process of making sure current processes of interaction with the environment keep the environmental impact as low as naturally possible based on an idea that in the longer term the impact is zero, or such that nature's resources are used at a rate at which they can be replenished naturally.

Second, is Economic Sustainability, which cannot at this stage be measured with a single index which tells us the extent of progress, but this might be by way of the economic value added in the form of salaries, wages and services spent.

Thirdly, Social Policies which increase human welfare and eventually eradicate poverty are also in line with sustainability objectives.

The measurement and monitoring of these aspects is problematic, never-the-less it is accepted that well defined and harmonised indicators are the only way to make sustainability realistic and meaningful. Those indicators are adjusted through testing and observation, trial and error. Commonly used terms, measures and reporting systems are: Carbon Footprint (CO2), Global Warming Potential (GWP), Ozone Depletion Potential (ODP), Material Input per unit of Service (MIPS) and Green Building Ratings Systems (Star rating), the Global Reporting Initiative, all contribute to achieving some comparability. This concept aims to be a practical guideline towards sustainable development following the principle of conservation and increase in value rather than restricting the consumption of resources.

ISO 15392; Sustainability in building construction – General principles: is based on the concept of sustainable development as it applies to buildings and other construction works, from "the cradle to the grave". Over their life cycle, construction works absorb considerable resources and contribute to the transformation of the environment. As a result, they can have considerable economic consequences, and impacts on both the environment and human health.

Green-house gases

Green-house gases are those gasses in the atmosphere of the earth which allow short-wave infra-red (heating) radiation to pass through and warm our surrounds, but do not allow the escape of long-wave infra-red radiant to occur, with a net build-up of heat in the atmosphere.

The principle green-house gas which is accumulating in our atmosphere is Carbon-dioxide. The concentration of this gas is increasing in our atmosphere as result of the burning of fossil fuels and the levels have more than doubled since the advent of the industrial age. Others which have greater impact, but which are in much lower concentrations are methane and various oxides of sulphur and nitrogen. The net result of the increased concentration of these gases is an increase in the average temperature of the Earth.

This rise in temperature is likely to cause climate change such as will kill off marginal animal and plant species, reduce global food production, cause a melting of the ice-caps and a rise in sea-levels with consequent flooding of low lying coastal areas.

If human economic activities are generating green-house gases they are harming future generations and these activities are more and more being considered to be unacceptable by society.

GHG Reporting has been voluntarily adopted by many organisations in South Africa as part of the international Carbon Disclosure Project (CDP). This is an independent non-profit organization holding the largest database of corporate climate change information in the world. Wal-Mart recently asked many of its suppliers to begin reporting to the CDP as part of the company's sustainability index.

The mandatory reporting of GHG is not expected in the RSA until such time as Carbon Taxation is implemented. This will require third-party verification of reported emissions as this is a prominent feature in the draft legislation currently circulating and can be expected to be included in any law that is passed.

The advantage of having an industry-wide GHG inventory or carbon-footprint within a Life Cycle Assessment will enable the CBA to make confident, credible claims about the Industry GHG footprint, and it will confirm the voracity of current industry claims for clay brick masonry to be a relatively clean industry and technology. This information can then be clearly communicated to specifiers, customers, investors, and media for the reporting objectives and requirements of financial, environmental, and social institutions. This will also ensure compliance with regulatory requirements for GHG emissions reporting and reduction, along with achieving local air quality emission standards.

Carbon Footprint

Greenhouse gases can be emitted through transport, land clearance, and the production and consumption of food, fuels, manufactured goods, materials, wood, roads, the operation of buildings, the provision of services and most human activity. For simplicity of reporting, it is often expressed in terms of the amount of carbon dioxide, or its equivalent of other GHGs emitted.

A carbon footprint is defined as a measure of the total amount of carbon dioxide (CO2) and equivalents of other gas emissions, of a defined population, system or activity, considering all relevant sources, sinks and storage within the boundaries of that population or that area of interest. The concept name of the carbon footprint is derived from the ecological footprint concept. There is a fair closeness of comparison between the Carbon Footprint per square meter calculated in the Energetics report for Think Brick of Australia and the results obtained by WSP in their research on the 130m² house, upon cursory examination. An estimation of masonry Carbon Footprint for the RSA will be valuable data for comparative analysis against other forms of construction.

Life Cycle Assessment

The LCA should report on expected environmental impacts, in particular energy use and resultant greenhouse gas emissions, water usage, product recyclability and local air quality associated with the manufacture of bricks and the production and operation of masonry houses and other structures, over the expected life-span. The economic and social contribution of bricks and masonry to the RSA economy and social fabric will also be reported on in the LCA, all in accordance with the principles and guiding provisions of ISO14040/14044.

This is in order that the sustainability of the Industry may be fairly compared fairly with that of houses and other buildings constructed from other building materials.

As part of a LCA the GHG emission assessment the product systems of bricks, brick walls and house/building designs, and ultimately the recycling and re-use of the original brick material, have to be standardised and attributed, in useful and acceptable inventory units - the Life Cycle Inventory- or LCI.

A set of well-defined and harmonized indicators are used as input to the Life Cycle Impact Assessment (LCIA). This is a classification and characterization of the LCI results. In this step, the input and output results from the LCI phase are sorted and assigned to environmental impact categories such as Global warming potential, Ozone depletion, Human toxicity, Eco-toxicity, Photochemical reaction, Acidification, Eutrophication, Resource depletion and Land use.

Factors which will need to be reported on (in greater detail than the Australian Energetics LCA Report) are the social and economic aspects. The employment creation within the brick-laying and associated trades in the RSA is a factor of National interest, and is a pillar on which the clay brick manufacturing and masonry walling industry stands.

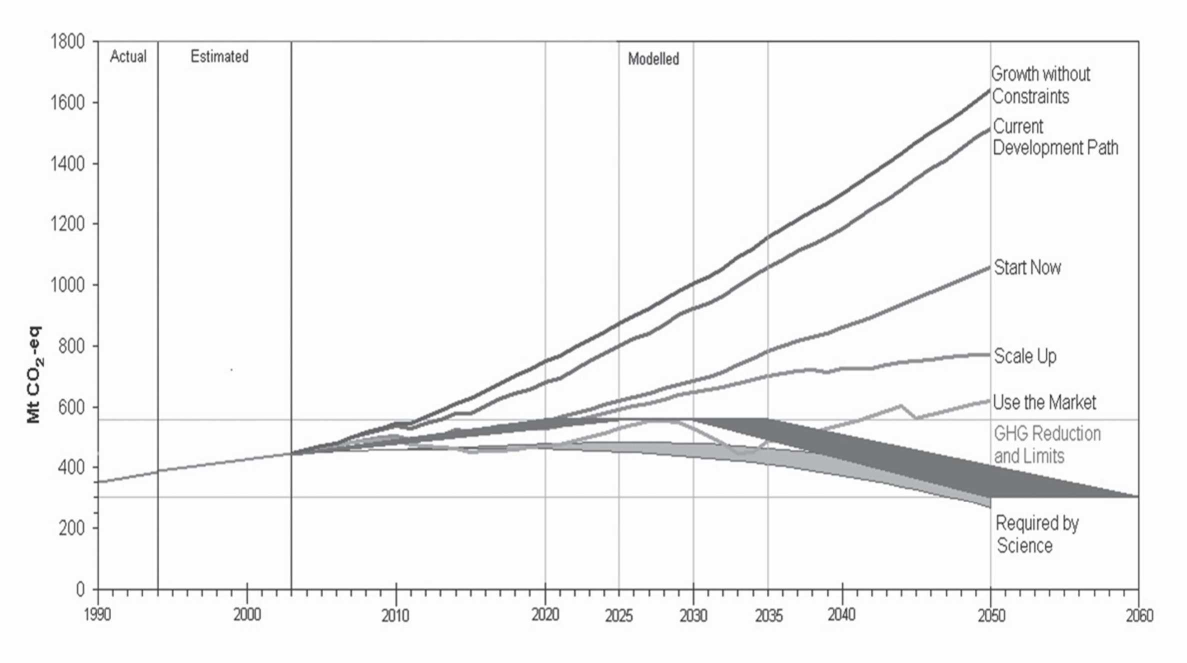
It is expected that a detailed analysis of the various extraction, production, distribution and construction aspects, as well as the dematerialisation impacts on energy, and the greenhouse gas performance of masonry in a house/non-residential structure over its life cycle, needs to be performed. The energy inputs and mix will need to be closely analysed, as will the atmospheric pollution record of RSA brick manufacturers, water impacts in all phases, and recycling realities in the RSA. The new paradigm is possibly Cradle to Cradle in place of Cradle to Gate.

It may be necessary to place the CBA LCA in the context of other materials and systems, and in the absence of similar LCA from other sectors the scope of the project may need to be expanded to a comparative against other building materials and systems. It will be important to bring Government into the decision making process such that the LCA methodology followed by the CBA will be accepted for use by other industries in time.

National Emission reduction programmes

All nations which are signatories to the Kyoto Protocol have developed their national plan to try to steer their economies on a path of reducing GHG emissions similar to that above for South Africa.

The below graph is developed as part of Long Term Mitigation Study for the RSA Department of Environment, and is backed up by a number of sub-strategies which pertain to the major non-renewable carbon usage such as the Mining and Manufacturing industries, liquid fuel industries and others. The graph shows that if no action is taken, CO2 emissions will more than double



CHAPTER 8

in the next 30 years, at present rates of economic growth, and present fuel usage patterns.

The President of the Republic of South Africa has however committed the nation to a 34% reduction off the business as usual projection by 2020 and a 43% reduction by 2025. These are ambitious targets and will need to be supported by incentives and penalties to direct development to a lower emissions growth trajectory in such a short period of time.

Incentives to encourage Industries to adopt lower electrical energy usage, and penalties by way of Carbon Taxes are available or under development to effect the above reductions in GHG. It is expected that the movement toward lower environmental impact and lower energy usage will also be forced on consumers by the inexorable rise in primary energy costs as result of inherent shortages or supply constraints, as result of the slow rates of discovery of oil and gas resources, and inadequate investment in electrical generating and refining capacity worldwide.

Green buildings rating systems

The Green Building Rating Systems are standards which provide practical guidelines for improving the environmental quality of buildings relative to current typical building practices.

The first of the International Green Building Rating Systems was the United Kingdom's (UK) Building Research Establishment Environmental Assessment Method (BREEAM), established in 1990. A number of other building environment assessment and rating systems have followed in other countries, and the object has been to put the concept of Sustainable Construction into effect. These countries are HK BEAM (Hong Kong, 1995), ECO-Profile (Norway, 1996) LEED (USA, 1997), CASBEE (Japan, 2001), Green Star (Australia, 2002) and Green Star (South Africa, 2007).

The expected performance of candidate buildings is linked to credits, against which the environmental performance of buildings can be assessed. By totalling the credits an overall score and Star Rating for the assessed building is the result. In the RSA a minimum Four Star Rating is awarded, and recently a Six Star Building has been confirmed. A Green Star SA rating tools consist of eight environmental impact categories and an innovation category. Within each category, there are credits which represent individual design initiatives. Finally, within each credit, points are awarded based on the relative environmental impact of the credit (bigger impact credits have more points available). Though many of the credits are similar across tools and have common code references, tools also have sector specific credits that address initiatives only relevant in those building types.

The Green Star SA rating tools are developed to be equitable across building sectors. In other words, a 5 Star Green Star SA – Retail Centre project will exhibit a degree of industry leadership comparable to that of any other 5 Star Green Star SA project under another tool. For more detail on the specific Green Star tools refer to CBA Technical Note 9.

Building rating systems need a scientific basis that links sustainability principles with solutions appropriate for the building sector. Trends in the environmental labelling of buildings, which are discussed in the next sub-chapter suggest that the sector will move towards this new route to Sustainable Construction. The Sustainable Building Alliance (SB Alliance) is an international coalition of standard setting organizations and construction industry sector stakeholders who aim to accelerate the international adoption of Sustainable Building (SB) practices through the promotion of shared methods of building performance assessment and rating. SB Alliance members include nine buildings assessment and rating tool developers, of which the most well-known are the US Green Building Council (LEED), the British Research Establishment (BREEAM).

In 2009 the SB Alliance identified a core set of six quantitative indicators for building performance assessments. Outdoor environmental affects will be assessed on the basis of four criteria, namely, primary energy, water, greenhouse gas emissions and waste. The assessment criteria for outdoor environmental quality (OEQ), and thermal comfort and indoor air quality (IAQ) reflects concerns for human health and well-being. The key source of information will be Environmental Products Declarations (EPDs) of building products, as is described in the next chapter.

The additional indicators under discussion are economic performances, and visual and acoustic comfort. For South African situations the social aspects will need to be included. Unlike the first generation building rating systems which limit assessments to building design, construction and operation, the harmonised environmental assessment and rating methodology looks to take the entire building life cycle into consideration, and the CBA will need to ready itself for this development.

Compulsory environmental rating systems may succeed the current voluntary schemes, and to this end the International Green Construction Code (IgCC) is set to mainstream “green“ building in the US as it stipulates enforceable minimum “green” requirements to be met by all buildings. In the South African environment the Construction Industry Development Board is developing such standards for state owned and occupied building and is endeavouring to take a similar leadership position, by settinga minimum four star requirement for such buildings.

It is well documented that between 30% and 40% of energy usage is attributable to buildings world-wide.The Green Building movement does not extend to influencing the operational energies or occupational usage energy after the construction phase, and this it is proposed, will be controlled via Building Energy Performance Certification or Labelling.

Green product labelling systems

The outdoor and indoor environmental impact of a building is the sum total of the environmental effects of the many contributing construction systems and products – structural, envelope and finishing materials. Product certification aims to avoid or reduce these potential effects at the level of individual construction products and is therefore an essential component of sustainable construction.

The outdoor environmental effects arising from building products used and pollutants released may occur at any stage from raw material extraction to disposal or reuse of the construction product. The effects occur at a global, e.g. Green-House gases (GHG), regional or local scale. Since not all

VOCs contribute to ambient air quality problems, 'No VOC" or "Low VOC "labelled products can still off- gas potentially toxic chemicals into the indoor environment. Evidence suggests that the air within buildings can be more seriously polluted than the outdoor air, and that the construction products which occupy large surface areas – floors, walls, and ceilings, are the single most important source of indoor air contaminants.

From an indoor air quality (IAQ) perspective, the key chemicals of concern are Volatile Organic Compounds (VOCs) and Semi-Volatile Organic Compound (SVOCs) used in the manufacture of furniture, upholstery, cleaning supplies and a broad range of construction products found in the indoor environment. As people spend most of their time indoors their exposure to such pollutants is possibly continuous. For more information on VOC issue and masonry construction see the CBA Technical Note 4.

Standards certifying the indoor or outdoor environmental performance of building products can be utilised to affect some control in buildings. The objective of the ISO14020 series of standards is to develop internationally accepted a best practice on environmental labelling, which is verifiable and accurate information – which is not misleading in anyway – with respect to the environmental aspects of product and services. It is intended that the demand and supply of those products and services causes less stress on the environment and that they stimulate the potential for market-driven continuous environment improvement.

The ISO 14020 standards series of Environmental Labels and Declarations comprises of:

ISO 14020 (2000): General principles; requires that the criteria be based on life cycle considerations that is, the criteria selection process shall consider in a qualitative manner the function of the product (or service) and all life cycle stages and embodied effects associated with the product in question.

ISO 14024 (1999): Type I Environmental Labelling, which is commonly known as an "Ecolabel". This conveys business –to- consumer information in the form of a symbol or seal of approval which confirms the environmental preference of a labelled product within a specific products category. An Ecolabel is awarded by an impartial third-party who operates an Eco labelling programme which sanctions the use of the label.

ISO 14021 (1999): Type II Self-declared Environmental Claim for first parties prohibits the use of vague or non-specific language such as "environmentally friendly' or "non-polluting" or "green" in a claim. Under this type of Label the assessment, verification and certification protocols are all under the control of the product manufacturer. As there are no definitive methods for measuring sustainability, the international standards specifically exclude usage of the terms "sustainability" or "sustainable" in the contents of a first –party claim. Type II labels are typically marketed on the basis of only one environmental attribute, for example, energy efficiency, with a risk that possibly adverse environmental impacts are not made known to the consumer. This label type is the most frequently dogged by concerns of "green washing ". Industry agreements can be to direct association member companies to adopt such a standard as the acceptable code.

ISO 14025 (2006): Type III Environmental Declarations have the following built-in features:

These are designed to foster transparency, impartiality and credibility in the market place, via:

- Independent, third party verification and certification of product claims.
- A whole life cycle assessment based on multiple criteria so that all environmental consequences of a product are identified and addressed in a holistic manner.
- Thorough consultation; and participation of stake holders (producers, consumers, authorities, etcetera) in the standard development process.

Many manufacturers are now resorting to second or third party certification to boost the public image of Type II labelled products. An EPD standard for building products, which is currently under development, is likely to become a US National Standard, subordinating existing Types I and II labels in the USA. The development of a harmonised, European EPD standard for construction products is set to be published in 2012.

In the RSA the White Paper on environment management policy for South Africa (1998)makes specific reference to eco labelling as a means for industry to take greater responsibility for environmental protection, and for the consumer public to gain access to environmental information. This infers a minimum preferred national standard for environmental labelling as per ISO Type I Ecolabel. The White Paper is based on multiple life cycle criteria; and requires public consultation and third- party certification. This policy position has been transcribed into the key items of consumer and environmental legislation. For example, the Air Quality Act of 2004 requires the use of environmental labelling to achieve emissions reductions target; and the minimum requirements set out by the Consumer Protection Act of 2008 include labelling of products which may result in hazardous waste.

A view advanced is that the status of environmental labelling in the SA construction industry supply sector is that the basis for environmental performance assessment and labelling will be Eco Product, a tool founded on the principles and procedures of the Type I Environmental labelling standard ISO 14024: 1999. Eco Standards completed a pilot project in 2011 and intends to launch its construction product programme, which will rely on voluntary participation by construction product manufacturers, in January 2012.

The goal of the South African National Ecolabelling Scheme (SANES), a government funded initiative established in 2007, is to create an enabling environment for South Africa to achieve an important environmental policy milestone – that of using industry self- regulation to complement environmental regulation. SANES provides third-party certification of environmental claims in accordance with principles and procedures of the Type I environmental labelling standards, ISO 14024; 1999. Participation in SANES is voluntary. The stated objectives of SANES are to:

- Unite the growing number of environmental claims "under one umbrella",
- Provide environmental assessment, certification and labelling services for all South African industry sector products;
- Encourage new actions which will enhance biodiversity, minimise waste and pollution and conserve (water and energy)

SANES has developed and piloted Ecolabels for domestic cleaning products and tourism sector. There is currently a process underway to develop SANES Ecolabels for construction products.

SANES is administered by Indalo Yethu, a legacy project of the Third Earth Summit which was held in Johannesburg in 2002. Indalo Yethu was created by the Department of Environmental Affairs (DEA) in 2003.

Environmental Product Declarations

In the European Community key information will routinely be made available by suppliers on an Environmental Performance Declaration (EPD). All aspects and impacts are captured where they occur in the building life cycle stages and sub-stages. For example, waste from the brick production process is allocated to "production", waste generated during transport of the bricks to "transport", brick-waste generated in the bricklaying is allocated to "construction", etc. We can expect that this information will be required to be provided by suppliers in terms of supply contracts and purchase agreements. This will be provided in terms of an Environmental Performance Declaration (EPD).

In the chain of supply of information to the building industry the environmental, social and economic information is based on the input and output of resources, energy and emissions. By Industry Agreement this data may be standardised in terms of assumptions around quarry conditions, brick manufacturing methods, firing fuel sources, distances from point of supply, type of masonry construction etc. This is effectively a further development in Material Safety and Specification Sheets.

Conclusions; The impact of the above issues on the Clay Brick Industry

Materials manufacturing industry initiatives are resulting in a growing "green "marketing effort. Nine out of twenty-one major construction material groups surveyed feature an environmentally sound or "green "brand. There is however a strong trend toward ISO Type II Self – declared claims and therefore a high risk of loss of consumer confidence due to fears of green washing.

Five out of the nine major materials groups identified in the survey (Table 6) – floor covering; decorative paints; doors; windows and frames; particleboard and medium density fibreboard (MDF); and insulation are suspected to have environmental issues which are driving their marketing message. In the absence of a sound basis for the claims the credibility of companies in the long term is a risk, unless they move towards a Type I or Type III approach.

The relevance of the GHG issue and the Industry carbon foot-print must be a concern to some of the CBA publics, and if the Industry players continue to show progress towards cleaner production and innovation, and continue to promote means of making buildings more efficient these publics will be supportive of the CBA and their members initiatives.

NOTES

CHAPTER 9

THERMAL EFFICIENCY & COMFORT ACHIEVED WITH MASONRY WALLING

THERMAL EFFICIENCY & COMFORT ACHIEVED WITH MASONRY WALLING

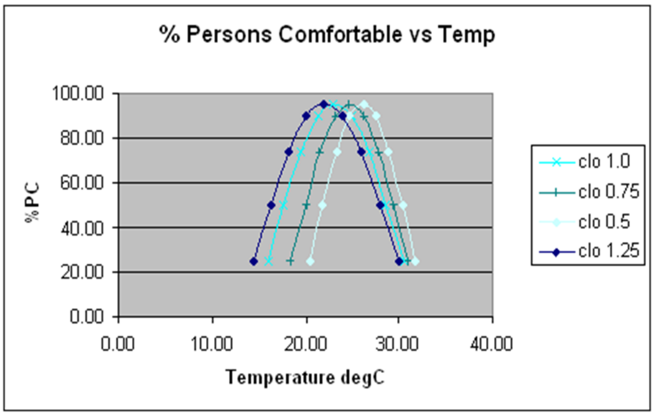
Human Comfort & Adaptive Theory

'Thermal comfort is that state when a certain proportion (80-90%) of respondents surveyed under varying temperatures, humidity, radiant heat, clothing and air movement indicate that they are most comfortable'.

This fundamental research was performed by Professor P.O Fanger who developed the equations linking human comfort to thermal environment.

Fanger produced an index of responses to temperature, which can be translated into the percentage of persons satisfied at each temperature. This work is now incorporated into recognised international standards, such as ISO 7730: 1994 and the ASHRAE Standard 55.

Comfort graphs are developed for sedentary persons at various clothing resistance levels (clo), and are expressed as the Percentage of Persons Comfortable vs. Temperature – as per Figure 9.1

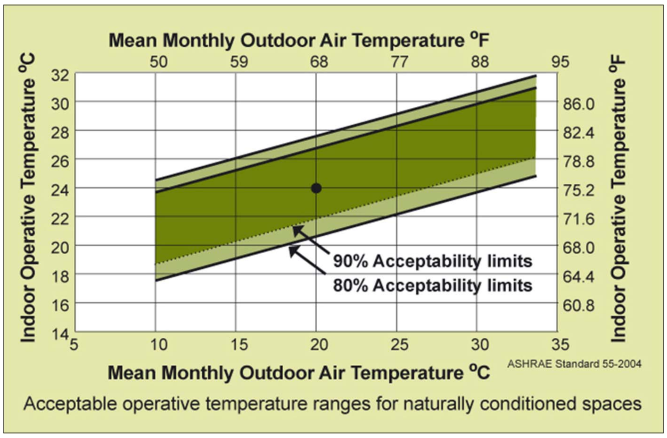


9.1 - The relationship between % persons comfortable and average temperature

For naturally ventilated buildings the thermal comfort range is a range ± 7˚C above or below the temperature, which has been set as the Thermal Neutrality Temperature for that region.

The Thermal Neutrality temperature varies from region to region due to the ability of humans to adapt to local climate conditions.

It is intuitively obvious perhaps, that humans, like other mammalian species, adapt to cooler temperatures in winter and the opposite in summer, such that people living in the hotter regions are able to tolerate the higher temperatures more naturally compared to those living in the colder/elevated localities that are able to function normally despite the very low temperatures. Figure 9.2 expresses these observations graphically, as per the mathematical relationships developed by Schokolay & Elluciems.



9.2 - The range of human comfort temperatures

Benefits of Providing Comfort in Buildings

An immediate benefit of good thermal design for house and building occupants is improved health, which results directly from improved thermal comfort levels.

Improved comfort in buildings will also generate heating or cooling cost savings, due to building occupants requiring less energy to heat or cool their surrounds when they are comfortable. This reduction in energy consumption translates directly into a reduction in greenhouse gas (GHG) emissions.

The poor standard of thermal performance in low income and informal housing in South Africa has been identified by researchers as disproportionate to the expenditure required for heating/cooling energy by the underprivileged as result of these low standards. The financial wellbeing of this community can be improved, through efficient thermal design to meet the required comfort standards.

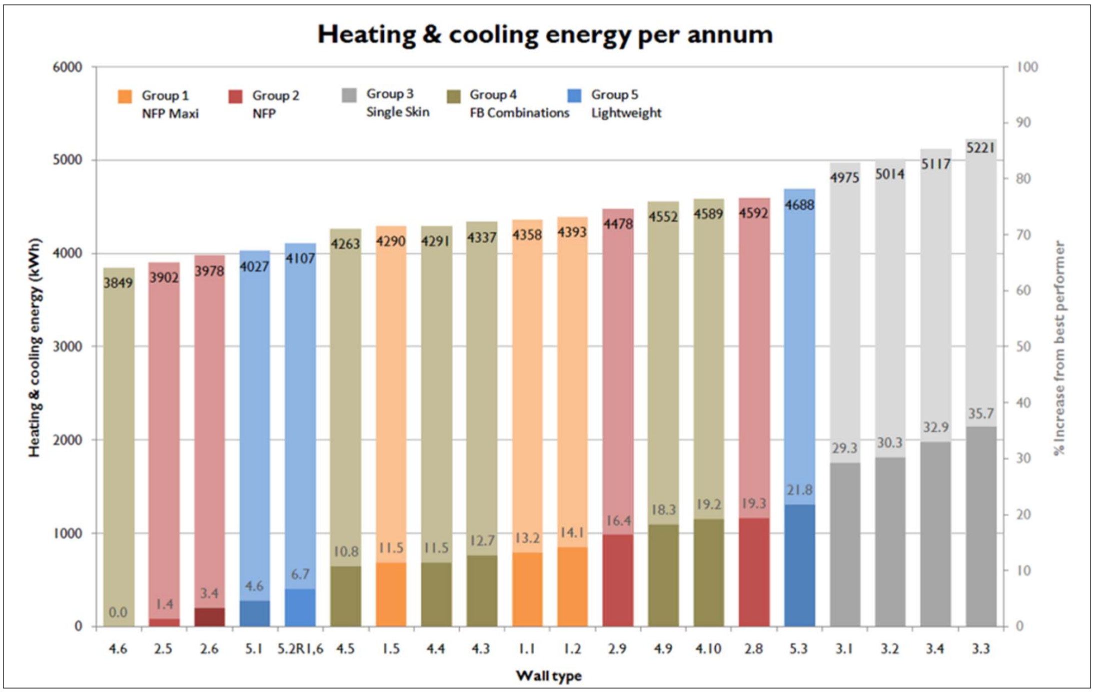
The Clay Brick Association of South Africa has conducted independent research which proves that buildings with optimised thermal performance in the walling, and constructed with clay brick, as well as the appropriate levels of thermal resistance, will consume less heating and cooling energy and are the cheapest for occupants to run.

Building Human Comfort into Building Designs

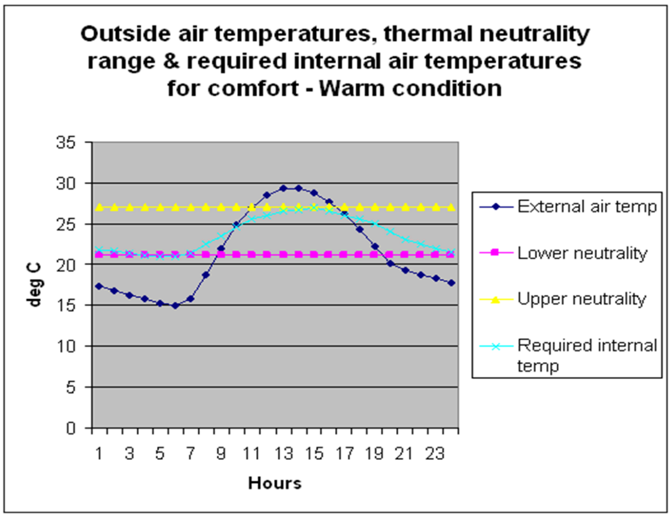
Design strategies that ensure interior air temperatures are within 80% of the human comfort range can be developed using thermal resistance and the thermal mass of walls and floors.

The fluctuation or swing in temperature within a house can be restricted to be within the range of thermal comfort for any region. If this is achieved, the heating requirement can be minimised in winter, with the hot peak temperatures maintained below the upper limits of summer thermal comfort.

The target or maximum daily temperatures permissible or necessary to ensure that indoor temperatures are within the recommended comfort range/s should be incorporated into the



9.3 - Energy usage in housing for various walling solutions, WSP Green-by-Design



9.4 - The range of temperature fluctuation about the comfort range

building design, so as to minimise energy usage. This target swing can be calculated from the building design and materials specification using the CR Method, which is built into SANS 204: Energy Efficiency in building, or by using computer energy modelling techniques.

Important in achieving the above objective is to ensure that the walling, flooring and ceiling surface temperatures are on average or close to the same air temperatures. This is the required Mean Radiant Temperature (MRT), which can be achieved with the requisite thermal resistance and thermal mass designed into these elements.

The importance of maintaining the MRT close to the desired air temperature is as result of the fact that human comfort is 2/3 the radiant effect and 1/3 the conductional and convectional effect of air temperature.

Passive Design Strategies for the various RSA Climates

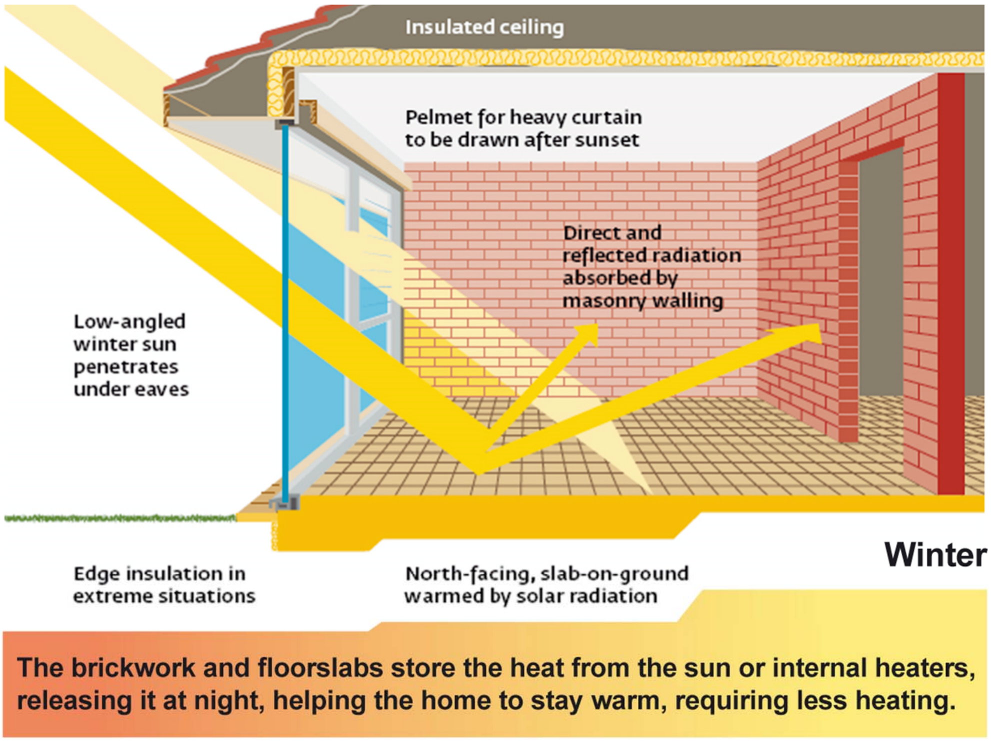
If the design objective is to build an 80% persons comfortable standard in housing in South Africa, it would imply that houses at all times are within the limits of Thermal Neutrality for a particular region. Buildings with a daytime occupancy might have a lower requirement.

Under winter conditions, the range of Thermal Neutrality for most elevated and southerly locations in South Africa is (with acclimatisation) above the range of daily temperature fluctuation. Therefore, advantage needs to be taken of warming via solar radiation entering via windows.

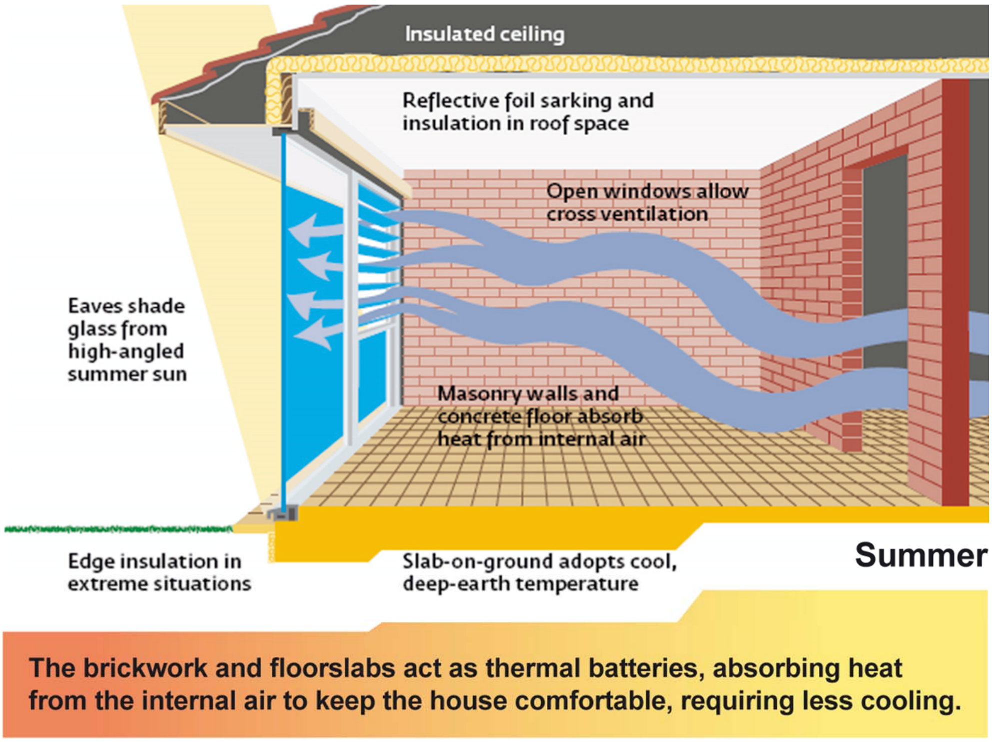
Heating is necessary to bring occupants to human comfort levels, except for the Eastern coastal belt, and for the Lowveld and Limpopo valley region. With adequate ceiling insulation, optimal design of the windows and by adding wall insulation to the cavity, thickening North facing walls and by making use of perimeter insulation heating is reduced.

Under hot conditions, in many temperate South African climates, the range of Thermal Neutrality is within the daily range of temperature fluctuation. In these regions interior comfort can be achieved simply by reducing the amplitude of fluctuation in temperature within the structure, by means of :

- Adding insulation in the ceiling
- Incorporating heavy elements such as Clay Brick walling
- Introducing night cooling/ventilation, by adding wall and perimeter or foundation insulation
- Excluding solar radiation with the shading of windows.



9.5 - Winter Passive Solar Design solutions



9.6 - Summer passive design solutions

Thermal Resistance (R-value)

Building elements, particularly those in the shell of a structure give protection from the outside environment, and from extremes of hot and cold temperature. The measures of how effectively the shell of a building maintains an equable temperature for the benefit of occupants is in part via the Thermal Resistance of the shell.

R-value:

In mathematical terms the Thermal Resistance of an element is the inverse of the Thermal Transmittance; i.e.

R = 1/U and R = d/k;

Where:

R is the Thermal Resistance of an element (m^2K/W)
d is the thickness of the element and
k is the thermal conductivity
(See Technical Note 6 for further explanation)

The Thermal Resistance of a building element or materials provides that the flow of heat always from hot to cold) is impeded. This impedance is measured in terms of the total R-value for a building element, which is the sum of all component R-values of the various materials, the inner and outer air surfaces and any airspaces that make up the composite building element.

The range of R-values for different walling types are as follows:

Double Clay Brick solid wall 0.35 m^2K/W
Double Clay Brick Cavity Wall 0.60 m^2K/W
Double Clay Brick Wall with thermal insulation contributing R=1.0 in the cavity 1.35 m^2K/W

Further discussion on the adequacy of these R-values is provided in Chapter 3.

The thermal insulation materials capable of providing an R=1.0 level of thermal resistance are elaborated on in Technical Project # 1: Masonry Insulation Solutions.

The following will meet the above requirement:

40mm of Expanded polystyrene (partial fill)
30mm of Extruded polystyrene
25mm of Polyurethane foam board (with vapour retarder facing)

These products should be fixed to the inner wall leaf via penetrations of the wall ties.

Thermal Mass or Thermal Capacitance

Thermal Mass is a concept in building design that describes how the mass of the building provides “momentum or inertia” against temperature fluctuations.

The Thermal Mass of a wall absorbs heat (thermal energy) when the surrounds are higher in temperature than the wall mass and gives heat (thermal energy) back when the surrounds are cooler.

Scientifically, thermal mass is similar to specific heat, capacitance or heat capacity.

Thermal Capacity is typically referenced by the symbol ‘c’ and measured in units of J/kg K [J= Joules of heat energy and K = Degrees Kelvin].

Heat Storage Capacity of a building element or material is represented by the equation:

$Q = m \times \Delta T \times c$

Where:

Q = is the thermal energy transferred,
m =the thermal mass of the body
ΔT= is the change in temperature.

C-value:

It is convenient to express the heat-storing capacity of the envelope in terms of the building shell area, i.e. external walls as these are generally the major contributors to the total capacity, and are unlikely to be compromised by wall covering as may be the case for floors, and this we can refer to as the C-value of the walling.

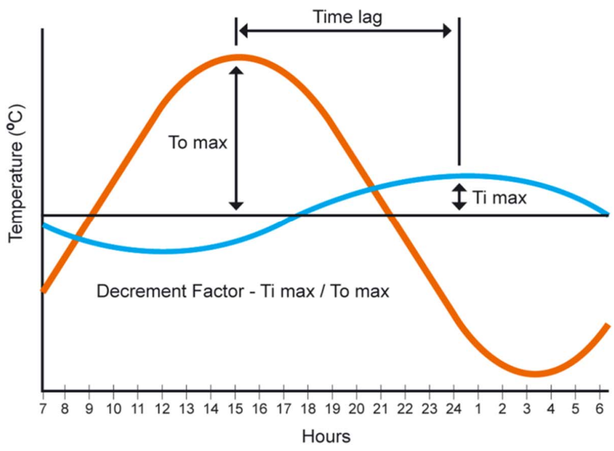
CR-value:

The rate of heat transfer through the element (wall or layer within a wall) is determined by the Thermal Diffusivity which is a combination of the Thermal Resistance and the Thermal Capacity, and equates to the CR-value as developed in SANS 204, and which may be used as a rational design for energy efficient walling.

The CR-Value is conveniently calculated using the product of the calculated R-value and C-value i.e. the Thermal Transmittance and the Thermal Capacity per square meter of the shell of a structure, with a factor to translate the kilo-second units to hours.

$CRs = Cs * Rs * 0.2777$

In the following Chapter the application of the CR-value as per SANS 204 is discussed.



9.7 - Graphical illustration of CR-value effects

In the above graph, the orange and blue - ‘Internal Temperature Fluctuation’ and ‘External Temperature Fluctuation’ depict how Thermal Mass / Thermal Capacitance of a mass enhanced walling envelope can serve to flatten out the daily external temperature swings.

Thermal Mass is effective in improving building comfort in places where average diurnal temperature swings exceed 7°C as is found in South Africa’s six major climatic zones.

NOTES

CHAPTER 10

COMPLIANCE WITH REGULATIONS & STANDARDS

Developments in the National Building Regulations for Energy Usage in Buildings

COMPLIANCE WITH REGULATIONS & STANDARDS

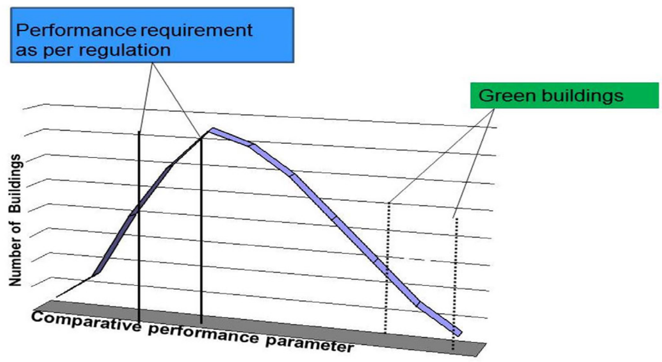
Introduction

The amendments to the National Building Regulations for Energy Usage in Buildings have been implemented with SANS 10400XA Energy Usage in Building established to meet these requirements. The modus operandi of the new Regulatory Environment is outlined in this Chapter.

The South African Constitution clause 24 requires that the Environment is protected, and this clause has given an imperative to Government and citizens establishing a Regulatory Environment, which will shift the nation to move towards a more sustainable future.

The publication of the Amended Regulations National Building Regulations and SANS10400XA; Energy Usage in building is a milestone in the progress towards sustainability for the South African building sector.

The combination effect of Regulation and the voluntary upgrade of the national stock of buildings, in response to market forces, should cause a gradual shift in improvement of performance of all buildings, as per the figure 10.1 below.



10.1 - Gradual movement towards compliance and increasing green building population

Over a period of time, the addition of the new and compliant buildings will add to the total building set and the proportion of non-compliant buildings will drop. The leadership position of the Green Buildings Council of South Africa will be preserved possibly by the addition of further stars, along with other sustainability measures, and the bar will continue to be raised with some buildings eventually achieving an energy positive status.

In line with public sentiment and this gradual improvement in the standard of energy efficiency of prestigious buildings, the norms for compliance with Regulation for all buildings, will need to be revised at some time in the future.

The SANS10400XA documents will therefore need to be continuously reviewed in order to continue to be relevant to the needs of society.

The SABS Technical Committee SC 59G: Construction Standards - Energy efficiency and Energy use in the built environment, is established in part for this purpose.

Amended Regulations

The amendments to the National Building Regulations are made in terms of the National Building Regulations and Standards Act 103 of 1977 and require that:

XA1:Buildings use energy-efficient materials and reduce Greenhouse Gas emissions in accordance with requirements detailed.

XA2: Not more than 50% of the annual volumetric requirement of domestic hot water may be supplied by means of electrical resistance heating.

XA3:Provides for three methods by which compliance with the functional Regulation (XA1) is demonstrated. Compliance with the requirements of Part XA of SA National Standard 10400 will be deemed to be in conformity with the requirements of Part XA of the National Building Regulations.

The Regulations, as published, are legally effective from 10 November 2011, and the Government is bound to promote and defend their implementation, via the mechanisms and procedures established to control new buildings. This is a function of municipalities and specifically Building Control Officers.

SANS 10400XA Satisfies the Regulations

SANS10400 Part XA: Energy Usage in Buildings, is "Deemed-to-Satisfy" the Regulations.

This document is therefore the logical starting point for those persons who need to demonstrate compliance with the Regulations, and this will apply to most projects except the Production and Warehouse portion of a building.

Regulation XA3 and SANS10400XA sets out three routes to compliance with SANS 10400XA, namely

a) Prescriptive provisions for the building envelope and services per XA3(a)
b) A Reference Building route per XA3(b)
c) The Energy Usage and Demand performance requirement method per XA3(c)

The three methods of compliance are all 'Deemed-to-Satisfy the Regulations', however, not all routes are generally available to all persons. A distinction is made between the projects for which compliance is demonstrated by way of a Rational Design by a "Competent Person – Energy" and projects for which the Building Envelope and Services route is followed. The latter route is available to all persons.

Rational Design Options

Two of the compliance routes established in Regulation XA3 and in SANS10400XA, provide that a Rational Design may be performed in compliance of the Regulations by the Competent Person.

The definition of a Rational Design is provided in the Regulations and is the application of a process of reasoning and calculation, possibly based on a widely accepted standard or document. In the wider sense (the) document may be a computer programme, such as reputable energy modelling software, which are usually based on standards like ANSI/ASHRAE Standard 140-2007.

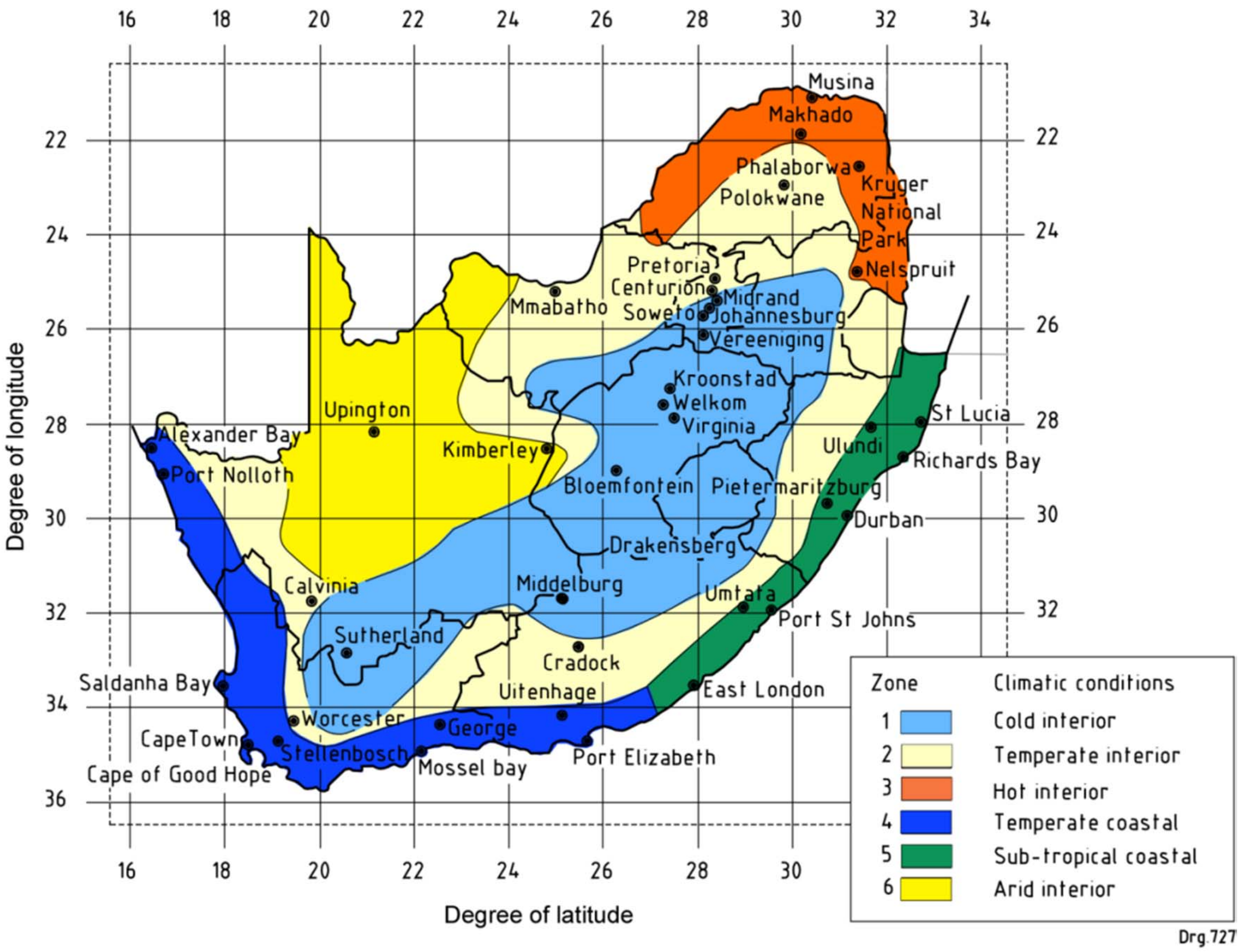
The Rational Design in terms of SANS10400XA can only be performed by the 'Competent Person (Energy).

Prescriptive Route

Regulation XA3 (a) provides that route (i) (the Building Envelope and Services route is generally available to the Appointed Person or his/her nominee, and is the person who may be responsible for the design of a building and compliance with the Regulations.

This route requires the detailed observance of all relevant provisions of SANS10400XA and SANS204, where specifically invoked.

The Climatic Zones



Zone	Description	Major centre
1	Cold interior	Johannesburg, Bloemfontein
2	Temperate interior	Pretoria, Polokwane
3	Hot interior	Makhado, Nelspruit
4	Temperate coastal	Cape Town, Port Elizabeth
5	Sub-tropical coastal	East London, Durban, Richards Bay
6	Arid interior	Upington, Kimberley

A.1 — Climatic zone map

Table A.1 - Locations of cities and towns according to climatic zone

1	2	1	2	1	2
Location	**Zone**	**Location**	**Zone**	**Location**	**Zone**
Alexander Bay	4	Jacobsdal	6	Pretoria	2
Aliwal North	1	Jan Kempdorp	1	Prieska	6
Amsterdam	2	Johannesburg	1	Pudimoe	1
Baberton	2	Kammieskroon	4	Queenstown	2
Badplaas	2	Kainoplaagte	6	Reivilo	2
Barrydale	4	Kimberley	6	Richards Bay	5
Beaufort West	2	Kingwilliamstown	5	Richmond	2
Bloemfontein	1	Kirkwood	4	Riversdale	4
Boshoff	2	Klerksdorp	1	Rooibokkraal	3
Brakpan	1	Kokstad	2	Sabie	3
Brandfort	2	Komatipoort	3	Sakrivier	6
Butterworth	5	Kroonstad	1	Saldanha Bay	4
Calvinia	2	Kruger National Park	3	Sibasa	3
Cape Agulhas	4	Krugersdorp	1	Soweto	1
Cape of Good Hope	4	Kubus	4	Springs	1
Cape Town	4	Kuruman	2	St Lucia	5
Cederberg	4	Ladysmith	2	Standerton	1
Centurion	2	Laingsburg	1	Stellenbosch	4
Ceres	2	Makhado	3	Steytlerville	2
Colesburg	1	Marken	3	Stoffberg	2
Conway	1	Melmoth	5	Stutterheim	2
Cradock	2	Mica	3	Swartberg	1
Dealsville	1	Middelburg	1	Swellendam	4
Delmas	1	Midrand	1	Thabazimbi	3
Dendron	2	Mkuze	5	Toska	6
Derdepoort	2	Mmabatho	2	Touwsrivier	2
Dordrecht	1	Mosselbay	4	Uitenhage	4
Drakensberg	1	Musina	3	Ulundi	5
Dullstroom	1	Nelspruit	3	Umtata	5
Dundee	2	Newcastle	1	Upington	6
Durban	5	Niewoudtville	4	Utrecht	2
East London	5	Northam	2	Ventersdorp	2
Elliot	1	Olifantshoek	6	Vereeninging	1
Ermelo	1	Ottosdal	2	Victoria West	1
Estcourt	2	Oudshoorn	2	Vioolsdrif	2
George	4	Petrusburg	1	Virginia	1
Gouda	4	Phalaborwa	3	Volksrust	1
Grahamstown	4	Piet Plessis	2	Vryburg	2
Graskop	3	Piet Retief	2	Warrinton	2
Gravelot	2	Pietermaritzburg	5	Watervalboven	1
Guyani	2	Pilgrims Rest	2	Welkom	1
Harrismith	1	Pofadder	6	Wellington	4
Hartbeesfontein	1	Polokwane	2	Williston	1
Heidelberg	4	Pongola	2	Witbank	1
Hopetown	1	Port Elizabeth	4	Worcester	2
Hotazel	2	Port Nolloth	4	Zeerust	2
Hutchinson	1	Port St Johns	5		

Compliance Route Decision

Regulation A19 sets out the administrative requirement for the Responsible Person (building owner) to make a declaration appointing a Professional (as identified by the Council for the Built Environment Act 43 of 2000), as the Appointed Person. This will in most cases be the architect, and this person is required to make a Declaration as to the means by which the regulations will be satisfied, and to provide the names of the Competent Persons who will assist the Appointed Person, on the requisite Form 1.

The acceptance of responsibility by the Competent Person is set out on Form 2, together with a Declaration by the Competent Person as to the qualifications, experience and contextual knowledge necessary to undertake such work, and the Local Authority's acceptance of the declarant as an approved Competent Person.

The responsibility assumed by the appointed Competent Person for a portion of the system is acknowledged in Form 3, which also contains critical design Information.

A Certificate of Completion is required on completion of the construction and commissioning of the building by submitting to the local authority a fully completed Form 4 as contained in SANS 10400-A. The implications for this are that the Competent Person (Energy) retains responsibility for seeing the energy aspects of project through to completion.

Energy Usage and Demand Compliance Route

The Energy efficiency performance requirements for the building types in occupancy categories specified (Offices, Shopping Centres and Institutional Buildings) are set out as per Table 2 & 3 below.

It will be necessary to perform a calculation or modelling of the theoretical annual energy usage and energy demand, to assess whether the required energy and demand criteria of Tables 2 & 3 are met.

Even for a very simple building it will be difficult to calculate the Annual Energy Usage to the degree of accuracy required. It is therefore assumed that most such estimates will be performed with software and computer programmes developed for the purpose.

Table 2

Maximum energy demand per building classification for each climatic zone							
Classification of occupancy of building	**Description of building**	**Maximum energy demand[a] VA/m²**					
		Zone					
		1	**2**	**3**	**4**	**5**	**6**
A1	Entertainment and public assembly	85	80	90	80	80	85
A2	Theatrical and indoor sport	85	80	90	80	80	85
A3	Places of instruction	80	75	85	75	75	80
A4	Worship	80	75	85	75	75	80
F1	Large shop (incl. shopping malls)	90	85	95	85	85	90
G1	Offices	80	75	85	75	75	80
H1	Hotel	90	85	95	85	85	90

[a] The maximum demand shall be based on the sum of 12 consecutive monthly maximum demand values per area divided by 12 m²which refers to the net floor area.

Table 3

Maximum annual energy usage per building classification for each climatic zone							
Classification of occupancy of building	**Description of building**	**Maximum annual energy usage kWh/m²/annum**					
		Zone					
		1	**2**	**3**	**4**	**5**	**6**
A1	Entertainment and public assembly	420	400	440	390	400	420
A2	Theatrical and indoor sport	420	400	440	390	400	420
A3	Places of instruction	420	400	440	390	400	420
A4	Worship	120	115	125	110	115	120
F1	Large shop (incl. shopping malls)	240	245	260	240	260	255
G1	Offices	200	190	210	185	190	200
H1	Hotel	650	600	585	600	620	630

Note:
1. The annual consumption per square meter shall be based on the sum of 12 months monthly : of consecutive months.
2. Non-electrical consumption, such as fossil fuels, shall be accounted for on a non-renewable primary energy thermal equivalence basis by converting mega joules to kilowatt hours.

Table 4

Design occupancy times	
Classification of occupancy of buildings (See annexure at end of Chapter)	**Design occupancy times hours per day/days per week**
A1 and A2	18/7
A3 and G1	12/5
A4	6/4
F1	12/7
H1	24/7

The theoretical annual energy consumption of the buildings are calculated using certified thermal calculation software and climatic data, as published by Agrément South Africa, to formulate the energy usage forecast.

In order to achieve a uniform basis for assessing building performance, standardised stipulations are required to be made, when using energy design software. These cover the following areas:

- Occupancy hours
- Occupancy density
- Small power internal heat gains
- Temperature set points for operation of the building
- Ventilation assumptions
- Heat gains for occupants

Building Envelope and Services Route

All buildings including residential buildings, hospitals and those classes of buildings which are not built according to a rational design by a 'Competent Person' and the performance requirements of Tables 2 & 3, need to be designed & built in accordance with paragraph 4.2.1 b) of the standard.

This section contains requirements for walls, fenestration & roofs, and floors if in-slab heating is installed, and for hot water. The orientation, shading and building services invoke the provisions of SANS 204: Energy Efficiency in buildings and these are hence deemed-to-satisfy.

This will require the architect and/or engineering professionals, as well the contractors to ensure that the prescriptive requirements of SANS10400XA and relevant parts of SANS204 are met.

This method of compliance is required to be selected by the Appointed Person at the outset of the project and may be implemented by the professional design and the construction team without the appointment of a Competent Person - Energy.

The Reference Building Route

A reference building is initially designed with all of the elements necessary in terms of the above Building Envelope and Components route, and is then compared with the planned design.

The initial building is modelled with the prescriptive aspects built into a base case design in order to establish a reference energy usage and demand budget. SANS10400XA is specific in regard to certain aspects of the buildings shell, but the balance of the detailed Deemed-to-Satisfy requirements for Building Services, are to be found in SANS204.

The design is thereafter modified with the required features of the professional team and the annual energy usage and demand is compared to the reference building.

If the modified design shows an equivalent or improved energy usage over the reference building it can be said to comply with the regulations.

Some potential for flexibility is built into the standard by the introduction of the so called 'Reference building method'. This will give opportunity to the architect or the engineering professionals or the Contractor to introduce innovative energy efficiency aspects which will yield the same or more energy efficient building than would be achieved by the application of the Building Envelope and Components methods.

This (Reference Building) method is exclusively available to the Competent Person - Energy.

Guidance and Comments as the choice of Compliance Routes

The factors influencing the choice of compliance route are:

- Size of projects
- Skills of the professional team
- Client preferences and willingness to pay for energy modelling

Clients will be advised to appoint a professional team with the requisite skills in the energy usage area. Thus, the architect, quantity surveyor should all be aware of the need to design for energy efficiency aspects, even if simply to meet the regulations, but also to make the appointment of the Competent Person - Energy, who can add considerable value to the project.

The Regulations are applicable to A1, A2, A3, A4, C1, C2, E1, E2, E3, E4, F1, F2, F3, G1, H1, H2, H3, H4 and H5 occupancies or building classifications in accordance with A20 of Part A of the Regulations.

If the Competent Person – Energy is not appointed then the project has only the option of the prescriptive Building Envelope and Services route available to them.

If the Competent Person has at his or her disposal a team with the requisite energy modelling expertise, then designs can be checked for compliance at an early stage, and a cost effective design can be developed, by way of the Rational Design options available in the regulations.

Compliance with Regulation & Standards for masonry walling in South Africa

The prescriptive requirements for walling of SANS 10400XA are easily met, and constitute little change in so far as Clay Brick walling is concerned. Walls are considered as either fundamentally low mass or as masonry solutions.

Low mass walling is required to have a level of thermal resistance which is differentiated between extreme and mild climates:

Climate Zones 1 and 6 : An R-value of 2.2m²K/W is required
Climate Zones 2,3,4 & 5 : An R-value of 1.9 m²K/W is required

Masonry walls are deemed to comply as follows:

- 140mm hollow concrete block, plastered and painted on both side
- A double skin masonry wall, plastered internally and painted
- Other masonry combinations should have an R-value of at least 0.35 2m²K/W

Research has indicated that the above masonry solutions are inadequate for an energy efficiency design and hence the walling solution offered in SANS 204 (the CR-Value approach) is suggested. This should be used as a Rational Design, with the Reference Building compliance route being applied, in order to optimise the walling and other energy saving solutions.

CR-value Application

Table 1: Sets out the minimum CR product requirements for various occupancies in differing climatic zones.

Table 2: Indicates how the CR-product values may be achieved with masonry walling.

Table 1 - Recommended CR-product values for Regions and Occupancies

Minimum Thermal Capacity & Resistance CR Product, in hours, for external walling						
Occupancy Group / Climate Zone	**1**	**2**	**3**	**4**	**5**	**6**
Residential E1-3,H1-5	100	80	80	100	60	90
Office & Institutional A1-4,C1-2,B1-3,G1	80	80	100	100	80	80
Retail D1-4, F1-3,J1-3	80	80	120	80	60	100
Unclassified A5, J4	NR	NR	NR	NR	NR	NR
Note: NR = No requirement						

Table 2 – Typical CR product values for masonry walls

Wall Type	106mm Double Brick (DB)	DB with 50mm air cavity	DB with R=0.5 cavity insulation	DB with R=1 cavity insulation
CR (hours)	40	60	90	130

Notes to the above tables

a) For the CR product values of walls, contact the relevant manufacturer/s.
b) Table 2 provides typical values for masonry walls, with or without additional insulation.
c) R=0.5 and R=1.0 refers to the thermal resistance of the insulation only, in m²K/W.
d) Thermal resistance that is added to external walling with high thermal capacity, should be placed in between layers e.g. in the cavity of a masonry wall.
e) Thermal resistance should not be added to the internal face of a wall with high thermal capacity.
f) Wall systems that have low thermal capacity and / or resistance will not meet the above requirements.
g) Designers should consider that interstitial condensation occurs in walling systems which are not able to prevent or accommodate moisture migration. The selection of vapour barriers and appropriate construction materials, including insulation, is important for the thermal efficiency of walling in climate zones where damp and high relative humidity is experienced.
h) Occupancies as per SANS 10400 A are listed below

NOTES