SALES PRODUCT TRAINING

Clay Brick Manufacture & Performance






THE VOICE OF THE CLAY BRICK INDUSTRY

CLAYBRICK for good

SECURE SAVE SUSTAIN STYLE

environment-friendly

CLAYBRICK.ORG

THE SMART CHOICE FOR LIFE

INTRODUCTION

ClayBrick.org has pleasure in providing this Sales Training Manual which has been designed as a practical resource tool for ClayBrick members to train their sales personnel and other representatives on Clay Brick products.

This information covers the basic requirements of Clay Brick manufacture and its performance attributes. While reference has been made to regulatory standards and codes of practice, these are not intended to overrule or replace any new or existing building regulations and/or SABS Codes of Practice.

At all times, it remains the responsibility of the building professional to ensure that the building conforms to the architectural plans, appropriate building standards and conditions of the project.

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Environmentally Friendly

PART 1
THE BENEFITS OF CLAY BRICK

Clay brick is the most reliable and enduring of all building materials. Few other fabricated building units have enjoyed such widespread and continuous popularity.

The benefits of clay brick include the following:

1.1 Acoustic Insulation

Apart from its natural thermal qualities, clay brick has highly sought after acoustic properties that facilitate the reduction of external noise. Acoustic insulation is the ability of a wall to resist the transmission of airborne sound. The density of clay brick provides maximum insulation against noise.

1.2 Aesthetic Appeal

In colour, form and texture, clay brick is a harmonious building material with an ageless ability to blend in with any structural and building design. It is also a natural complement to the functional and aesthetic needs of the area. Clay brick buildings retain their original beauty even after long-term exposure to weather and other environmental elements.

1.3 Comfort

The nature of clay brick has a number of benefits in terms of breathability, thermal insulation and sound insulation. This ensures that the inside of a building is a place where people can feel truly comfortable.

1.4 Consistency

Clay bricks are made to the same formula that has been used in the construction of many prominent landmarks. To date, it is proven to be a durable and aesthetically pleasing building material that performs consistently over long periods of time. Clay brick owes its unique properties such as strength, durability, dimensional stability, longevity, fire- and weather-resistance to the final composition of raw materials as well as a time trusted process that is as rich in tradition as it is in performance.

1.5 Compatibility

Clay brick is a natural complement to other organic building materials like stone and timber.

1.6 Cost Effective

Buildings should be built to last and as such the life cycle value of a building derived from long-term durability, low maintenance and energy savings should be the key determining factors to be taken into account. Clay bricks fulfil all these requirements in ensuring solid quality constructions, and offer the most efficient and cost-effective solutions in the long-term.

1.7 Dimensional Accuracy and Symmetry

Clay bricks have the highest dimensional stability and compressive strength. Deformations in buildings can lead to creep and shrinkage of mortar, which in turn can lead to surface cracking due to compressive strains and temperature fluctuations, thus jeopardising the safety of the entire building. These cracks can be avoided by adapting the structural design to the properties of the building material, using a building material with extremely low deformation values, like clay brick.

1.8 Durability

Durability is as an important factor in sustainable building design. The longer the building lasts the fewer materials and less energy it will consume over the long term. Clay brick is a durable and timeless building material that complements the aesthetic and functional needs of any building. Structures that were built from clay brick, and still remain standing, even after centuries of exposure have proved the durability of clay brick many times over. Thus, with very little maintenance, buildings made from clay brick can outlast many generations.

1.9 Ease of Use

Seldom do clay brick become too wet to work with, which means builders and developers benefit from significant savings on time and labour too.

1.10 Energy Efficiency

Clay bricks are renowned for their thermal attributes that provide warmth in winter and cooler conditions in summer, thus ensuring that energy is not squandered on artificial heating and cooling mechanisms.

1.11 Environmentally Friendly

Clay brick is a product of 'mother earth' and after use, can be crushed and returned to earth, or recycled. Not only do recycled clay bricks contribute towards embodied energy savings, they also extend the life cycle of this material.

1.12 Fire Resistance

Since clay brick is incombustible it cannot contribute to the start or rapid spread of fires, nor can it add fuel to make a fire more intense. Tests have proven that clay brick walls obtain maximum fire ratings, which means that they can withstand fully developed fires longer than any other standard building material.

1.13 Strength

Clay bricks vary in compressive strength due to the differing qualities of raw materials and the method of firing. The compressive strengths of clay bricks can vary from 7MPa for NFP, to more than 50MPa for Face Brick Extra. Clay brick products for load-bearing designs can be provided according to specific tolerances and strength.

1.14 Symmetry

The majority of clay bricks in South Africa are regular in size and shape. Although they are fashioned from a very forgiving material that does not require perfect symmetry, all clay brick products conform to stringent SABS industry codes that define the parameters of product manufacture, building design and materials application, and are deemed fit for purpose.

1.15 Value Retention

Buildings constructed from clay bricks are built for generations to enjoy. Thanks to their natural inherent properties they are able to resist the extreme and varying weather conditions. Clay brick is renowned as an everlasting material, and requires very little maintenance to preserve its elegant looks, thus enhancing its desirability for future owners.

1.16 Versatility

Clay bricks are available in a variety of colours, shapes, and textures to suit any building application. A key characteristic is the way clay brick walls and pavers remain solid and pleasing to the eye, even after long term weather exposure.

1.17 Weatherproof

Clay bricks are rendered water resistant making them impervious to all forms of climate conditions. They comprise of a fine capillary pore system, which enables moisture from rain or water vapour to be absorbed and then released back into the atmosphere again as quickly. This property is specific to clay brick. Other building materials can certainly absorb moisture, but lack a capillary system, which means they remain moist for much longer and may have relatively high permanent moisture content.

CLAY BRICK MANUFACTURE

PART 2
CLAY BRICK MANUFACTURE

Clay brick is the simplest and most ancient of all building materials. Few other fabricated building materials have enjoyed such widespread and continuous popularity. This enduring public acceptance is based on the unique combination of inherent 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, the clay can be readily moulded into various shapes and sizes. The flexibility this gives to design and construction makes building with brick most cost-effective.

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 wide range 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% and 10%. By adding manganese dioxide in proportions from 1% to 4%, a range of grey and brown colours can be produced.

More important than their chemical composition are the facts that:

i) When mixed with water, the clay minerals give a plastic mass that can be shaped by pressure to form a brick

ii) Controlled evaporation of the free water surrounding the particles in plastic clay minimises excessive shrinkage and defects in the structure of the brick.

iii) At economically practical temperatures ranging between 1000° to 1200°C, the clay particles can be fused into a cohesive mass of great compressive strength.

Modern brick manufacture involves high speed processing at extrusion rates of at least 25000 bricks per hour.

Solid bricks, the size more traditional to South Africa, i.e., 222mm x 106mm x 73mm, weigh 3kg to 3.5kg. Therefore, 1000 fired bricks weigh approximately 3.5 tons.

In the wet state before firing, the clay is heavier. For every 1000 bricks at least 4 tons of material must be dried, and fired to a temperature of 1000°C to 1200°C (depending on the clay used) and cooled down.

2.1 The Brickmaking Process

The brick-making process can be divided into five separate stages namely:

i) Winning and stockpiling of the clay
ii) Preparation of the clay
ii) Shaping of the products
iv) Drying of the products
v) Firing of the products

2.2 Winning and Stockpiling of Clay

Mining or quarrying takes place using the open cast mining method, i.e. the topsoil and overburden (unusable material) is removed using mechanical scrapers or hydraulic excavators, exposing the usable clay material. Heavy earth-moving equipment such as bulldozers, hydraulic excavators and mechanical shovels are then used to extract the suitable clay and shale from the pit. Clays and shales with different properties can be found in the same quarry and it is the brickmaker's skill and experience that determines the mining procedure and volume of each material mined.

The clay is then transported by dumper truck or by fixed conveyor system to stockpiles. The clay is stockpiled either as the individual material or blended in a layered stockpile. The stockpiles function as blending piles, conditioning piles and storage piles and can hold a capacity from one month to a year's production. The main aim of stockpiling is to obtain uniform clay material over long periods of time.

2.3 Clay Preparation

After the mining process the materials used for brickmaking range from very soft and fine clays to very coarse and hard lumps of shale. A large variety of methods and machinery are therefore employed by the industry for the preparation of the raw materials.

The size reduction process can be divided as follows:

Primary Crushing	:	Reducing the lump size to ± 80mm
Secondary Crushing	:	Reducing the size further to ± 8mm
Tertiary Crushing	:	Reducing the size to 0.8mm

For softer materials often only one type of crusher is used.

The most common crushing and grinding machinery used in South Africa are rolls crushers, hammer mills, impactors, pan mills and refining rolls.

The preparation process includes screens through which the material passes either before (scalping screens) or after crushing. At this stage, additives such as coal, manganese, sand, grog (crushed brick) and ash are added depending on the properties required.

The material can now either be stored under shelter or taken directly to the forming process. More advanced processes involve passing the material through a primary mixer where water is added and the moist material stored in bunkers. This enables souring to take place, i.e. the water molecules penetrate and surround individual clay particles improving workability, resulting in more uniform shrinkage of the green bricks.

2.4 Shaping of Clay Bricks

2.4.1 Soft-Mud Hand Moulding

This method is still used in rural areas across South Africa, and basically requires the use of moulds only. The process involves throwing a clot of soft clay into a wooden mould, the working surfaces of which have been wetted and sanded.

The clot, larger than the mould, is rolled on a sanded bench to produce a loaf-shaped lump, which is thrown into the mould. Surplus clay is removed by means of a wire bow or a wooden striker. The brick is then turned out of the mould for drying.

The mixture, with a water content of about 30% also contains an appropriate amount of sand, which helps to ensure the correct consistency. This also assists with drying and minimising the potential of cracking during drying.

Due to the high moisture contents and low forming pressures involved, these bricks are generally of poor quality with large dimensional variances. They are also non-uniform in shape with low compressive strength.

2.4.2 Semi-dry Pressing

Although still used at some brick factories in South Africa, this method is best for low volume special shaped bricks rather than high volume mass production. In this process, the body mix is prepared with sufficient water to bind the mass together on exposure to high pressure, but not enough for plastic flow to occur.

Semi-dry pressing can be used to shape most clays into regular solid shapes, including bricks for walls and floor tiles. The amount of pressure required depends on the nature of the raw material and moisture content. In general, as the water content goes up, so too does the pressure required for shaping go down. Greater dimensional accuracies are attainable with the use of low moisture contents of the dry powder, but the risk of lamination increases.

The clay is ground and screened in the usual way. The water content up to 12%, depends on the particular material. The clay is stored in a feed hopper above the press and is gravity fed into the hopper box, which transports the clay directly to the mould box. Pressing takes place in the mould box between two moveable piston heads.

Due to the low moisture contents used and the high forming pressures involved, pressed bricks can be of high quality and strengths, with small dimensional and shape variances.

2.4.3 Extrusion

The most characteristic property of moist clay is plasticity and it is this property, which enables the bricks to be shaped by passing a clay water mixture through a suitable orifice or die to form a continuous column, which is then cut into appropriate sizes. Since the cross-section of the column must be constant, extrusion is limited to relatively simple shapes, for example solid or perforated bricks and hollow blocks.

There are two types of extrusion processes:

i) Stiff Extrusion : 12% to 20% moisture content
ii) Soft Extrusion : 20% to 30% moisture content

Each of these processes has their own advantages and disadvantages. The stiff extrusion process is fast becoming the worldwide standard for the production of bricks. The prepared material (crushed and ground) is fed into a mixer and tempered with an appropriate amount of water. The mix then passes through a de-airing chamber where all the trapped air is removed.

This improves the density, strength and workability of the material. The de-aired fragments are forced together by decreasing the diameter of the auger barrel so that it tapers to fit the die. The auger forces the material through the die forming a long continuous column. The pressure created depends on the ease with which the clay flows, which is determined by the type of clay, water content, lubrication of the die and the reduction in the cross-sectional area from the barrel to the die.

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

The individual green bricks are removed from the offset belt either manually or by machine/robot and then set into packs on pallets, which are then loaded directly onto dryer trolleys or kiln cars.

2.5 Drying of Clay Bricks

Water is required to shape the brick products, and once formed is extracted as part of the drying process through evaporation.

A wide range of dryers are used throughout the brickmaking industry, which is broadly classified into two types:

Intermittent : This is a batch process. The goods are placed in the dryer where they remain until sufficiently dry. They are then removed and replaced with fresh moist products.

Continuous : The stacked bricks pass continuously through the dryer, entering one end of the system wet and leaving the other end dry.

2.5.1 Intermittent Dryers

i) Open Air or Hack Drying

In South Africa, there is adequate sun for the drying operation and most clamp kiln brickmakers make full use of this free source of energy by placing the bricks on open hack lines. Hack lines are open-air storage facilities where the green brick pallets are stockpiled in individual lines and left to dry naturally. This process can take three to six weeks depending on weather conditions.

Despite the absence of fuel costs and complicated machinery there are a number of downfalls to this method of drying:

- The unpredictability of the weather even in the most stable climates.
- Climates are seasonal with weather patterns varying from summer to winter, therefore the production rate cannot be controlled.
- Considerable handling is always required, with accompanying wastage.
- Even for a small factory the space required is enormous.

ii) Shed Drying

This is an improved version of hack drying in that it uses a permanent structure, which may simply comprise of a roofed structure with or without sides. It is a more flexible process that is not affected by the weather, and if necessary can be adapted to use waste heat form the kilns to assist the natural drying process.

iii) Chamber Dryers

Chamber dryers are very popular in brickmaking, although they are not as efficient as tunnel dryers. Chamber driers are large rooms where the bricks are packed onto pallets, with a capacity of 50000 to 60000 bricks. With these dryers the pallets can either be set to discharge through a single door (chamber type) or for better production flow can be loaded from one side and discharged through the other (corridor type) end, either on cars, or on rails or simply on pallets.

Chamber dryers can virtually be any size, but typically around 2-3m wide x 3m high and any length depending on the output of the factory. Although these dryers are normally heated from the base, various types have hot air entering through the walls, and/or roof. There is normally an inlet at the low level and an outlet at the high level to remove the moist air.

To control the dryer chambers is relatively simple and flexible, in that it is very easy to change the temperature and humidity in a very short time. They can be heated using waste heat from the kiln or supplementary heat can be added via a chain grate stoker.

Drying time is between 30-45 hours - much quicker than the 14-42 days required for hack drying.

2.5.2 Continuous Dryers

i) Tunnel Dryers

Tunnel Dryers are commonly used with tunnel kilns when the clay-ware is rigid enough to enable it to be set onto kiln cars, either directly from the making machine or after a brief drying period to create a little more rigidity.

Most tunnel dryers operate on the counter-flow principle. This process has one main disadvantage, in that the air is so saturated by the time it reaches the end, that instead of drying the bricks it tends to make it even wetter, which means that the drying only takes place in the second half of the tunnel.

This can largely be overcome by introducing air, at several points along the tunnel, which will also help in re-circulating some of the humid air so that the drying rate is stabilised along the whole length of the tunnel. This operation can take 40 - 50 hours, from green to dry.

2.6 Firing of Clay Bricks

On firing clay brick products, chemical and mineralogical changes occur. These are accompanied by physical changes in density, porosity, volume, strength and hardness, for example. It is these changes, which determine the usefulness of clay bricks.

2.6.1 Chemical Changes when Firing Clays

Chemical changes when firing clays can be divided into three distinct stages:

i) Dehydration Stage (water smoking stage): 100ºC - 650ºC
Despite drying there is always a considerable amount of water left in the bricks when placed in the kiln. Much of this is combined water, which never comes off under normal drying conditions. Usually at about 150ºC all of the uncombined water (physical water) removed, with most of it at about 100ºC (boiling point). It is not until about 650ºC that all of the combined water is removed, i.e. water, which is part of the crystal lattice.

ii) Oxidation Stage: 300ºC - 800ºC
Oxidation reactions already take place as the water comes off and also when vitrification starts. Many reactions occur during this stage, depending on the composition of the body materials. Typical reactions include the oxidation of carbon, sulphur compounds, and iron bearing minerals, as well as the oxidation of lime and magnesium bearing minerals.

iii) Vitrification Stage: 800ºC upwards
For some clays, vitrification starts at ±800ºC, although for refractory clays this is much higher. This stage stretches from the point where vitrification starts through to the highest temperature the material can withstand without any serious distortion.

The temperature during vitrification ranges from ± 30ºC for some very impure clays, up to ± 250ºC for very pure clay. This is known as the vitrification range. Essentially vitrification is the stage in which reactions occur that produce the glassy phase, which on cooling is responsible for the strength and other properties of ceramic articles.

Fired Colour:
Colour changes take place throughout the whole firing cycle, with the most significant changes occurring during the vitrification stage. Nearly all of the colour changes are due to the presence of iron compounds, and in this respect it is the oxidation state of the iron which controls the colour. During firing all iron compounds, no matter whether they are oxide, sulphate, sulphide, carbonate or anything else are at the beginning of vitrification - all converted to the oxide. If the firing is done under oxidising conditions, one gets Ferric Oxide Fe_2O_3 and it is this compound, which is responsible for reds and yellows produced by firing. Alternatively, if done under a process of reducing temperature conditions then the oxides produced are FeO and Fe_3O_4 and this gives the blues and blacks, which are characteristic of a reduced product.

2.6.2 Physical Changes when Firing Clays

i) Porosity
With brickmaking materials the particles decrease in porosity during firing. Bricks for building should be moderately porous, however these pores should not be too big or the porosity too high, as rain water will be absorbed causing permanent damp spots on the walls. At the same time the bricks must be sufficiently porous to be able to absorb mortar to give it a strong bond in the walls. The water absorption of bricks is classified as:

- 16% - 20% as high but acceptable for stock bricks
- 12% - 16% as medium but satisfactory for stocks and face
- 8% - 12% as low for stock but acceptable for face bricks

ii) Permeability
Building bricks should as far as possible be completely permeable to air, and only partially permeable to water. An increase in temperature will result in a decrease in permeability.

iii) Volume Change
During the vitrification stage, part of the ceramic material melts, resulting in the remaining crystals move closer together. Up to the point of vitrification, shrinkage is not very high, thereafter the material shrinks quite rapidly until completion of vitrification process. These volume changes are important in determining brick sizes.

iv) Strength and Hardness
Generally the higher the temperature the bricks are fired at, the stronger they become. As the strength increases, so too does the porosity decrease proportionally. The same applies to hardness, i.e. the higher the firing, the harder the product although the hardness of a brick product is not often determined.

v) Weight
Nearly all bricks show a decrease in weight after firing as a result of the reactions as outlined above, like the removal of water during the dehydroxilation stage, the oxidation of carbon and in fact any mineral that is decomposable.

To sum it up, different classes of bricks require different properties:

a) Stock (Plaster) Bricks
In order of importance the desired properties are strength, porosity and dimensional stability, with appearance being of no consequence as the bricks will be plastered.

b) Face Bricks

Strength and appearance are equally important, followed by porosity and dimensional stability.

c) Engineering Bricks

Strength and porosity are the main properties, with both being subject to rigid specifications, followed by dimensional stability

2.6.3 Kilns

Clay bricks can either be fired through an intermittent process by using clamp kilns or a continuous process using Hoffman kilns, TVA kilns or tunnel kilns.

a) Clamp Kilns

A clamp kiln is not a permanent structure, with the bricks themselves constituting the kiln. It is a solid pack of green bricks set on a grid base containing small coal nuts. The grid is the fuel bed that supplies the initial energy to light the clamp kiln. The rest of the energy required for firing is contained within the bricks. Firing a clamp can take anything from ten days to four weeks depending on weather conditions, as well as the packing pattern and amount of fuel used.

A continuous clamp involves setting bricks in front of the fire whilst de-hacking behind the fire. Very little control over the firing process is possible with brick qualities ranging from under-fired to clinkered products being obtained.

b) Continuous Chamber Kiln

More modern and advanced brickworks in South Africa are making use of continuous firing methods. Continuous chamber kilns include the Hoffman Kiln and the Transverse Arch or the TVA kiln. Basically, the air required for combustion is pre-heated by cooling the bricks, before it passes through the firing zone. The products of combustion are used to heat the bricks, prior to firing. The fire thus travels around the kiln from chamber to chamber.

Each day, green bricks are placed in cleared chambers, in front of the fire with the fired bricks removed from behind. Two or three adjacent wickets (kiln chamber doors) are usually kept open for this purpose. When a chamber is full, the wicket is bricked up and fuel (coal, oil or gas) is fed 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 around the entire kiln every 7 to 10 days. The hot gases from the firing zone are drawn forward 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.

Open roof Hoffman Kilns, Zigzag Kilns and Bull's Trench Kilns which operate on similar firing principles as the TVA Kiln have become more popular in South Africa to ensure compliance with the Air Qualities Act. These kilns are different from TVA and Hoffman kilns in that they do not have a fixed roof. After the green bricks are set in the kiln, the top of the setting is sealed off, normally with a layer of reject fired bricks, soil and mud. Natural or forced drafts are used to control the firing process. All the fuel required for firing can be added to the body or from the top into the setting during the firing process.

c) Continuous Tunnel Kiln

Tunnel kilns were originally only coal fired, but in recent years oil and gas have taken precedence. In principle a tunnel kiln has three main zones: pre-heat, firing and cooling.

The cars pass through the zones at a pre-determined rate, controlled by a hydraulic pusher at the entrance. For a particular firing schedule the zones are maintained at a given temperature. Fans supply the air for combustion and cooling, which moves in a counter-flow direction to that of the cars. Products of combustion are drawn to the entrance of the kiln and extracted by exhaust fans.

Over the years tunnel kilns have undergone steady development and today represent the most economical type of kiln for firing heavy clay products. Other advantages of tunnel kilns are that cars can be loaded and unloaded in open areas, and always at the same loading points, so that handling problems are simplified. The kiln car acts as a conveyor belt with the bricks being fired as they pass through the firing zone.

Tunnel kilns are mainly used to produce large volumes of face bricks, that are consistent and of high quality. However, plaster bricks are also often produced in tunnel kilns when the demand or economic conditions dictate.

d) Vertical Shaft Brick Kiln (VSBK)

The VSBK has only recently been introduced to the South African clay brick industry. Given its low polluting capability and high-energy efficiency, it is one of the most environmentally-friendly kiln technologies. It is classed as a continuous updraft kiln and represents a unique method of firing. It combines the simplicity of low cost updraft firing with very good fuel economy, as well as the benefits of continuous operation.

The VSBK consists of a vertical shaft approximately 6.5m in height by 1m². At the base of each shaft is an unloading tunnel running through the centre of the kiln. This allows for access to both sides of the base of the firing shaft which contains the brick support and unloading equipment. Bricks and coal are loaded one batch at a time at the top of the shaft, with coal fines sprinkled amongst the bricks one layer at a time. Each tunnel has a capacity of 3840 bricks every 12 hours.

The position of the fire in the shaft is maintained by the rate of removing the fired bricks and reloading green bricks. The firing temperature is controlled by the amount of coal fines added to each batch of bricks loaded. Despite there being no controllable fireboxes with the kiln operating on a least efficient up-draught, it is extremely fuel efficient. This is because the firing shaft creates just enough natural draft for efficient combustion of the fuel, which is spread evenly throughout the firing zone.

The packing of the bricks restricts the draft sufficiently to limit the amount of excess air not required for combustion. The cooling bricks below the firing zone heats up the air for combustion. The hot exhaust gases from the firing zone pre-heats the green bricks prior to combustion. The firing shaft is very well insulated on all four sides, so heat loss is minimised. Once the kiln reaches the required temperature, all the heat from the coal fines goes into the firing of the bricks. Very little heat is lost through exhaust gases or in steady state through the fabric of the kiln.

Brick wastage is very low, between 2% to 5%. This is attributed to the even firing of the kiln, with no over or under-fired wastage due to careless brick handling and low quality green bricks being loaded.

2.7 Sorting and Delivery

After firing, the clay bricks are selected and sorted from the kiln cars for colour and quality. They are then packed onto pallets or into cube packs in quantities of ± 500. Mechanical handling of bricks is a familiar sight in South Africa. In pack systems, signode strapped packs of ± 500, the bricks are arranged in suitable stacks 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.

PRODUCT TYPES AND CLASSES

PART 3
PRODUCT TYPES AND CLASSES (NOMENCLATURE)

Brickmaking and the sale of clay brick products was until recently largely area bound. Local architects and builders have since become more informed on the different qualities, performance standards and types of bricks available from the different regions.

Over the past 10 years, there has been a noticeable trend for bricks to cross new boundaries, with specification and design often undertaken hundreds of kilometres from site. Furthermore, both central and local/provincial government departments have defined the product types and classes in their building material specifications, regardless of parochial nomenclature, so the need for standard nomenclature and performance criteria has become essential.

Examples of brick terms used in the past by the different regions:

- Commons in KwaZulu-Natal
- Stock Bricks in Gauteng
- Fair Face Commons in KwaZulu-Natal
- Hard Burnt Stocks in Gauteng
- ROK's (run of kiln) often require sorting on site to find bricks deemed fit for face, stock and semi-face brick applications.

Some of these terms and descriptions are still used by many building professionals to this day.

The SABS adopted a South African based system of Clay Brick Classification to ensure national definitions of bricks. These are detailed in the specification, SABS 227.

3.1 Standard Clay Brick Types

There are three standard types of Clay Bricks produced in South Africa:

3.1.1 Bricks for Rendered or Plastered Use: NFP's (Non-Face Plaster)

Whether for internal and/or external leaves of a full brick wall, or as the backing to an external face brick leaf, or as a single leaf or half a brick internal wall - rendering/plastering is essential to protect the brick from the weather, or to provide a suitable finish for painting/ceramic cladding. These are called NFP's (Non Face Plaster) known in some quarters as ‘stock bricks’, ‘Commons’ or ‘common bricks’.

3.1.2 Bricks with No Rendering

Bricks produced to face the environment without rendering, and which appearances provide an aesthetic value through colour, texture, accuracy of size and uniformity, or the purposefully produced lack of size uniformity.

This class is divided into three types or grades:

a) Face Brick Aesthetic (FBA)
Durable Clay Face Bricks are produced or especially selected/sorted for a highly individual and aesthetic look derived from deliberate non-uniformity of size, shape and colour. Brickwork using these products are lively and full of character in respect of colour and texture, at close to medium vantage points. Products include the heavy ‘leaf rustics’, rock face bricks, blackhearts and clinkered bricks, which are sometimes known (quite erroneously) as ‘semi-face’.

b) Face Brick Standard (FBS)

Clay Bricks that are durable, uniform in size and shape and require no further rendering or aesthetic treatment. Standard facings are ideally suited to the creation of horizontal and vertical brickwork, with medium to long viewing distances. Travertine and smooth satin textures are the most widely produced finishes in FBS products.

c) Face Brick Extra (FBX)

Durable Face Bricks possess the highest degree of size, shape, colour and uniformity. FBX's are ideally suited to the creation of detailed, disciplined brickwork and may be used for close-up viewing through to the creation of dramatic and visually large design elements, thus providing opportunities for long viewing distances.

3.1.3 Non Face Extra (NFX)

Bricks produced for building work below damp proof course (DPC), under damp conditions or below ground level where aesthetics are unimportant. NFX bricks may be plastered or left unrendered. Bricks of this class are sometimes referred to as ‘hard burnt commons’, ‘footing bricks’ or ‘foundation bricks’.

3.1.4 Engineering Units (E)

These are any class of 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 Mega Pascals (MPa), e.g. FBSE21.

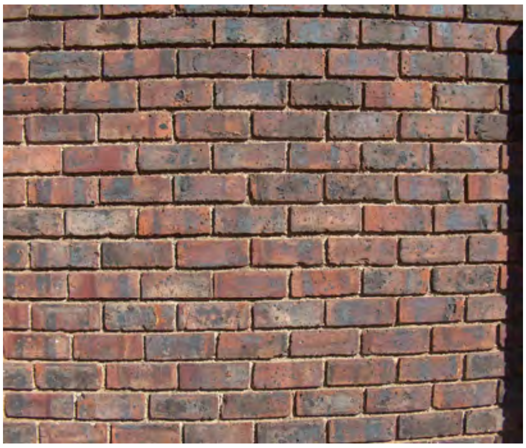
3.2 Surface Finish – Texture and Colour

SABS 227 requires that unless otherwise specified, the texture and colour of masonry units shall be uniform. For the purpose of assessing uniformity of colour and texture, the manufacturer shall, by agreement with the purchaser, submit for the purchaser's approval a sample of 20 units, 10 of which are to be retained by the purchaser and the manufacturer.

The following textures are possible:

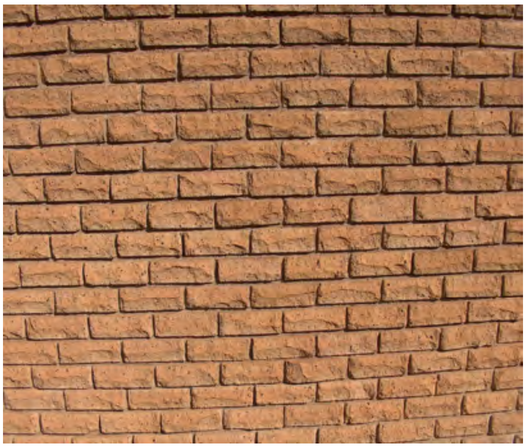
3.2.1 Clinker:

At the heart of these gnarled, bloated, multi-coloured bricks is a distinctive blue or black carbon core.



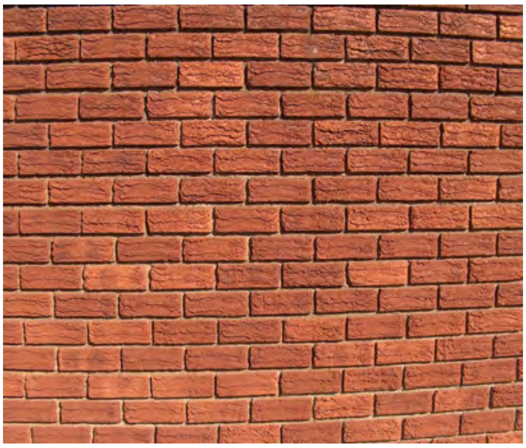
3.2.2 Rockface:

A completely irregular rock-like finish to the stretcher face achieved by chiselling the brick surface, resulting in a raw, craggy and natural appearance.



3.2.3 Rustic:

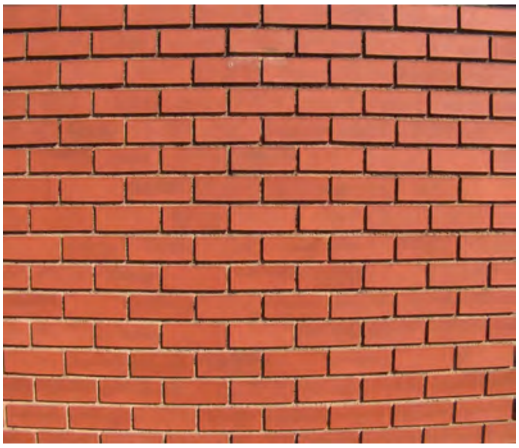
A crusty finish resembling the bark of a pine or oak tree, with a textured surface accentuating differences between light and shadow.



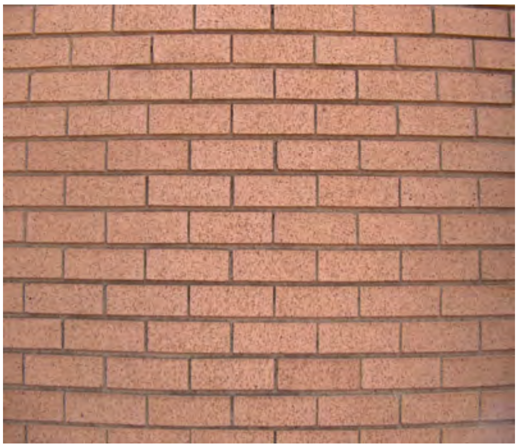
3.2.4 Coral:

A horizontal texture, the 'regular' uneven finish resembles coarse woven cloth.

3.2.5 Satin: A smooth, non-grainy face finish with no texture.



3.2.6 Travertine: Almost smooth but with a natural 'clay grain' appearance.



3.3 Shape and Appearance

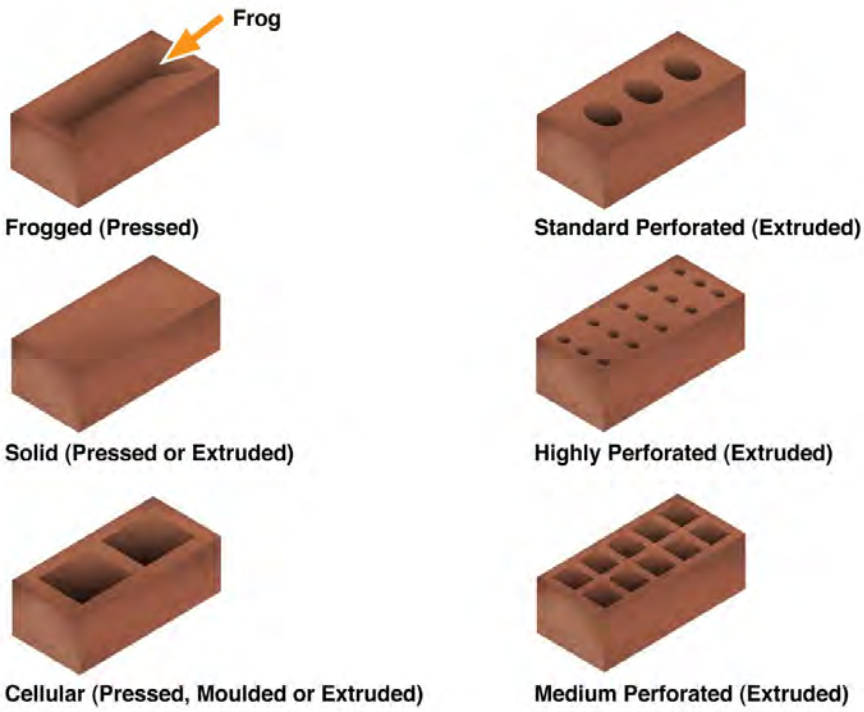
3.3.1 Shape

All units may be with or without frogs, perforations or cavities and (except FBAs), shall be true to the appropriate acceptable pattern. They should have rectangular faces, and those units to be used in facing and structural applications should also have uniform arises. See Brick Units by Method of Manufacture.

3.3.2 Appearance

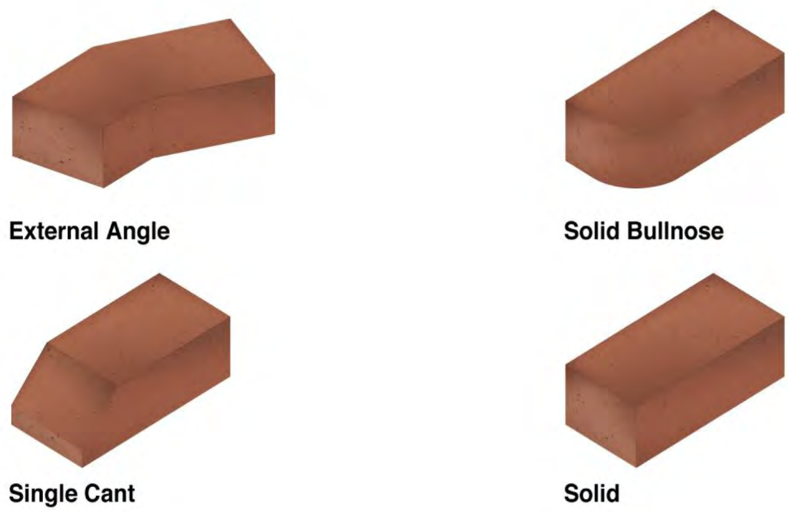
All units should be well burnt and acceptably free of deep or extensive cracks, damage to edges and corners, pebbles and expansive particles of lime. When a cut surface of a unit is examined, it should show an acceptably uniform texture.

Brick Units by Method of Manufacture:



3.3.3 Specials

Standard bricks are shaped as rectangular prisms, but varieties of other shaped bricks are commonly made. These include bricks with splayed or rounded edges. Those shapes which are commonly made are described as 'standard specials' to distinguish them from other forms which may be made to order only.



THE LANGUAGE OF CLAY BRICKS

FBX	**Face Brick Extra**	Clay bricks that are selected or produced for their **durability** and **high degree** of	**uniformity** of **size, shape** and **colour**.
FBS	**Face Brick Standard**	Clay bricks that are selected or produced for their **durability** and **uniformity** of **size** and **shape**.	
FBA	**Face Brick Aesthetic**	Clay bricks that are selected or produced for their **durability** and **aesthetic** effect deriving from	non-uniformity of **size, shape and colour**.
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 criteria for selection
NFP	**Non-Facing Plastered**	Clay bricks suitable for **general building work** that is to be **plastered.**	
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 designed by the addition of the letter E followed by a number equal to the nominal compressive strength in megapascals, e.g FBSE21
PA	**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	**PB Clay Pavers**	Clay pavers that are selected or produced for their durability and for their uniformity in size and shape.	

PRODUCT SPECIFICATION
&
PHYSICAL PROPERTIES

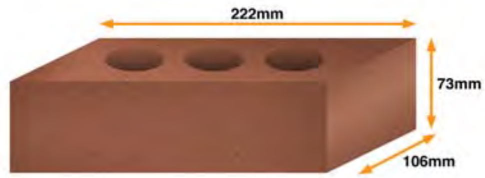
PART 4
PRODUCT SPECIFICATION AND PHYSICAL PROPERTIES
(SABS 227: Burnt Clay Masonry Units)

4.1 Overall Dimensions and Tolerances (SABS 227:4.2)

The most commonly used and manufactured brick size is the 'Imperial Brick'. It measures 222mm (long) x 106mm (wide) x 73mm (high) with a mass of between 3.0kg and 3.5kg, depending on the materials used, the degree of vitrification and perforations provided. (*See Table 4.1 for tolerances)*

Two important criteria determine this size. First, it is the ideal width for the human hand to lift and place in position with minimum strain and secondly, it satisfies the need for bricks to be modular in terms of Bond patterns. Thus, there is an approximate arithmetic relationship of length to width of 2:1 and in length to height of 3:1, which allows for bonding in any direction.

Figure 4.1: Imperial Brick Dimensions



Tolerance on Work Sizes			
Class of Unit	Tolerance (m)		
	Length	Width	Height
	Individual Units		
FBX FBS FBA and no face	+-5 +-7 -	+-3 +-4 -	+-3 +-4 -
	Average 32 Units		
FBX FBS FBA NFP, NFX	+-2.5 +-3.5 - +-3.5	+-1.5 +-2 - +-2	+-1.5 +-2 - +-2

Table 4.1: Individual manufacturers may offer tighter tolerances than above.

Other sizes of bricks and blocks made by independent manufacturers are as follows:

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

4.2 Warpage and Tolerance (SABS 227: 4.3)

FBX Products : Individual 5mm. Average of 3 bricks not more than 3mm
FBX & Engineering : Individual not to exceed 5mm
FBA & NFP : No requirement

4.3 Brick Strength (SABS 227:4.4)

A wide range of bricks are available in this country. Bricks vary in compressive strength due to the differing qualities of raw materials used and the method of firing. The compressive strengths range from 3.5Mpa for NFP to more than 50Mpa for Face Brick Extra and Engineering products.

Standard testing is carried out on samples of 12 units, to prescribed procedures. Most local manufacturers are able to produce clay bricks to specified needs. 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 load-bearing designs can be provided to suitable tolerances and strengths.

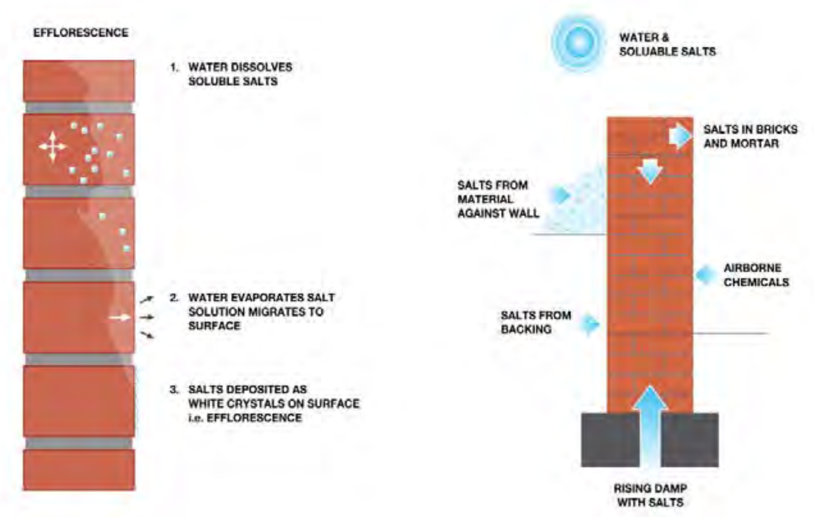
Compressive Strengths		
Class of Unit	**Nominal Compressive Strength** (Mpa)	**Individual Compressive Strength** Mpa (min)
FBS) FBX) FBA)	*12.0 17.0	*9.0 12.5
NFP) NFX)	3.5 7.0 10.5 14.0	3.0 5.5 7.5 10.5
Table 4.2:	❖ For hand-moulded units	

4.4 Efflorescence (SABS 227:4.5)

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. SABS 227 describes degrees of efflorescence and the limits of efflorescence caused by salts in clay bricks during manufacturing.

Figure 4.2: Formation of Efflorescence



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 slightly heavier deposit 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 SABS 227, the numbers that exhibit efflorescence should not exceed the limits given in Table 4.3 for special or normal grade, appropriate to the class of the units, namely:

Special Grade : When tested in accordance with SABS 227, no facing unit is to exhibit more than slight efflorescence. With non-facing (plastering) units, no unit is to show heavy efflorescence and not more than 10 out of 20 units tested are to exhibit moderate efflorescence.

Normal Grade : No facing unit is to exhibit heavy efflorescence and not more than 10 out of 20 units tested are to exhibit moderate efflorescence. For non-facing units not more than 10 out of the 20 units tested are to exhibit heavy 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

Table 4.3

4.5 Irreversible Moisture Expansion (refer SABS 227: 4.7)

Burnt clay masonry units, in general, should have an irreversible moisture expansion of not more than 0.20% 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.

Burnt clay masonry units undergo an irreversible moisture expansion, which occurs as a result of the absorption of moisture from the atmosphere after firing. 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 4.3).

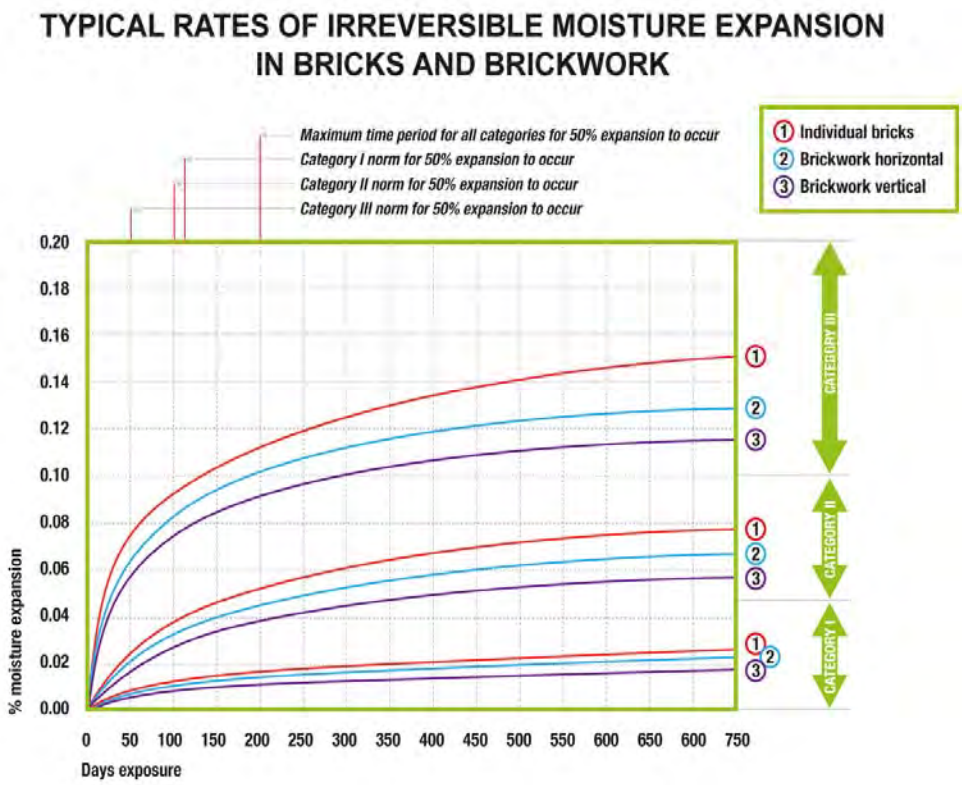
Clay bricks are normally classified into three groups of moisture expansion ranges:

Category I **:** For bricks exhibiting irreversible expansions of 0.00% - 0.05%
Category II **:** For bricks exhibiting irreversible expansions >0.05% ≤ 0.10%
Category III **:** For bricks exhibiting irreversible expansions >0.10% ≤ 0.20%

The curves below show the irreversible moisture expansion for:

1. Individual Bricks
2. Horizontal Brickwork or length of a wall
3. Vertical brickwork or the height of a wall

Figure 4.3: Irreversible Moisture Expansion



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 clay bricks. For ceramic materials the rate of expansion decreases steadily with the passage of time.

4.6 Durability: Selection Criteria

The best indicator of a product's durability performance in any application is at least 5 years of satisfactory performance in the application concerned. A single global value of compressive strength 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 any 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 and micro-climatic conditions with regard to the building's height and the material's position within the building.

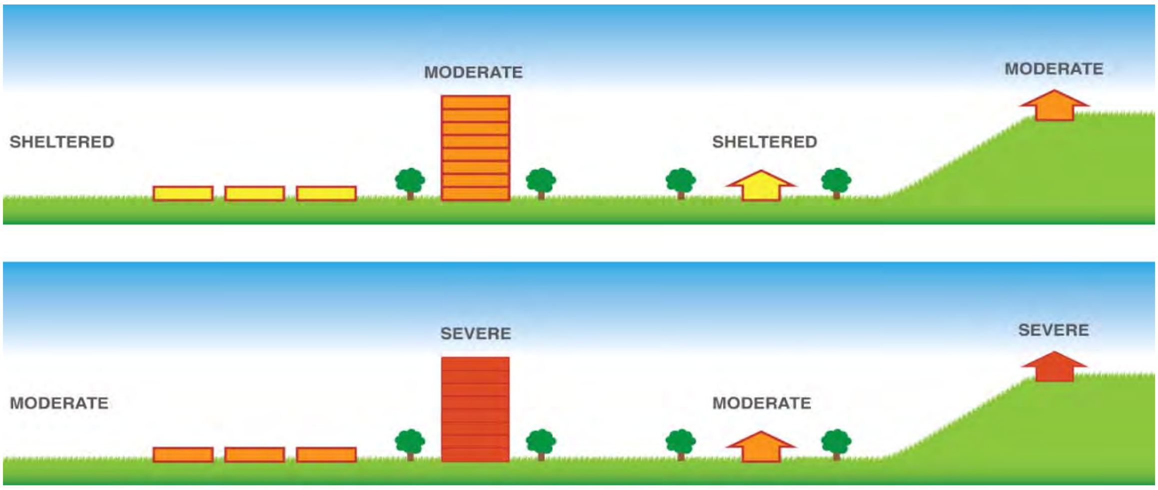


Figure 4.4: Regional Geographic Exposure

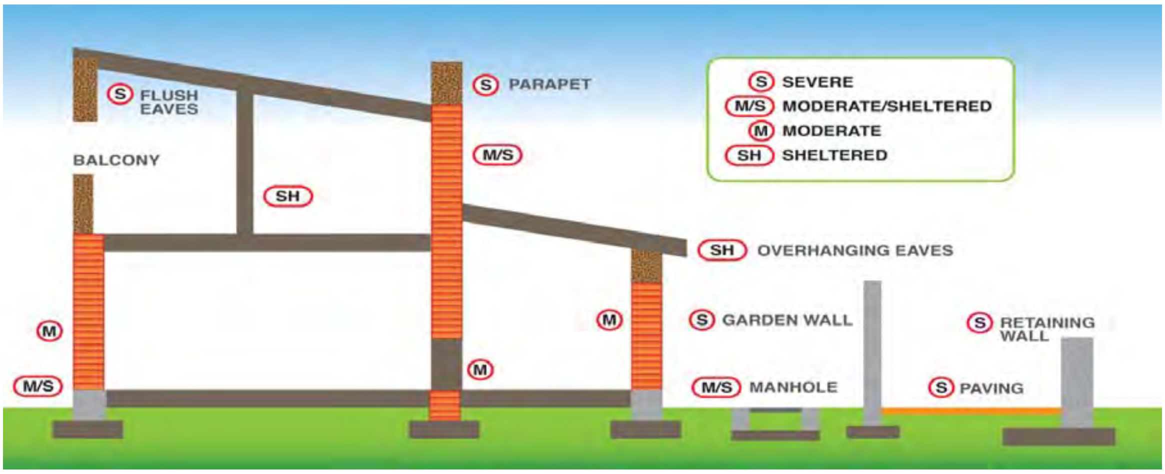


Figure 4.5: Micro Climatic Exposure

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 bricks for external face brick applications.

The use of facings and non-facings selected for durability in an area geographically close to the brick factory poses few problems. The local knowledge of exposure conditions and of the performance of the bricks concerned, which is generally available from the brick manufacturer, specifier 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, that the risk of a brick being used that is not suited to a particular application is increased.

The durability of bricks in the wall, or brickwork, is dependent on a number of factors:

- Orientation of the structure in terms of prevailing weather
- Design detailing in terms of protecting the exposed walling with adequate eaves, overhangs, guttering, flashings, etc
- Macro and Micro climatic conditions
- Good building practice with emphasis on mortars, joints and pointing, sealants and damp proofing materials
- The assurance/certification from the brickmaker / supplier that the bricks are fit for purpose.

However, clay brickwork has history on its side. Numerous buildings around the world have stood the test of time for hundreds and even thousands of years against other building materials and under adverse and extreme conditions.

4.6.1 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 experience weathering. Broadly, experience and SABS 0249: *Masonry Walling* has shown that Southern Africa may be grouped into four 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.

4.6.1.1 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, special selection of clay facings from a factory can provide a product with enhanced durability and performance suited to more severe exposure applications.

4.6.1.2 Recommended Specifying Procedure

All sales personnel should define the relevant exposure zone and site orientation in terms of prevailing winds, driving rain, etc., and insist that specifiers clearly identify the type of brick and its required performance criteria in bills of quantities and on architectural drawings. Sales staff should ensure that in all structures to be built in severe and very severe exposure zones, bricks are supplied with the manufacturers' warranty to the effect that they are "fit for purpose". Similarly, bricks to be used below ground or in damp to very wet conditions should be specified and supplied to quality standards ensuring their adequate performance over time.

4.7 Initial Rate of Absorption (SABS 0164-1.B-4.1.1)

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.

Structural units of clay with an initial rate of absorption exceeding I.8kg/m².min should be moistened prior to laying to reduce the rate to between 0.7 and I.8kg/m².min. This is a requirement of SABS 0164-1: *The structural use of masonry Part 1: Unreinforced masonry walling.*

4.8 Fire Resistance, Acoustic and Thermal Performance of Various Walling Types

4.8.1 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 4.6.

FIRE RESISTANCE AND ACOUSTIC INSULATION VALUES
FOR CLAYBRICK CAVITY WALLS

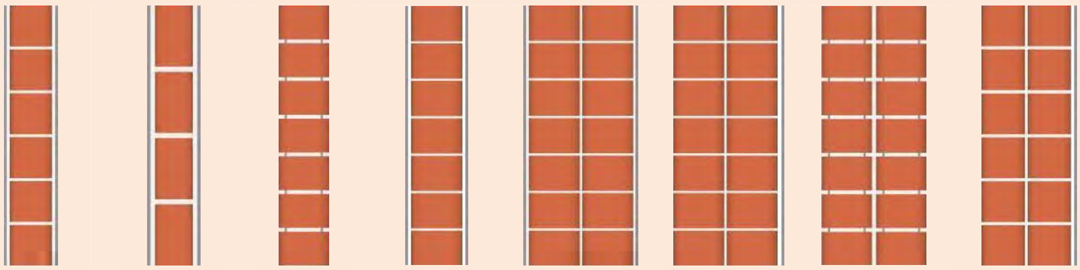
UNIT	BRICK	CLAY BRICK MAXI	FBA/NFP CLAY BRICK	NFP CLAY BRICK	FBA/NFP CLAY BRICK	FBA/NFP CLAY BRICK	FBA CLAY BRICK	FBA/NFP CLAY BRICK
PLASTER	12mm Cement/ Sand both sides	12mm Cement/ Sand both sides	None	12mm Cement/ Sand both sides	12mm Cement/ Sand both sides	12mm Cement/ Sand inside only	None	12mm Cement/ Sand inside only
								
THICKNESS	106	90	106	140	222	222	222	222
ACOUSTIC INSULATION	44db	43db	44db	45db	49db	49db	47db	48db
FIRE RATING* Load Bearing Non-Load Bearing *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

Figure 4:6

4.8.2 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 4.6.

4.8.3 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.

4.8.3.1 Thermal Transmittance

Thermal transmittance, (U-value) is measured in Watts (W) per square metre (m^2) per degree Celsius, W/m^2 °C 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 heat flow through a wall, it is the figure used to compare the performance of different constructions and to make energy-use calculations.

4.8.3.2 Thermal Capacity

Thermal capacity is measured in Joules (J) per square metre (m^2) per degree Celsius, J/m^2 °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.

BRICKWORK

PART 5
BRICKWORK
BOND PATTERNS, MORTAR JOINT PROFILES AND POINTING, STRENGTH AND STABILITY

5. Masonry Bonds

5.1 General

Bond in masonry is achieved by laying the masonry units in each course so that they overlap those in the course below, the amount of lap usually being approximately half the length of a unit (stretcher bond), but not less than a quarter of the length of a unit (quarter bond). Care should be taken, especially in faced work, to ensure that the vertical joints are truly plumb and in vertical alignment in alternate courses.

Stretcher bond, which consists of stretchers only in each course, is normally used for leaves one unit thick, whether in solid or in cavity walls; other bonds should not be used for cavity walls unless purpose-made bats are available.

Sleeper walls and non-load bearing walls may be built using honeycomb construction, provided the lap between masonry units in each course is at least one quarter of the length of the units.

An aspect of economy that must be considered in face work is the number of face bricks required per unit area of wall surface. Stretcher bond is the most economical due to the absence of headers, while header bond requires twice as many face bricks, as does stretcher bond, English bond requires 1.5 and English garden-wall bond 1.25 times as many face bricks, as does stretcher bond.

5.2 Bond Patterns

5.2.1 Bonds in Brickwork

Standard "imperial" size bricks (222mmx106mmx73mm) may be bonded in a number of ways. Bonding is important in terms of vertical load carrying capacity and the horizontal strength of masonry walling. The difference between unbonded and bonded walls is illustrated in Figure 5.1.

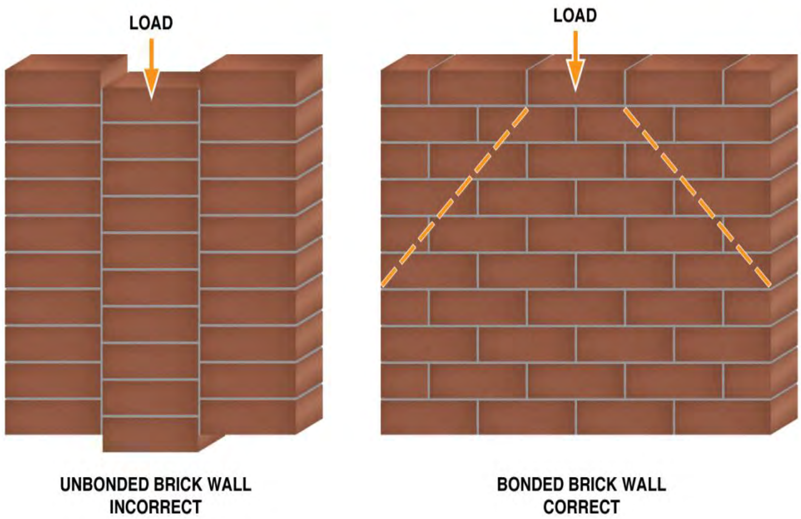
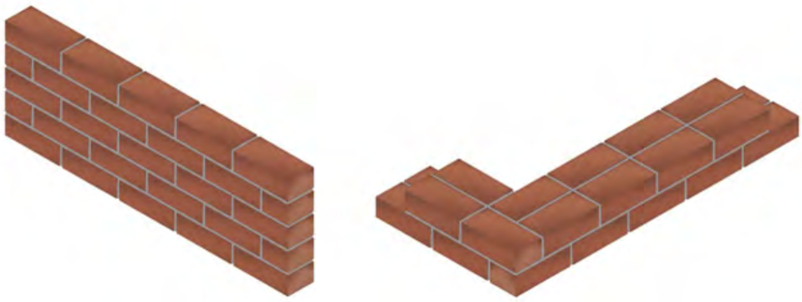


Figure 5.1: Un-bonded and Bonded Brick Walls

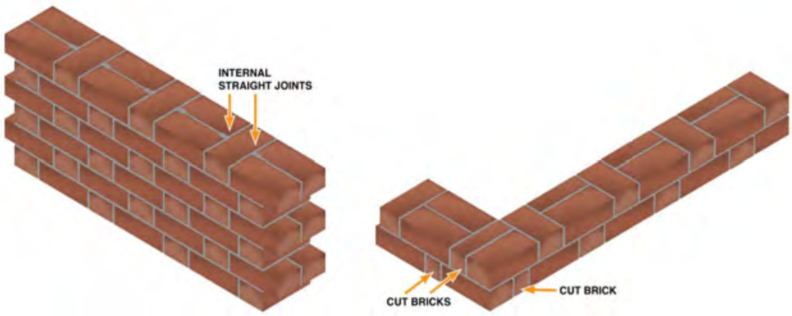
5.2.2 Masonry Bonds

There are three masonry bonds most commonly used in South Africa:

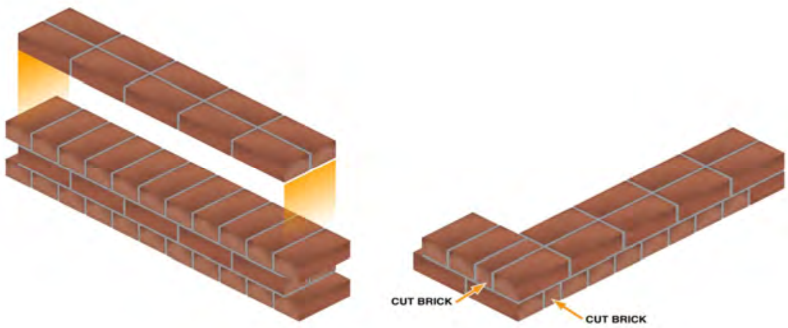
Stretcher Bond: Most popular due to its ease of laying, is basically a half brick wall bond



Flemish or Flemish Garden Wall Bond: Provides a strong full brick solid wall



English Bond: Considered strongest full brick wall bond, mostly used in foundation/retaining walling.

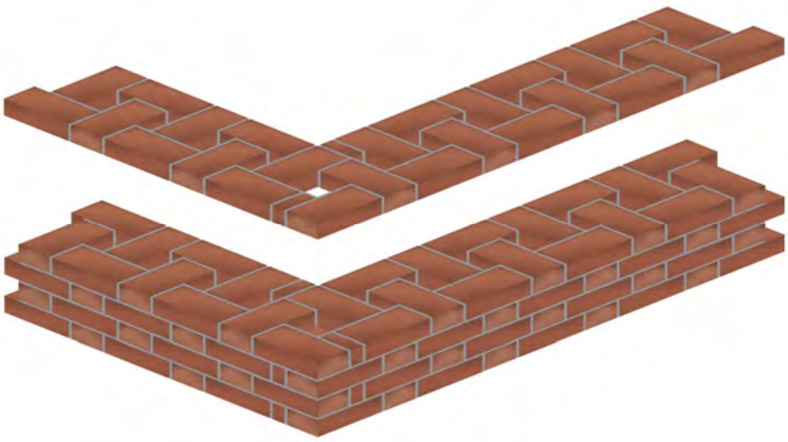


Note: A wall comprising of two brick leaves is known as a full brick wall, and a wall with only one leaf is a half brick wall.

5.2.3 Other Bonds

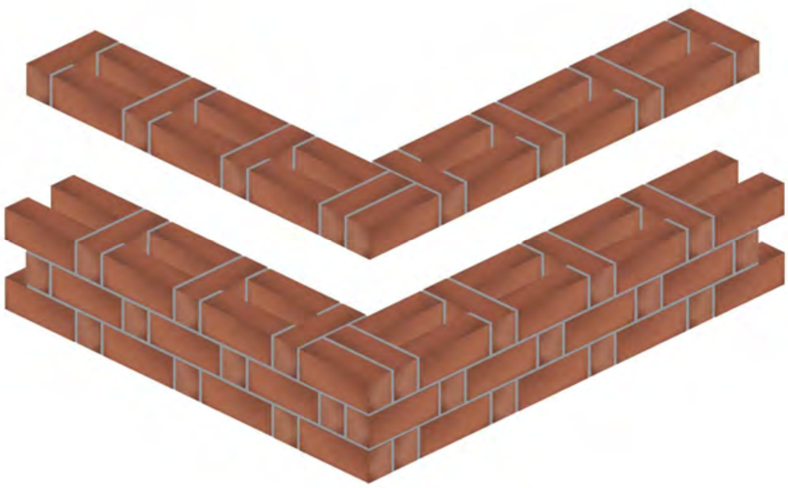
Quetta Bond

This bond is used in walls of not less than one and a half brick thickness and consists of alternate stretchers and headers in each course, so arranged to provide a series of vertical voids in the wall thickness. Vertical reinforcement is placed in the voids, which are then filled with grout or fine concrete.



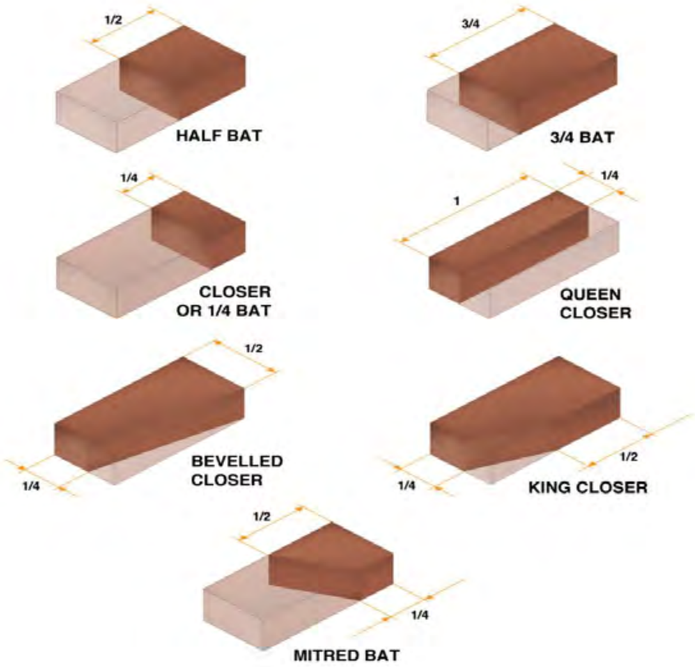
Rat-trap Bond

This bond shows on both faces of alternate headers and stretchers of bricks laid on edge in each course. Vertical reinforcement is placed in the vertical voids and the cavity is grouted in a similar manner to that in a Quetta bond wall.

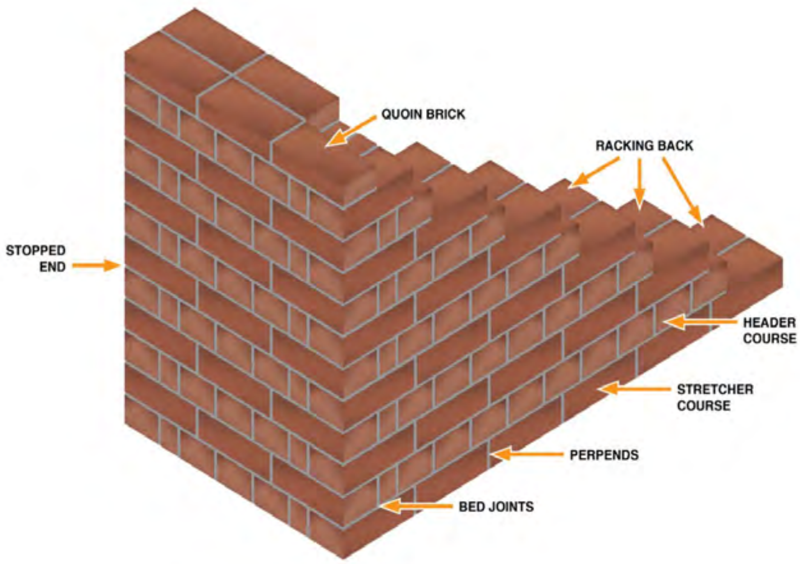


5.2.4 Cutting Specials

In order to achieve correct bonding, certain special units must be used. These can be cut from standard bricks or may be available from manufacturers.

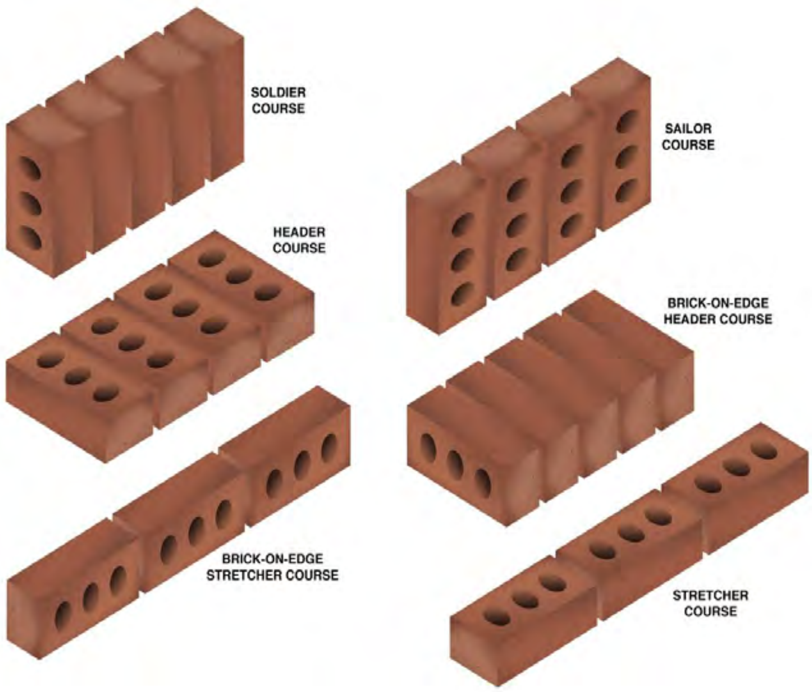


5.2.5 Quoin (Corner)



5.3 Ways to Lay a Standard Brick

There are six different ways to lay a course of bricks. The bond patterns described above are constructed from any one or a combination of courses. In addition, the use of various types of courses enhances the designer's range of aesthetic effects in decorative brickwork.



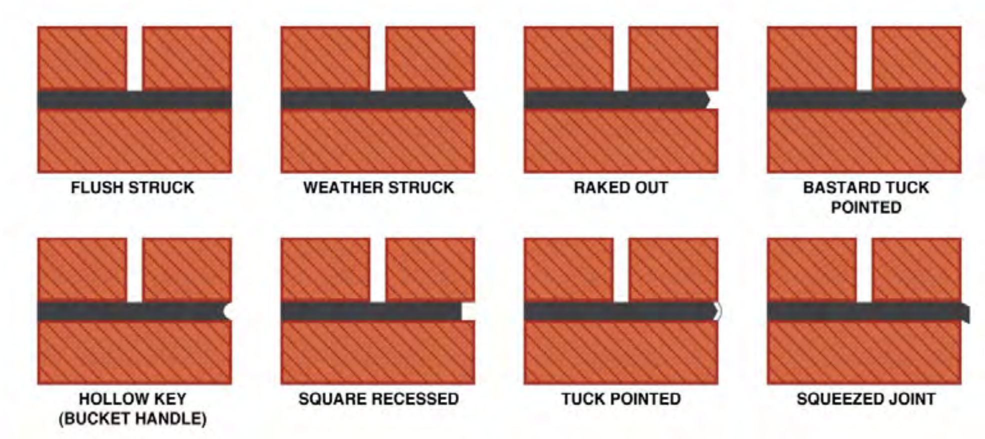
5.4 Mortar Joint Profiles and Pointing

Mortar Joints In face brick walling, the quality and the profile of the mortar joints have a direct bearing on both the weather performance and aesthetics of the wall.

Jointing The process of finishing a joint by compressing the mortar during the laying of masonry units.

Pointing The process during which mortar joints are raked out during the laying process and subsequently filled and tooled.

The following are the basic mortar joint profiles:



5.5 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

5.5.1 Mix Proportions

The approximate limiting proportions of these mortars are detailed in Table 5.1.

Proportions of Mortar					
Mortar Class	**Common Cement** (Kg)	**Lime** (Litres)	**Sand (measured loose & damp)** (Litres max)	**Masonry Cement: Sand or Common Cement: Sand with Mortar Plasticiser**	
				Kg	Litres
I	50	0-10	130	50	100
II	50	0-40	200	50	170
III	50	0-80	300	50	200

Table 4.1:

Class II Mortar:

General purpose mortar for all brickwork.

Concrete wheelbarrows have a capacity of 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 50Kg unit common cement.

Common Cement 50Kg	: 2 Bags
Lime	: 0-40 Litres
Sand (measured loose and damp)	: 200 Litres / 6 Wheel Barrows

Masonry Cement Mortar:

Masonry Cement 50Kg	: 2 Bags
Sand (measured loose and damp)	: 170 Litres / 6 Wheel Barrows

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

5.6 Cement

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

Cement Designation	Strength Grade
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 B V	32,5N or higher
CEM III A	32,5N or higher

[1 N (Newton) = 1 $kg.m/s^{-2}$]

5.7 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.

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

5.8 Sand

Sand for mortar should comply with SABS 1090 and must be well graded from 5mm downwards, in accordance with Table 5.2.

Grading Requirements of Sands for Mortar Extract From SABS 1090: Aggregates From Natural Sources 'Fine Aggregate for Plaster and Mortar'		
Size of square apertures (mm)	Percentage by mass passing	
	Fine Aggregate For Plaster	**Fine Aggregate for 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

Table 5.2:

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 sand yields a smooth, plastic and cohesive mix, its quality, based on 'water demand' can be determined by the following test.

The quantities used should be weighed on an accurate kitchen scale, and the 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.

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.

5.9 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, water-cement ratio, temperature of the mortar, volume of plasticiser and other factors or site conditions.

5.10 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.

5.11 Ready-mixed Mortar

Ready-mixed mortar with an extended board life has been successfully used for many years. Ready-mixed mortar has advantages of convenience 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 minimizes 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 setting 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.

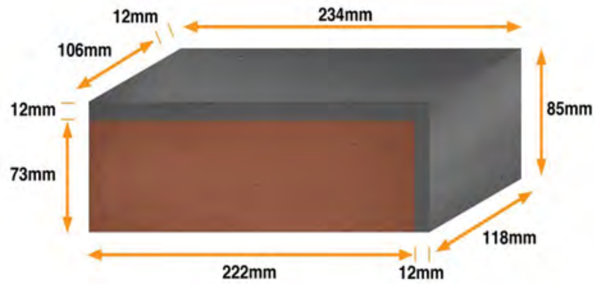
QUANTITIES
OF
BRICK AND MORTAR

PART 6
QUANTITIES OF BRICKS AND MORTAR

6.1 Format Size (Standard Imperial)

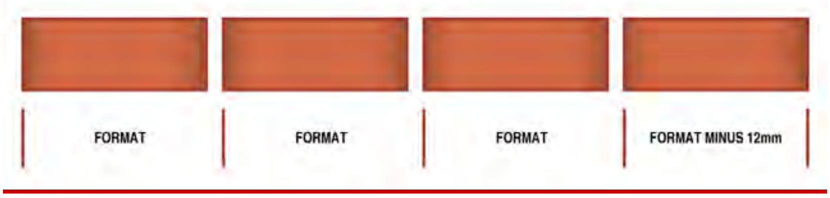
Bricks are manufactured to a standard imperial size of 222mm (long) x 106mm (wide) x 73mm (high). It is recommended to use 12mm mortar joints. Therefore the format size becomes 234mm (long) x 118mm (wide) x 85mm (high - Figure 6.1.

Figure 6.1: Brick Format



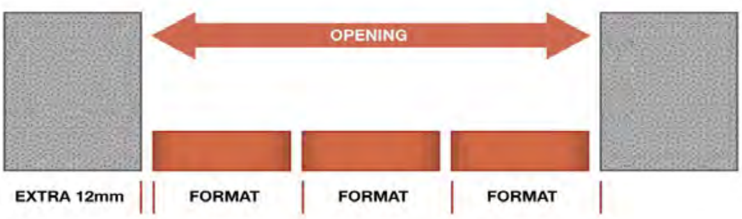
The format length, i.e. 234mm is the spacing of stretcher perpends. The format width, i.e.118mm is the spacing of header perpends. The format height, i.e. 85mm is the coursing height. It should also be noted that the actual length of a brickwork panel is less by one 12mm joint than the overall distance between format lines - Figure 6.2

Figure 6.2: Format Length



The actual widths of openings between brick reveals are greater by one 12mm joint than the width between format lines - Figure 6.3

Figure 6.3: Widths of Openings



The height of brickwork measured conveniently between the tops of the courses is equal to the format height multiplied by the number of courses. The clear height of an opening (measured to the brickwork) is therefore greater by one joint than the coursing height of the opening - Figure 6.4

Figure 6.4: Coursing Height

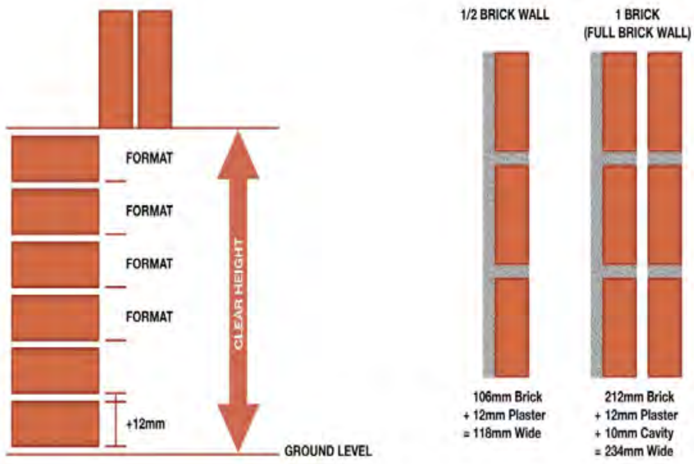


Table 6.2: Quantities

BRICK	THICKNESS	Quantities/m^3	
		Bricks	Mortar *(ℓ)* 12mm Full Joint
222 x 106 x 73mm	½ Brick 1 Brick 1½ Bricks Cavity	51 102 153 102	21 43 66 42

Note:
i) No allowance has been made for waste
ii) The bedding mortar is across the full joint width
iii) 1000 litres (ℓ) = 1 cubic metre (m^3)

Table 6.1: Brick Coursing

No.	Vertical	Horizontal	No.	Vertical	Horizontal	No.	Vertical	Horizontal
1	85	234	34	2890	7956	67	5695	5678
2	170	468	35	2975	8190	68	5780	15912
3	255	702	36	3060	8424	69	5865	16146
4	340	936	37	3145	8658	70	5950	16380
5	425	1170	38	3230	8892	71	6035	16614
6	510	1404	39	3315	9126	72	6120	16848
7	595	1638	40	3400	9360	73	6205	17082
8	680	1872	41	3485	9594	74	6290	17316
9	765	2106	42	3570	9828	75	6375	17550
10	850	2340	43	3655	10062	76	6460	17784
11	935	2574	44	3740	10296	77	6545	18018
12	1020	2808	45	3825	10530	78	6630	18252
13	1105	3042	46	3910	10764	79	6715	18486
14	1109	3276	47	3995	10998	80	6800	18720
15	1275	3510	48	4080	11232	81	6885	18954
16	1360	3744	49	4165	11466	82	6970	19188
17	1445	3978	50	4250	11700	83	7055	19422
18	1530	4212	51	4335	11934	84	7140	19656
19	1615	4446	52	4420	12168	85	7225	19890
20	1700	4680	53	4505	12402	86	7310	20124
21	1785	4914	54	4590	12636	87	7395	20358
22	1870	5148	55	4675	12870	88	7480	20592
23	1955	5382	56	4760	13104	89	7565	20826
24	2040	5616	57	4845	13338	90	7650	21060
25	2125	5850	58	4930	13572	91	7735	2129
26	2210	6084	59	5010	13806	92	7820	21528
27	2295	6318	60	5100	14044	93	7905	21762
28	2380	6552	61	5115	14274	94	7990	21996
29	2465	6786	62	5270	14508	95	8075	22230
30	2550	7020	63	5355	14742	96	8160	22464
31	2635	7254	64	5440	14976	97	8245	22698
32	2720	7488	65	5525	15210	98	8330	22932
33	2805	7722	66	5610	15434	99	8415	23166

STRUCTURAL MASONRY
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PART 7
STRUCTURAL MASONRY WITH CLAY BRICK

7.1 Strength Requirements for Masonry Units and Mortar (SABS 0400 Table 1-Part KK4)

Strength Requirements For Masonry Units And Mortar				
Wall Type	**Position**	**Minimum Average Compressive Strength** MPa		**Class* of Mortar Required**
		Solid Units	Hollow Units	
Structural other than foundation and retaining walls	Single storey building - internal / external	7.0	3.5	II
	Double-storey building internal / external	10.5 or **14.0	7.0	II
Non-structural other than parapet, balustrade and freestanding walls	External	7.0	3.5	II
	Internal	7.0	3.5	III
Free-standing	External / internal	10.5	7.0	II
Foundation	Supporting single storey	7.0	3.5	II
Foundation	Supporting double-storey	10.5 or 14.0	7.0	II
Parapet	—	7.0	3.5	II
Balustrade	—	7.0	3.5	II
Retaining	—	10.5	7.0	II
Table 7.1:	* Lime may be added to the mortar mix ** See table 7.2			

7.2 Dimensions of Masonry Walls in Buildings (SABS 0400 Table 2– Part KK5)

Permissible Dimensions of Masonry Walls in Buildings							
Nominal Wall Thickness	Use of Wall in a Building	Maximum Storey Height ($m^{1.5}$)	Maximum Height ground floor to top of external gable (m)	Maximum Unsupported length (m^2)	Minimum Average Compressive Strength (Mpa)		Minimum Class of Mortar (4)
					Solid Units	Hollow Units	
90	Non-structural internal wall in any storey. External infilling and cladding to framed building to height of 25m. Wall providing lateral support in single storey building but carrying no gravity load other than its own weight.	3.0 3.3 3.0	n/a n/a n/a	6.0 note (3) 6.0	7.0 7.0 7.0	3.5 n/p 3.5	III II II
110	Non-structural internal wall in any storey. External infilling and cladding to framed building to height of 25m. Structural wall in single storey building. Wall providing lateral support in single or double-storey building but carrying no gravity load other than its own weight.	3.3 3.3 2.6 3.3	n/a n/a 4.0 n/a	7.0 note (3) 6.0 7.0	7.0 7.0 7.0 7.0	3.5 3.5 3.5 3.5	III II II II
140	Non-structural internal wall in any storey. External infilling and cladding to framed building to height of 25m. Structural wall in single storey building. Structural wall in double storey building.	3.0 3.0 3.3 3.0	n/a n/a 5.0 7.5	7.0 5.0 6.0 6.0	7.0 7.0 7.0 10.5	3.5 3.5 3.5 7.0	III II II II
190	Non-structural internal wall in any storey. External infilling and cladding to framed building to height of 25m. Structural wall in single storey building. Structural wall in double storey building.	3.5 3.3 3.5 3.3	n/a n/a 5.5 8.5	9.0 7.0 8.0 8.0	7.0 7.0 7.0 10.5	3.5 3.5 3.5 7.0	III II II II

Permissible Dimensions of Masonry Walls in Buildings							
Nominal Wall Thickness	Use of Wall in a Building	Maximum Storey Height (m[1.5])	Maximum Height ground floor to top of external gable (m)	Maximum Unsupported length (m[2])	Minimum Average Compressive Strength (Mpa)		Minimum Class of Mortar (4)
					Solid Units	Hollow Units	
230	Non-structural internal wall in any storey. External infilling and cladding to framed building to height of 25m. Structural wall in single storey building. Structural wall in double storey building.	4.0 3.3 4.0 3.3	n/a n/a 6.0 8.5	9.0 8.0 9.0 9.0	7.0 7.0 7.0 10.5	3.5 3.5 3.5 7.0	III II II II
90-50-90 to 90-110-90 Cavity Wall	External infilling and cladding to framed building to height of 25m. Structural wall in single storey building. Structural wall in double storey dwelling unit without concrete slab roof.	3.3 3.0 2.8	n/a 4.5 7.5	5.0 8.0 8.0	7.0 7.0 14.0	3.5 3.5 n/p	II II II
110-50-110 to 110-110-110 Cavity Wall	External infilling and cladding to framed building to height of 25m. Structural wall in single storey building. Structural wall in double storey building.	3.3 3.0 3.0	n/a 5.0 8.0	6.0 9.0 9.0	7.0 7.0 14.0	3.5 3.5 7.0	II II II

Table 7.2:

Note: n/a = not applicable, n/p = not permitted

1. Measured from floor level to floor level or from floor level to eaves in case of top storey.
2. Distance between intersecting walls, concrete columns or other members providing effective lateral support to wall and to which it is securely bonded or anchored. Where a wall panel is supported at one end only, the unsupported length should not exceed one-half of the tabulated length.
3. Only permitted as exterior leaf of cavity wall in which internal leaf is a structural concrete wall to which a masonry wall is tied as required for cavity walls by rule (KK8 SABS 0400).
4. A parapet wall of 500mm in height added to storey height is permitted.

7.3 Structural Design Requirements

Any building should be designed to provide strength, stability, serviceability and durability in accordance with accepted principles of structural design. The design of the structural system of any building should be carried out in accordance with SABS 0160 (for loads) and SABS 0164 (for structural masonry).However, 'deemed-to-satisfy rules' for single and double-storey buildings (with certain limitations) are covered in:

- SABS 0400: The Application of the National Building Regulations
- National Home Builders Registration Council's Home Building Manual, Parts 1, 2 and 3.

7.3.1 Building Limitations

The building shall not exceed two storeys in height and shall be subject to the following limitations:

- The building plan-form and the layout of the intersecting, mutually stabilising walls that form part of such a building shall provide a structure that is stable against the action of horizontal forces from any direction and shall consist of rectangular, polygonal or circular cells or a series of contiguous or intersecting cells.

- The span between supporting walls of a timber or metal roof truss, roof rafter or roof beam shall not exceed 10m and the span between supporting walls of any first floor or roof slab shall not exceed 6m.

- The dead load of the roof covering material shall not exceed 800 N/m² slope area for roofs other than concrete slabs. Concrete roof slabs shall not exceed 175mm in thickness if of solid construction, or the equivalent mass if of voided construction.

- Concrete first floor slabs shall not exceed 175mm in thickness if of solid construction, or the equivalent mass if of voided construction.

- In order to limit floor loading on first floor space or on suspended ground floor slabs, the use of such floors shall be restricted to:

  - Detached dwelling houses and dwelling units
  - Bedrooms, wards, dormitories, bathrooms containing soil fixtures, kitchens, dining rooms, lounges and corridors, in educational buildings, hospitals, hotels and other institutional occupancies
  - classrooms; offices
  - cafes and restaurants

Note*:*
SABS 0400 does not cover the construction of buildings in areas of seismic activity (earthquakes). In the code of practice of the Joint Structural Division of the South African Institution of Civil Engineering and the Institution of Structural Engineers on the assessment of the performance of housing units in South Africa, details are given of seismic hazard zones in the country and values of peak ground acceleration to be used in design.

7.3.2 Free-standing Walls (SABS 0400 Table 5 - Part KK11)

- Where any free-standing wall is a masonry wall, the height, thickness and pier size of such a wall shall conform to the relevant values given in Table 7.3. Any cavities in piers in a wall constructed of hollow units shall be filled with concrete.

- A damp-proof course shall not be installed in any free-standing wall.

- Where moisture is likely to be encountered from ground water, high density bricks with a water absorption not exceeding 7% shall be used up to 150mm above ground level in any free-standing wall.

Note:
Where any wall consists of sections of two or more different thicknesses, the maximum height of any such section shall not be greater than the value given in Table 7.3 for the thickness in question. The sum of the heights of the various sections of such a wall shall not be greater than the value of the maximum height given in Table 7.3 for the thickest section of such a wall.

Free-Standing Walls				
Nominal wall Thickness (mm)	Maximum height of wall above finished ground (m)		Piers	
	Without piers	With piers	Nominal (projectionxwidth) mm	Maximum spacing (centre-centre) m
90 110 140 190 230 290	0.8 1.0 1.3 1.5 1.8 2.2	1.2 1.4 1.6 2.0 2.3 2.6	200 x 290 240 x 230 300 x 290 400 x 290 480 x 350 400 x 290	1.8 1.8 2.0 2.5 3.5 4.5
Table 7.3				

7.3.3 Retaining Walls (SABS 0400 Table 6 - Park KK 12)

A masonry retaining wall, excluding basement or foundation walls of buildings, constructed in accordance with these rules, shall not be erected in a position where the ground or fill which it retains may be subjected to superimposed loads, other than that from pedestrian traffic, within a distance equal to the height of the fill retained by such a wall.

Where any structure is to be erected on top of such a wall, it shall be designed for structural adequacy, provided that a wire fence not greater in height than 1.5m shall not be regarded as a structure.

There shall be no excess of fill behind such a wall within a distance equal to the height of the wall. Movement joints shall be provided at distances not exceeding 10m (moisture expansion) apart. Subsoil drainage shall be provided behind such a wall, together with sufficient weepholes to prevent the accumulation of water. No horizontal damp-proof course of sheet material shall be used in any such retaining wall.

No height, wall thickness and pier size for any masonry retaining wall hall exceed the limits contained in Table 6.4. Where piers are indicated in the table, any length of wall shall be supported at each end by such a pier and all piers in the wall shall project from the face of the wall that is not in contact with the fill, shall be bonded into the wall and shall extend to the full height of the

Retaining Walls			
Nominal Wall Thickness mm	Maximum height of fill to be retained (m)	Piers	
		Nominal dimensions (projection x width) mm	Maximum spacing (centre - centre) m
190	0.8	No piers required	
	1.1	300 x 190	2.0
	1.3	400 x 190	2.4
230	0.9	No piers required	
	1.4	360 x 230	2.5
	1.5	480 x 230	2.7
290	1.1	No piers required	
	1.5	300 x 290	3.0
390	1.4	No piers required	

Table 7.4

7.3.4 Cavity Walls

A cavity wall consists of two parallel walls (leaves) of masonry units built side-by-side and tied to each other with wall ties, with a cavity width of not less than 50mm and no more than 110mm.

Weepholes shall be formed in the outer leaf of walling, at intervals not exceeding 1000mm and immediately above the damp-proof courses, by leaving perpend joints open for a height of approximately 50mm, or providing openings approximately 30mm wide in the shell bedding of hollow units.

Where ducts, sleeves or pipes are laid across a cavity, the construction shall prevent the transmission of moisture. The cavity in cavity wall construction shall be kept free of mortar and debris as the work proceeds. Ties shall be cleaned of mortar droppings. Mortar droppings reaching the base of the cavity shall be removed daily through temporary openings. Care shall be taken not to damage the damp-proof course membrane while cleaning the cavity.

Timber battens spread across the uppermost layer of wall ties may be used to prevent excess mortar being spilt into cavities.

Stainless steel (Grade 816) ties shall be used in the following areas:
- sea spray zones; and
- tidal and splash zones.

Figure 7.1 illustrates the shapes of ties that are commonly used.

- Crimp wire ties must not be used in cavity wall construction.They may be used in collar jointed walls.
- Butterfly and modified PWD wall ties are suitable for use in cavity wall construction where the cavity width does not exceed 110mm.

7.3.5 Empirical rules for foundations (SABS 0400 Part H)

Empirical 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 is 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 or be mixed in proportions (by volume) not weaker than 1 part cement to 4 parts of sand to 5 parts of coarse aggregate
- Any continuous strip foundation shall have a thickness of not less than 200mm
- The minimum width of 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.

7.3.5.1 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 6.2.
- Sites to 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 1500mm in diameter, unreinforced strip foundations may be centrally reinforced with two No. Y12 bars, extending a distance of not less than 1500mm beyond the face of such soft spots as shown in Figure 7.3.

Excavations should be prodded with a 10mm - 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 7.3.

- 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 1000mm 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 of foundations has dried out excessively due to exposure or has softened due to rain or ground water, the excavation shall be rebottomed prior to concreting.

Figure 7.1: Wall Ties

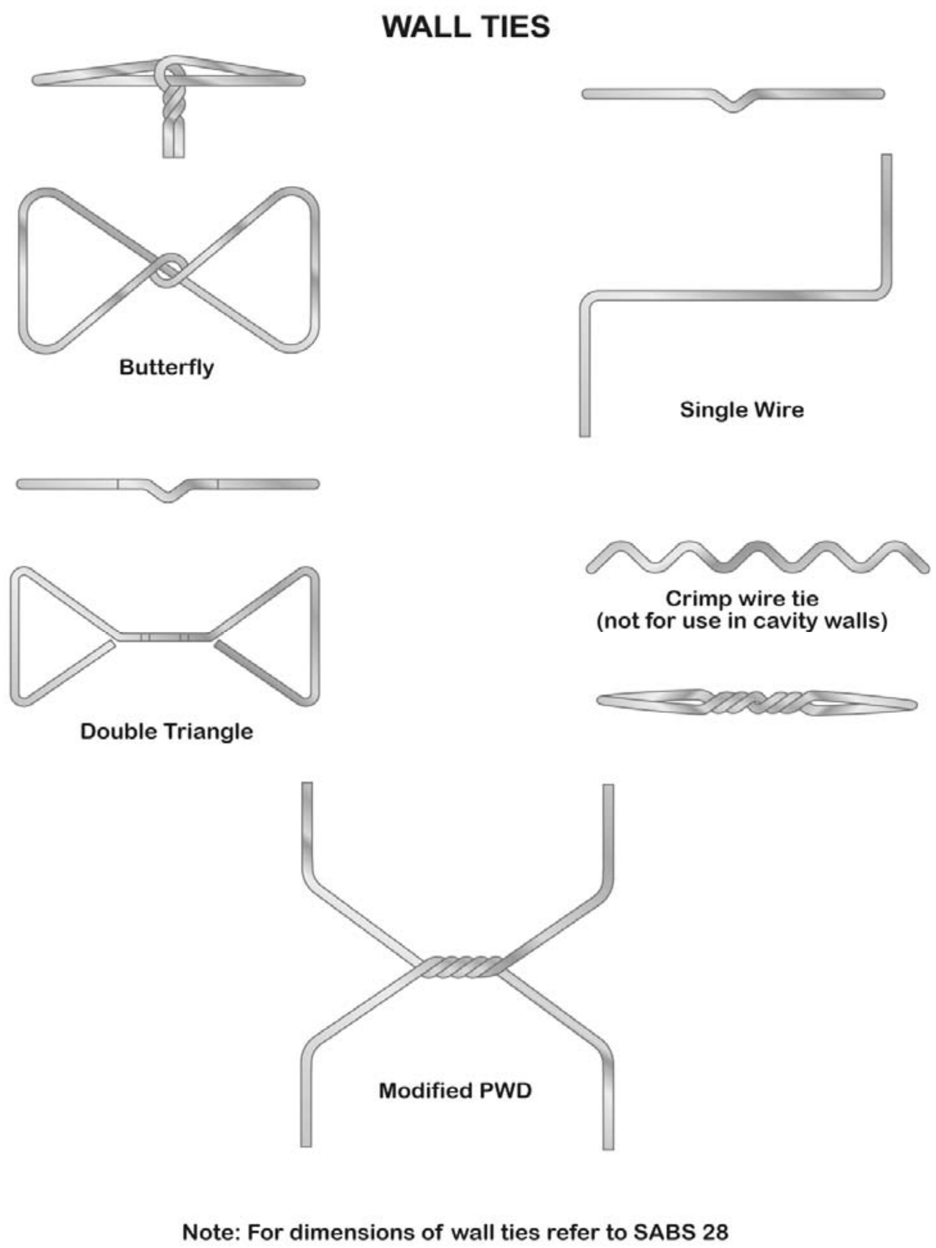


Figure 7.2:

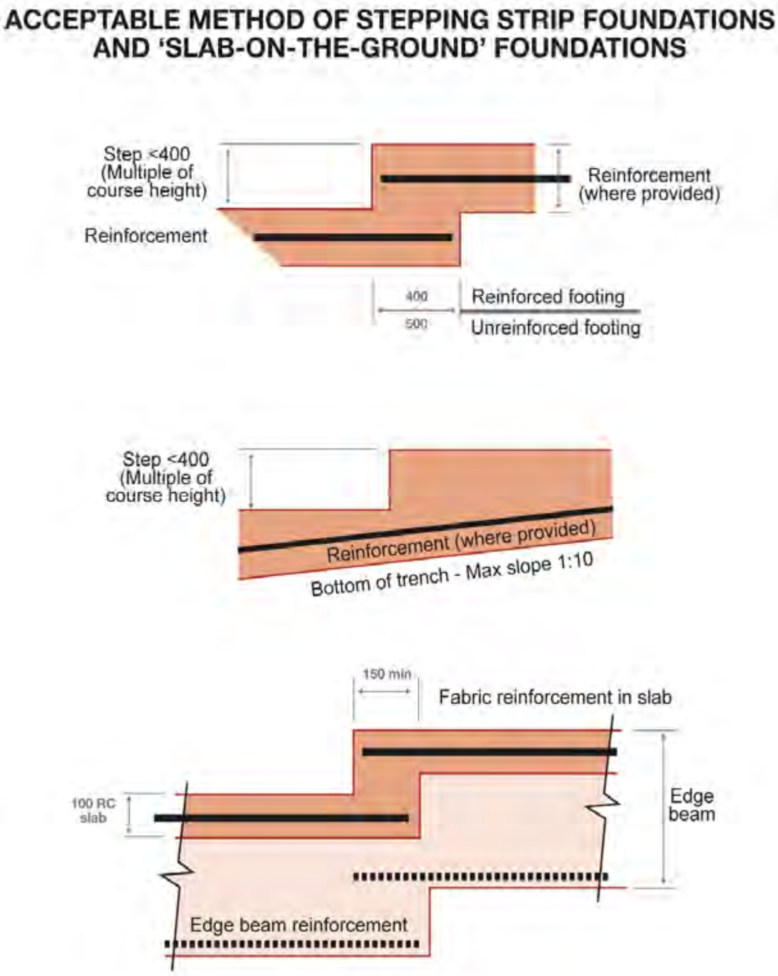
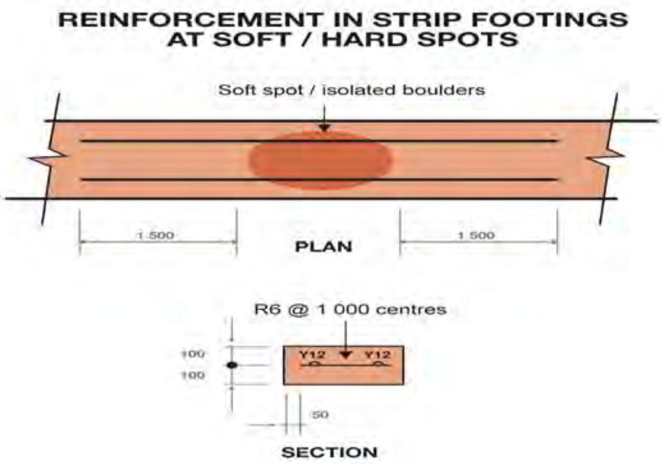


Figure 7.3:



Minimum width of strip foundations in single storey structures (SABS 0161: Part 4, Section 2)

MINIMUM WIDTH OF STRIP FOUNDATIONS IN SINGLE STOREY STRUCTURES				
Type of founding material	Tiled or 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
Table 7.5:	*Note:* Internal walls upon which reinforced concrete roofs do not bear may have a foundation width of 400 mm			

7.3.5.2 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 uncompacted layers not exceeding 100mm in respect of hand compaction, or 150mm in respect of compaction by mechanical means.

Each uncompacted layer shall be well compacted before additional fill material is added.

7.3.6 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 7.6 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.

Minimum Thickness of Foundation Walls							
Type of foundation wall	**Minimum thickness of wall (mm)**						
	Acting as a retaining wall			**Not acting as a retaining wall**			
	*** Difference in ground level (mm)**			**Height (mm)**			
	Less than 500	500 - 750	750 - 1000	Less than 300	300 -500	500 - 1000	1000 - 1500
Single leaf brick							
External Internal	140 -	190 190	230 230	140 90	140 140	140 140	190 190
Single Leaf hollow block (cavities filled with concrete)							
External Internal	140 140	190 190	230 230	140 90	140 140	140 140	190 190
Cavity wall							
External (Cavity filled to 150mm below damp-proof course level)	190	190	230	190	190	190	190
Table 7.6	* For difference in ground level of more than 1000 mm see Table 10						

WATER EXCLUSION
AND
DAMP PROOFING
OF CLAY BRICK WALLING

PART 8
WATER EXCLUSION AND DAMP PROOFING OF CLAY BRICK WALLING

Water ingress occurs through 4 main causes:

a) Poor design and detailing especially in roof to wall junctions, window and door installations, parapet walls and flashing specification and detailing.
b) Cracks and voids in mortar joints and the incorrect specification of masonry units for the various exposure zones and poor/inferior mortar.
c) The incorrect specification, detailing and installation of damp proof materials
d) Poor workmanship.

8.1 Waterproofing

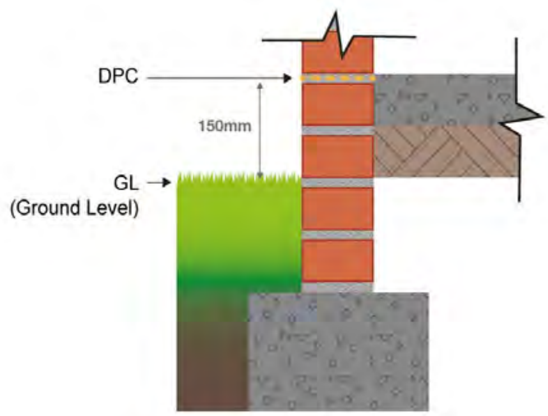
The use of damp proof course (DPC) is very important, and should be done according to the SABS Specification 021.

There are 3 functions of DPC:

a) To provide a barrier against rising damp
b) To resist water penetration from above
c) To resist horizontal water penetration

DPC in an outside wall must be at least 150mm above the adjoining, finished ground level as shown in the figure below.

Figure 8.1: The Use of DPC in Outside Wall



Various materials may be used for DPC, the most popular being black polyethylene sheeting which can be obtained in rolls. It provides a complete barrier against moisture penetration and is easy to store, handle and lay.

There are 2 suitable types of cavity construction:

a) DPC interrupted by the cavity (See Figure 8.2).
b) Continuous DPC stepped at the bottom of the cavity (See Figure 8.3).

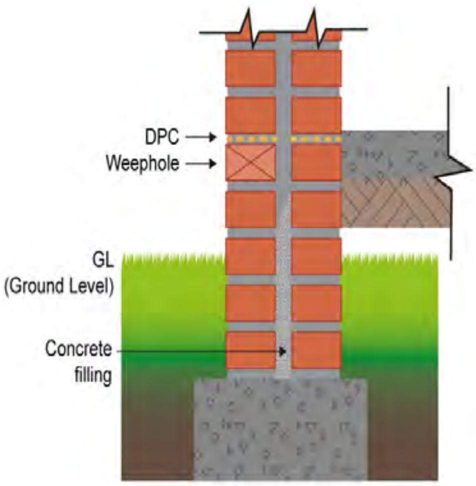


Figure 8.2: Interrupted

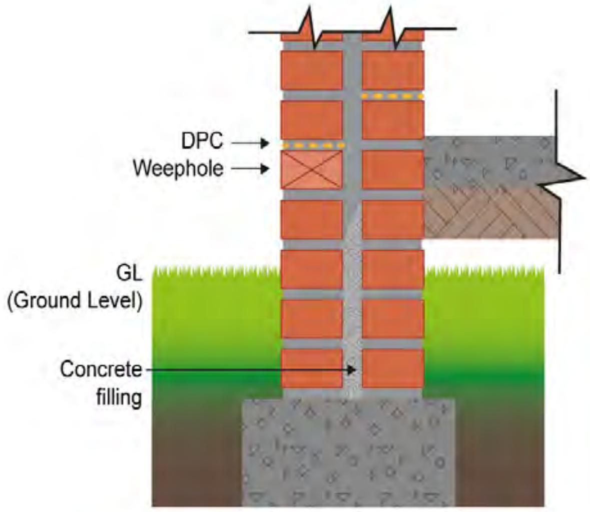


Figure 8.3: Continuous, Stepped

8.2 DPC in Window Openings

Below Sill

The DPC must be the full length of the window opening and turned up at the back and sides See Figures 8.4 and 8.5

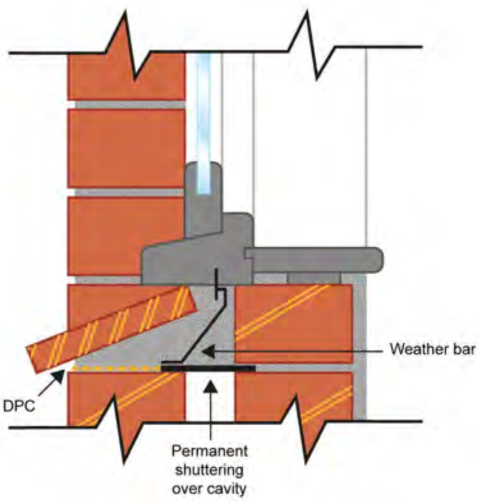


Figure 8.4: Below Sill

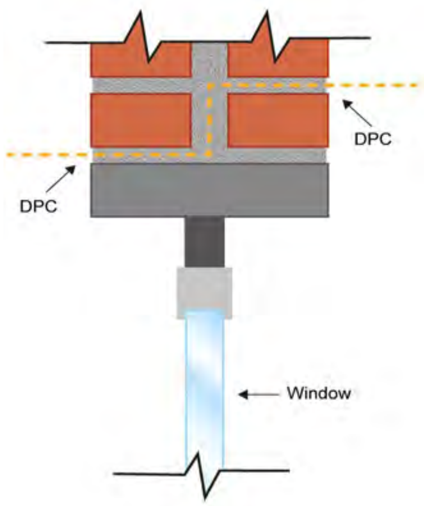


Figure 8.5: Above Lintel

8.3 DPC in Parapets

- DPC should be high adhesion type for stability
- DPC in parapets should be at a height of at least 150mm above the abutment with the roof
- It should form a moisture-resistant connection with the flashings or roof-sheeting
- Shaped concrete pre-cast copings for parapets minimises the risk of rain penetration and water staining in these very exposed areas - see Figure 8.6

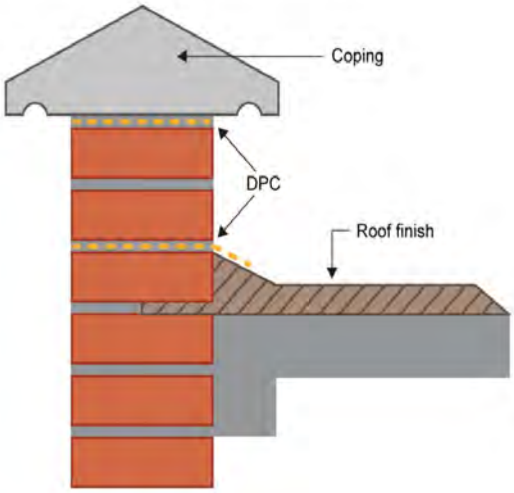


Figure 8.6: DPC in Parapets

8.4 Beware of Common Mistakes with DPC

a) Not Taking the DPC right through the mortar Joint

- This leads to a path for rising damp to penetrate past the DPC
- This is important in areas with a high water table, particularly salty ground water - See Figure 8.7

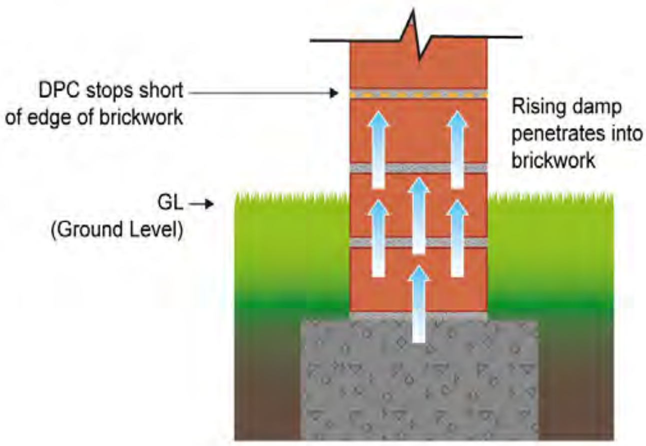


Figure 8.7: Not taking DPC right through mortar joint

b) **Not Sandwiching the DPC between Wet Mortar**

- It is wrong to lay DPC on the concrete slab or brickwork without providing a seal between the materials
- When there is no seal - a capillary path will open up, allowing rain penetration
- Mortar is a very good sealant
- The DPC should be sandwiched between wet mortar layers - See Figure 8.8

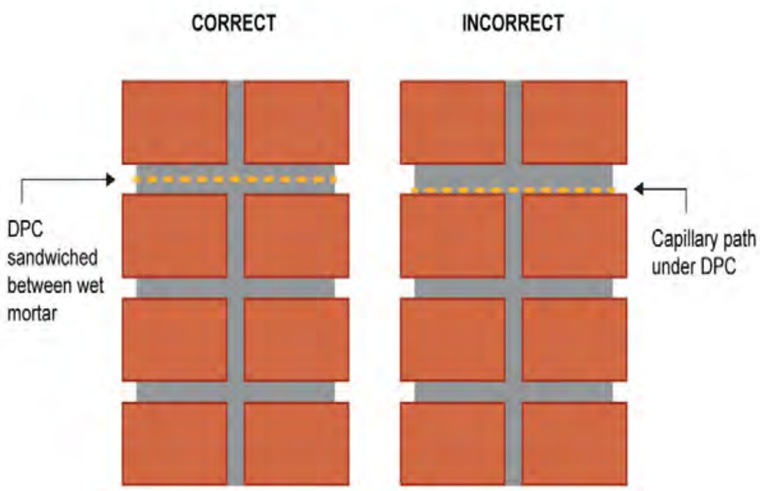


Figure 8.8: The sandwiching of DPC between wet mortar layers

c) **Not Lapping and Sealing the DPC**

- Joints should be lapped by at least 150mm along the run of walling
- They should be sealed so the joints will resist rain penetration
- When using polyethylene DPC, ensure that the sealant does not react against the polyethylene or burn through it.

ACCOMMODATION OF MOVEMENT

PART 9
ACCOMMODATION OF MOVEMENT

9.1 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. SABS 0249: Masonry Walling has a section on movement in masonry.

9.2 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 9.1). 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 of free movement that is calculated should still be modified to allow for the effects of restraints.

LINEAR THERMAL MOVEMENT OF MASONRY UNITS AND MOTAR		
Material	Coefficient of liner 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		
Table 9.1:		

9.3 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 mortar 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.

SABS 0249 recommends design for potential movement due to moisture expansion, in mm/m, of < 0.5 for category I bricks, 0.5-1.0 category II and 1.0-2.0 for category III bricks.

9.4 Moisture Content Movement

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

9.5 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 can 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 5mm to 12mm.

9.6 Mortars

The lowest strength of mortar consistent with structural and durability requirements ought to be used, as weaker mortars, especially those with lime additions, are more flexible and better able to accommodate minor walling movements in practice without cracking.

Stronger mortars in walling subject to movement are likely to lead to cracking through the masonry units themselves rather than along the bed-face joints around the units.

9.7 Differential Movement from Composite Walling

No single face of a wall should consist of more than one brick material, that is to say, clay, concrete and calcium silicate bricks must not be coursed together because they have different thermal and moisture movements and moisture absorption characteristics.

In the event that dissimilar units are on site, then providing that the different units are built into the brickwork in a totally random pattern, the effects of differential movement will be minimised. The use of dissimilar units in the same wall, is not recommended under normal circumstances.

However, where two leaves of an external wall require, for example, clay facing and calcium silicate or concrete backing plaster bricks to be adjacent, then a cavity should be provided with metal wall ties which permit slight differential movements to occur between the two walls without distress.

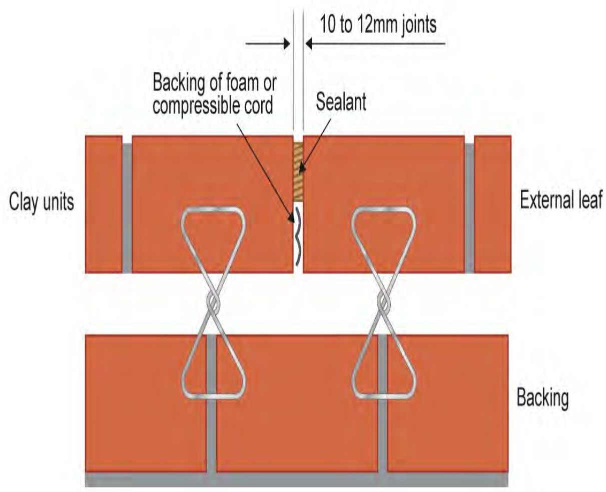


Figure 9.1: Metal Wall Ties in Composite Walling

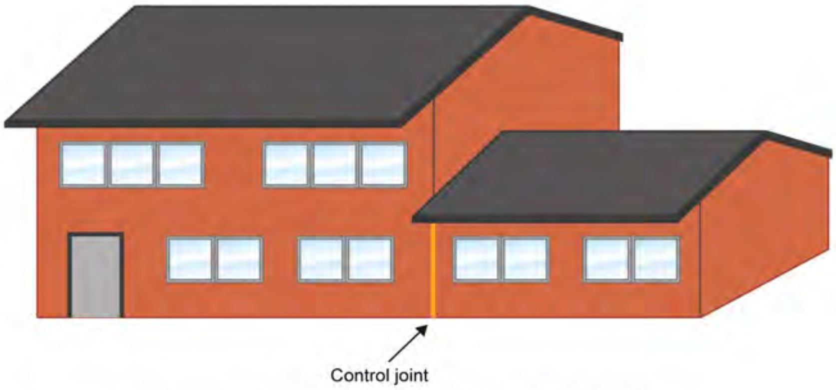
9.8 Provision of Control Joints

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 impermeability, sound insulation and fire-resistance.

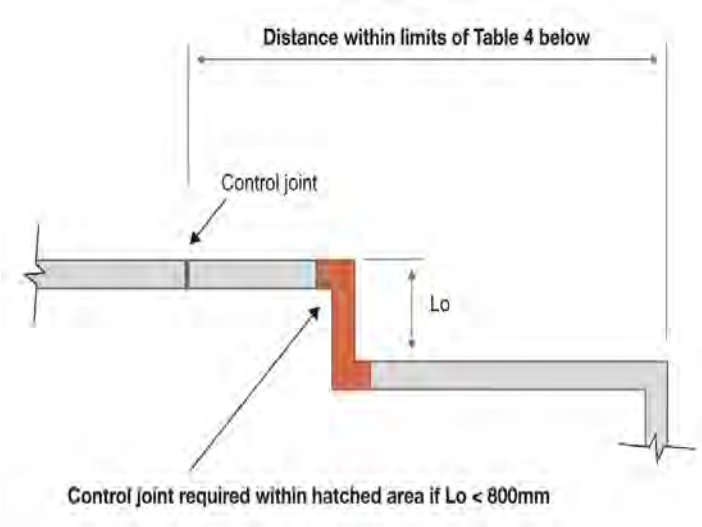
Figures 9.2, 9.3 and 9.4 show the position of control joints in buildings and free-standing walls.

Figure 9.2:



CONTROL JOINT AT CHANGE IN EXTERNAL WALL HEIGHT

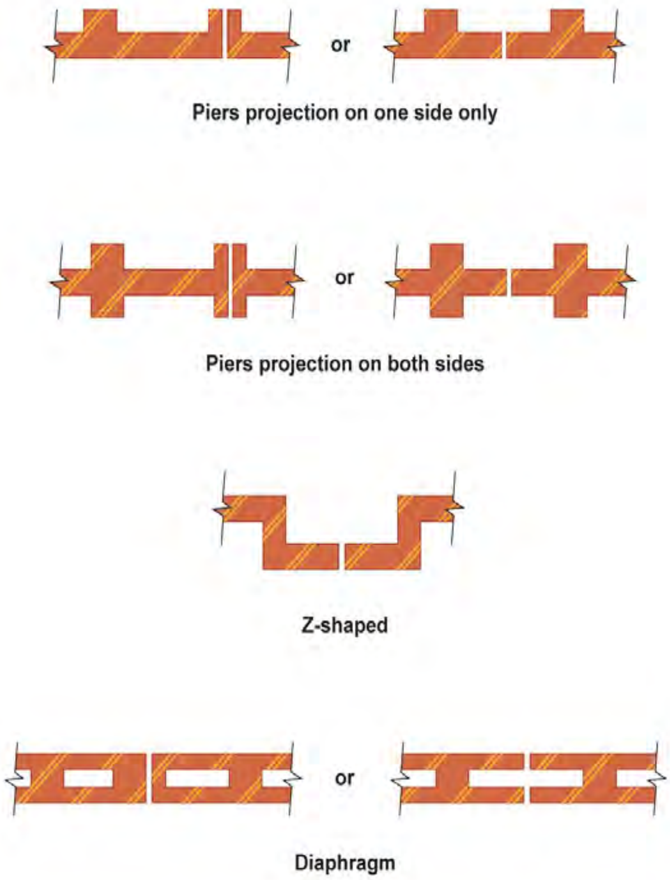
Figure 9.3:



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

Table 9.2:

Figure 9.4: Location of Control Joints in Free Standing Walls



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
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

Table 9.3:

9.9 Movement Joints – General

Movement joints in walling may be one of the following general types:

- Expansion joints, either vertical or horizontal, incorporating easily compressed resilient material to accommodate strains arising from both compressive and tensile stresses
- Contraction joints, which are free and open to accommodate stresses arising from tensile stresses only
- Slip joints between dissimilar materials permitting some degree of sliding between the adjacent materials to prevent excessive build up of shear stresses

A movement joint must be designed to achieve the following functions:

- Permit movements to occur without distress of adjacent walling materials
- Provide an adequate barrier to the passage of rain and moisture
- Prevent air and dust ingress
- Prevent significant loss of fire resistance and acoustic properties of the wall

Care should be taken to ensure that no finishes or fixings are tied across the movement joints themselves.

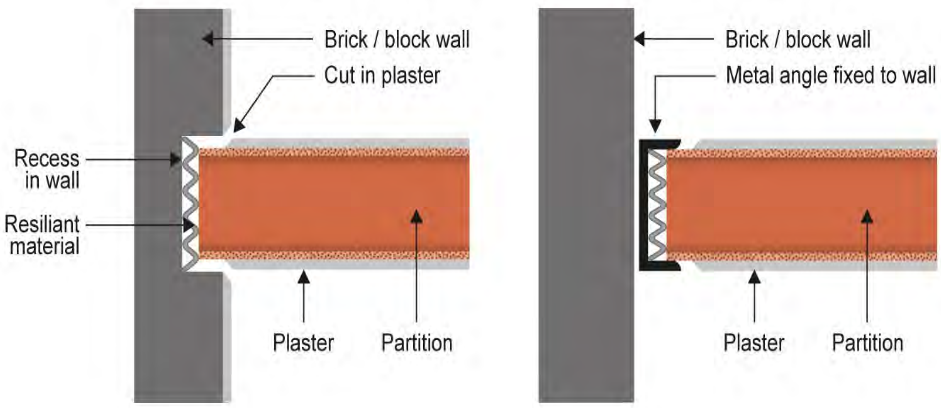
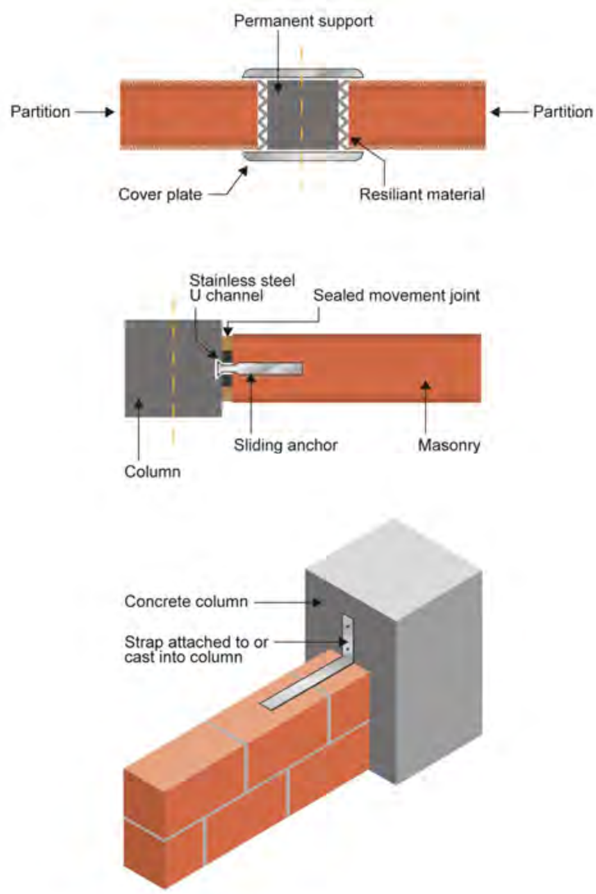


Figure 9.5: Plan view of Edge Isolation of Partitions

Figure 9.6: Lateral Support to Brick Partitions



9.10 Low Rise Walling: Residential and Commercial Buildings and Free Standing Walls

Low rise walling constructed of either clay, calcium silicate or concrete not exceeding two storeys in height (approximately 6m) would generally not require the provision of horizontal expansion joints provided that joint spacings recommended in Table 9.2 to accommodate horizontal movements are designed and built in.

The movement joints are built in during normal construction and remain in place throughout the life of the building. Joints can be expediently and advantageously placed at door, or under openings, changes in wall height and thickness, or concealed at wall angles or behind service pipes.

Figure 9.7 indicates the positioning and disposition of joints to achieve adequate stability and accommodation of expansion and contraction movements.

Figure 9.7: Positioning of Joints

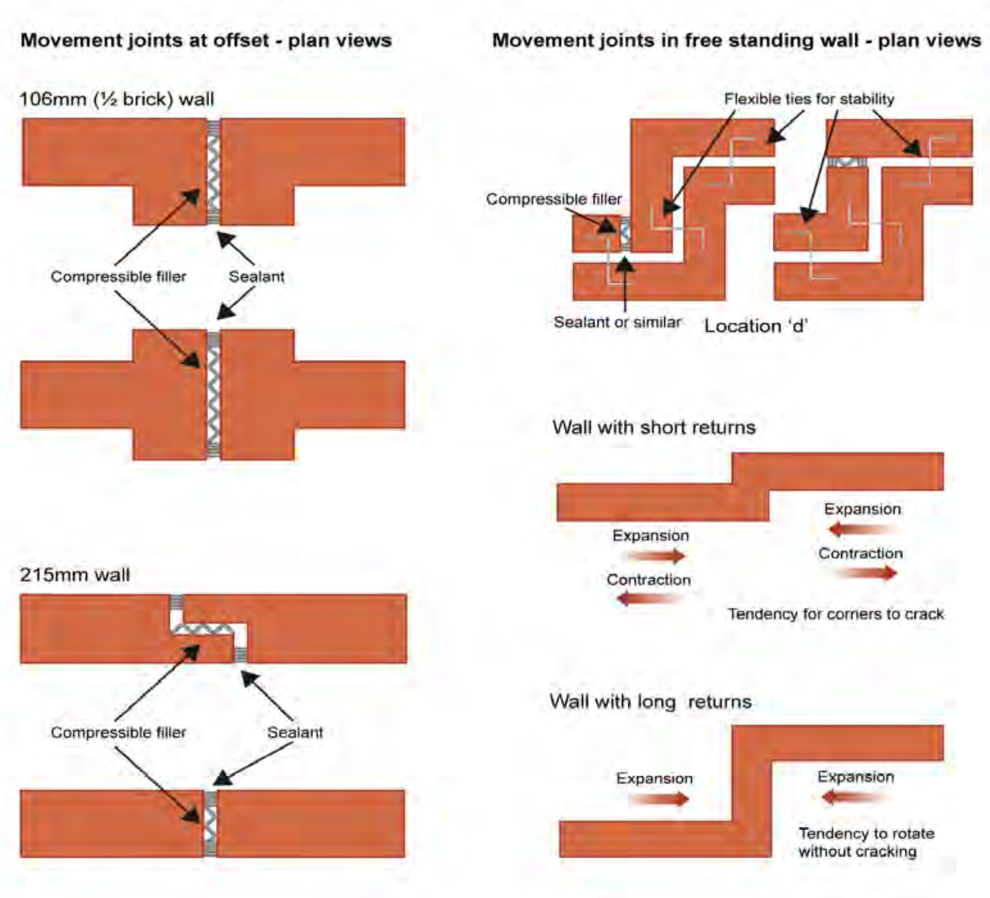
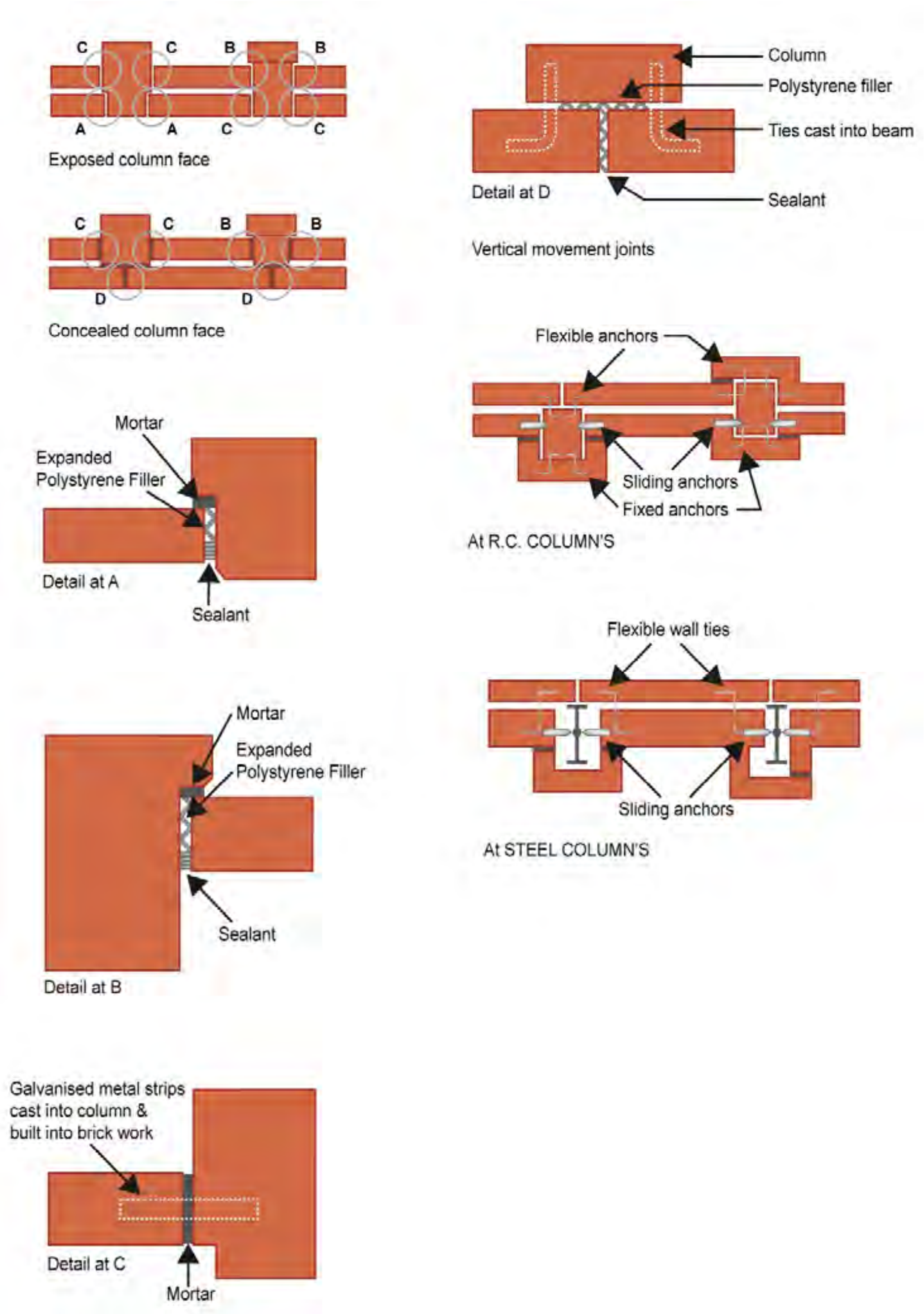


Figure 9.8: Provision for Movement – Plan Views



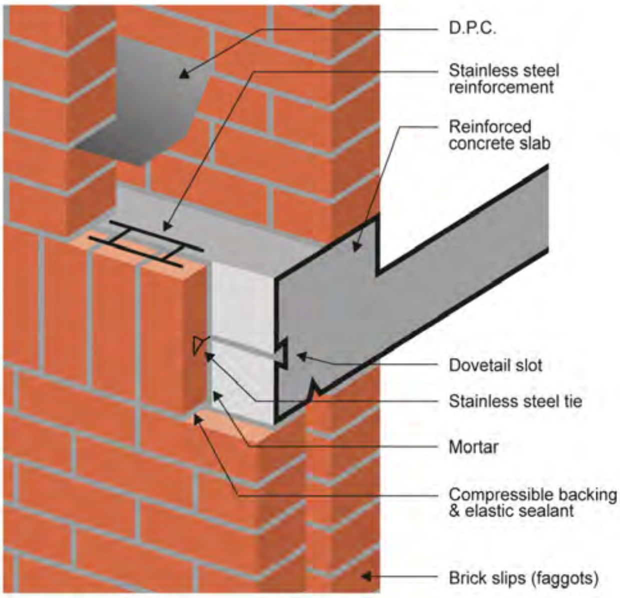
9.11 Wall Cladding to High Rise Reinforced Concrete Frames and Steel Column Structures

The provision of a 10mm-15mm horizontal joints at each storey height (approximately 3m) of external masonry cladding (for clay, calcium silicate and concrete masonry units) to all reinforced concrete frame structures is recommended in order to accommodate the differential movements between the reinforced concrete frame and the cladding.

The maximum overhang of a leaf of brickwork supported by a floor slab or nib must not exceed one-third of the thickness of the brickwork, i.e. 35mm.

When brick slips (faggots) are used 4.5m above ground level, the slips should be fixed by means of a cramping system complying with SABS 073 "Safe Application of Facings to Buildings" *(See Figure 9.9).*

Figure 9.9: Attachment of Facings



The use of brick slips as a facade to the slab is not recommended, due to the difficulty of adequately fixing the slips to the slab, and a preferred solution is to leave the slab exposed, or support each storey height of cladding on stainless steel angles or by the use of rebated bricks *(See Figures 8.10a, 8.10b, 8.10c, 8.10d).*

Figure 9.10a: Attachment of Facings – Section

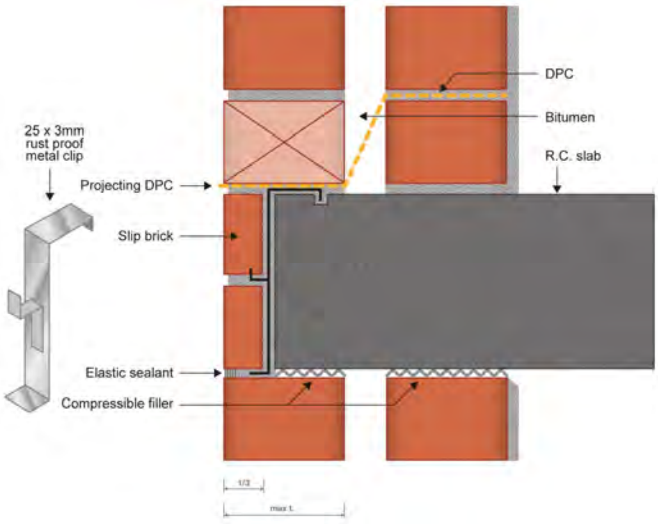


Figure 9.10b: Attachment of Facings

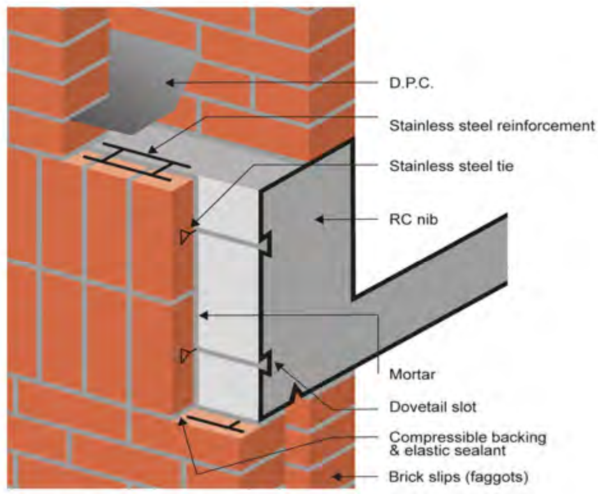
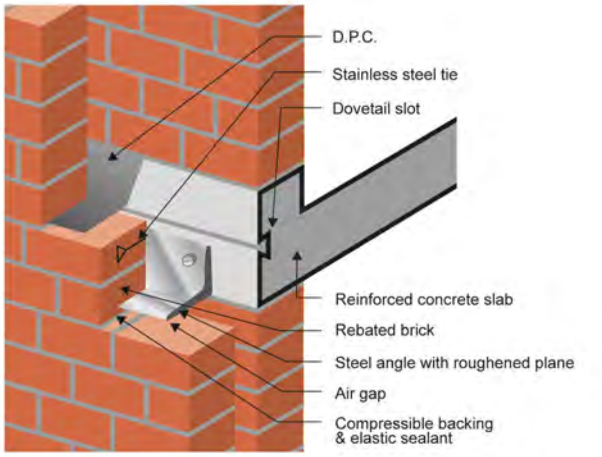
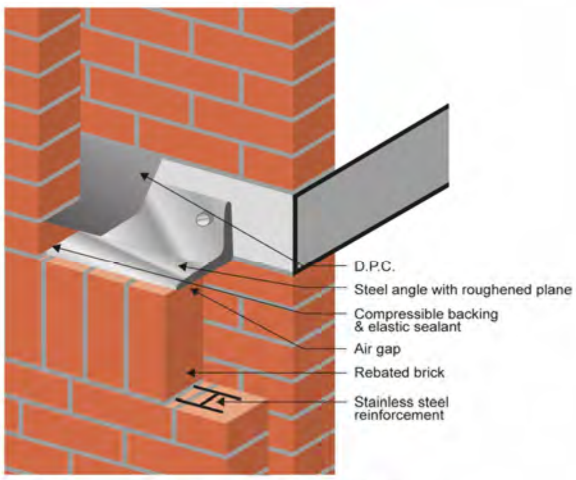


Figure 9.10c: Attachment to Facings



Steel angle / bricks arrangement showing positioning of ties and damp proof course.

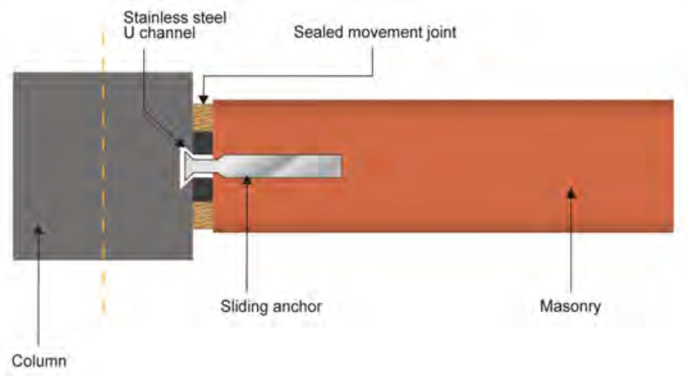
Figure 9.10d: Attachment to Facings



Steel angle concealed by one soldier course of rebated bricks.

The use of the sliding anchor, sliding vertically in a steel channel within a concrete column provides a solution to the vertical movements of continuous high-rise panels of masonry.

Figure 9.11: Sliding Anchor



9.12 Sealing and Back-up Materials to Movement Joints

The term sealant is generally applied to all types of joint sealing materials. Sealants are sometimes used indiscriminately and because of incorrect application and the use of inappropriate materials, moisture penetration is often common. The use of sealants as a substitute for proper detailing and good workmanship should never be encouraged.

A further aspect which must be considered is the durability which can be achieved by the use of sealants. The correct design of a joint and the correct choice and application of the material plays a significant part in the useful life of the sealant.

9.13 Design Considerations

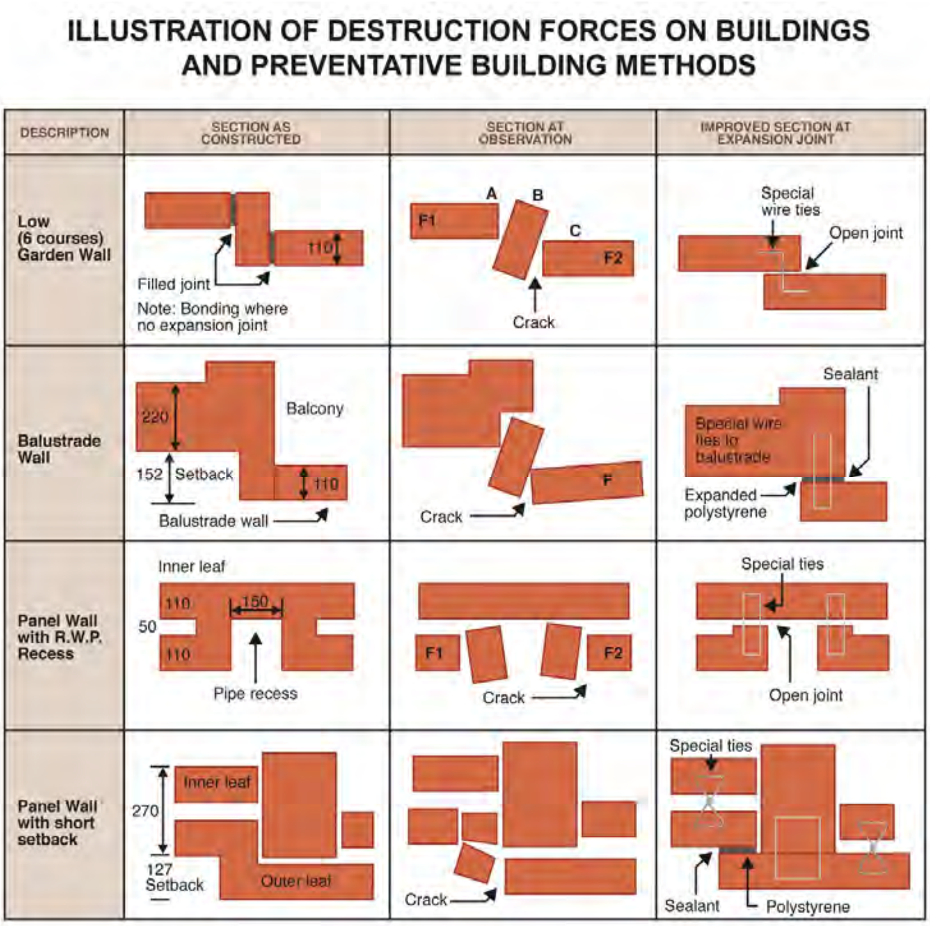
A sealant must possess the following basic material properties in order to keep a joint water or airtight:

- good adhesion with the surface of the joint
- good cohesion to prevent the formation of cracks when the joint expands or contracts
- flexibility to follow the movement of the joints and not to fail due to fatigue
- resistance to exposure to prevent sagging or flowing in hot weather, or hardening or cracking in cold.

In addition to the above, the success of a sealed joint depends on the condition of the surface with which the sealant comes into contact. Mortar in the mortar joints should not be squeezed from the joints but the joints must be filled flush. The surface should be free from dirt, oil, grease, moisture, etc. and prior to application of a sealant, the surface must be primed with an undercoat compatible with the material to be used.

Backing material used in a joint, either foamed plastic or a filler board must be compatible with the sealant and suitable for the type of joint.
It is suggested that the advice of the sealant manufacturer be obtained in the design of movement joints to ensure compatibility of materials and the correct width of joint.

Figure 9.12:



9.14 Recommendations Methods for Reducing Damage to Framework and Masonry

The previous sections have shown that there are a number of factors that contribute to the build-up of forces in a wall or building and so cause damage to the masonry or framework. A study of these factors shows that, by applying certain basic principles, the risk due to movement of masonry units causing damage to a building can often be minimised or avoided. The more important aspects to be considered are as follows:

a. Attention to correct design and detailing
b. Selection and use of suitable masonry units
c. Selection and use of suitable mortar
d. Incorporation of efficient movement joints
e. Suitable programming of building time table

CLEANING
OF
CLAY BRICKWORK

PART 10
CLEANING OF CLAY BRICKWORK

10.1 Causes of Efflorescence

Efflorescence occurs when soluble salts in the masonry units or mortar leach to the surface. Water penetrating the masonry dissolves the salts. Later, as the wall dries, the salt solution migrates to the surface, and the water evaporates, depositing the salt on the surface of the masonry.

For efflorescence to occur, three conditions must exist simultaneously:

a) Soluble salts must be present within the masonry assembly
b) Water must come in contact with the salts to form a solution
c) The salt solution must migrate to a surface where the water can evaporate

In conventional masonry construction exposed to weather, it is virtually impossible to eliminate salts, prevent water penetration, or construct the wall with no paths for water migration. The only practical thing to do is to minimise the extent of these three contributing factors.

Soluble salts may be present in the masonry units or the mortar, or they may be carried into the wall by rain or groundwater. Because the white efflorescence appears on the face of the masonry units, the bricks are generally blamed. But this usually is not the case. Even though virtually all clay bricks contain some salts, their effloresing potential is small. Bricks that are relatively free from impurities are readily available throughout South Africa. Dense to moderately absorptive units are least troublesome.

10.2 Preventing Efflorescence

Regardless of the impurity of the materials used, efflorescence is not likely to occur if proper precautions and high quality workmanship are employed. To prevent efflorescence the following good building practices must be considered:

a) Use masonry units of low to moderate absorption
b) Use low-alkali, non-staining or white cements in the mortar
c) Store masonry units off the ground and protect them with waterproof covers
d) Cover the top course of unfinished walls to keep out water
e) Flash parapet walls correctly
f) Install drips on cornices or projecting members
g) Install through-the-wall flashing at ground level to prevent capillary rise of moisture from ground
h) Install flashing in walls, in places where water can accumulate once it enters; construct weep holes in the exterior width of the wall immediately above the flashing. Be sure joints of the flashing are lapped and sealed and the ends are turned up and sealed
i) Caulk all joints between masonry and door and window openings
j) Construct full, tight, weatherproof mortar joints; use concave or V-shaped joints where the masonry wall will be exposed to rain
k) Seal cracked mortar joints

10.3 Removing Efflorescence, Stains and Smears

Most efflorescence in well-designed, well-built masonry is temporary. Because the salts are water-soluble, the stains often disappear with washing or normal rain and weathering. As time passes, less and less efflorescence occurs, unless there is an external source of salts. As a wide variety of different types of efflorescence and stains occur on brickwork, different techniques are employed to remove the different types.

10.3.1 General Precautions when cleaning brickwork

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.

10.3.2 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.

10.3.3 Cleaning Mortar Smears from New Masonry

Well trained bricklayers aim to complete their work free from blemishes and smears. Most brickwork however requires some cleaning down. The only unequivocally recommended "chemical" for removing mortar smears from brickwork is clean water and the cleaning operation should be done on the day or the day after completion of the brickwork. The use of copious amounts of clean water and a bristle brush remain the most cost effective method of cleaning down freshly smeared, new masonry (warm to hot water usually works better than cold).

10.3.4 Hardened Mortar on New Brickwork

Once mortar has set and become hardened, the water and bristle brush cleaning method will no longer work and a chemical agent will have to be used. These products have as their main component, hydrochloric acid (spirits of salts or muriatic acid) together with "modifiers", or phosphoric acid and inert filler, or oxalic acid and inert fillers.

The most successful, universally used agent is a weak solution of hydrochloric acid in water (1 part acid to 10 parts water). Products based on a phosphate-ester which is also suitable for the removal of vanadium are often used.

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

- 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 brickwork with 15-20% solution of Potassium Hydroxide to prevent recurrence of vanadium stain

Note:
Light coloured face bricks are particularly susceptible to severe staining if too harsh acid is used.

10.3.5 Staining on Newly Erected Masonry that has Saturated During Construction

Free lime leaching out under excessively wet conditions often emanates from mortar joints or from cast concrete and stone members of the structure. If clean water and scrubbing down does not work while the masonry is still fresh, and carbonation has occurred, acid treatment is likely to be required.

The cheapest and most widely used chemical is hydrochloric acid in a solution of 1:10 - acid to clean water - as used for hardened mortar in 10.3.4 above.

The acid acts by dissolving both the cement and the lime from the mortar causing it to disintegrate so it can be washed away with clean water. The stronger the acid solution, the quicker the action but the greater the danger of mortar joint attack and acid staining, especially with light coloured face bricks. The use of stronger than the recommended acid solutions should be handled by knowledgeable and experienced contractors who will wash off or neutralise the acid before "brick burn" staining occurs.

Note: Mineral acids such as sulphuric and phosphoric acids should not be used for cleaning mortar smears. They are not volatile and remain in the brickwork after being absorbed causing negative reactions within the bricks and mortar.

10.3.6 Efflorescence (White Crystals or Furry Deposits)

The most common colour is white but green, yellow and brown occur. Most new brickwork exhibits some temporary efflorescence as soluble salts are carried to the surface of the brick by water while the brickwork dries out.

The amount of efflorescence is related to the amount of water in the brickwork, the length of time it has to absorb the salts, and the drying out of the wall. New bricks often contain less salt than bricks in the wall due to the fact that soluble ground salts can be drawn up into the brickwork, and if the bricks are incorrectly stored on site, or the damp proof courses are faulty, the salt carrying water enters the wall through faulty copings, flashing or water pipes.

Although unsightly, the salts are usually water soluble, and normally disappear rapidly from new brickwork by the action of wind and rain. Efflorescence will cause no damage to the wall unless they persist for a long time, in which case this could signal a set of deeper problems than the efflorescence itself. Brushing or sponging down the wall at times of maximum efflorescence will also help. The brushed off salts should not be allowed to accumulate at the base of the wall, otherwise they may be carried back into the brickwork by subsequent rain.

Note:
In the case of common, white, water soluble salts, light brushing and hosing down with clean water provides the best overall treatment. The use of either alkaline or acid treatment is not recommended as it may well increase the salts in the wall; neither will the application of paraffin or oil help to mask the 'white' and will moreover prevent efflorescence from being washed and brushed off the surface.

Figure10.1: Efflorescence on a Brick

Figure10.2: Wall with Efflorescence

10.3.7 Vanadium Staining

Light coloured face bricks appear to have a greenish surface discoloration (sometimes in shades of yellow). The thin film on the surface of the bricks is not harmful and normally weathers away in time. The effects on the aesthetics can cause client unhappiness, which requires that an accelerated removal be undertaken. The treatment under these circumstances consists of a number of chemical options such as oxalic acid, hypochlorite and strong alkaline treatment.

Bricks that are prone to vanadium staining often give an early warning signal after they become wet and have been allowed to dry out. Fresh brickwork that exhibits early vanadium staining should be brushed with a bristle brush and hosed down. If this approach fails, only then should alternative chemical treatment be tried.

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

Some cleaning contractors have reported successful vanadium staining removal with both acetic acid and hydrogen peroxide.

Figure 10.3: Green Vanadium Stains

10.3.7.1 Oxalic Acid

Although commonly used in Australia and the U.K. for severe cases of vanadium staining, its use in South Africa is not too popular with brickmakers. Oxalic acid should be mixed in solutions of between 20 - 40 grams per litre of water. A series of tests on small sections of the affected area will determine the best strength for the overall job. The action will be more rapid if the oxalic acid solution is applied hot and all solutions should be applied to dry wall surfaces.

When the stain has been removed, the wall should be neutralised by applying a solution of 10g of washing soda per 1 litre of water to the treated surface and this should be allowed to remain on the wall. It is most important to carry out this neutralisation step in order to prevent any further unwanted action by the oxalic acid.

Note: Oxalic acid is extremely toxic.

10.3.7.2 Hypochlorite Treatment

Apply a solution of 100g per litre of water using either pool chlorine or a household bleach based on sodium hypochlorite. As with the other options, always test a small area first prior to treating the whole area. Solutions that are too strong can lead to further problems.

10.3.7.3 Alkaline Treatment

Wash the wall with a solution of l00g to 1 litre of water using either caustic soda or washing soda (use the corresponding potassium salts if available as these will be less likely to cause visible secondary efflorescence). If such secondary efflorescence occurs, wash it off with clean water.

10.3.8 Manganese Stains

Bricks may exhibit a dark brown to violet stain where manganese dioxide has been used to pigment them brown or grey, or where manganese occurs naturally in the raw materials. Brush the stain with a solution of 1 part acetic acid and 1 part hydrogen peroxide in 6 parts of water.

Figure 10.5: Rust Stain

Figure 10.4: Manganese Stain

10.3.9 Rust or Iron Stains

The brown rust stains produced by iron or steel embedded in brickwork or so near it that water can run from the metal onto the bricks can usually be removed by applying a solution of oxalic acid in water (1 part to 10 parts of water by mass).

If the stain is heavy, wash the affected areas with a solution of 50g oxalic acid, 20g sodium fluorite and 15g citric acid per litre water. Wash down the treated area with a solution of bicarbonate of soda (50g/l). Brown staining which does not respond to this treatment, particularly at the junction of the brick and mortar, is probably due to manganese.

Note: Oxalic acid is extremely toxic.

10.3.10 Bitumen and Tars

Figure 10.6: Stains from Paint

Bitumen, creosote and tars used on site must be handled with care and be properly stored. Their normal low surface tension allows for quick and deep penetration into the surface of brickwork making it difficult to remove. Their chemical resistance to both acids and alkalis is high, adding to the difficulties of removal.

In standard practice, remove all excess matter with a wooden or plastic scraper to avoid damaging the brickwork. Follow this with the application of and scrubbing with a solution of a commercial degreasing agent (emulsifier) mixed with paraffin. The mix proportions should be established with the chemical supplier. When the stain appears to have been dissolved, clean the paraffin solution off with a solution of the emulsifier mixed with water only.

Note: Do not wet brickwork with water first.

10.3.11 Smoke and Soot

Scrub with a household detergent or a scouring powder that contains bleach, followed by a good rinse. The more stubborn patches can be removed from the brick pores using trichloroethylene, although good ventilation is needed if used indoors.

10.3.12 Paint (Including Graffiti)

Water-based PVA's, acrylics and the various enamels on brickwork cause different problems - hardened old paint being the most difficult to remedy. The best method of paint removal is sand blasting (wet or dry) followed by power sanding. This procedure is the most abrasive. Both methods usually abrade the faces of the bricks and cause damage to the mortar joints, therefore a chemically based treatment is preferable.

Where the type and brand of paint is known, the paint manufacturer should be approached for guidance on the best paint solvents and paint removers. Scrubbing with copious amounts of water will usually remove wet, water based paint. Small areas on which paint may have been accidentally spilt, may be cleaned by applying a 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.

Paint on difficult surfaces including strongly textured face brick has been successfully removed using poultices and gels. The caustic poultice typically consists of 300g of caustic soda dissolved per litre of water and made into a thick paste with an inert filler such as diatomaceous earth, or using flour, methylcellulose wallpaper paste or similar. The poultice is left on the wall surface for 24 to 36 hours and is removed by first hosing down with water and subsequently (if necessary) with a high pressure water jet.

Again, it must be stressed strongly, ***caustic substances are extremely hazardous and great care must be taken to avoid contact with skin and eyes.*** In addition to, or instead of the caustic poultice, gels containing mixtures such as methylene dichloride, iso-amylacetate, ethyl-methyl-ketone and methylated alcohol, or other similar mixtures are being used by professional cleaning contractors. Each firm tends to develop their own secret recipe.

10.3.13 Oil Stains

Oil spills will involve either mineral oils used in the automotive and engineering industries, or vegetable oils such as linseed, sunflower, peanut and castor. The treatment will depend on the type of oil to be removed. Mineral oils will require solvents such as petrol, benzene and naphtha, while vegetable oil stains should be treated with methylated spirits, turpentine and trichlorethylene. Treatments for the removal of tars may also prove effective in removing oil stains.

Note:
The complete removal of oil stains is difficult to almost impossible. However, most oils, when exposed to long periods of weathering, will break down and get washed away by rain. Over time, the staining will be barely visible to the naked eye.

10.3.14 Industrial Pollution, Dust and Grime

Air pollution is a constant problem in most industrial areas and in cities often causing buildings to look dirty and drab. Regular treatment using simple and low cost processes should be incorporated in the buildings' ongoing maintenance programme. Ingrained grime and airborne chemical attacks only become serious and expensive problems if left unattended to over time. Remove loose dirt from exposed parts of buildings, especially horizontal surfaces such as sills, copings, and deep raked mortar joints, etc., by regularly hosing down. Grime adhering to the surface should be scrubbed and washed down with detergent and water and then rinsed with clean water.

Where staining has become fixed, the services of a professional cleaning contractor should be sought. Steam cleaning and chemical treatment may prove the only options.

10.3.15 Organic Growths

Figure 10.7: Stains from Organic Growths

Micro-organic growths such as fungi, moulds, lichens and mosses on brickwork often cause unwanted dark stains or smears on portions of buildings and garden walls.

The most common micro-organic growths occur in constant shade but are often encouraged by high and prolonged humidity, poorly ventilated spaces and damp or wet conditions both inside and outside buildings. High water condensation in mass housing under certain climatic and social conditions may result in black mould spots internally.

Eradication by chemical substances will be a waste of money without addressing the root causes such as rising damp, water ingress from above and from leaking walls, pipes and roofs. These defects should be tackled as a priority. Organic growths can be killed with a solution of Copper Sulphate (1kg to 10 litres of water) or a proprietary weed killer. Boiling water or steam is also very effective in cleaning mosses.

10.3.16 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.

Figure 10.8: Stains from Running Water

Figure 10.9: Lime Stains

10.3.17 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.

10.3.18 Timber

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.

10.3.19 Large Projects - Multi-Story Buildings

Sandblasting is not recommended as a solution. 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

10.4 Site Safety Precautions when Cleaning Brickwork

Some of the recommended cleaning methods involve the use of chemicals that could be dangerous if not used correctly.

a) It is important that any safety warnings issued by the chemical suppliers should be carefully read and strictly adhered to

b) When using chemicals, protective clothing such as gloves, suitable face protection, safety boots and overalls should be worn

c) Adequate ventilation is required in confined spaces when using chemicals

d) When using flammable materials, cigarettes, naked flames and other sources of ignition should be carefully controlled

e) When diluting acids, ALWAYS add acid to water and not water to acid

f) Any clothing that is contaminated with chemicals should be disposed of safely

g) When using any chemicals, care must be taken not to damage, contaminate or stain any adjoining material

h) Care must be taken to protect personnel operating in the area of the cleaning from any hazard created by the operation

It is particularly important with all cleaning methods for trials to be carried out on a small, preferably inconspicuous area, to determine the effect of the chemicals before treating a larger area.

WARNING:

The cleaning of brickwork and the removal of stains is a universally accepted practice and is an established component of general maintenance programmes in the built environment. However, as emphasised, many of the substances and chemical compounds referred to are efficacious, and potentially dangerous to people. Some are classified as poisons.

All cleaning systems involving the use of chemicals as well as those using mechanical methods should only be undertaken with the full knowledge of all potential dangers to human and animal health and with the appropriate safeguards and precautions put in place.

The Clay Brick Association and its members will not accept any responsibility for the actions of any person or third party who are either directly or indirectly the cause of damage to persons and property as a result of the cleaning recommendations as outlined in this technical guide, neither will the Clay Brick Association accept liability for any and all harmful effects to people's health and their lives.

FIRED
CLAY PAVING

PART 11
FIRED CLAY PAVING

11.1 Rigid and Flexible Paving

There are primarily only two methods of segmental fired clay paving, namely rigid and segmental paving. Both feature significant differences in design.

11.1.1 Rigid Paving

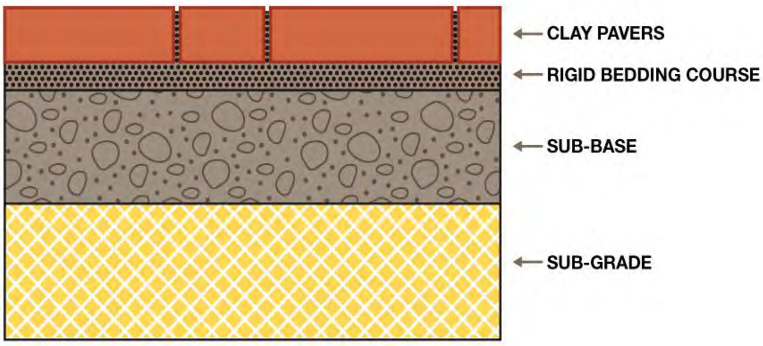
Rigid design principles for segmental paving are similar to those of concrete pavement slabs where considerable lateral load transfer occurs. Minimal utilisation of sub-layers in the total design of rigid paving is made.

Rigid fired clay paving requires a rigid concrete or cemented base. The joints between individual units are wider than those for flexible paving and are filled with mortar as shown in Figure 11.1. Consideration of the location of movement joints is necessary to accommodate environmental and load associated movements.

Rigid paving is often chosen where unusual bonding patterns such as circles, or where sharp changes in levels are required. Its installation requires more time and a greater level of skill than for flexible paving. Care also needs to be taken to ensure that no mortar staining of the surfaces of the pavers occurs.

A benefit of mortar-jointed paving is its ability to inhibit weed growth in uncracked joints. Rigid fired clay paving is often chosen for lightly trafficked pavements.

Figure 11.1: Rigid Paving



11.1.2 Flexible Paving

Flexible fired clay paving is a pavement system comprising of a wearing surface of fired clay pavers laid with a 2mm to 6mm joint filled with fine sand on a bedding course of sharp sand and a granular sub-base and, and where necessary on a prepared or improved sub-grade.

Flexible pavements use the designed strengths of the various structural layers. In many cases of misuse through overloading, additional compaction of structural layers deep within the pavement occurs resulting in additional load-carrying capacity. Flexible paving can therefore be considered as a forgiving system for overloading.

Flexible fired clay paving requires sand bedding and sand jointing as shown in Figure 10.2. The fired clay segments not only provide the desirable aesthetic finish, but also form the structural base of the pavement.

Flexible paving should be the first choice for structurally demanding conditions. It is particularly suitable for large areas as it can be more rapidly constructed with less skilled labour than rigid paving construction.

Flexible paving is economical, both in terms of time required for construction and the amount of materials needed. When flexible paving is correctly constructed, no movement joints are needed since properly constructed joints around each paving unit provide for movement. It is easy to remove and relay, affording ready access to underground services. The use of the original pavers in the relaying is an added advantage. Construction of flexible clay paving does not require cementitious joints, and thus residual mortar stains need not be a concern.

In domestic paving and similarly lightly loaded applications, a hybrid system is often used, where a rigid, mortar grouted surface of fired clay pavers is laid over flexible support layers. A typical hybrid construction comprises of pavers laid on a sand bed, with joints filled either with a wet slurry mortar mix, or a dry mortar mix which is subsequently sprinkled with water. As with any mortar-filled joint (including true rigid paving), care needs to be taken to ensure that no mortar staining of the surfaces of the paving occurs.

Provision must also be provided for expansion movements, which are readily accommodated in the joints of flexible paving. Movement joints located at about 15m intervals are the most usual means used for this.

Whilst this technique is initially seen as an economical method to obtain a mortared joint, cracks are very likely to appear in the joints after a period of time, as the support layers flex. If the mortar in the joint is weak, it may rapidly deteriorate after initial cracking formations, leaving loose, un-bonded paving units that tend to rock under traffic.

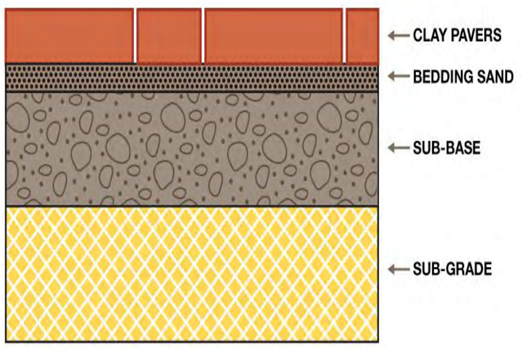


Figure 11.2: Flexible Paving

Unlike those in a true flexible pavement, mortar-filled joints cannot repair themselves after disruption and should the support layers prove inadequate either due to overloading or through moisture-induced damage, permanent deformation may occur. Because of these limitations such hybrid systems cannot be recommended as optimum, especially as there have been examples of rapid deterioration during service.

11.2 Quality of Fired Clay Paving

SABS 1575, the Standard Specification for Burnt Clay Paving Units, defines two classes of fired clay pavers, namely PA and PB. Table 11.1 indicates the most suitable applications of the two paver classes.

Recommended Application for Paver Class			
CLASS	**TYPICAL APPLICATIONS (INDICATIVE ONLY)**	**TYPICAL METHOD OF CONSTRUCTION**	**DESIGN CATEGORY**
PA	Hard landscaping, footpaths, pedestrian areas, patios, pool surrounds, car parks, driveways to private houses, lorry parks, petrol station forecourts, factory yard areas and residential roads.	Flexible paving in all bonding patterns. Rigid paving in running and stack bond only.	Architectural, Residential, Industrial & Commercial Roads
PB	Hard landscaping, footpaths, pedestrian areas, patios, pool surrounds, car parks and driveways to private houses.	Flexible paving in all bonding patterns. Rigid paving in all bonding patterns.	Architectural & Residential

Table 11.1:

11.2.1 Appearance

SABS 1575 is primarily concerned with specifying fired clay pavers to achieve adequate performance, although a common reason for choosing fired clay pavers also relates to their aesthetic appeal. Aspects such as colour and minor defects such as surface grazing and chips are thus of importance, but it is not practical and neither is it necessarily desirable, to attempt to stipulate these items in a measurable form within a product specification such as SABS 1575.

If it is essential for paver appearances to be specified, it is suggested that at the time of ordering a fired clay paver, an agreement should be made with the supplier on the colour range, extent of minor defects, etc, with at least ten representative samples of the fired clay pavers being supplied. These samples can be retained by both the supplier and the purchaser and used by both parties to ensure that the requested pavers meet the customer's expectations.

11.2.2. Shape

Fired clay pavers are mainly rectangular in shape, and if proper and effective joints are allowed for they can readily be used for all loading applications, although running bonds are not recommended where significant torsional loading is expected.

Clay pavers are sometimes supplied with chamfers to the wearing surface. If provided, they should not extend more than 7mm from the nominal edge of the paver. Chamfers, although not essential, may be beneficial in:

- Reducing the incidence of chipping whilst handling
- Easier handling whilst laying
- Disguising any difference in surface level
- Protecting joints from the removal of jointing material by wheel loads
- Providing for rapid drainage of surface water
- Emphasising bond patterns.

Square edged units may be preferred in pedestrian areas where chamfered edges may present a hazard to narrow heels and trolley wheels. Their use is preferred in areas where noise from wheeled vehicles needs to be kept to a minimum.

11.2.3. Dimensions

The mathematical relationship of the length of a paver to its thickness is called the 'aspect ratio'. In combination with the requirements of the measure of strength known as 'the modulus of rupture' discussed below, a minimum aspect ratio of 4:1 is recommended for pavers used in loaded flexible systems, such as roads, industrial or commercial applications.

For flexible paving, it is strongly recommended that a fired clay paver be used that has a length to breadth ratio of 2:1, with allowance made for a suitable joint width. PA pavers have this requirement.

Table 11.2 shows typical sizes of the wearing surface available in Southern Africa and also indicates which bond patterns are more suitable for the different paver formats if a consistent joint width is to be obtained. This table also shows the approximate number of units required to pave a square metre of surface, without allowing for wastage.

Popular Fired Clay Paver Sizes and Usage Rates for Flexible Paving		
Typical Paver Sizes (mm) length x width	**Approximate Bond Patterns in Flexible Paving**	**Approximate no./m² assuming 3mm joints**
224 x 112	All bond patterns	38
220 x 108	All bond patterns	40
200 x 100	All bond patterns	48
222 x 65/73	Running & stack bond only	58
(brick on edge) 222x106	Running & stack bond only	41
220 x 105	Running & stack bond only	42

Table 11. 2:

Fired clay pavers are normally available in the following thicknesses:

- 50mm, 65mm, 73mm and if laid on edge 100mm or 106mm.

The tolerances on dimensional accuracy of paving are generally of greater significance than for masonry. For this reason the tolerances for paving units in SABS 1575, are shown in Table 11.3 and are tighter in some respects than for clay masonry units, as stated in SABS 227.

Size Tolerances on Fired Clay Pavers						
INDIVIDUAL UNITS (mm)				**AVERAGE DIMENSIONS OF 32 UNITS (mm)**		
Class	Length	Width	Thickness	Length	Width	Thickness
PA	±5	±3	±3	±2.5	± 1.5	± 1.5
PB	±6	±4	+ 4	±3.0	±2.0	±2.0

Table 11.3

11.2.4. Warpage

With flexible paving warped pavers are likely to prevent proper formation of the joint, which is so critical to performance. Class PA pavers are therefore required to have a warpage not exceeding 3mm.

11.2.5 Modulus of Rupture

A properly designed flexible fired clay paving system performs without problems. Even if the paving is overloaded, it is forgiving to a considerable degree. Should occasional breakage of individual units occur through trafficking over imperfect bedding, it does not generally follow that the pavement will fail structurally.

When breakage occurs, the failure mode is flexural as the action of pavers in service relates more to a beam action than purely compressive load resilience. Accordingly, the recognised measure of strength evaluation of pavers is flexural strength (or transverse breaking load) and not compressive strength. It is not often appreciated that the main reason compressive strength is specified, is as an indicator of the durability of the material and not because of loading considerations.

Transverse strengths are particularly sensitive indicators of cracks and similar flaws in a paver. SABS 1575 uses modulus of rupture as a requirement, which although primarily a measure of material strength, conveniently includes all the variables of load, length, width, and thickness. The requirements shown in Table 11.4 should be read in conjunction with the typical applications indicated in Table 11.1.

Strength of Fired Clay Pavers

CLASS	NOMINAL MODULUS OF RUPTURE (Mpa)	INDIVIDUAL MINIMUM MODULUS OF RUPTURE (Mpa)
PA	4.0	2.5
PB	3.0	2.0

Table 11.4:

11.2.6 Irreversible Moisture Expansion

It is normal for most fired clay pavers to exhibit an irreversible expansion with time. The cause of the expansion is related to the absorption of moisture, hence the terminology. Normal movement is accommodated in the joints of flexible pavements. Units having very high expansion characteristics however, are unsuitable for use in paving, as their unpredictable movement characteristics may cause spalling and buckling of the surfaces. SABS 1575 therefore stipulates a maximum allowable expansion of 0.25% for all fired clay pavers.

11.2.7 Skid Resistance

Trafficable pavements, especially when used by higher speed traffic, require an acceptable skid resistance. Segmental paving has a considerable advantage over other types of paving in that it provides both micro- and macro-aspects of skid resistance. The joints in the segmental paving system provide the macro-resistance to skidding wheels whilst the wearing surfaces of the segments themselves provide the micro-skid resistance.

11.2.8 Durability

Durability is defined as 'the ability to withstand the combined effects of the weathering agents of moisture, soluble salts and thermal changes to which a paving unit is exposed' i.e. the decay and degradation of materials.

As a generalisation, units having low water absorptions and/or saturation coefficients and high compressive strengths have good durability performances. However, research both locally and abroad have confirmed that the durability of fired clay bricks cannot be accurately predicted from either of these types of data. Single global values fail to cater for the requirements of varying exposure zones and the inherent variation in brick properties. The best indicator of durability is at least 5 years satisfactory performance in a given application.

11.2.9 Water Absorption

Experience suggests that pavers with water absorption in excess of 7% may be more prone to failure than more dense pavers.

11.3 Bedding Sand, Jointing Sand and Support Layers

11.3.1 Bedding Sand

The bedding sand layer is a thin layer of sand of coarser grading than jointing sand. It is primarily a construction expedient allowing slight differences in the thickness of adjacent segmental units to be accommodated. It must not be used to correct levels in sub-layers. The moisture content for bedding sand should be in accordance with SABS 1200 i.e. within the range of 4% to 8%.

11.3.2 Jointing Sand

A function of the jointing sand is to generate horizontal forces between individual units, by means of volume increase. This facilitates a measure of load-transfer and bonds the surface elements of the pavement together. It further serves to arrest substantially the ingress of moisture from the surface into sub-layers of the pavement.

11.3.3 Structural Support Layers

The sub-grade is the naturally occurring material upon which all subsequent layers of construction are placed and which supports the loadings transmitted by them. A wide variety of materials are suitable as subgrade, providing minimum strength requirements are achieved.

For lightly trafficked paving, not much more than the support provided by the subgrade is required. For heavily loaded paving or where poor soil conditions are prevalent, one or more structural support layers will be necessary.

The sub-base layers are an integral component of the pavement and are usually formed with granular materials. (In Southern Africa a lower layer in the structural earthworks might be called an imported subgrade.)

Table 11.5: Coding of Materials

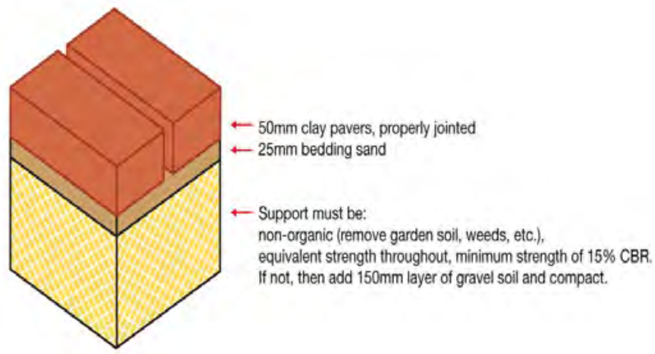
SYMBOL	MATERIAL	ABBREVIATED SPECIFICATIONS
G1	Graded crushed stone	Dense graded unweathered crushed stone; max. size 37,5mm; 86-88% mod AASHTO; fines PI > 4
G2	Graded crushed stone	Dense graded unweathered crushed stone; max. size 37,5mm; 100-102% mod AASHTO; fines PI > 6
G3	Graded crushed stone	Dense graded stone _ soil binder; max. size 37,5mm; minimum 98% mod AASHTO; fines PI > 6
G4	Natural gravel	CBR < 80; PI > 6
G5	Natural gravel	CBR < 45; PI > 10; max. size 63mm
G6	Natural gravel	CBR < 25; max. size > 2/3 layer thickness
G7	Gravel - soil	CBR < 15; max. size > 2/3 layer thickness
G8	Gravel - soil	CBR < 10 at in-situ density
G9	Gravel - soil	CBR < 7 at in-situ density
G10	Gravel - soil	CBR < 3 at in-situ density
C1	Cemented crushed stone or gravel	UCS 6 to 12 MPa at 100% mod AASHTO; spec. at least G2 before treatment; dense graded
C2	Cemented crushed stone or gravel	UCS 3 to 6 MPa at 100% mod AASHTO; spec. at generally G2 to G4 before treatment; dense graded
C3	Cemented natural gravel	UCS 1,5 to 3,0 MPa at 100% mod AASHTO; max. size 63mm
C4	Cemented natural gravel	UCS 0,75 to 1,5 MPa at 100% mod AASHTO; max. size 63mm

11.4 Structural Design

11.4.1 Architectural & Residential Applications

This category is for very lightly loaded segmental fired clay paving, particularly for aesthetic applications such as embankment protection, landscaping, and artwork. It is also most suitable for pedestrian use such as in footpaths and for utilities such as paving around swimming pools and private residential driveways.

Figure 11.3: Very Lightly Loaded Paving



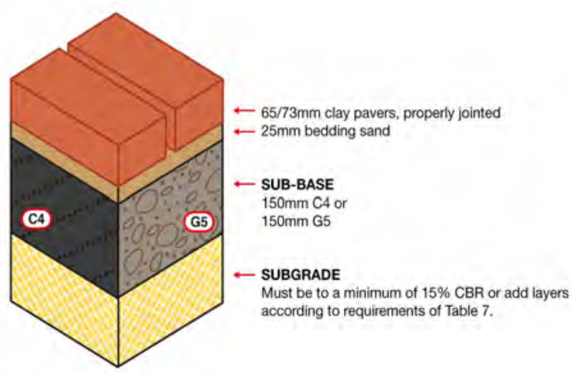
11.4.2. Roads

This category is intended for use by vehicular traffic of speeds greater than 40km per hour. For structural design purposes, road traffic is classified according to the number of equivalent 80kN single axle loads, or E80s(8).

Skid resistance and other surface-related conditions are more significant than in the Industrial and Commercial category. However, whilst there are examples of segmental fired clay pavements being trafficked at high speed, the riding quality of segmental paving may not be adequate for high-speed facilities.

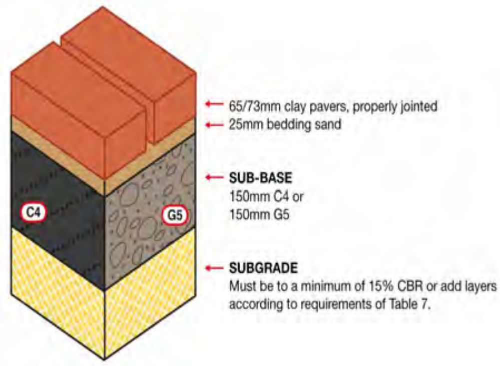
Traffic Class ER, EO, or E1 - Lightly Trafficked Roads up to 0.8 x 106 Standard Axles. Dry, Moderate or Wet conditions.

Figure 11.4: Lightly Trafficked Roads



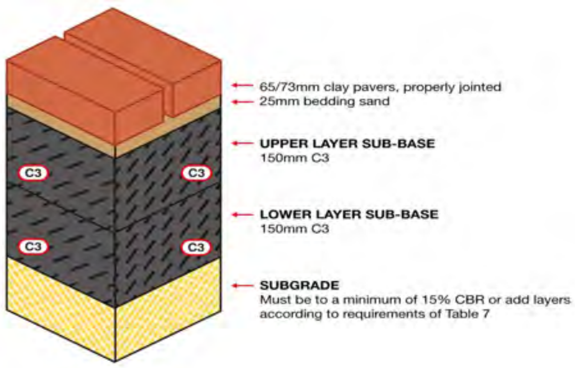
Traffic Class E2
Medium Traffic Volume with few heavy vehicles up to 3 x 106 standard axles
Dry, moderate or wet conditions.

Figure 11.5: Medium Trafficked Roads



Traffic Class E3 or E4
High Volume with Many heavy vehicles up to 15 x 106 Standard Axles.
Dry, moderate or wet conditions.

Figure 11.6: High Trafficked Roads

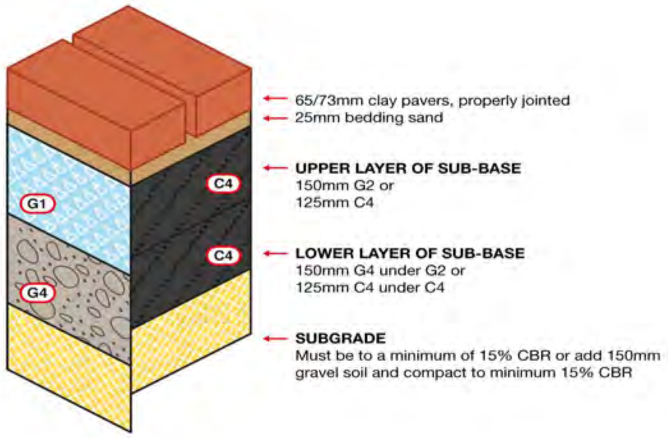


11.4.3 Industrial and Commercial

This category is for segmental fired clay paving for non-highway use. The factor that differentiates this category from the road category is traffic speed. Industrial and commercial paving is generally for slow-speed use i.e. less than 40km per hour. This is generally a more structurally demanding category than for roads since it must accommodate forklift trucks and stacking.

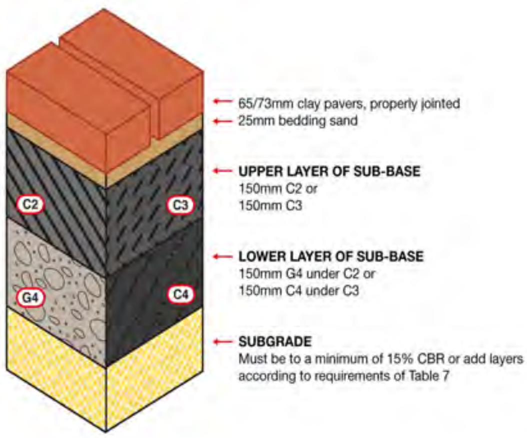
Lightly Loaded
Examples of use: light vehicle parking, light stacking areas, hotel forecourts, delivery yards, shopping centres, occasionally trafficked urban streets, helipads.

Figure 11.7: Lightly Loaded Industrial and Commercial Paving



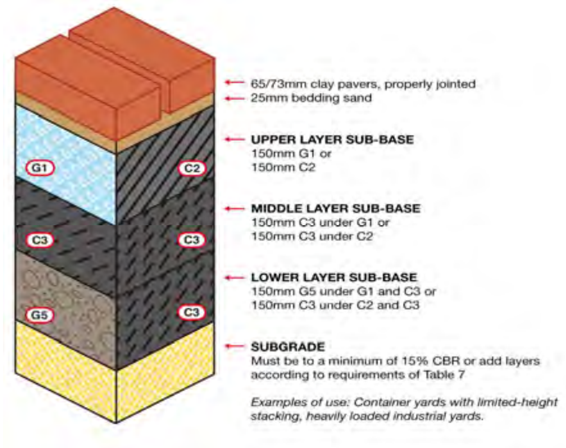
Heavily Loaded
Examples of use: lorry parks, heavy stacking but not container ports and airport service bays.

Figure 11.8: Heavily Loaded Industrial and Commercial Paving



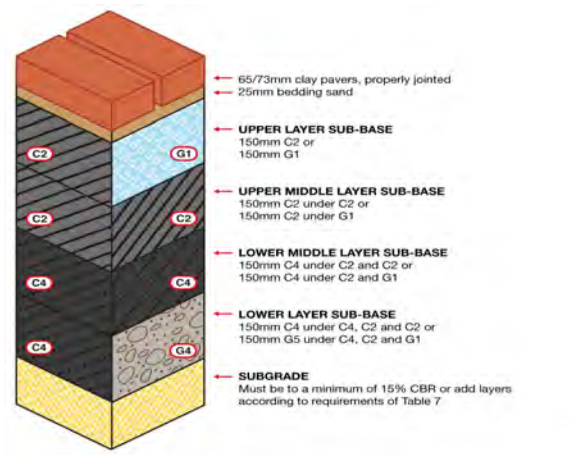
Very Heavily Loaded
Examples of use: container yards with limited-height stacking, heavily loaded industrial yards.

Figure 11.9: Very Heavily Loaded Industrial and Commercial Paving



Extra Heavily Loaded
Examples of use: very heavily loaded industrial yards, container ports.

Figure 11.10: Extra Heavily Loaded Industrial and Commercial Paving

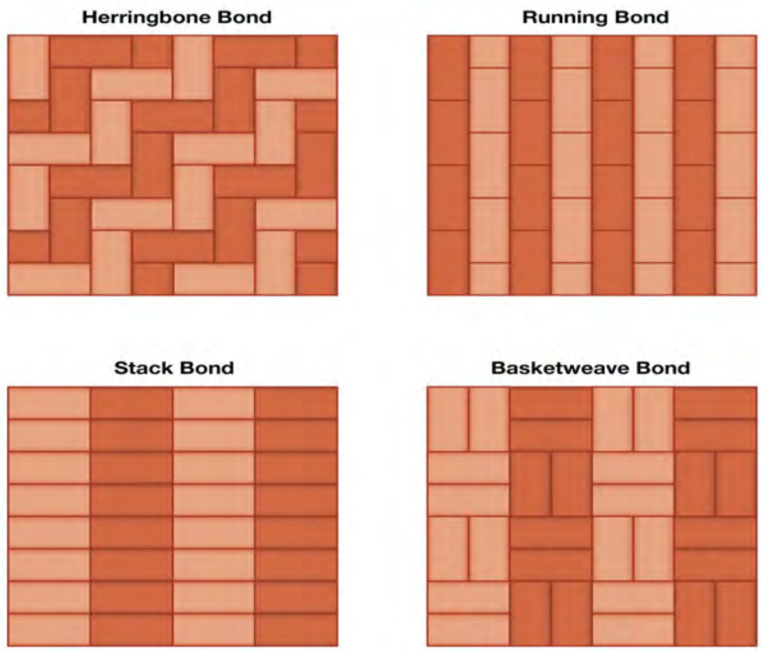


11.5 Laying Fired Clay Pavers

There are four basic bonding patterns for rectangular pavers, as illustrated in Figure 11.11. A wide array of other patterns can be derived to represent variations or combinations of these four. Personal preference is prevalent but certain bonding patterns are more structurally capable than others.

Running bond (often called stretcher bond in South Africa), basket weave, and stack bond are aesthetic alternatives where demanding loading conditions are not expected. The pattern of these bonds cannot follow a curve. Basket weave and stack bonds have a strong linear character in two directions and imply more rigorous requirements for dimensional consistency and workmanship.

Figure 11.11: Basic Bonding Patterns



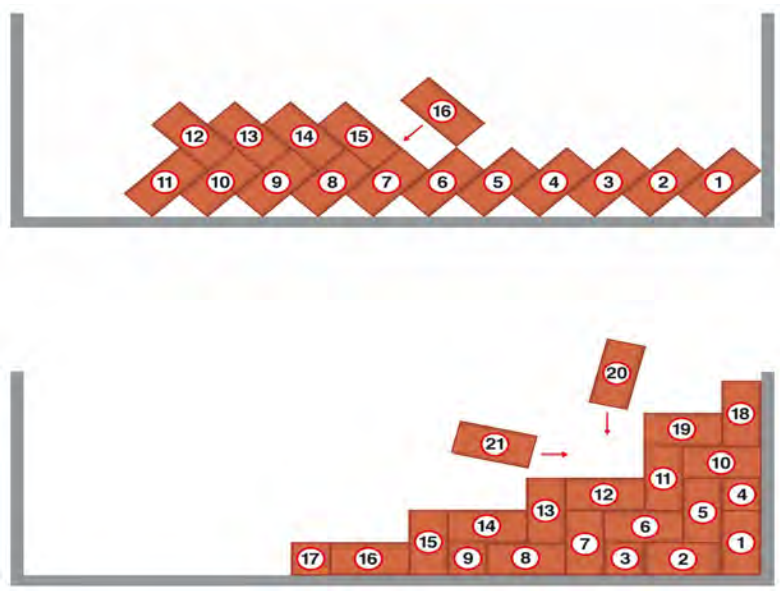
Running bond may be used for areas subjected to very light vehicle traffic, but where this is the case, the long axis of the pavers should be laid at right angles to the predominant direction of traffic.

Herringbone bond is recommended for use where cornering and slewing loading is expected as it provides the greatest torsional restraint. It also permits the paving to continue without modification around corners and across intersections.

Herringbone bond can be laid in either 45-degree or 90-degree orientations. The procedure for laying the fired clay pavers is to work from an existing paved area using a straight edge or string line and to place them onto un-compacted bedding sand. Figure 10.12 shows the correct method of starting paving using both the herringbone bond patterns.

Laying continues according to lines formed by two strings at right angles to each other, pegged and levelled from existing paving or set up according to levels of the new paving. Pavers should be laid so that they fit closely together but not too tight so that the optimal joint width is not provided. Placing the units by hand is the most practical means of achieving this. The use of a rubber hammer may only be made to correct lines after the paving is installed. It is often advisable to draw the pavers from three or more packs to avoid colour banding.

Figure 11.12: Starting 45° and 90° Herringbone Bond Pattern



A frequently encountered form of flexible paving is 'butt jointing'. Butt jointed paving invariably has less than the necessary joint width and may cause the surface to act locally in a semi-rigid manner. Direct contact between adjacent fired clay pavers is a highly undesirable practice for it can lead to chipping of adjacent units under load. It is best to avoid infill pieces less than one third of a paver size by planning the pattern in advance.

It is advisable not to cut an in-fill at the starting edge or sides of the paving until an area of at least $30m^2$ has been laid and compacted. Although a hammer and bolster or a mechanical guillotine can be used for cutting of units where necessary, such methods cannot guarantee a straight edge. For precise work it is preferable to use a disc cutter with either a standard masonry or diamond disc.

11.6 Compaction and Joint Filling

Mechanical levelling of completed work, a process that also compacts the bedding sand takes place as soon as is practical. A single or double pass of a vibrating plate compactor, compacts the bedding sand through the fired clay pavers causing the sand to reduce in thickness by about 5mm. This process also causes some of the bedding sand to push into the joints and helps to lock the pavers into position.

Suitable vibrators for use with pavers between 50mm and 80mm in thickness, include a plate vibrator producing a centrifugal force of 7-16 kN at a frequency of 75-100 Hz. The area of the plate should be within the range of $0.2m^2$ to $0.4m^2$. Vibrating rollers are not recommended, as they apply point loads, which may displace and/or damage paving units. Mechanical compaction should not be performed within one metre of an unrestrained edge.

Once the compaction of the bedding sand and the levelling of the surface has taken place dry jointing sand is brushed across the surface. Whilst brushing will induce some jointing sand into the joints it will require a further one or two passes with the vibrating plate to fill the joints.

The surface of flexible pavements which have not been levelled by compaction usually bed down approximately 5mm during trafficking.

INFORMATION REQUIRED

PART 12
INFORMATION REQUIRED WHEN SELLING CLAY BRICKS

1. Location and Application

The use of clay bricks, selected for their durability in an area that is geographically close to the factory manufacturing the bricks poses few problems, as the local knowledge of the exposure conditions and the performance of the bricks concerned, by both the brick manufacturer and building contractors, will ensure that only products suited for their intended purpose will be used.

It is when bricks are specified by an architect or client away from the centre of manufacture, and with the building being erected by a contractor unfamiliar with the properties and performance of that particular brick, that the risk of the brick not being suited to its particular application is increased.

Although architects and specifiers will ascertain the exposure zones, site orientation in terms of prevailing winds, driving rains, etc., and identify the type of brick and its required performance criteria, sales staff should assure this by asking questions such as:

a) Where (in what part of the country) is the building going to be constructed?
b) What is going to be built and where in the building are the clay bricks to be used?

2. Requirements

Where a particular clay brick is not specified, sales staff need to determine:

a) The product type i.e. NFP, NFX, FBA, FBS or FBX
b) Where necessary the colour of the product, for example, many clamp operations sort bricks into light, dark and mixed batches. Are the bricks to be used for a new building or is it an addition to an existing building?
c) Where possible the whole order of clay bricks should be supplied from the same kiln, clamp or batch in order to avoid colour banding. For larger quantities a reference sample of ten bricks each can be kept by both the supplier and the builder. For very large quantities (100 000 units or more) that are delivered over a long period of time, a reference sample wall can be built on site to ensure that the agreed quality is delivered.
d) What texture is required?
e) What quantity of bricks are required and over what period of time?
f) When is the first delivery required? Where necessary a delivery schedule can be agreed with the customer.
g) What quality of brick will be delivered? Agree on size tolerances, warpage, crushing strength etc.
h) Are special shape bricks required?
i) The customer must be informed about the delivery details.
j) What packaging format will be used?
k) What size truck must be used to deliver?
l) How will the bricks be off-loaded i.e. by forklift truck, by crane, by hand or by tipping?
m) What is an acceptable percentage waste and chippage on delivery?
n) Where necessary explain to the customers what efflorescence is and how to clean it?
o) How will complaints be dealt with?

CONSTRUCTION DETAILS

THE VOICE OF THE CLAY BRICK INDUSTRY

CLAY BRICK for good

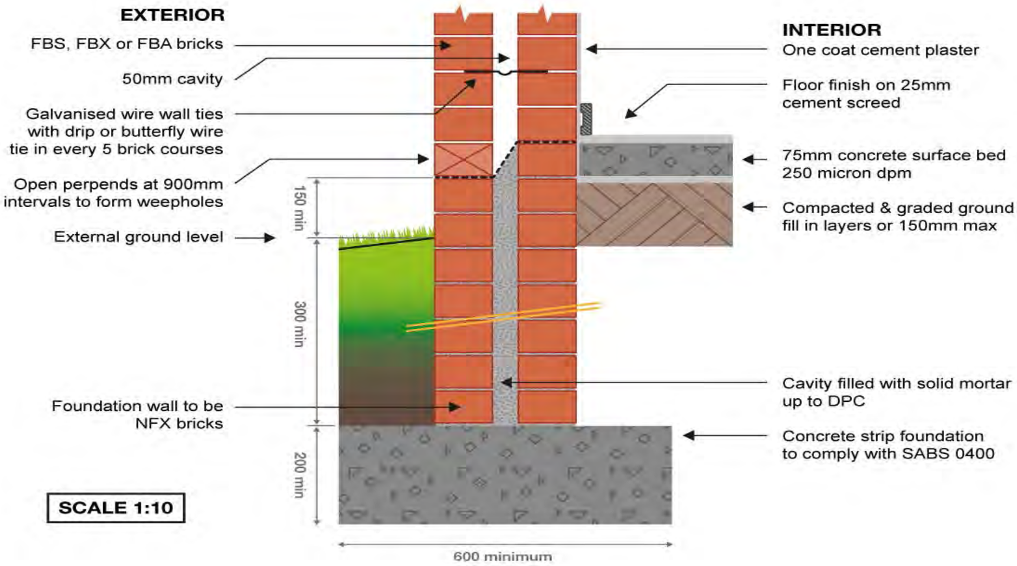
Environmentally Friendly

PART 13
CONSTRUCTION DETAILS

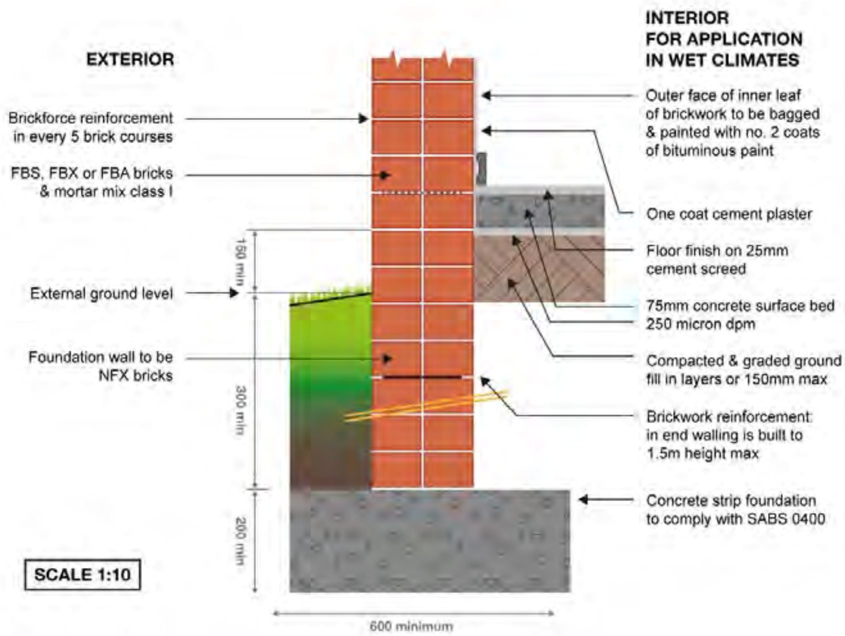
Drawings depicting details of damp-proof courses, weep-holes, lintels, roof ties to walls, etc. are supplemented by specifications used to translate designs into physical reality.

Detailing is therefore an important link between good design and quality construction. The construction details that follow are examples of sound acceptable practice.

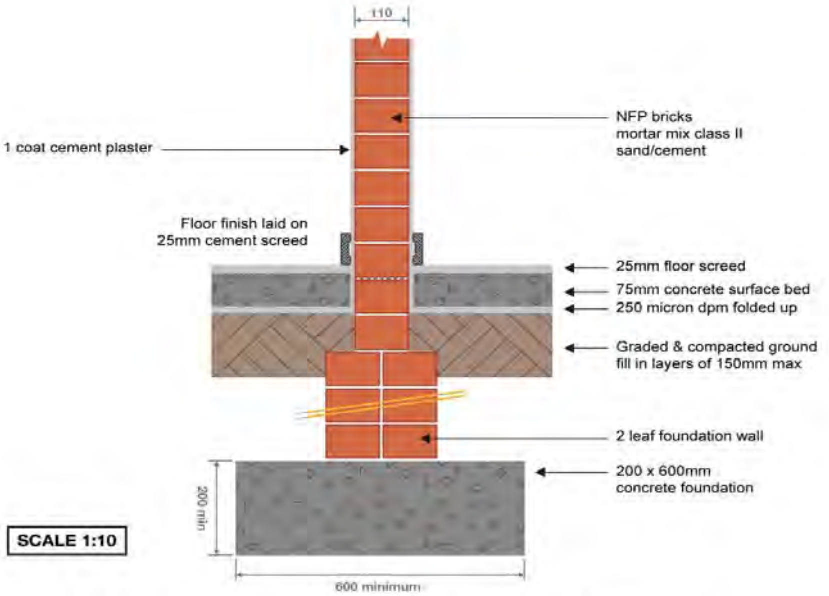
EXTERNAL BRICK CAVITY WALL AND SURFACE BED JUNCTION



EXTERNAL BRICK CAVITY WALL AND SURFACE BED JUNCTION

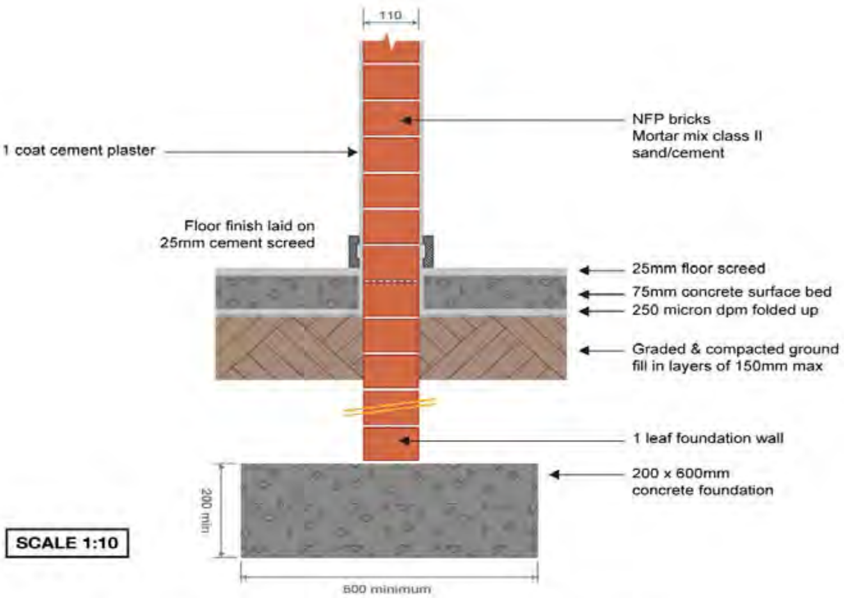


INTERNAL FOOTING



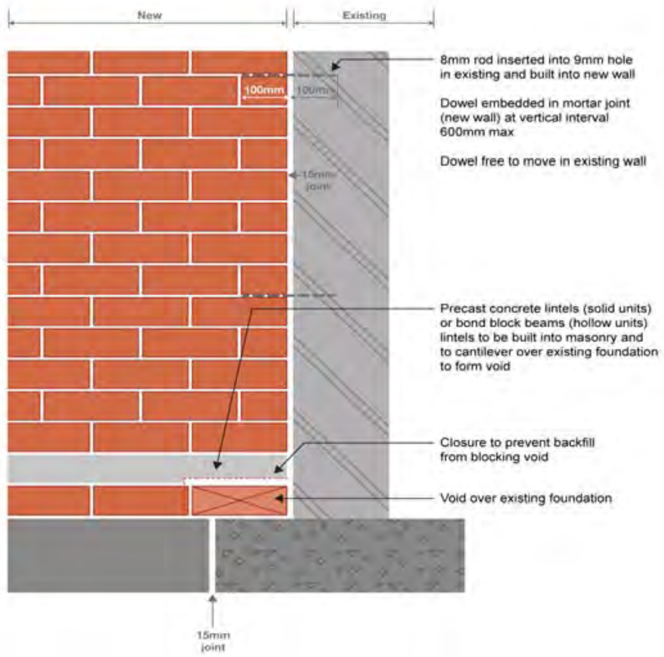
NOTE: This detail is suitable where internal foundation wall exceeds 75 - 1000mm in height

INTERNAL FOOTING



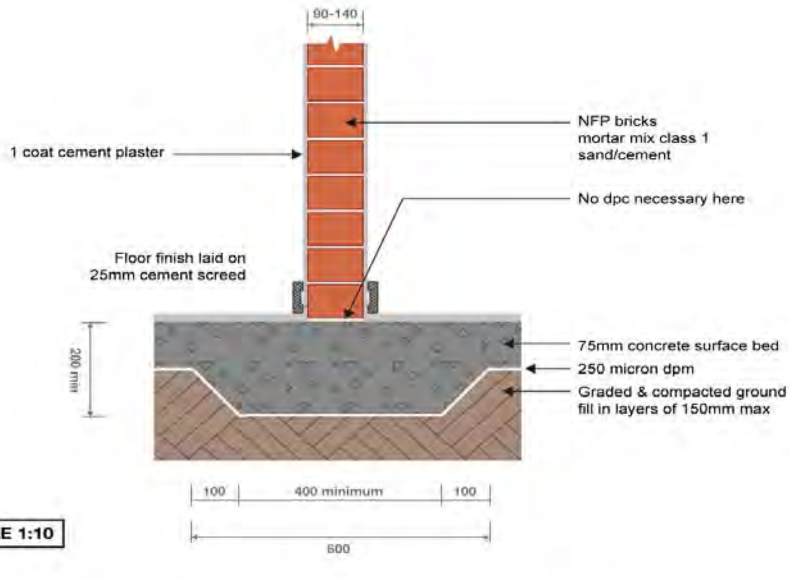
NOTE: This detail is suitable where internal foundation wall is 300mm in height

NEW WALL JOINED TO AN EXISTING WALL



SCALE 1:10

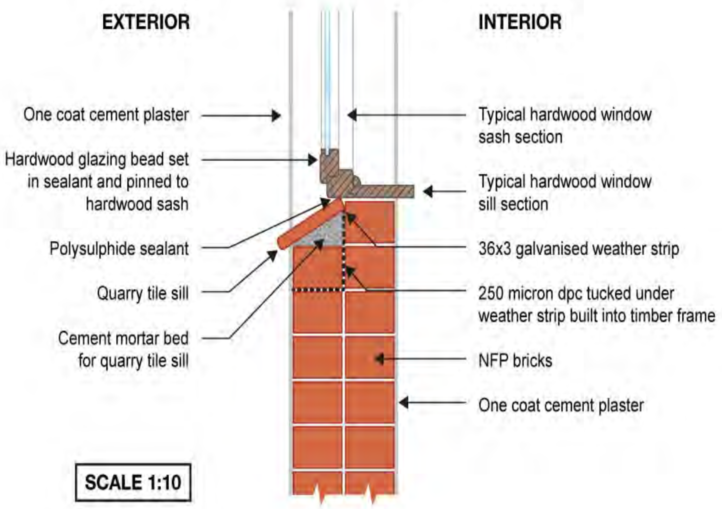
INTERNAL FOOTING



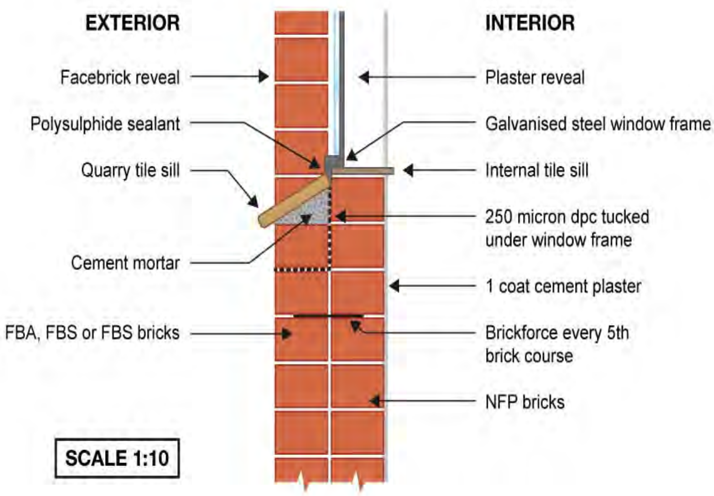
SCALE 1:10

NOTE: This detail is suitable for areas where ground fill is 300 maximum and where internal walls are kept to a minimum height

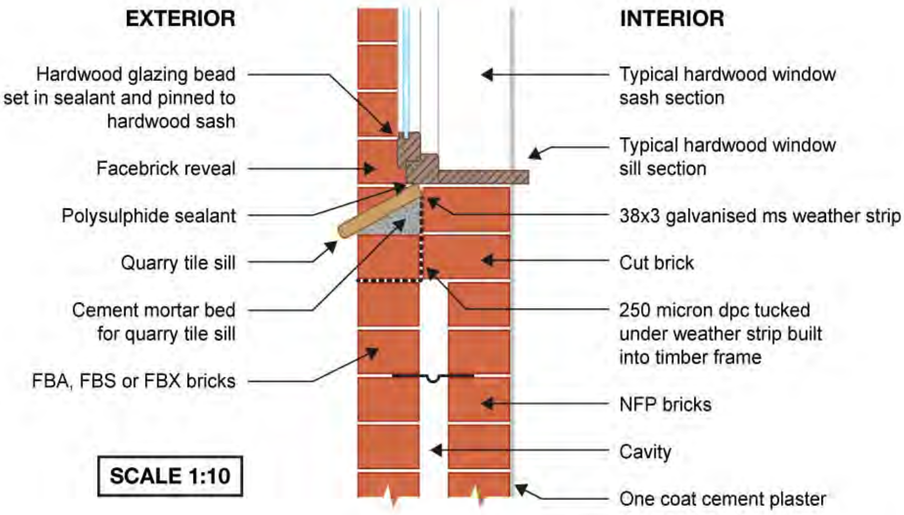
TYPICAL DETAIL OF A HARDWOOD WINDOW AT SILL LEVEL IN A BRICK WALL



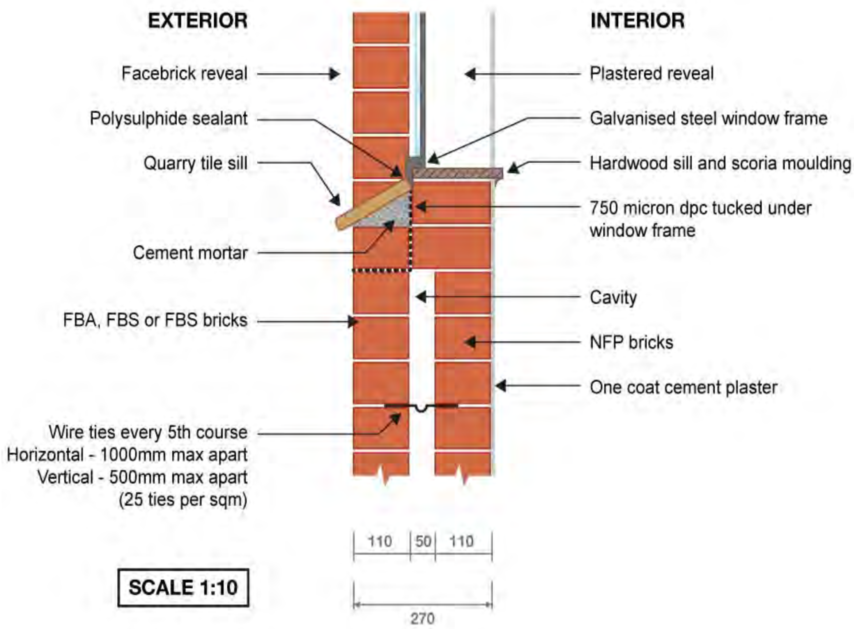
FACEBRICK EXTERNALLY WITH QUARRY TILE SILL FOR BRICK WALL



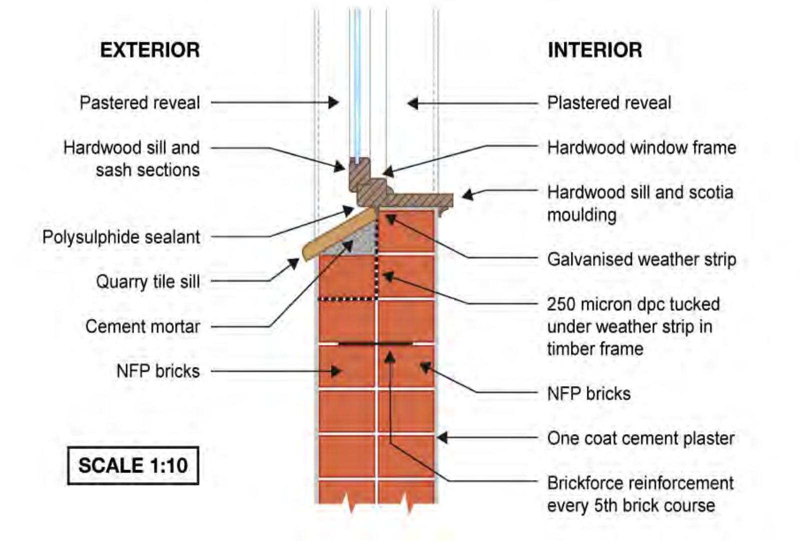
FACEBRICK EXTERNALLY WITH TIMBER WINDOW FRAME AND QUARRY TILE SILL FOR CAVITY WALL



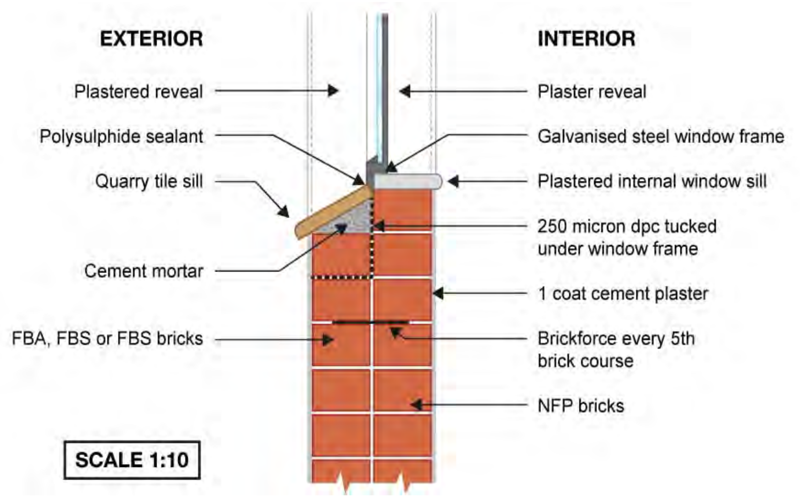
FACEBRICK EXTERNALLY WINDOW FRAME AND QUARRY TILE SILL FOR CAVITY WALL



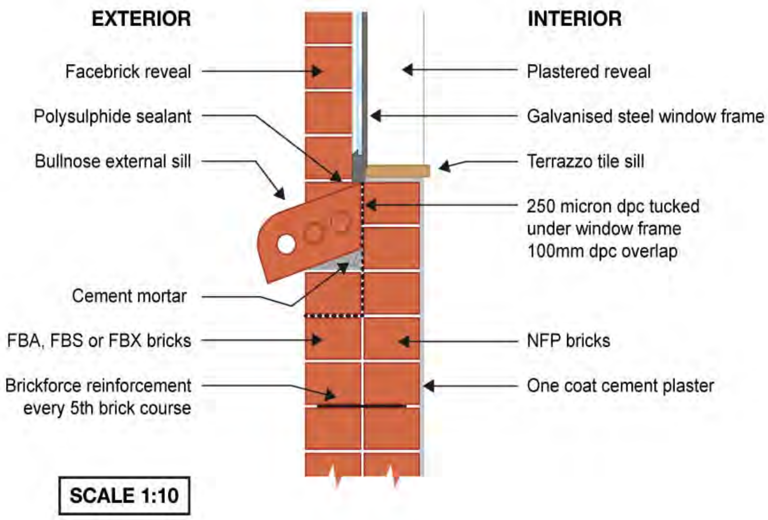
EXTERNAL BRICK WALL WITH QUARRY TILE WINDOW SILL (HARDWOOD WINDOW)



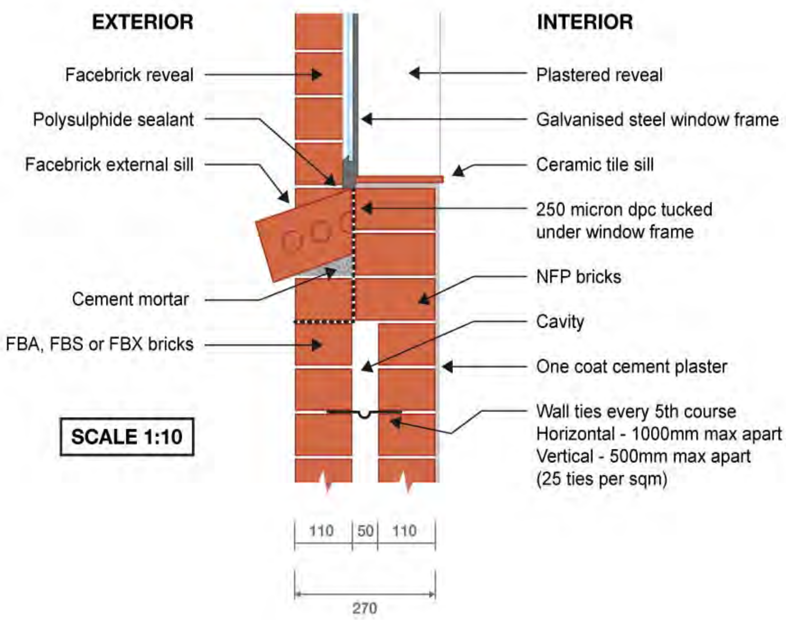
EXTERNAL BRICK WALL WITH QUARRY TILE WINDOW SILL (STEEL WINDOW)



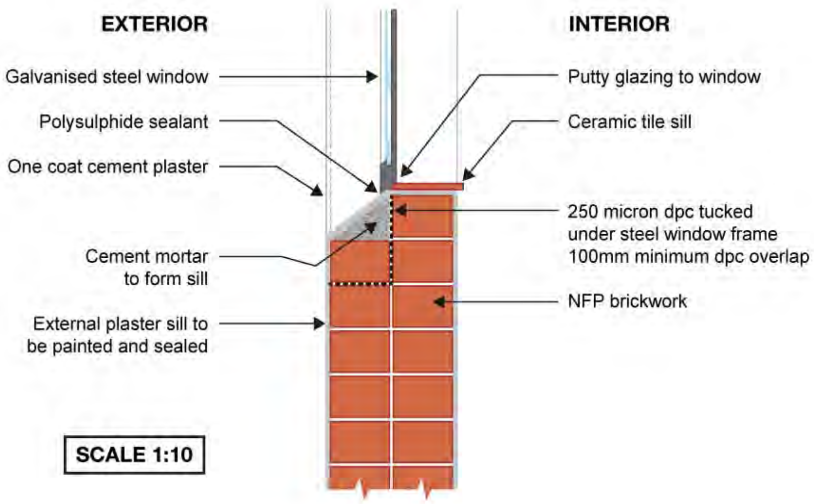
FACEBRICK WITH BULLNOSE SILL EXTERNALLY FOR BRICK WALL (STEEL WINDOW)



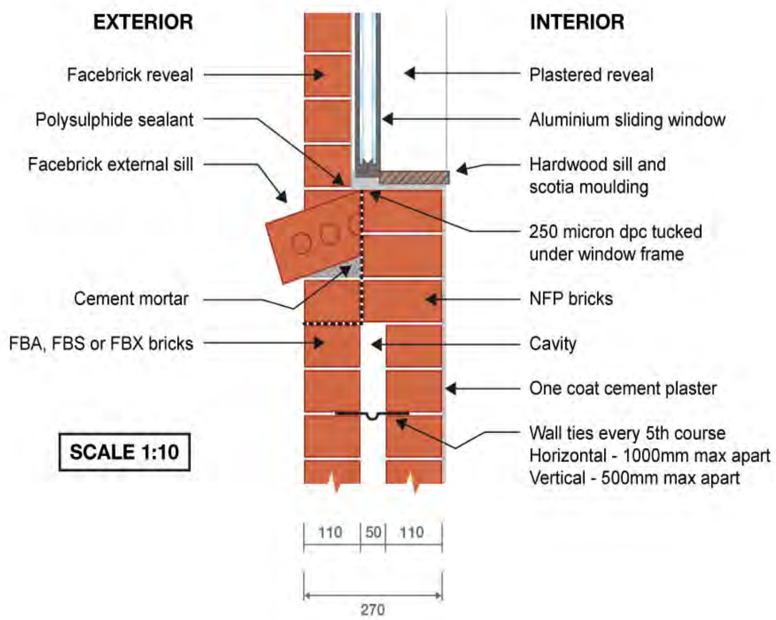
FACEBRICK WITH BULLNOSE SILL EXTERNALLY FOR CAVITY WALL (STEEL WINDOW)



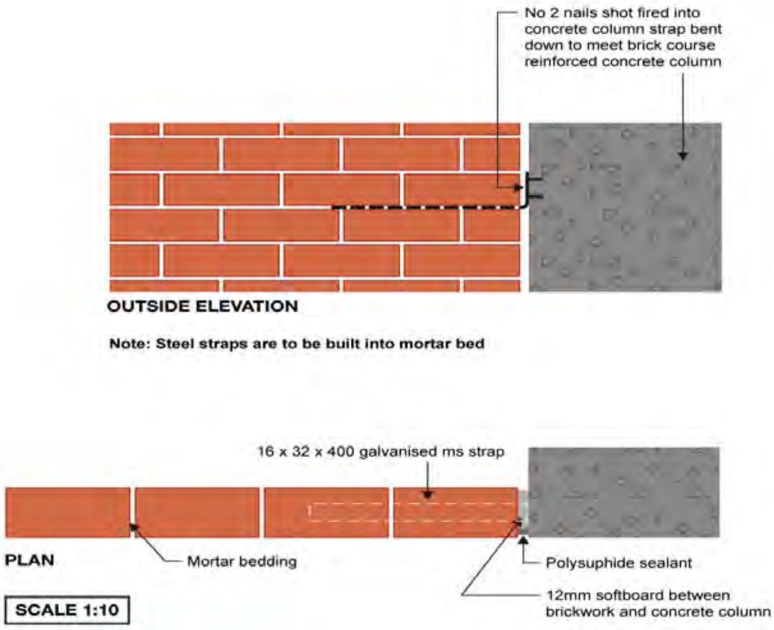
STEEL WINDOW WITH PLASTER EXTERNAL SILL IN BRCK WALL



FACEBRICK WITH BRICK SILL EXTERNALLY FOR CAVITY WALL SLIDING ALUMINIUM WINDOW

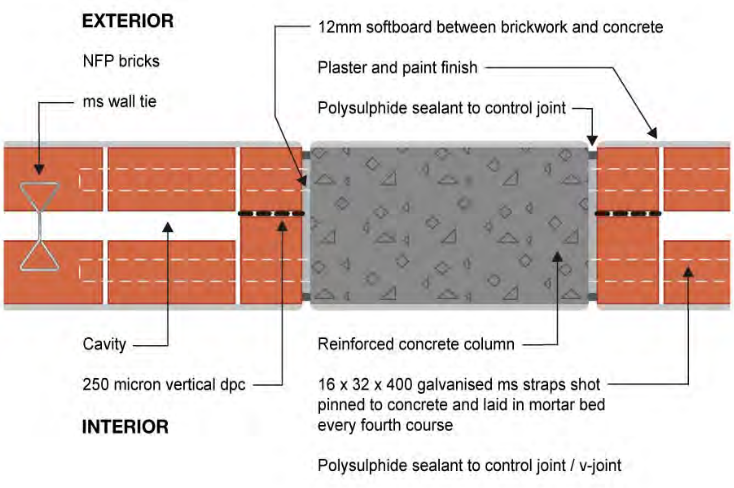


TYPICAL DETAIL GALVANISED STEEL STRAP FIXING WALL TO R.C COLUMN / BRICK WALL



SCALE 1:10

TYPICAL R.C COLUMN / BRICK CAVITY WALL JUNCTION WITH VERTICAL JOINTS



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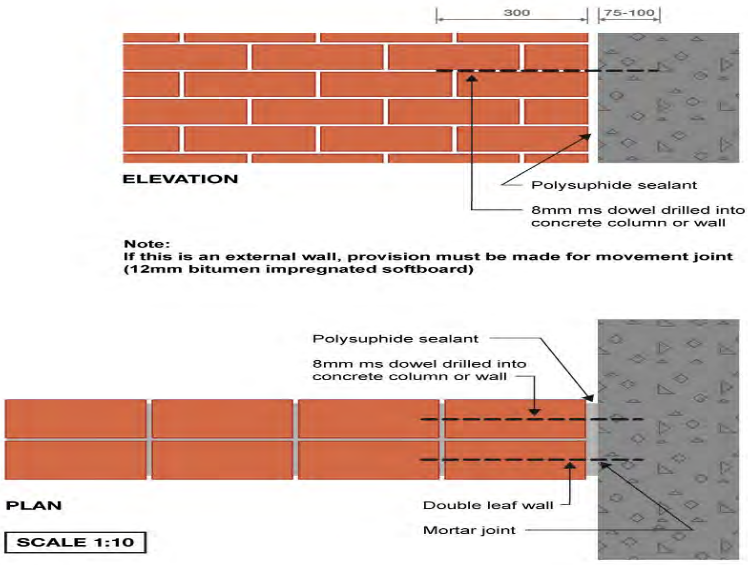
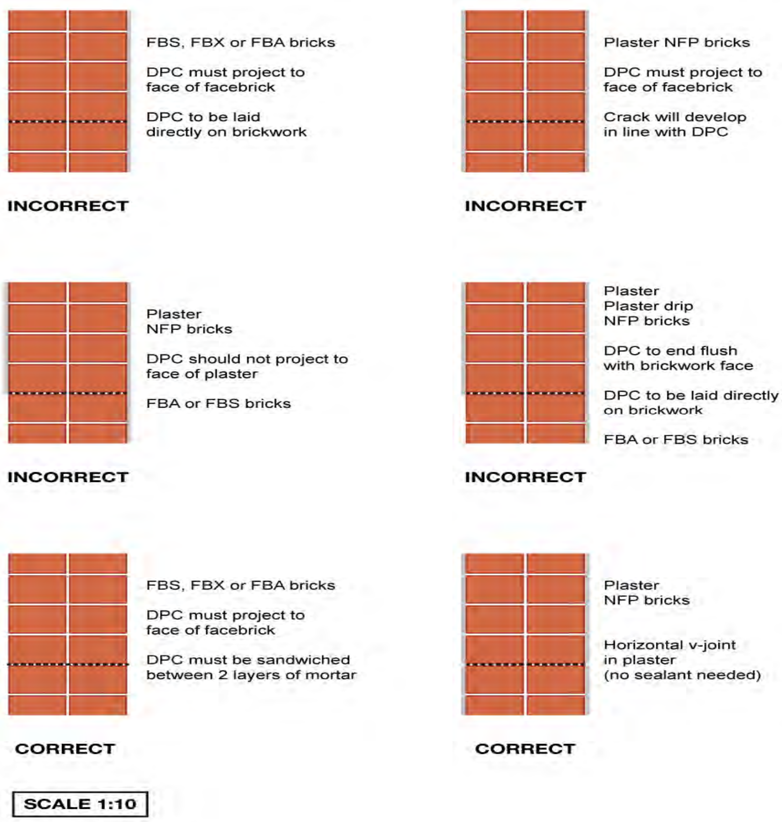
SECTION OF BRICK WALL JOINED TO CONCRETE COLUMN

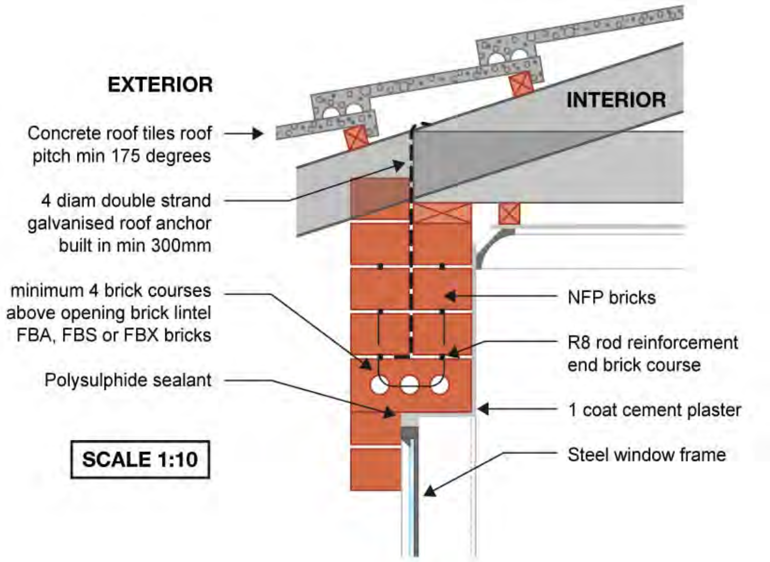


PLACEMENT OF DPC IN TWO LEAF BRICK WALL

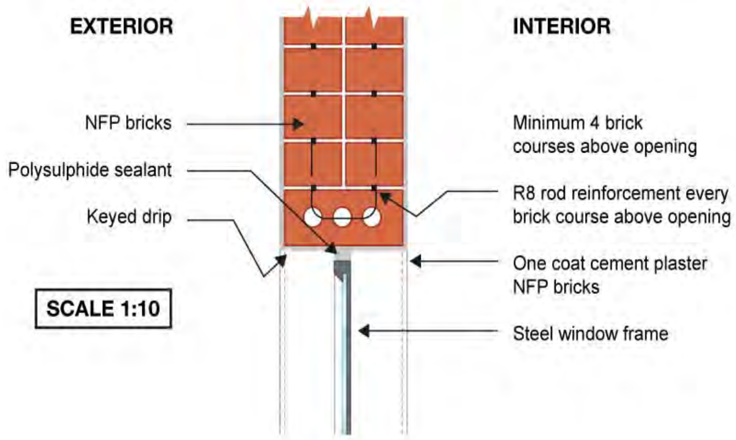


Environmentally Friendly

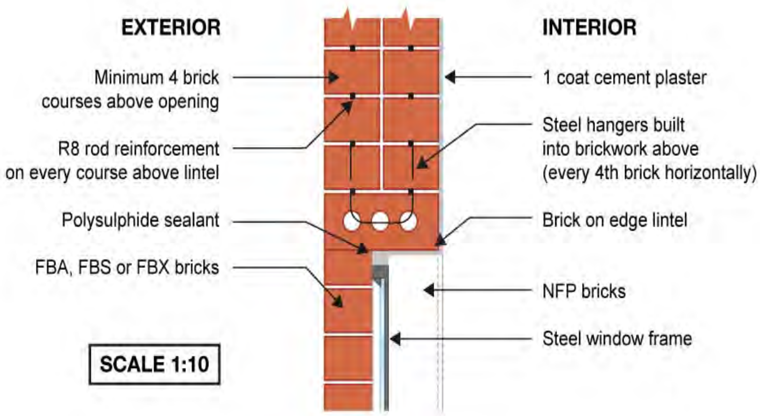
BRICK LINTEL FOR FACEBRICK EXTERNAL WALL (STEEL WINDOW)



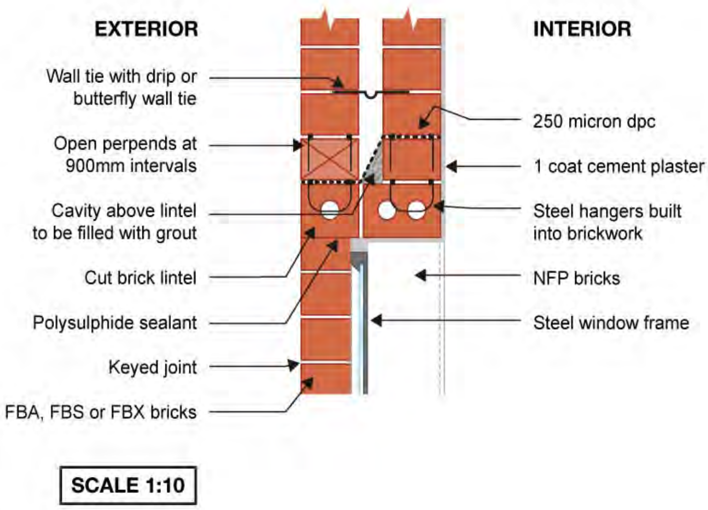
BRICK LINTEL FOR AN EXTERNAL PLASTER FINISHED BRICK WALL



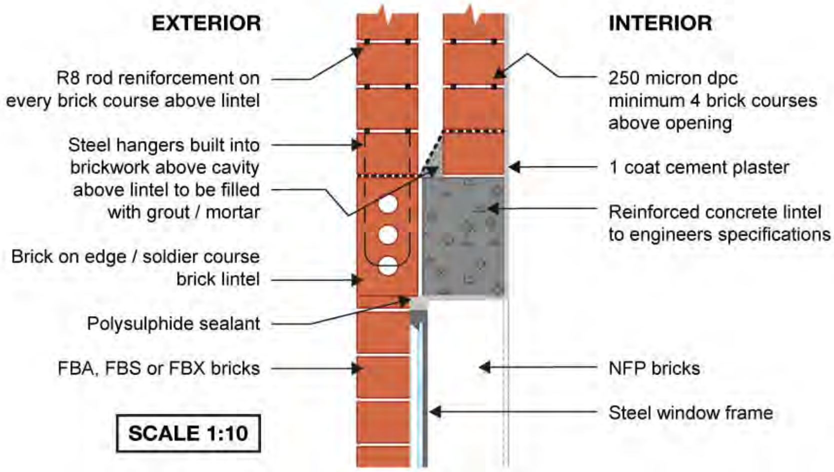
BRICK LINTEL FOR AN EXTERNAL FACEBRICK WALL



BRICK LINTEL FOR AN EXTERNAL CAVITY WALL

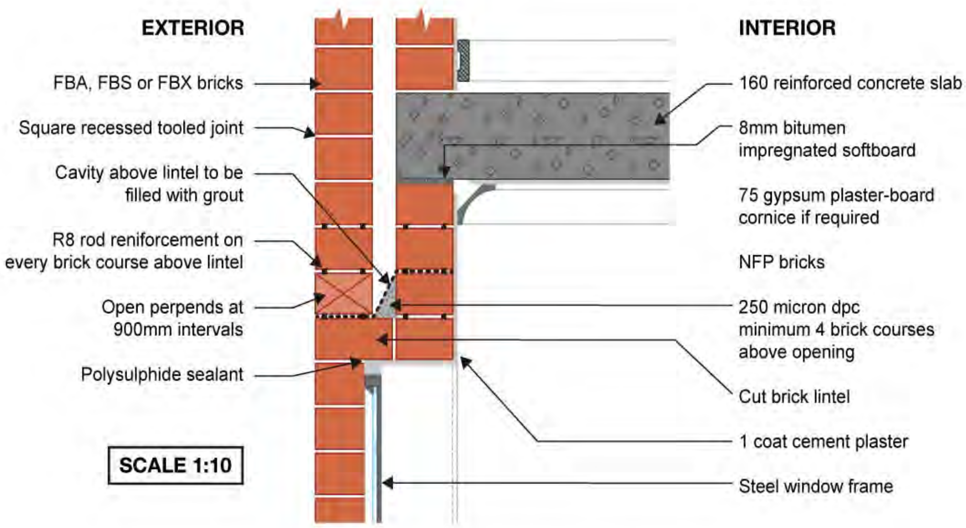


BRICK ON EDGE (SOLDIER COURSE) LINTEL FOR CAVITY WALL



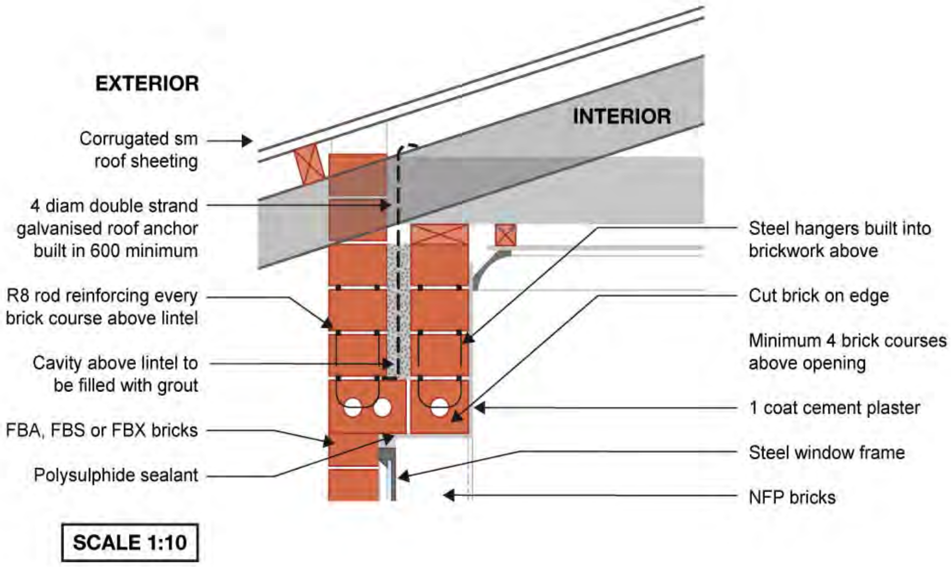
Note: This detail is suitable for a multi-story building where there is no protection from rain to the area above the window

BRICK LINTEL FOR FACEBRICK EXTERNAL WALL (STEEL WINDOW)

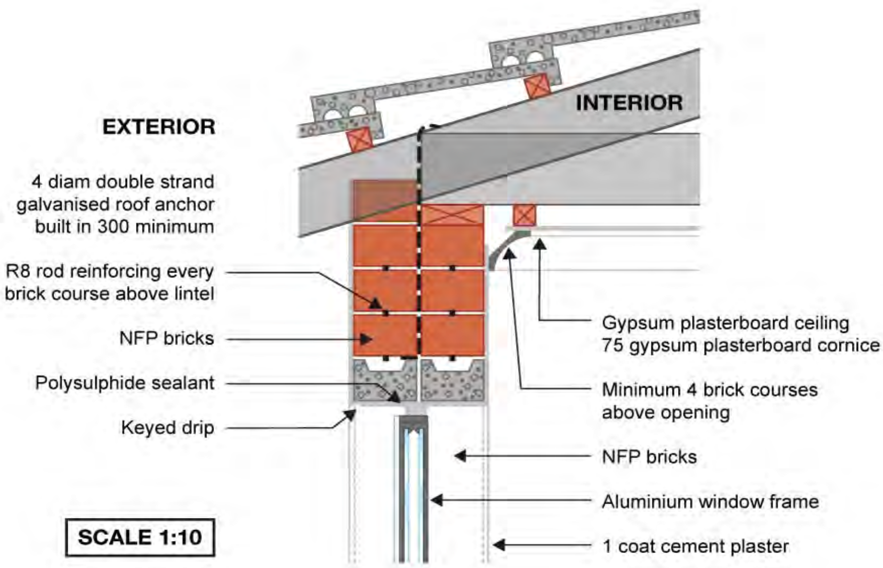


Note: This detail is suitable for a multi-story building where there is no protection from rain to the area above the window

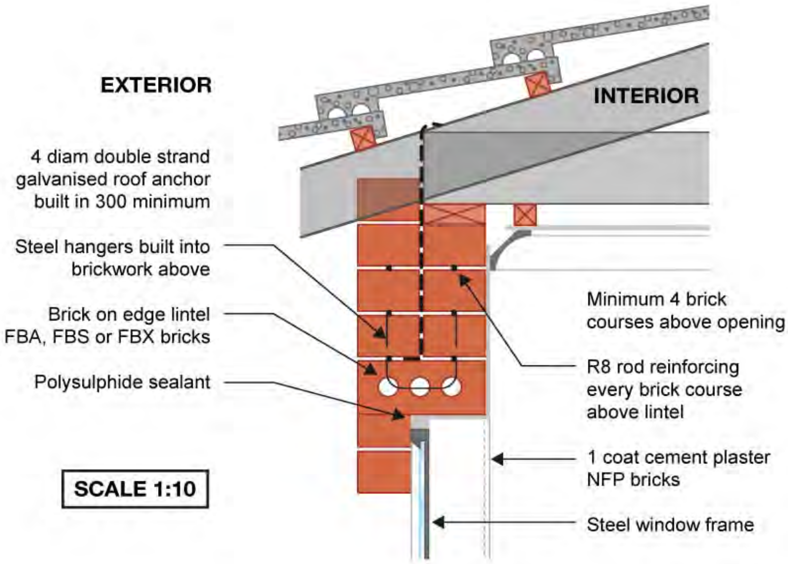
BRICK LINTEL FOR FACEBRICK EXTERNAL WALL
(STEEL WINDOW)



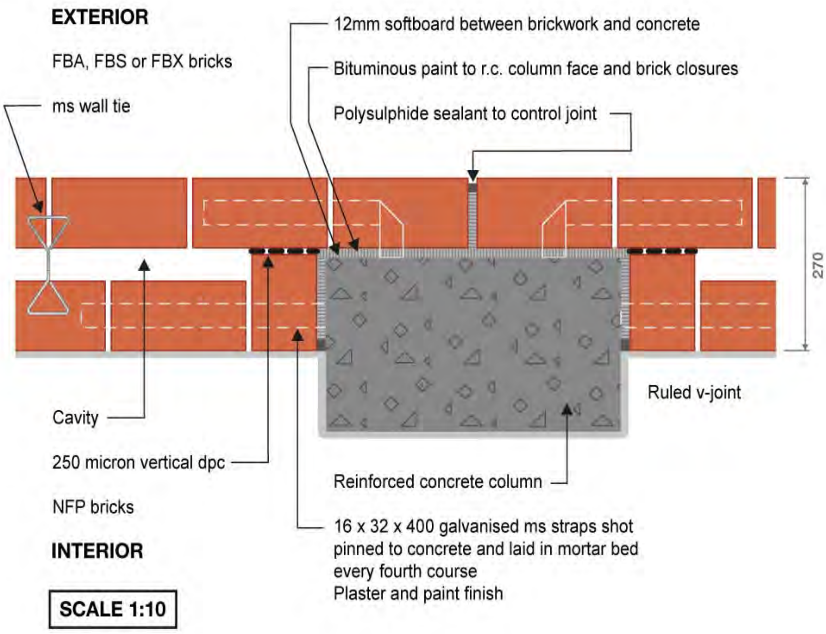
DOUBLE PRECAST CONCRETE LINTEL FOR PLASTERED
EXTERNAL BRICK WALL (ALUMINIUM WINDOW)



BRICK ON EDGE LINTEL FOR FACEBRICK EXTERNAL WALL (STEEL WINDOW)



TYPICAL R.C COLUMN / BRICK CAVITY WALL JUNCTION WITH VERTICAL JOINTS



GLOSSARY
OF
TERMS

PART 14
GLOSSARY OF TERMS

AGGREGATE	Any hard, inert material, i.e. sand, gravel or stone, used for mixing with cementitious materials to form mortar or concrete
ARCH	An arrangement of bricks over an opening.
ARRIS	The sharp edges of a brick.
BAT	Portion of a brick larger than a quarter.
BEAM FILLING	A filling of brick between the roof timber, from wall plate to roof covering, to prevent the entry of birds and vermin and to render the wall weather-tight.
BED JOINT	The horizontal layer of mortar on which a masonry unit is set.
BOND 1	The arrangement of bricks in brickwork usually interlocking to distribute the load and attain a pleasant appearance.
BOND 2	The resistance to displacement of individual bricks in a wall provided by the adhesive property of mortar.
BROKEN BOND	The use of part bricks to make good a bonding pattern where dimensions do not allow regularised bond patterns of full bricks.
BUTTERING	Applying mortar to the end of a brick when laying bricks.
CAVITY WALL	Wall of two leaves effectively tied together with wall tie with a space between them, usually at least 50mm wide.
CHASES	Recesses cut in walls to accommodate service cables or pipes.
CLOSER	The last masonry unit or portion of a unit laid in a course.
COPING	The materials or masonry units used to form a cap or a finish on top of a wall, pier, or chimney, to protect the masonry below from water penetration, commonly extended beyond the wall face and incorporating a drip.
COMPRESSIVE STRENGTH	The average value of the crushing strengths of a sample of bricks tested to assess load-bearing capability.

CONCRETE	A mixture of sand, stone, cement and water that sets and hardens.
CORBEL	A feature, or course, or courses of brick, projecting from the face of the wall.
COURSE	One complete level row of bricks in brickwork.
DAMP-PROOF COURSE (DPC)	A course or layer of impervious material which prevents vertical movement of water.
DATUM	A fixed reference point from which levels are set out.
DURABILITY	The ability of materials to withstand the potentially destructive action of natural conditions and chemical reactions.
EFFLORESCENCE	The unsightly chalk-like appearance on a building due to the crystallisation of soluble salts contained in the bricks or mortar.
FACE WORK	Brickwork built neatly and evenly without applied finish.
FLASHING	Waterproof sheet materials, usually galvanized sheet iron shaped to prevent entry of rainwater.
FOUNDATION	A structure to carry brickwork onto soil or earth.
FROST DAMAGE	The destructive action of freezing water and thawing ice in saturated materials.
FOOTING	The broadened concrete base of a foundation wall or pier.
GABLES	Portion of wall above eaves level that enclosed the end of a pitched roof.
GAUGE ROD	Batten marked at intervals for vertical setting-out of brick courses.
GAUGE BOXES	Boxes of specific volumes to accurately measure the proportions of cement, lime and sand when preparing mortar.
HEADER	The end face of a standard brick.
HEADER COURSE	A continuous course of header brick.

INITIAL SET	The first setting action of mortar, the beginning of the set.
JOINT REINFORCEMENT	Steel reinforcement placed in mortar bed joints.
JOINTING	The finishing off of joints between courses of masonry units before the mortar has hardened.
LAP	The distance the bricks of one course overlaps the bricks of another course.
LEAF	One or two parallel walls that are tied together as a cavity wall.
LIME STAINS (BLEED OR BLOOM)	White insoluble calcareous deposits on the face of brickwork derived from common cement mortars which have been subjected to severe wetting during setting and hardening.
LINTEL	A beam placed or constructed over an opening in a wall to carry the superimposed load.
MORTAR	A mixture of sand (lime), cement and water.
MOVEMENT JOINT	A continuous horizontal or vertical joint in brickwork filled with compressible material to accommodate movement due to moisture, thermal or structural effects.
PARAPET	A low wall around the perimeter of a building at roof level or around balconies.
PIER	A vertical block of brickwork which may either be isolated or attached to the face of a wall.
PERPENDS (PERPS)	Vertical lines controlling the vertically of cross-joints appearing in the face wall.
DRAWING OR PLANS	A construction drawing showing a view of a building or object in a horizontal plane. A floor plan shows the floor area of a building or object in a horizontal plane.
PLUMB	The verticality of brickwork.
QUOIN	Corner brick — the first brick of each course at the corner.

RACKING BACK	The steps left in the brickwork back when pulling up corners.
REINFORCED BRICKWORK	Brickwork incorporating steel wire or rods to enhance resistance to loads
REINFORCING	Metal that is built into brickwork, e.g. reinforcing bars, brickforce.
RETAINING WALL	A wall that provides lateral support to higher ground at a change of level.
REVEAL	The area of walling at the side of an opening which is at right angles to the general face of the wall.
RETEMPERING	To moisten mortar and re-mix, after original mixing, to the proper consistency for use.
ROOF TIES	Lengths of hoop-iron or double strands of wire built into the wall to secure the roof to the superstructure.
SCAFFOLDING	A temporary framework, usually of tubular steel or aluminium, and timber boards to give access for construction work.
SEALANT	A stiff fluid material that sets but does not harden. Used to exclude wind driven rain from movement joints and around door and window frames.
SILL	The part of the brickwork directly below a window.
SOFFIT	The exposed lower surface of any overhead component of a building such as a slab lintel, vault or cornice, or an arch.
SOFT-BURNED	Clay products fired at low temperature ranges, producing units of relatively high absorptions and low compressive strengths.
STRETCHER	The longer face of a brick showing in the surface of a wall.
SUCTION RATE	The tendency of a brick or block to absorb water from the mortar used for its bedding and jointing. Dense vitrified bricks have a low suction rate. Porous bricks have a higher suction rate (IRA - Initial Rate of Absorption - affects bonding properties).

THRESHOLD	The section of the floor at the doorway.
TOOTHING	Leaving indents in the wall. This means removing every second brick when adding new brickwork to existing brickwork
WALL TIE	A metal piece that connects leaves of masonry to each other or to other materials.
WATER ABSORPTION	The amount of water a unit absorbs, when immersed in either cold or boiling water for a stated length of time; expressed as a percentage of the weight of the dry unit.
WATERPROOFING	Prevention of moisture flow through masonry.
WEEPHOLE	An opening placed in mortar joints of facing materials at the level of flashing, to permit the escape of moisture.

QUESTIONS

QUESTIONS
SALES TRAINING COURSE

PART 1 - CLAY BRICK MANUFACTURE

1.	In what five stages can the brickmaking process be divided?	(5)
2.	Name three types of machinery used to extract the clay and shales from the clay pit	(3)
3.	What are the three main functions of clay stockpiles?	(3)
4.	What is the main aim for stockpiling of clay material?	(2)
5.	In what three categories can the size reduction process be divided?	(6)
6.	Name three types of crushing and grinding machinery used by brick factories in S.A	(3)
7.	Name three shaping methods commonly used in brickmaking	(3)
8.	Name the two types of extrusion processes used for brickmaking	(4)
9.	What benefits are obtained by de-airing the clay material before extrusion?	(3)
10.	In what two categories can dryers broadly be classified?	(2)
11.	What is a hackline?	(2)
12.	How long does it take to dry bricks in a chamber dryer?	(1)
13.	Name the three stages and the temperature ranges where chemical changes take place during the firing of clay material	(6)
14.	What mineral is responsible for the red colour in bricks?	(1)
15.	How will the following physical properties change (increase or decrease) during firing: Porosity, permeability, volume, strength, hardness, and weight?	(6)
16.	Name four types of continuous kilns used in the brickmaking industry	(4)

TOTAL MARKS (54)

PART 2 - PRODUCT TYPES AND CLASSES (NOMENCLATURE)

1. Explain the following classes of clay brick produced in South Africa:
   - Non Face Plaster (NFP) (3)
   - Face Brick Aesthetic (FBA) (3)
   - Face Brick Standard (FBS) (3)
   - Face Brick Extra (FBX) (3)
   - Non Face Extra (NFX) (3)
   - Engineering Units (E) (3)

2. Name five textures used on clay bricks in South Africa (5)

3. What, in general, is an acceptable appearance of a clay brick (4)

TOTAL MARKS (27)

PART 3 - PRODUCT SPECIFICATION AND PHYSICAL PROPERTIES

1. What are the dimensions of the most commonly used brick in South Africa, the "Imperial Brick"? (3)
2. What are the tolerances for the Individual units of the FBS class clay brick? (3)
3. What are the average tolerances for 32 units of the FBS class clay brick? (3)
4. What are the warpage tolerances for FBA & NFP bricks and FBX bricks? (2)
5. What is the minimum allowable compressive strength of individual NFP clay bricks? (1)
6. What is efflorescence? (3)
7. Describe a heavy degree of efflorescence on clay bricks? (3)
8. Name the three groups of irreversible moisture expansion ranges that clay bricks are normally classified into? (3)
9. Give the four regional geographic exposure zones for clay bricks in South Africa? (8)
10. What is meant by the fire resistance rating of clay bricks? (2)
11. What is meant by the acoustic insulation of a clay brick wall? (2)

TOTAL MARKS (33)

PART 4 - BRICKWORK:
BOND PATTERNS, MORTAR JOINT PROFILES AND POINTING, STRENGTH AND STABILITY

1. By means of a sketch, illustrate the difference between an un-bonded and a bonded wall? (2)

2. Name three types of brick bonds use in the building of walls? (3)

3. What is Jointing and Pointing in brickwork? (4)

4. Why is lime added to mortar mixes? (2)

TOTAL MARKS (11)

PART 5 - QUANTITIES OF BRICKS AND MORTAR

1. What is meant by the building terms, format length, format width and format height? (3)

2. How many bricks and mortar per m^2 in half a brick thickness wall? (2)

3. How many bricks and mortar per m^2 in a full brick thickness wall? (2)

4. How many bricks and mortar per m^2 in a cavity wall? (2)

TOTAL MARKS (9)

PART 6 - STRUCTURAL MASONRY WITH CLAY BRICK

1. What is the minimum average compressive strength requirement of bricks (in MPa) for:

1.1	Structural wall in a single storey building?	(1)
1.2	Structural wall in a double-storey building?	(1)
1.3	Non-structural external wall?	(1)
1.4	Non-structural internal wall?	(1)
1.5	Free-standing external or internal walls?	(1)
1.6	Foundation bricks supporting a single storey building?	(1)
1.7	Foundation bricks supporting a double-storey building?	(1)

2. Which SABS regulations, for load and structural design, control the design of the structural system of buildings? (2)

3. 'Deemed-to-satisfy rules' for single and double-storey buildings are covered in which SABS regulations? (1)

4. What is the maximum allowable height of a 110 mm free-standing wall without piers? (1)

5. What is the maximum allowable height of a 110 mm free-standing wall with piers? (1)

6. How many damp-proof courses in a free-standing wall? (1)

7. How far from a constructed masonry retaining wall, may the fill or ground that it retains, be subjected to superimposed loads? (1)

8. How many damp-proof courses may be used in a retaining wall? (1)

9. How is subsoil drainage provided in a retaining wall in order to prevent the accumulation of water? (1)

10. What is the maximum allowable height of fill to be retained by a 190mm retaining wall without piers? (1)

11. What is meant by a cavity wall? (3)

12. How must weep-holes be formed in the outer leaf of cavity walls? (3)

13. In which zones must stainless steel ties in cavity walls be used? (2)

14. What are the mixed proportions of concrete for foundations recommended by the Empirical rules for foundations (SABS 0400 Part H)? (3)

15. What is the thickness of any continuous strip foundation? (1)

16. The height of any foundation wall not acting as a retaining wall shall not exceed ---m? (1)

TOTAL MARKS (30)

PART 7 - WATER EXCLUSION AND DAMP PROOFING OF CLAY BRICK WALLING

1.	What are the 4 main causes of water ingress in clay brick walling?	(4)
2.	What are the three main functions of the damp proof course?	(3)
3.	How high above the adjoining, finished ground level must the DPC in an outside wall be?	(1)
4.	What problems can occur if the DPC was not sandwiched and sealed between wet mortar layers?	(2)

TOTAL MARKS (10)

PART 8 - ACCOMMODATION OF MOVEMENT

1.	What factors affect movement in buildings?	(5)
2.	What is the acceptable range for the irreversible moisture expansion of clay bricks?	(1)
3.	How can problems caused by the expansion of bricks be avoided in buildings?	(3)
4.	Why should dissimilar units never be used in the same wall?	(2)
5.	Name three general types of movement joints?	(3)
6.	What are the functions of movement joints?	(4)
7.	By means of a sketch, illustrate the operation of a sliding anchor?	(2)

TOTAL MARKS (20)

PART 9 – CLEANING OF CLAY BRICKWORK

1.	For efflorescence to occur, what three conditions must exist simultaneously?	(3)
2.	To prevent efflorescence, what good building practices must be considered?	(10)
3.	What is the best method for cleaning mortar smears from new masonry?	(2)
4.	What is the best method for cleaning hardened mortar on new brickwork?	(2)
5.	What is the best method for cleaning efflorescence on new brickwork?	(2)
6.	What is the best method for cleaning vanadium staining on new brickwork?	(2)
7.	What is the best method for cleaning organic growth on new brickwork?	(2)
8.	What safety precautions must be taken when using chemicals to clean brickwork?	(4)

TOTAL MARKS (27)

PART 10 - FIRED CLAY PAVING

1.	Explain the terms rigid and flexible paving?	(2)
2.	What are the advantages of flexible paving?	(6)
3.	What is meant by a hybrid paving system?	(2)
4.	Name the SABS regulation for Burnt Clay Paving Units?	(1)
5.	What are the benefits of chamfering on pavers?	(6)
6.	What is meant by the ‘aspect ratio’ of a paving unit?	(2)
7.	What is the minimum recommended aspect ratio of clay pavers?	(1)
8.	What is the recommended length to breadth ratio for flexible clay paving?	(1)
9.	How many pavers (222 x 106) in a square metre?	(1)
10.	In what thicknesses are fired clay pavers normally available?	(5)
11.	What is the warpage requirement for clay pavers?	(1)
12.	What is the minimum individual modulus of rupture for type PA and type PB clay pavers?	(2)
13.	What does the SABS 1575 regulation stipulate for a maximum allowable irreversible moisture expansion for fired clay pavers?	(1)
14.	What are the four basic bonding patterns for rectangular pavers?	(4)
15.	For which applications are the herringbone bond recommended?	(3)
16.	What is ‘butt jointing’?	(1)
17.	What type of vibrator is recommended for use with pavers between 50mm and 80mm in thickness?	(1)
18.	Why are vibrating rollers not recommended for the use of paving?	(1)

TOTAL MARKS (41)

TOTAL MARKS FOR THE TEST (262)

ANSWERS

ANSWERS
SALES TRAINING COURSE

PART 1: CLAY BRICK MANUFACTURE

1. Winning and stockpiling of the clay, preparation of the clay, shaping of the products, drying of the products, firing of the products. (5)

2. Bulldozers, hydraulic excavators and mechanical shovels. (3)

3. The stockpiles function as blending piles, conditioning piles and storage piles. (3)

4. To obtain uniform clay material over long periods of time. (2)

5. Primary crushing i.e. reducing the lump size to ± 80 mm, secondary crushing i.e. reducing the size further to ± 8 mm, and tertiary crushing i.e. reducing the size to 0.8 mm. (6)

6. These include rolls crushers, hammer mills, impactors, pan mills and refining rolls. (3)

7. Soft-mud hand moulding, semi-dry pressing, extrusion. (3)

8. Stiff extrusion (12% - 20% moisture content) and soft extrusion (20% - 30% moisture content). (4)

9. De-airing improves the density, strength and workability of the material. (3)

10. Intermittent and continuous dryers. (2)

11. Hacklines are open-air storage facilities where the green brick pallets are stockpiled in individual lines and allowed to dry naturally. (2)

12. Drying time of a chamber dryer is between 30 and 45 hours. (1)

13. Dehydration stage or water smoking stage in the temperature range between 100ºC and 650ºC. Oxidation stage in the temperature range between 300ºC and 800ºC. Vitrification stage in the temperature range from 800ºC upwards. (6)

14. Iron oxide. (1)

15. Decrease, decrease, decrease, increase, increase, decrease. (6)

16. Hoffman kilns, TVA kilns, tunnel kilns, open roof Hoffman kilns, zigzag kilns, bull's trench kilns and the vertical shaft brick kiln (VSBK). (4)

TOTAL MARKS (54)

PART 2: PRODUCT TYPES AND CLASSES (NOMENCLATURE)

1. NFP (Non Face Plaster). (3)
   Bricks for rendered or plastered use, whether for internal, and external leaves of a full brick wall, or as the backing leaf to an external face brick leaf, or as a single leaf or half brick internal wall.

   Face Brick Aesthetic (FBA). (3)
   Durable Clay Face Bricks produced or especially selected/sorted for a highly individual aesthetic look derived from deliberate non-uniformity of size, shape and colour.

   Face Brick Standard (FBS). (3)
   Clay Bricks that are durable, uniform in size and shape and require no further rendering or aesthetic treatment.

   Face Brick Extra (FBX). (3)
   Durable Face Bricks possessing the highest degree of size, shape and colour uniformity.

   Non Face Extra (NFX). (3)
   Bricks produced for building work below damp proof course (DPC), under damp conditions or below ground level where aesthetics are unimportant. NFX bricks may be plastered or left unrendered.

   Engineering Units (E). (3)
   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.

2. Rockface, Rustic, Coral, Satin, Travertine. (5)

3. A clay brick shall be well burnt and shall be acceptably free from deep or extensive cracks, damage to edges and corners, and pebbles and expansive particles of lime. (4)

TOTAL MARKS (27)

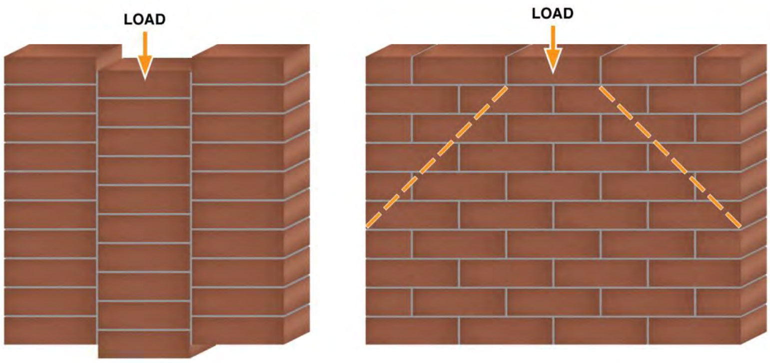
PART 3: PRODUCT SPECIFICATION AND PHYSICAL PROPERTIES

1.	222mm (l) x 106mm (w) x 73mm (h)	(3)
2.	FBS individual units: ±7mm (l) x ±4mm (w) x ±4mm (h)	(3)
3.	FBS (32 units average): ±3.5mm (l) x ±2mm (w) x ±2mm (h)	(3)
4.	FBA & NFP: No requirement. FBX Products: Individual 5mm; average of 3 bricks not more than 3 mm.	(1) (1)
5.	3 Mpa.	(1)
6.	Efflorescence is the crystallization of soluble salts on or near the surface of brickwork, that results from the evaporation of water carrying salts through or from the brickwork.	(3)
7.	Heavy efflorescence is a thick deposit of salts covering a large area of the unit, but that has not caused powdering or flaking of the surface.	(3)
8.	Category **I** : For bricks exhibiting irreversible expansions of 0,00% - 0,05% Category **II** : For bricks exhibiting irreversible expansions >0,05% ≤ 0,10% Category **III** : For bricks exhibiting irreversible expansions >0,10% ≤ 0,20%	(3)
9.	Zone 1 Protected : • All inland areas more than 30km from the coastline. Zone 2 Moderate : • The 30km zone along the coast, but excluding the sea spray zone. Zone 3 Severe : • Sea spray zone such as the seaward sides of Durban Bluff and other exposed coastal headland areas; • The 15 km 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. • Industrial areas where high acid or alkaline discharges occur.	(8)
10.	Fire resistance rating is a measure of the length of time a walling element will resist a fully developed fire.	(2)
11.	Acoustic insulation, measured in decibels (dB) is the ability of a wall to resist the transmission of airborne sound.	(2)

TOTAL MARKS (33)

PART 4: BRICKWORK - BOND PATTERNS, MORTAR JOINT PROFILES AND POINTING, STRENGTH AND STABILITY

1. (2)



2. Stretcher Bond, Flemish OR Flemish garden bond, English Bond, Quetta Bond, Rat-trap Bond. (3)

3. Jointing is the process of finishing a joint by compressing the mortar during the laying of masonry units. (2)

   Pointing is the process during which mortar joints are raked out during the laying process and subsequently filled and tooled. (2)

4. Lime imparts the properties of plasticity and water retention to mortar. (2)

TOTAL MARKS (11)

PART 5: QUANTITIES OF BRICKS AND MORTAR

1. The format length (234) is the spacing of stretcher perpends. (3)
   The format width (118) is the spacing of header perpends.
   The format height (85) is the coursing height.

2. Half a brick thickness wall = 51 bricks, 21 litres mortar. (2)

3. Full brick thickness wall = 102 bricks, 43 litres mortar. (2)

4. Cavity wall = 102 bricks, 42 litres mortar. (2)

TOTAL MARKS (9)

PART 6: STRUCTURAL MASONRY WITH CLAY BRICK

1.1	7 Mpa	(1)
1.2	10.5 Mpa	(1)
1.3	7 Mpa	(1)
1.4	7 Mpa	(1)
1.5	10.5 Mpa	(1)
1.6	7 Mpa	(1)
1.7	10.5 Mpa	(1)

2. SABS 0160 (for loads) and SABS 0164 (for structural masonry). (2)

3. SABS 0400: The Application of the National Building Regulations. (1)

4. 1.0 metres. (1)

5. 4 metres. (1)

6. A damp-proof course shall not be installed in any free-standing wall. (1)

7. Not within a distance equal or less than the height of the fill retained by such a wall. (1)

8. Nil. (1)

9. To provide sufficient weepholes. (1)

10. 0.8 metres. (1)

11. A cavity wall consists of two parallel walls (leaves) of masonry units built side-by-side and tied to each other with wall ties, with a cavity of width not less than 50mm and not more than 110mm. (3)

12. Weepholes shall be formed at intervals not exceeding 1000 mm and immediately above the damp-proof courses, by leaving perpend joints open for a height of approximately 50mm, or providing openings approximately 30mm wide in the shell bedding of hollow units. (3)

13. Sea spray zones, tidal and splash zones. (2)

14. Not weaker than 1 part of cement to 4 parts of sand to 5 parts of coarse aggregate. (3)

15. Not less than 200mm. (1)

16. 5 metres. (1)

TOTAL MARKS (30)

PART 7: WATER EXCLUSION AND DAMP PROOFING OF CLAY BRICK WALLING

1. a. Poor design and detailing especially in roof to wall junctions, window and door installation, parapet walls and flashing specification and detailing. (4)

   b. Cracks and voids in mortar joints and the incorrect specification of masonry units for the various exposure zones and poor/inferior mortar.

   c. The incorrect specification, detailing and installation of damp proof materials.

   d. Poor workmanship.

2. (3)
   - To provide a barrier against rising damp.
   - To resist water penetration from above.
   - To resist horizontal water penetration.

3. At least 150mm. (1)

4. A Seal between the materials will not be provided and a capillary path will open up, allowing rain penetration. (2)

TOTAL MARKS (10)

PART 8: ACCOMMODATION OF MOVEMENT

1. Temperature changes, 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. (5)

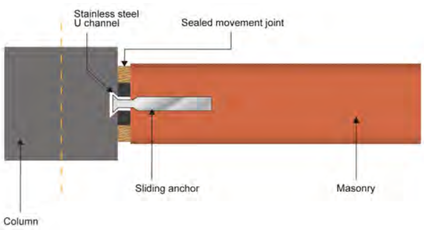
2. Between 0 - 2mm per metre. (1)

3. By using mortar 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. (3)

4. Clay, concrete and calcium silicate bricks have different thermal and moisture movements and absorption characteristics. This can lead to cracks being formed. (2)

5. (3)
   - Expansion joints; either vertical or horizontal, incorporating easily compressed resilient material to accommodate strains arising from both compressive and tensile stresses.
   - Contraction joints, which are free to open to accommodate stresses arising from tensile stresses only.
   - Slip joints between dissimilar materials permitting some degree of sliding between the adjacent materials to prevent excessive build up of shear stresses.

6. (4)
   - Permit movements to occur without distress of adjacent walling materials.
   - Provide an adequate barrier to the passage of rain and moisture.
   - Prevent air and dust ingress.
   - Prevent significant loss of fire resistance and acoustic properties of the wall.
   -

7. 

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TOTAL MARKS (20)

PART 9 - CLEANING OF CLAY BRICKWORK

1. Soluble salts must be present within the masonry assembly. Water must come in contact with the salts to form a solution, which can then migrate to a surface where the water can evaporate. (3)

2. (10)
   - Use masonry units of low to moderate absorption.
   - Use low-alkali, non-staining, or white cements in the mortar.
   - Store masonry units off the ground and protect them with waterproof covers.
   - Cover the top course of unfinished walls to keep out water.
   - Flash parapet walls correctly.
   - Install drips on cornices or projecting members.
   - Install through-the-wall flashing at ground level to prevent the capillary rise of moisture from the ground.
   - Install flashing in walls in places where water can accumulate once it enters; construct weep holes in the exterior width of the wall immediately above the flashing. Be sure joints of the flashing are lapped and sealed, and the ends are turned up and sealed.
   - Caulk all joints between masonry and door and window openings.
   - Construct full, tight, weatherproof mortar joints; use concave or V-shaped joints where the masonry wall will be exposed to rain.
   - Seal cracked mortar joints.

3. The use of large amounts of clean water and a bristle brush remain the most cost effective method of cleaning down freshly smeared, new masonry (warm to hot water usually works better than cold). (2)

4. The most successful, universally used agent is a weak solution of hydrochloric acid in water (1 part acid to 10 parts water). Where possible, remove larger pieces with a scraper, then wash down with a dilute solution of acid cleaner. (2)

5. Light brushing and hosing down with clean water provide the best overall treatment. (2)

6. Wash down with a 20% solution of Potassium Hydroxide. Do not wash the wall with clean water afterwards. (Hydrochloric or sulphuric acid should never be used on vanadium stains since it 'fixes' them and turns them brown), alternatively, apply a solution of lOOg per litre of water using either a pool chlorine or a household bleach based on sodium hypochlorite. As with the other options, always test a small area first prior to treating the whole area. Solutions that are too strong can lead to further problems. (2)

7. (2)
   - Organic growths can be killed with a solution of Copper Sulphate (1kg to 10litres of water) or a proprietary weed killer.
   - Boiling water or steam is very effective in cleaning mosses.

8. Protective clothing such as gloves, suitable face protection, safety boots and overalls should be worn. Adequate ventilation is required in confined spaces when using chemicals. When diluting acids, ALWAYS add acid to water and not water to acid.
   Any clothing that is contaminated with chemicals should be disposed of safely. (4)

TOTAL MARKS (27)

PART 10: FIRED CLAY PAVING

1. Rigid segmental paving is similar to concrete paving with joints between individual units filled with mortar. (1)

   Flexible paving is a pavement system comprising of pavers laid with a 2 to 6mm joint filled with fine sand. (1)

2. (6)
   a. Particularly suitable for large areas as it can be more rapidly constructed with less skilled labour than rigid paving construction.
   b. Flexible paving is economical, both in terms of time required for construction and the amount of materials needed.
   c. When flexible paving is correctly constructed, no movement joints are needed since properly constructed joints around each paving unit provide for movement.
   d. It is easy to remove and relay, affording ready access to underground services.
   e. The use of the original pavers in the relaying is an added advantage.
   f. Construction of flexible clay paving does not require cementitious joints, and thus residual mortar stains need not be a concern.

3. A typical hybrid construction comprises of pavers laid on a sand bed, with joints filled with either a wet slurry mortar mix, or a dry mortar mix which is subsequently sprinkled with water. (2)

4. SABS 1575 is the Standard Specification for Burnt Clay Paving Units. (1)

5. (6)
   - Reducing the incidence of chipping whilst handling
   - Easier handling whilst laying
   - Disguising any difference in surface level
   - Protecting joints from the removal of jointing material by wheel loads
   - Providing for rapid drainage of surface water
   - Emphasizing bond patterns.

6. This is the mathematical relationship of the length of a paver to its thickness. (2)

7. A Minimum aspect ratio of 4:1 is recommended for pavers. (1)

8. A Ratio of 2:1. (1)

9. 41. (1)

11. It may not exceed 3mm. (1)

12. PA = 2.5 MPa and PB = 2 MPa. (2)

13. Expansion of 0.25% for all fired clay pavers. (1)

14. Herringbone Bond, Running Bond, Stack Bond, Basketweave Bond. (4)

16. Flexible paving with direct contact between adjacent pavers. (1)

17. A Plate vibrator producing a centrifugal force of 7-16 kN at a frequency of 75-100 Hz. (1)

18. Vibrating rollers apply point loads, which may displace and/or damage paving units. (1)

TOTAL MARKS (41)

TOTAL MARKS FOR THE TEST (262)

EVALUATION FORM

EVALUATION FORM
CLAY BRICK SALES TRAINING COURSE

TRAINING MATERIAL

Good ↔ Not so good

Comments:

INFORMATIVE

Good ↔ Not so good

Comments:

VALUE IN YOUR WORKPLACE

Good ↔ Not so good

Comments:

OVERALL IMPRESSION

Good ↔ Not so good

Comments:

First Name: ____________________ Surname: ____________________

Company: ____________________ Position: ____________________

E-mail: ____________________ Phone: __________ Fax: __________

Please list the names of friends or colleagues you feel would benefit from this training

First Name	Last Name	Position	Company	Phone Number

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ABOUT CLAYBRICK

ClayBrick.org is the official body representing all Clay Brick and Paver manufacturers in South Africa.

As the industry watchdog, ClayBrick.org monitors all legislative and standards issues and acts as liaison between the industry, government and other organisations related to housing, building and construction.

All ClayBrick.org members are committed to the production and supply of premium Clay Bricks and Pavers in the interest of best practice and quality building and construction - for good.

CBA Website

THE VOICE OF THE CLAY BRICK INDUSTRY
CLAYBRICK for good

Environmentally Friendly

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