

OVERVIEW OF SOUTH AFRICA'S CLAY BRICK INDUSTRY; 2008

DIRECTORATE: MINERAL ECONOMICS



mineral resources

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1. INTRODUCTION

The purpose of this report is to provide technical and economic information on clay brick manufacturing, with a view to assist entrepreneurs to start up new plants or improve their production techniques, furthermore to generate productive employment and thereby decrease dependency on the government assistance.

The fundamentals of brick manufacturing have not changed over time. However technological advances have made contemporary brick plants substantially more efficient and have improved the overall quality of the products. A more complete knowledge of raw materials and their properties, better control of firing, improved kiln designs and more advanced mechanization have all contributed to advancing the brick industry.

2. ORIGIN AND DISTRIBUTION OF RAW MATERIALS

Geology and mineralogy are essential for the study and characterization of raw materials. The relationship between the essential clay properties and the technological behaviour of the raw material is of great importance. There is an enormous range and variety of brick making clays. The term clay is frequently applied to any very fine grained, plastic raw material, regardless of its origin, particle size distribution, mineralogical association and chemical constitution. The varying attributes of the individual clayey materials are responsible for differences in their technical behaviour.

For brick manufacturing, clay must possess some specific properties and characteristics. Such clays must have plasticity, which permits them to be shaped or molded when mixed with water; and must have sufficient wet and air-dried strength to maintain their shape after forming. Also when subjected to appropriate temperatures, the clay particles must fuse together. Origin, particle size and mineral association are the most important properties of raw material for bricks.

Clay minerals typically derived from rock weathering. Mechanical and chemical weathering causes disintegration and decomposition of rocks. This results in formation of secondary minerals, including clay minerals. The severity of

SOME FACTS ABOUT BRICKS

- Brick is made of clay or shale formed, dried and fired into a durable ceramic product.
- There are three ways to form the shape and size of a brick: extrusion, molding and dry-pressing. The majority of bricks are made by the extrusion method in South Africa.
- Brick colour is influenced by the minerals in the fired clay or through coatings that are applied before or after the firing process, providing a durable colour.
- Brick shrinks during the manufacturing process as vitrification occurs. Bricks will vary in size dependant on the manufacturing process.
- The method used to form a brick has a major impact on its texture. Sand-finished surfaces are typical with molded brick. A variety of textures can be achieved with extruded brick.
- Brick manufacturers improve cost efficiency by locating manufacturing facilities near clay sources and use of recycled processed waste, by reclaiming land where mining has occurred and by taking measures to reduce plant emissions.

weathering depends on geographical relief, climate, exposure time and vegetation.

Clay as a raw material for brick making comes from a wide variety of sources including bedded shale/ mudstone formations, weathered / hydrothermally altered igneous and metamorphic rocks, as well as alluvial and colluvial soils.

A few important clay sources in each province are mentioned below.

Figure 1: Provincial map of South Africa

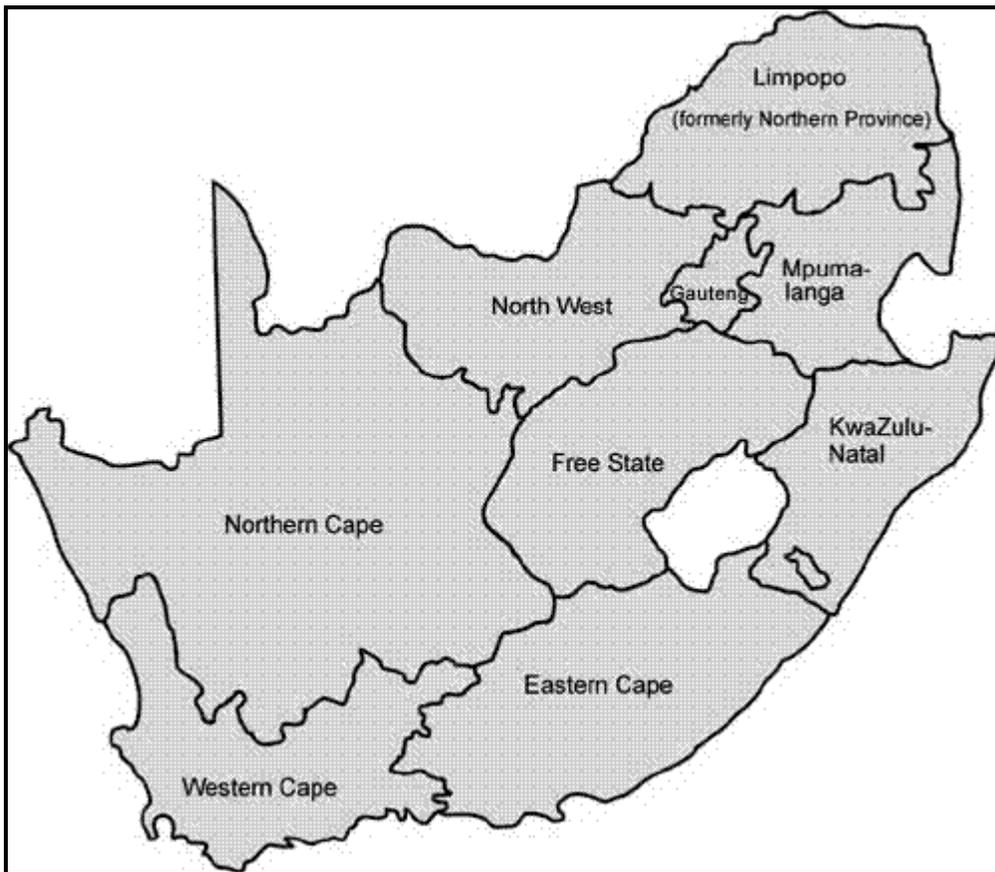


Table1: Brick making clay occurrences by provinces

Province	Stratigraphic location
Gauteng	Witwatersrand, Ventersdorp and Transvaal Supergroups. Vryheid Formation (Ecca Supergroup).
Limpopo	Weathered inliers of Pietersburg Group sediments.
Mpumalanga	Vryheid Formation (Ecca Group).
Free State	Volkruis Formation (Ecca Group). Sediments of the Tarkastad Subgroup (Beaufort Group).
Kwa-Zulu Natal	Ecca Group shales.
North West	Outliers of the Vryheid Formation (Ecca Group). Timeball Hill Formation of the Pretoria Group (Transvaal Supergroup). Weathered andesite of the Allanridge Formation (Ventersdorp Supergroup).
Eastern Cape	Mudstones of the Kirkwood and Sundays River Formations (Uitenhage Group). Mudstone of the Middleton Formation (Beaufort Group).
Western Cape	Shales and phyllites of the Malmesbury Group. Mudstone of the Kirkwood Formation. Shale from the Prince Albert Formation.
Northern Cape	Shale from the Prince Albert Formation (Ecca Group) Dwyka group tillite, shale and mudstone. Clastic sediments of the Lucknow Formation (Olifantshoek Supergroup).

3. CONSTITUENTS OF CLAY BRICK

It is essential that the raw material used for brick production contains the following elements:

- Clay material to ensure a good plasticity of the clay body, thus allowing the latter to be formed and retain its shape.
- Sufficient unreactive coarser grained material such as sand.
- Proportions of silica and alumina (2:1), in the clay from which the strong durable glassy material may be formed on heating to approximately 1000°C.
- Alkalis or iron to assist in the formation of glassy compounds.
- Constituents who do not produce excessive deformation or shrinkage at the firing temperature in the kiln.
- No impurities or inclusions such as chlorite and muscovite, montmorillonite in large quantities, feldspars, micas, rock residues in the sand, carbonates and admixtures of hydrocarbons which will disrupt the structure of the brick.

The size of the particle present in the clay body affects the cohesiveness, forming characteristics, drying and firing properties of clay.

Table 2: Defination of particle sizes in brick soils

PARTICLE	FRACTION	SIZE RANGE (mm)
Sand	coarse	2-0.6
	medium	0.6-0.2
	fine	0.2-0.06
Silt	coarse	0.06-0.02
	medium	0.02-0.006
	fine	0.006-0.002
Clay		Less than 0.002

In practice, raw material for brick making should contain some clay fraction (between 10-50 percent) together with some silt and sand. Depending upon the relative proportions of various elements in the raw material, the latter might be described as silty clay or if containing some clay and similar proportions of silt and sand it would be described as loam. Since the presence of both clay and a good range of other particle sizes are desirable, loams are particularly suitable for brick making.

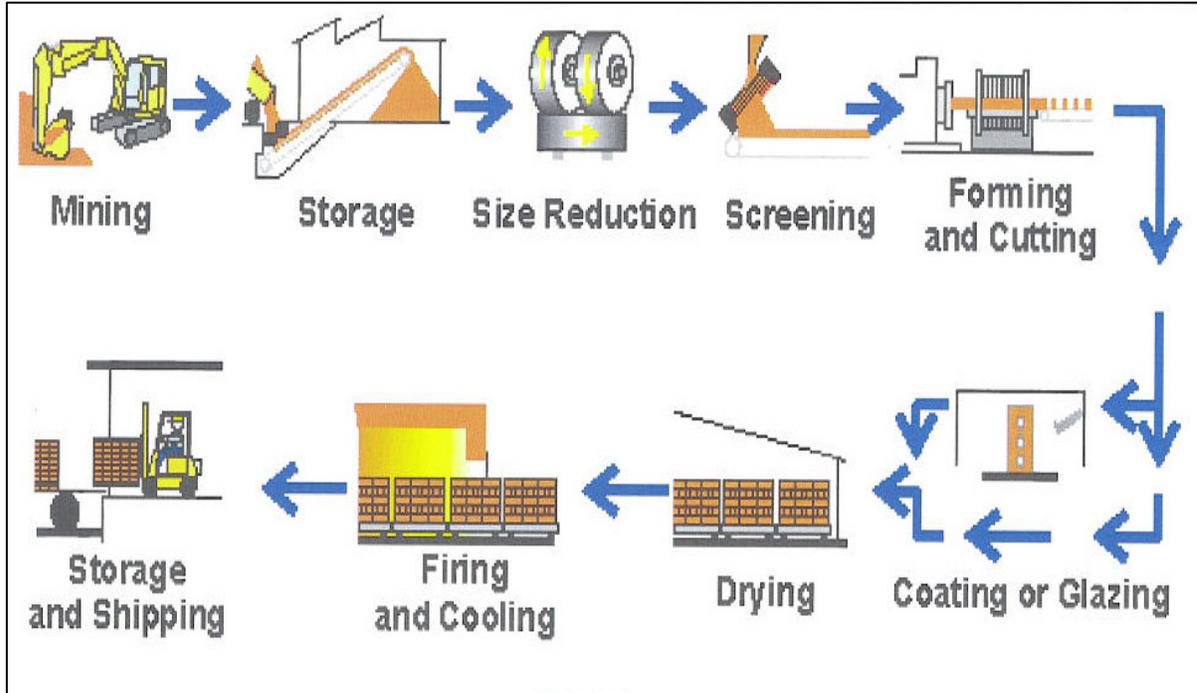
4. MANUFACTURING

Although the basic principles of manufacturing are fairly uniform, individual manufacturing plants are tailored to fit their particular raw materials and operation. Essentially bricks are produced by mixing ground clay with water, forming the clay into the desired shape, drying and firing.

Phases of manufacturing

The manufacturing process has six general processes: 1. mining and storage of input material 2. preparing raw materials 3. forming the brick 4. drying 5. firing and cooling and 6. packing and storing finished products. (Figure 2)

Figure 2: Basic brick making process



Source: Technical Notes on Brick Construction.

4.1. Mining

Surface/ near surface mining techniques are generally applied using: Scrapers, excavators, bulldozers, front end loaders or conveyor systems.

The most common and practical method is open-cast “bench-mining” using excavators and dump trucks. The method enables maximum removal of clay from the pit, and allows ease of access of the dump trucks. Bench mining also allows for easier blending of clays should it be necessary.

4.2. Preparation

To break up large clay lumps and stones, the material is processed through size-reduction machines before mixing. The equipment required for preparation of the clay is dependant on the type of clay being mined in a particular area.

4.3. Forming

There are three principal processes for forming bricks:

- Extrusion: water in the range of 10-15 percent is mixed into the clay to produce plasticity. After preparation the clay goes through a de-airing chamber that maintains a vacuum of 375-725 mm of mercury. De-airing

removes air holes and bubbles, giving the clay increased workability and plasticity, resulting in greater strength. The clay is extruded through a die to produce a column of clay. As the clay column leaves the die, textures or surface coatings may be applied.

- **Pressing:** it is particularly suited to clays of very low plasticity. Clay is mixed with a minimal amount of water (up to 10 percent) then pressed into steel molds under pressure from 3.4 to 10.3 Mpa by hydraulic or compressed air rams.
- **Hand-thrown:** it is particularly suitable for clays containing too much water for the extrusion process. Clays are mixed to contain 20 to 30 percent water and then formed into brick molds. To prevent clay from sticking, the molds are lubricated with either sand or water to produce “sand-struck” or “water-struck” brick. Brick may be produced in this manner by hand or machine.

4.4. Cutting

Two most common methods of cutting the bricks to size are:

- **Reel cutter:** cuts the clay column into brick units as it leaves the extruder.
- **Push trough cutter:** cuts a slug the length of the cutter, which is sent into the cutter by conveyor. The push through would then push the column through the cutter wires and returned ready for the next column. The cut brick in the meantime would be removed by another conveyor to the offset belt.

4.5. Drying

Wet brick from molding or cutting machine contains 7 to 30 percent moisture, depending upon the forming method. Before the firing process begins most of the water is evaporated in drier chambers at temperatures ranging from 38 to 240°C. The extent of drying time varies with different clays; it is usually between 24 to 48 hours. Heat may be generated specifically for dryer chambers.

It is usually supplied from the exhaust heat of kilns to maximize thermal efficiency. In all cases heat and humidity must be carefully regulated to avoid brick cracking.

4.6. Firing

The most commonly used methods of firing:

- **Clamp kilns** which date back to the ancient times, but are still widely used. In this case bricks are packed into a block formation with coal placed in

specific areas to assist with firing. This method is very much dependant on good weather.

- Transverse arch kilns consist of a number of chambers on either side of a building. The dry bricks are placed in the chambers which are bricked up. Heat is pulled through the chamber by an exhaust fan. Coal is fed through burners on top of the chambers and these are moved with the fire. Hot air from the rear of the fire is circulated through the drier.
- Tunnel kilns operate continuously as bricks packed on kiln cars move from the dryer into the kiln. The fire remains in one place and the cars move through increasing until fired, they enter a cooling zone where the hot air is removed and re-circulated to the dryer.

4.7. Sorting

Sorting the fired products into various grades is in most cases done by hand, or performed by robots in modern systems. Bricks are sorted, graded and packaged. They are placed in a storage yard or loaded into rail cars or trucks for distribution.

4.8. Brick properties

All properties of brick are affected by raw material composition and the manufacturing process. Most manufacturers blend different clays to achieve the desired properties of the raw materials and hence the fired brick. This improves the overall quality of the finished product. Quality checks during the manufacturing process ensure a uniform product.

The most important clay brick properties:

- Durability of a brick depends upon achieving incipient fusion and partial vitrification during firing. Compressive strength and adsorption values are also related to the firing temperatures, these properties together with the saturation coefficient are currently taken as predictors of durability in brick specifications.
- The colour of fired clay bricks depends upon their chemical composition, the firing temperatures and the method of firing. Given the same raw materials and manufacturing method, darker colours are associated with higher firing temperatures, lower absorption values and higher compressive values. For products made from different raw materials there is no direct relationship between strength and colour or absorption and colour.

- **Texture, Coatings and Glazes**
Many bricks have smooth or sand-finished textures produced by the molds. A smooth texture results from the pressure exerted by the steel die as the clay passes through it in the extrusion process. Brick may be tumbled before or after firing to achieve an antique appearance.

Manufacturing plants apply slurries of finely ground clay or colourants to the column. Slurries are clay slips that are fired into the ceramic body and develop hardness, but are not impervious to moisture or water vapour. This is done to create interesting and distinctive patterns in the finished products.

Glazed bricks are made through a carefully controlled ceramic glazing procedure. There are two basic variations of glazing, single-fired and double fired. Single-fired glazes are sprayed on brick before or after drying and the kiln are fired at the normal temperatures. Double-fired glazes are used to obtain colours that cannot be obtained at higher temperatures. Such a glaze is applied after the brick has been fired at temperatures less than 982°C. Glazes are available in a wide variety of colours and reflectances. They are both impervious to water and water vapour.

- **Size variations**
Because clays shrink during both drying and firing, allowances are made in the forming process to achieve the desired size of the finished product. Both drying and firing shrinkage vary for different clays, usually falling within the following ranges:

Drying shrinkage between 2-4 % and firing shrinkage between 2.5-4 %. Firing shrinkage increases with higher temperatures which produces darker shades. To obtain products of uniform size, manufacturers control factors contributing to shrinkage. Because of normal variations in raw materials and temperature variations within kilns, absolute uniformity is impossible.

The standard brick size is 222mm long x 106mm wide x 73mm high. Other sizes include:

Table 3: Overall dimensions of brick.

Length	Width	Height
222	90	73
222	40	73
222	90	114
222	140	114
190	90	90
290	90	90

Source: (<http://bricksales.co.za>)

- Compressive strength and absorption are both affected by the properties of the clay, method of manufacture and degree of firing. For a given clay and method of manufacturer, higher compressive strength values and lower absorption values are associated with higher firing temperatures. Although absorption and compressive strength can be controlled by manufacturing and firing methods.

5. PRELIMINARY INVESTIGATIONS

A number of factors must first be investigated prior to investing in a brick manufacturing unit. These factors are briefly discussed below:

A market for the product must first be ascertained. The mere knowledge that more building materials than available are needed at the present constitutes insufficient justification for embarking upon a new venture. Sustained demand is a prerequisite for profitable operation of the plant.

Future demand of wall building materials should be investigated by examining housing and commercial developments proposals and government's five-year plans.

The availability, extent of use, cost and performance of alternative building materials should be examined. The probability of a profitable investment will be greater if bricks constitute a favoured building material.

The site should be chosen in relation to the available infrastructure and raw materials supply.

The need for permission or licenses to operate the brickworks in a chosen location must be investigated. Information should be obtained on restrictions which may exist on the quantity or maximum depth which can be quarried.

The location of the works should be such that undue nuisance is not caused by noise, smoke, smell and pollution of water, as regulations may be in force regarding the protection of the environment.

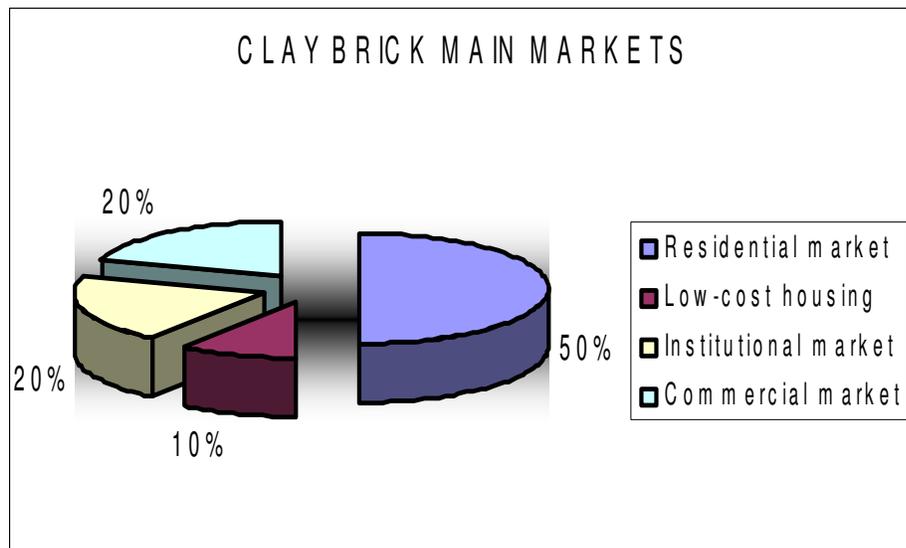
6. Product overview and application

Clay bricks are normally the preferred material for wall building because of their durability and strength, when compared to other or substitute material. They are preferred because:

- a. They naturally enhance the comfort of a habitable space.
- b. They are soundproof.
- c. They are weather proof.
- d. They are vermin proof.
- e. They are environmentally friendly.
- f. They help optimize environmental sustainability, affording life time value.

The clay brick industry serves four main markets. These include low-cost housing, conventional residential market, the institutional market (government, large corporations), fourthly the commercial sector (shopping centers, warehouses).

Figure 3: Clay brick main markets



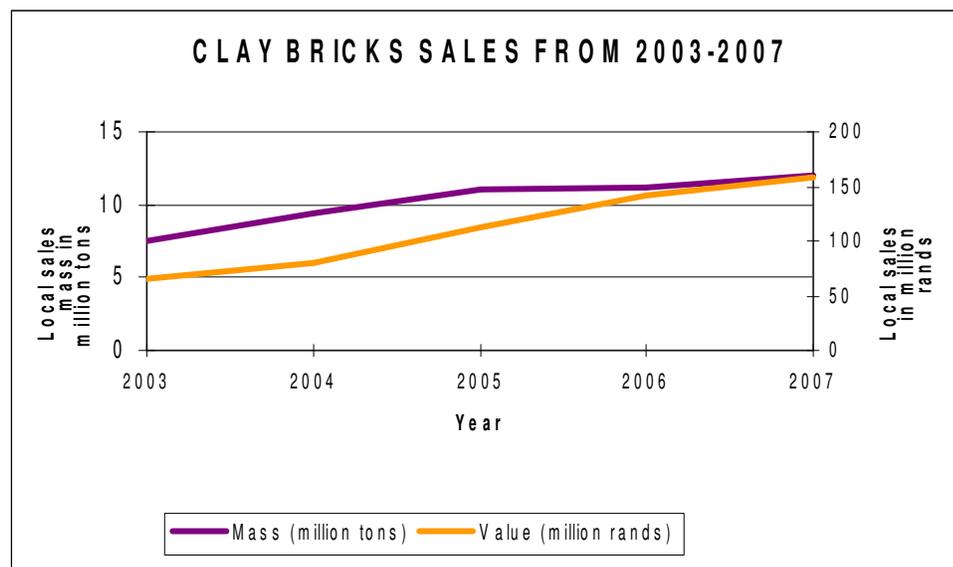
The choice of the product depends on the cost, quality and the desired finished product. Clay bricks remain a popular wall building material in spite of its higher initial cost. Bricks are renowned as a long lasting material and require little maintenance to preserve their elegant looks and thus enhance their desirability to property owners.

7. Supply and demand

The demand for building materials has increased markedly as a result of strong growth in the residential and other construction sectors since 2000. The increased demand follows a rise in construction of residential and commercial properties as well as the government spending on infrastructure. Sales from 2003 to 2007 have risen by 23 % (Figure 4). In 2004 sales mass increased by 24 % from 7.5t in 2003 to 9.3 t, in 2005 sales rose by 18.3% to 11t, a further 0.9 % in 2006 to 11.1 % followed by a 9 % rise in 2007 to 12t.

With the property market booming, people are either extending existing properties or putting up new buildings. There is also extensive upgrading of properties for the rental market, particularly in high density areas. Additional construction that will result from the construction of the 2010 Soccer World Cup and the building of new tourism facilities should boost sales further. Demand for bricks is high across the country with sales to levels not seen for 20 years or more.

Figure 4: Clay brick sales from 2003 - 2007



Source: Mineral Economics Directorate

It is estimated that 75 % of all the bricks used for buildings are genuine clay bricks, when compared to bricks made from other or substitute materials. Producers over the country have been under pressure to satisfy demand because of the products popularity. The producers have proactively increased production output without compromising quality.

South Africa has 151 registered clay brick producers, and there are a number of smaller operations that are not registered. Generally the industry is made up of

local producers that serve regional markets. There are a few prominent manufacturers such as Corobrick, which is a manufacturer, distributor and exporter of bricks; with 14 factories at different locations along with 28 sales centers around the country. The annual manufacturing capacity of the industry is estimated to be in excess of 3.5 billion clay bricks.

8. Exports and Pricing

Only about 2% of the total sales are exported to countries such as Botswana, Japan and Israel. Exports by brick manufacturers are done through agents and accredited distributors, who co-ordinate sales to places of destination. The reason for such a negligible amount on exports is that brick is a high bulk, low value commodity which does not generally tolerate high transport costs. As transport costs are particularly high in relation to production costs, long distance transporting is not very profitable. The brick industry is mainly local; most brick makers sell their products within a 70 kilometers radius of the factory giving a regional structure to the brick industry.

Bricks are often charged by pallet (approximately 500 bricks) and prices vary according to grade and quality.

9. Transportation

The clay brick manufacturers are normally situated closer to their markets. Road transport is the mainly used means of transport for the distribution of products. The vehicle configuration used for transportation of brick supplies ranges from rigids (8 ton) to articulated, articulated+ draw bar trailers and interlinks.

Optimization of transport and distribution of finished products has greatly affected end-users. To improve that manufacturers are now actively involved at the preliminary stages of a contract so that clay brick deliveries coincide with the building programme.

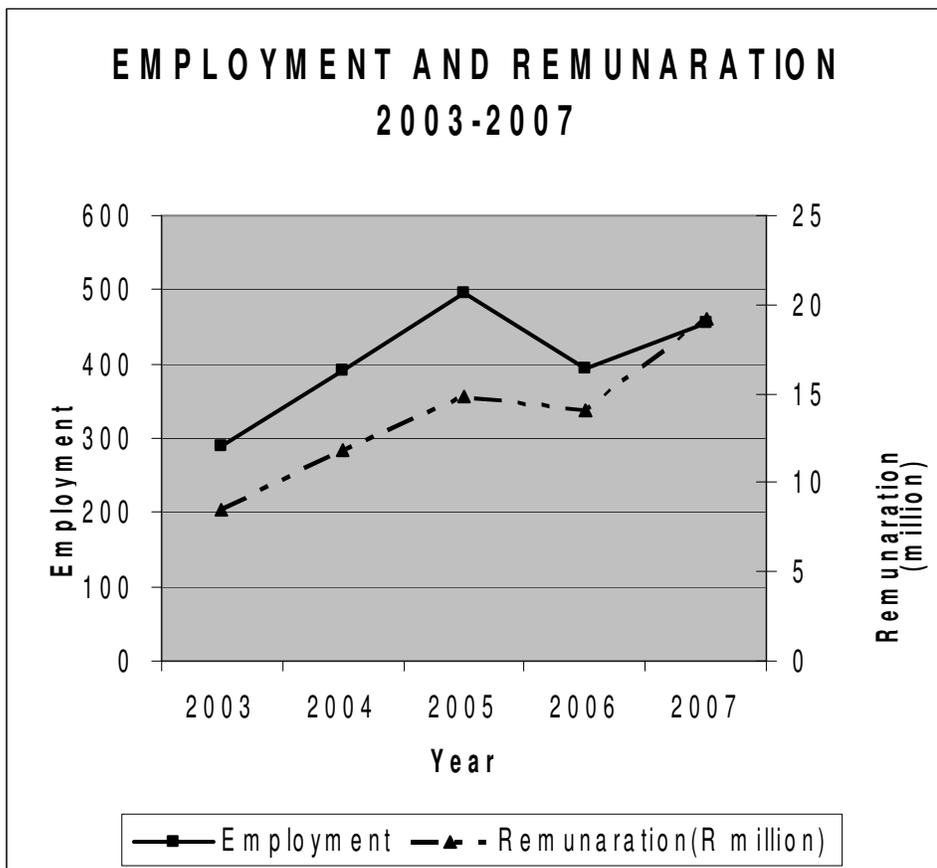
Table 4: Brick information

Nominal size	230mm x 110mm x 76mm
Number of bricks per pallet	500
Weight per pallet	1800kg
Weight per brick	3.6kg
Number of bricks per m2 (wall)	50

10. Employment and remuneration

There has been a steady increase of people employed in the industry from 2003. The increase is supported by the growth experienced in the various construction markets. The ratio of females to males is 1: 23 in the industry. Females are mostly involved in the less labour intensive part of the manufacturing, for example administration duties and the parking of the bricks to pallets. Some of the operations such as pit work are outsourced.

Figure 5: Employment and remuneration 2003-2007



Source: Mineral Economics Directorate

11. Sustainability of brick industry and Community development

Brick making has been in progress for a very long time. With adequate clay resources to continue almost indefinitely. More sophisticated manufacturers are adopting the ISO 14001 and EMAS accredited standards. Brickworks tend to provide employment for local communities. The stability of the demand for brick enables long term and stable employment. This serves to improve the standards

of life of the employees and their families. The popularity of bricks for the building industry provides a secure future for the industry. Building methods change and the brick industry must continue to provide new and innovative products to meet new challenges from rapidly changing markets. Bricks have a near limitless life span, and may even be recycled. Industry's role in the upliftment and economic empowerment of previously disadvantaged communities involves: education and training initiatives, donations, women empowerment initiatives, HIV programmes etc.

12. Environmental issues

Brick manufacturing is one of the most efficient uses of materials to produce a product. Brick plants are typically located close to raw material sources. Processed clay and shale removed in the forming process before firing are returned to the production stream. Bricks not meeting standards after firing are culled from the process and ground to be recycled in the system or crushed to be used as landscaping material, bedding material in road construction or as tennis court material. There is virtually no waste of raw materials in manufacturing brick.

Brick manufacturing uses readily available raw materials, including some waste products. Non-hazardous waste products from other industries are sometimes used. Examples include bottom and fly-ash from coal fired generators, other ceramic material, lubricants derived from processing organic materials in the forming of brick, and saw dust as a burnout material.

The brick industry's goal is to reduce resources used in the manufacturing process. Although water is used in brick manufacturing, it is not chemically altered but is evaporated. By using storage tanks to recirculate and re-use water, water use can be cut dramatically.

Natural gas is the most frequently used energy source for brick manufacturing, many manufacturers are using waste products, such as methane gas from landfills and saw dust, for brick firing.

Air emissions are minimized with controls such as scrubbers installed on kiln exhausts. Dust in plants is controlled by the use of filtering systems, vacuums, additives and water mists. Mined areas may be reclaimed by replacing overburden and topsoil that the resulting property can be used for a wide variety of functions, including farmland, residential and commercial sites.

13. Summary

Clay bricks remain a popular wall building material mostly because of the benefits offered by the finished product. Growth of the brick industry is anticipated at 3% per year. The producers are ready to meet this demand leading to the 2010 soccer world cup as well as other planned construction.

Brick manufacturing plants provide employment for the local communities and manufacturers are committed to the upliftment and economic empowerment of local people through dedicated projects.

Extraction of clay is only economical where the ratio of usable to unusable material is high. Extraction is not continuous so the immediate impact and rate of change is not significant, while numerous socially and environmentally beneficial uses are found for exhausted clay pits.

The development of new manufacturing techniques maintains clay bricks as competitive building materials that have good quality, long life and minimal maintenance requirements.

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