DEVELOPMENT OF THE CERAMIC TILE INDUSTRY IN THE REPUBLIC OF SOUTH AFRICA

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ABOUT CERAMICS - SOUTH AFRICA

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Ceramic consultant since 1995 and owner of ABOUT CERAMICS CC.

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ABSTRACT

The modern ceramics industry does the same things as old-style potters. It finds and refines clay, then shapes and fires it on a grand scale for the domestic, commercial and industrial markets.

The South African ceramics industry has grown steadily over the last 30 years and is at present the largest on the African continent. This paper traces the development of ceramic tile production in South Africa from as early as 2.000 years ago, through to design trends and the location of factories. Quality control of raw materials and the role of quality management in the manufacturing process is discussed in detail. Finally, the paper addresses the quality of workmanship in South Africa and takes a brief look at tiling systems and standards.

1. INTRODUCTION

Clays and minerals have been present in the earth's formation since the beginning of time. Following their discovery, it wasn't long before humankind found a way to put them to good use. Owing to human ingenuity, the production of ceramic goods is a thriving industry throughout the world today.

In South Africa, the ceramics industry is by far the largest user of clay raw materials. This industry produces glazed and unglazed wall and floor tiles, structural clayware for the building industry, whiteware and sanitaryware.

The ceramics industry makes a substantial contribution to the South African economy. Its economic significance not only results from the value of its output and the employment it provides, but also from its interrelationship with the building industry.

2. HISTORY

The earliest pottery made in southern Africa predates the colonial era by more than a millennium. Pastoralists known as the Khoikhoi migrated to the south-western and southern parts of the sub-continent some 2.000 years ago, introducing both sheep and pottery to the region. They, and the early Iron Age Bantu-speaking farming communities further north, made low-fired earthenware pots for various domestic purposes.

After the colonial occupation of the Cape by the Netherlands in 1652 - when the Dutch East India Company established a provisioning station for its merchant fleets on the shores of Table Bay - European earthenware and stoneware, as well as Oriental porcelain were introduced to the Cape. Historical sources indicate that some locally made pottery was available in 1665, but very little is known about this ware. Although the Netherlands occupied the Cape for almost a century-and-a-half, Dutch tiles did not feature prominently in the buildings of the period; those that did occur were usually introduced during restoration or rebuilding undertaken at a much later date.

The importation of domestic ceramics continued after Britain gained control of the Cape in 1806, although there were isolated attempts to produce basic household items in the eastern parts of the expanding colony. Mass-produced tableware from England was now used on an increasing scale by the region's European population, which expanded significantly during the second half of the century after the discovery of diamonds and gold in the interior. This so-called "mineral revolution" of gold and diamonds dramatically transformed the economy of the sub-continent, leading to rapid industrialisation and attracting further immigrants, mainly from Britain and Europe. It is estimated that at the end of the Dutch period, there were some 25.000 European settlers. Just over a century later, when the Union of South Africa was created in 1910, the country's so-called white community had grown to a million, providing a substantial market for ceramics and other goods manufactured in the northern hemisphere.

During the second half of the 19th century, wall and floor tiles began to be imported from England for houses, civic buildings and churches. Even complete Doulton terracotta facades were shipped out to South Africa. This flow of architectural ceramics increased as a result of the rapid urbanisation which accompanied the country's industrial expansion, and continued well into the 20th century. The products of all the major tile manufacturers of the time were exported to South Africa and still survive in fairly large numbers, despite widespread urban redevelopment.

At the beginning of the 20th century, South Africa was still almost entirely dependent on imported ceramics. Bricks and roof tiles had been manufactured in the country for a considerable period, but no domestic ware or decorative architectural ceramics were being produced locally. Against this background, the discovery in the early 1890s of a very large deposit of commercially viable clay at Olifantsfontein in Gauteng was an event of considerable significance. It led to the establishment of the pioneering tile manufacturing companies.

In 1947 Union Ceramics (Pty) Limited began mass producing tiles in Meyerton. Approximately 12 500 square metres a month were produced and consisted of mainly white and a few plain pastel colours. The tiles were produced in an electrically fired twin tunnel kiln - at that time unique in the world - with the bisque being fired on the one side and the second glaze firing taking place on the other with a dividing wall between.

In 1953 a leading English firm started manufacturing tiles in Olifantsfontein. Its kilns were also fired by electricity, as this was the cheapest fuel available at the time.

As production increased, kilns became larger and a more efficient fuel had to be found. Kilns were converted to firing with heavy fuel oil. During the fuel crisis in the late 1970s, firms were encouraged to convert their kilns to gas supplied by Sasol, a local producer of petroleum from coal. This was possible as Sasol had extended its network of pipelines extensively which, in turn, made it possible for the fast-firing of tiles through roller kilns. The first roller kilns for the manufacture of wall and floor tiles were commissioned in 1984.

For almost 20 years, only two major tile manufacturing companies existed in South Africa, but eventually other large companies began manufacturing ceramic tiles, providing much needed competition.

South African manufacturers of ceramic wall and floor tiles have invested heavily in modern plant and equipment and today are capable of producing world-class products.

All manufacturing equipment is imported from the continent, as there are no local manufacturers of presses, spray dryers, dipping machines and screen printers.

It is interesting to note that present day transfer decoration is but a sophisticated revival of the transfer decoration used in the local tile industry in the 1950s. Many of the original raw materials, glaze components and stains are still in use today, but manufacturing technology has evolved greatly in recent times.

3. DESIGN TRENDS

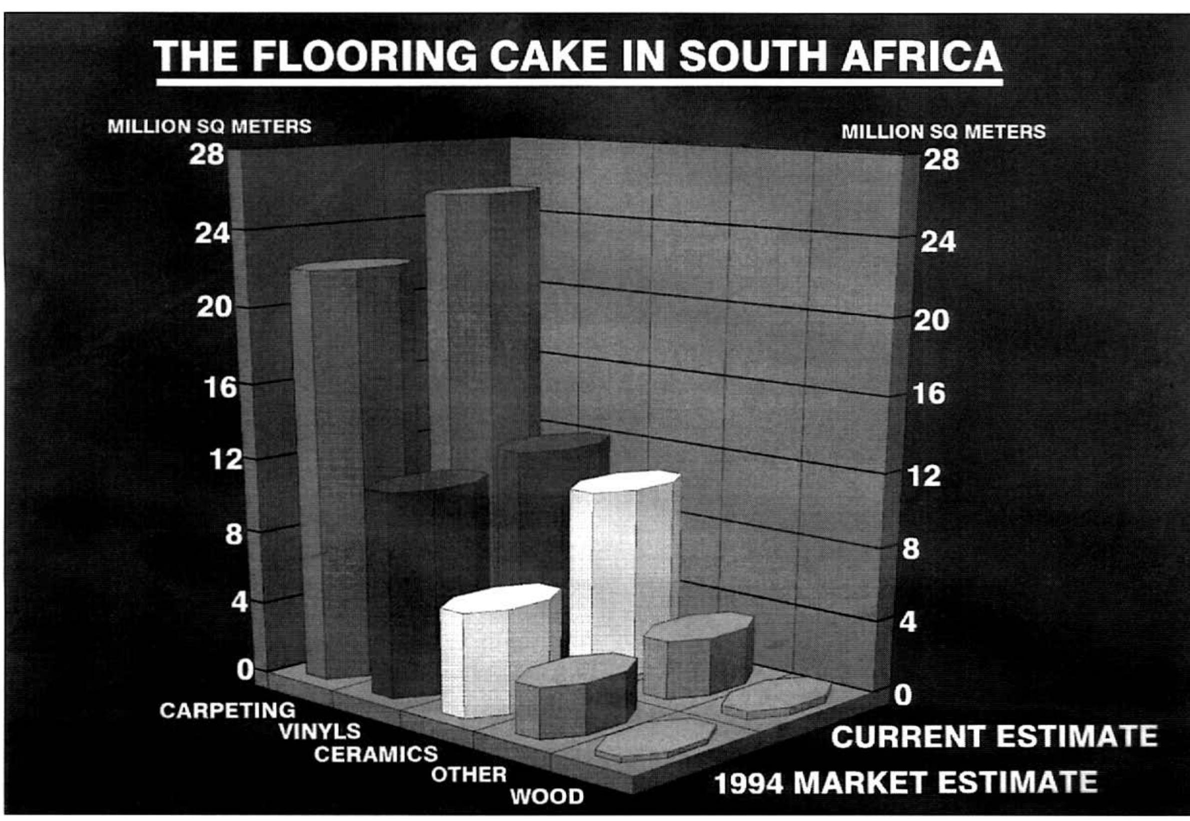
Early designs in South Africa were largely influenced by trends in Europe. One of the finest examples of this can be found in certain architectural designs such as the railway station in Johannesburg, commissioned in 1926 and inspired by the well-known

Spanish Alhambra. In the bar, the tiles consist of interlocking geometrical shapes glazed in bright, contrasting colours, creating an extremely rich and decorative effect. Similar designs on 150 x 150 mm tiles were later used for domestic commissions. In the station waiting room, there are panels with Dutch proverbs in Gothic lettering (the tea room also has three such panels), which were traced from canvas panels imported from the Netherlands to decorate the railway station.

Another European-inspired creation is the post office in the small town of Irene near Pretoria, which has a wall mural depicting early settlers in the country. The tiles used in the mural were hand-crafted by European tradesmen at Olifantsfontein in 1922. The tiles for the mural could possibly be the first mass-produced tiles in South Africa.

Today, approximately 22 million square metres of ceramic tiles are sold annually in South Africa. Of these, 12 million are floor tiles and 10 million wall tiles. The floor tile market continues to grow at a rate of about eight per cent per annum, while the wall tile market remains stable.

In an article published in FLOORS in Africa, a local publication which focuses specifically on the South African flooring industry, John Couzis, chief executive officer of a leading local ceramic tile distributor said: "Fifteen, twenty years ago, ceramics was very much a millionaire's product. It has now become a middle-income, even a poor man's floorcovering, with prices continuing the steady downward trend. I believe ceramics will eventually become the most affordable floorcovering on the market.



The flooring cake in South Africa.

"The international use of ceramics is on an upward trend. New production methods dramatically increased volumes, thus reducing the unit cost price and consequently, the price of ceramics. In Europe, replacing the ceramic floor tiles in a house every third or fourth year is becoming a trend, simply because the tiles are so cheap". (FLOORS April/May 1995).

'In a later article, FLOORS estimated a 75 per cent growth of the ceramic flooring and marble sector over five years (FLOORS Feb/Mar 1996).

Couzis was also quoted in the Sunday Business Times earlier this year: "Ceramic tile consumption continues to rise. In South Africa, demand is less than 0,5 m^2 per capita, against the current figure of ASCER (Spanish Ceramic Tile Manufacturers' Association of aproximately 2,33 m^2 in Europe, but our market has to grow... More people are becoming homeowners and ceramic tiles are becoming the product of choice".

Modern South African design trends are still highly influenced by European vogue, and to ensure that they keep up with the latest fashions, South Africans pay regular visits to international fairs such as Cevisama in Valencia.

Although rustic tiles remain the predominant fashion trend in South Africa, the original rustic design that has been seen for several years is beginning to disappear. There are very few loud colours and harsh transitions between the nuances. Instead, there are warm, natural colours with harmonious shading and finely tuned accessories such as friezes. One also sees many soft shades of grey, pink, cream, apricot and turquoise.

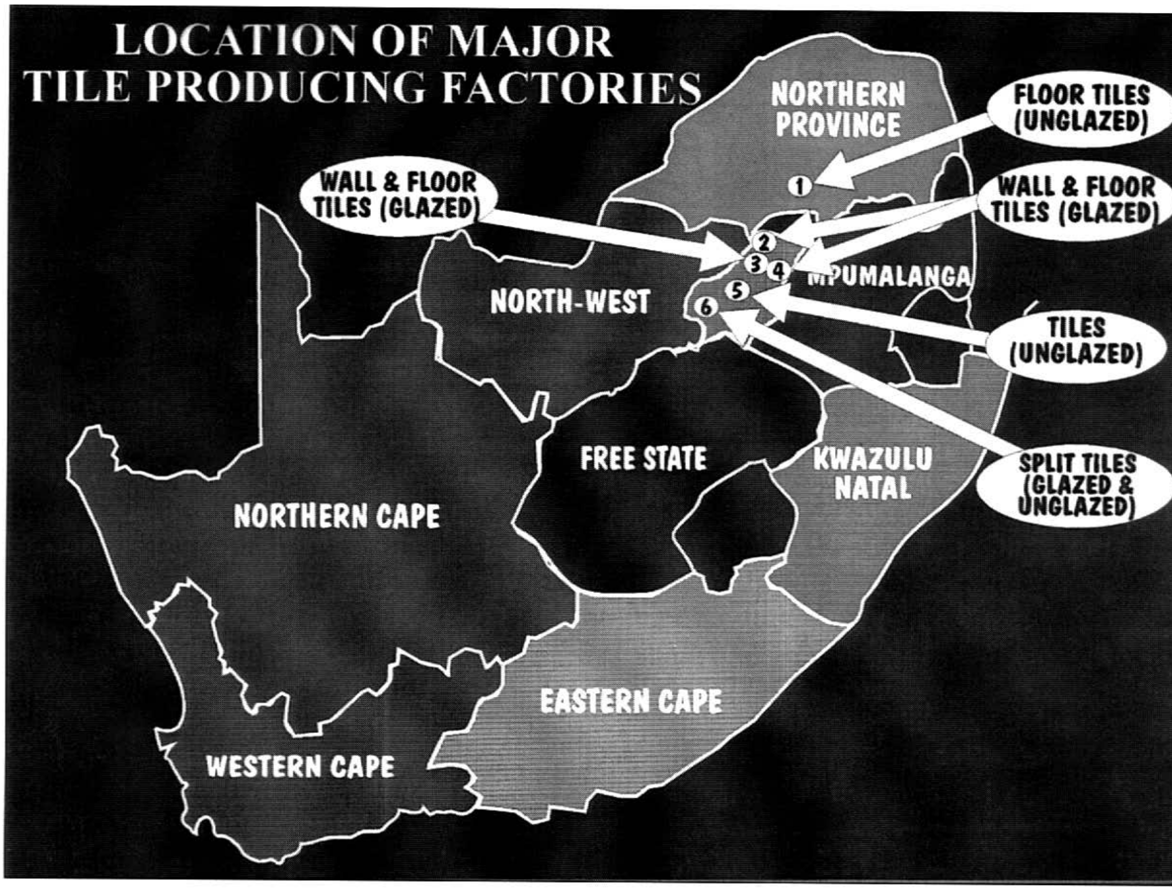
All this has led to a turnaround in the overall design concept. "Rustic" has been replaced by "country-home" style, which is very often elegant and suave and can be seen everywhere. Neither classic, nor cold and aloof, it is, in fact, an upgrade of the country-home style and conveys a feeling of cosiness.

South Africa's ethnic diversity and large immigrant population create a demand for a genuine multicultural aesthetic look. Outside facades are not popular in South Africa as the ambient temperatures, which, in Winter, can range from -6° to +18° Celsius in as little as five hours, can create movement in the tile panels. For this reason, extruded split tiles are preferred and allowances must be made at the design stage for movement joints and fastening systems.

South Africa's reconstruction and development programme includes the development of low-cost housing for previously disadvantaged communities. These projects could impact dramatically on the future use of wall and floor ceramic tiles. With it comes a move to more ethnic trends and the use of bright colours in geometric designs.

4. LOCATION OF FACTORIES

Most South African ceramic tile manufacturing facilities are concentrated in the province of Gauteng, the country's commercial capital. Engineering technology and expertise established in this region during the gold and diamond revolutions, and perfected during the subsequent Second World War, was easily converted to ceramic tile manufacturing facilities.



Location of factories in South Africa.

There are several reasons why Gauteng is the ideal province from which to operate a manufacturing operation. Its population density is the highest in the country, which means it has the largest market for the sales and distribution of tiles. Coastal areas, on the other hand, tend to be serviced primarily by imported ceramic tiles.

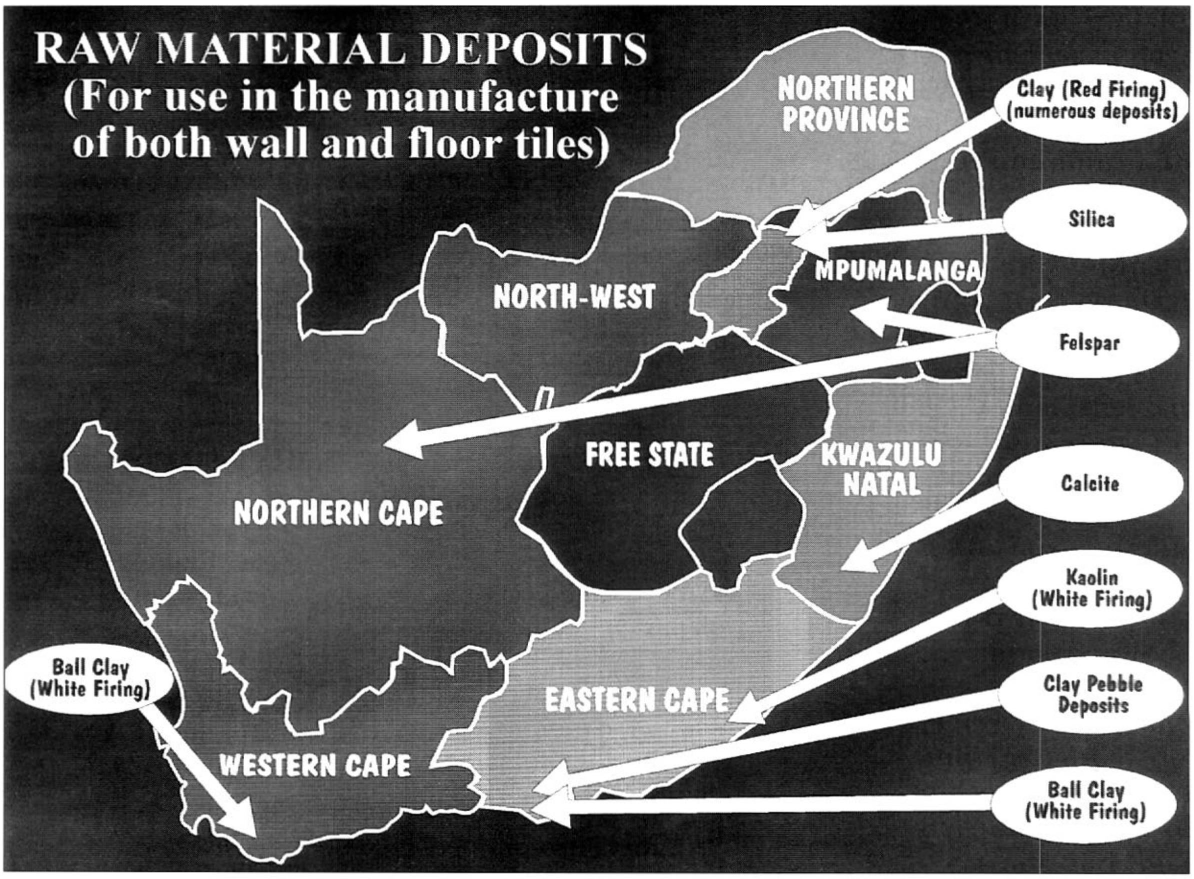
It has proved to be most cost-effective for tile manufacturers to purchase raw materials throughout the country and have them transported to their factories in Gauteng. Here the tiles are produced and then distributed throughout the rest of South Africa.

5. QUALITY CONTROL OF RAW MATERIALS

Research in the fields of clay mineralogy and ceramics in South Africa at first tended to lag behind the rapid pace of exploitation of clay raw materials. With the advent of modern techniques such as X-ray diffraction analysis, differential thermal analysis and electron microscopy, detailed studies of the clay mineralogy of South African clays were undertaken. Although South Africa is generally well-endowed with clay and hard raw materials, the quality of these raw materials can vary.

The term raw materials usually refers to all the materials that are physically incorporated into the final product, and often comprise auxiliary materials such as binders, which affect the products' intermediate properties such as unfired strength.

To appreciate the behaviour of products during manufacture and to develop new



Deposits, hard and soft materials.

products using the most appropriate materials, an understanding of the various raw materials is essential.

Naturally occurring minerals may either be used "as mined", or in a pretreated form - calcined, ground, blended. Pretreatment helps to reduce the natural variability of mineral deposits to give consistent supply when using raw materials, and is becoming increasingly commonplace as processes are automated and require more consistent materials.

The highly refined or synthetically produced materials such as the frits and the industrial chemicals which are often used, are relatively expensive, but are employed for the specific properties which they impart, such as lower firing temperatures.

Since the lifting of trade restrictions, South Africa operates in a global market where increased

1. FLOOR TILE PLANT
1.1. RAW MATERIALS
1.1.1. DAILY
1.1.1.1. MOISTURE CONTENT OF IN COMING RAW MATERIALS
1.1.1.2. RESIDUES OF IN COMING MILLED MATERIALS
1.1.1.3. CHEMICAL ANALYSIS AND BUTTON ON EVERY BATCH OF FELDSPAR
1.1.2. WEEKLY (CLAYS)
1.1.2.1. LITRE WEIGHTS
1.1.2.2. RESIDUES ON 106um SIEVE
1.1.2.3. CONTRACTION ON 4/2 SAMPLE
1.1.2. WEEKLY (ALL RAW MATERIALS)
1.1.2.5. CHEMICAL ANALYSIS - SAMPLES SENT TO C.S.I.R.
1.2. SLIP PROPERTIES
1.2.1. DAILY (MILLS, ARK, TANK)
1.2.1.1. LITRE WEIGHTS
1.2.1.2. RESIDUES ON 106μm SIEVE
1.2.1.3. VISCOSITY - TORSION VISCOMETER
1.2.1.4. PARTICLE SIZE DISTRIBUTION @ +20um, +10um, -10um.
1.2.2. WEEKLY
1.2.2.1. MON, WED & FRI ARK SLIP SAMPLES TO BE PRESSED INTO 4/2 FOR CONTRACTION AND WATER ABSORPTION
1.2.2.2. SAMPLE OF SLIP FROM ARK TO BE SENT TO HIGHGATE
1.3. DUST PROPERTIES
1.3.1. DAILY
1.3.1.1. SIEVE ANALYSIS AND DUST MOISTURE ON SPRAY DRIED DUST
1.3.2. WEEKLY
1.3.2.1. MON, WED & FRI SAMPLES TO BE PRESSED FROM DUST INTO 4/2 FOR CONTRACTION AND WATER ABSORPTION

Laboratory checks on incoming materials (floor tiles).

2. WALL TILE PLANT
2.1. RAW MATERIALS
2.1.1. DAILY
2.1.1.1. MOISTURE CONTENT OF IN COMING RAW MATERIALS
2.1.1.2. RESIDUES OF IN COMING MILLED MATERIALS
2.1.2. WEEKLY (CLAYS)
2.1.2.1. LITRE WEIGHTS
2.1.2.2. RESIDUES ON 106um SIEVE
2.1.2.3. CONTRACTION ON 4/2 SAMPLE
2.1.2.4. WATER ABSORPTION ON 4/2
2.1.2. WEEKLY (ALL RAW MATERIALS)
2.1.2.5. CHEMICAL ANALYSIS - SAMPLES SENT TO C.S.I.R.
2.2. SLIP PROPERTIES
2.2.1. DAILY (MILLS, ARK, TANK)
2.2.1.1. LITRE WEIGHTS
2.2.1.2. RESIDUES ON 106μm SIEVE
2.2.1.3. VISCOSITY - TORSION VISCOMETER
2.2.1.4. PARTICLE SIZE DISTRIBUTION & +20um, +10um, -10um.
2.2.2. WEEKLY
2.2.2.1. MON, WED, FRI ARK SLIP SAMPLES TO BE PRESSED INTO 4/2 FOR CONTRACTION AND WATER ABSORPTION
2.2.2.2. SAMPLE OF SLIP FROM ARK TO BE SENT TO HIGHGATE
2.3. DUST PROPERTIES
2.3.1. DAILY
2.3.1.1. SIEVE ANALYSIS AND DUST MOISTURE ON SPRAY DRIED DUST
2.3.2. WEEKLY
2.3.2.1. MON, WED, FRI SAMPLES TO BE PRESSED FROM DUST INTO 4/2 FOR CONTRACTION AND WATER ABSORPTION

Laboratory checks on incoming materials (wall tiles).

competition is demanding more diverse product ranges, higher product qualities, automated production methods, greater flexibility of production and lower manufacturing costs.

These driving forces for change have certain implications for raw materials and supplier-manufacturer interaction. In particular, the raw materials must possess tighter specifications, be consistent in terms of key properties and be competitively priced.

South African organisations have to face several constraints:

- transport costs both to and within South Africa;
- poor continuity of supply of indigenous raw materials - some local South African raw material suppliers are very mixed in their attention to a standard supply;
- small industry base with little purchasing power.

Owing to the ever-increasing demand for quality materials, both in-house companies and suppliers are being awarded ISO 9002 accreditation. Several respected institutions perform stringent testing to ensure the products conform to the user's requirements. One of these is the South African Bureau of Standards (SABS), while the other is the Mattek division of the Council for Scientific and Industrial Research (CSIR).

Criteria for the Choice of Materials

A number of criteria are used for choosing materials:

- cost and availability;
- chemical composition and consistency;
- unfired behaviour;
- fired behaviour;
- physical properties, for example, particle size distribution; and
- minerology.

Fortunately for ceramics, raw materials are plentiful and cheap, even in South

Africa. Silica is the second-most abundant element in the earth's crust (after oxygen), with feldspars accounting for 60 per cent of the earth's crust, while clays occur worldwide.

Other factors which determine the final choice of materials include shrinkage on drying and firing, suspension and binding properties, dry strength and plasticity. Vitrification and characteristics, decomposition of firing, presence of colouring oxides, particle size and mineralogy also influence the choice of raw materials.

4. COLOUR ROOM
4.1. RAW MATERIALS
4.1.1. DAILY
4.1.1.1. RESIDUES MESH SIZE SPECIFIED BY COLOUR ROOM
4.1.1.2. IRON CONTENT IN PPM
4.1.1.3. MOISTURE CONTENTS
4.2. FRIT PROPERTIES
4.2.1. DAILY
4.2.1.1. THERMAL EXPANSION INCLUDING DETERMINATION OF YIELD POINT
4.3. GLAZE PROPERTIES
4.3.1. DAILY
4.3.1.1. SEDIMENTATION
4.3.1.2. PARTICLE SIZE DISTRIBUTION (SEDIGRAPH)
4.3.1.3. THERMAL EXPANSION INCLUDING DETERMINATION OF YIELD POINT
5. LABORATORY TRIALS
5.1. NEW RAW MATERIALS
5.1.1. COMPLETION OF NEW RAW MATERIALS REPORT SHEET
5.1.2. 2 KG. SAMPLE SENT TO HIGHGATE
5.1.3. BOTTLE TRIALS USING NEW MATERIAL AND COMPLETION OF TEST SHEET
5.2. RECIPE ALTERATIONS
5.2.1. COMPLETION OF PROXIMATE ANALYSIS
5.2.2. FORMULATION OF TRIAL BODY RECIPE
5.2.3. BOTTLE TRIALS OF NEW BODY RECIPE AND COMPLETION OF TEST SHEET
5.2.4. TWO MILL TRIAL TO BE DONE AND COMPLETION OF PRODUCTION TRIAL REPORT SHEET
5.2.5. 5 KG. SAMPLE OF TRIAL BODY TO HIGHGATE

Glaze preparation.

Key Properties of Raw Materials

These are defined as:

Chemical Composition and Loss on Ignition: The chemical composition defines the nature and quantity of active ingredients and identifies the presence of impurities which can affect the fired colour or processing behaviour, i.e. soluble salts. Both organic and inorganic constituents are important. The most important property is that the materials are consistent, and this leads to improved predictability of the behaviour during production.

Particle size: Along with the composition of the incoming materials, the particle size should be monitored and controlled if any grinding operation takes place. Control of particle size in plastic materials such as clays can influence deflocculation demand, packing density and viscosity. Control of particle size distribution for non-plastics, (feldspar and silica) is crucial in ensuring that vitrification takes place at acceptable temperatures.

Bulk chemistry and particle size are particularly important, as without these two characteristics, vitrification and densification at acceptable firing temperatures in acceptable times would not be possible. This means that these two properties can only vary between narrow limits, otherwise it will lead to major differences in the way in which formulations interact with water and deflocculating chemicals.

It is often not practical to carry out chemical and mineralogical analysis of the materials at the factory site. It is feasible, however, to measure moisture content and particle size, and simple observations can be made on the state of the incoming raw materials, for example, wrong mining methods and clay containing overburden.

Mineralogical Composition: This identifies the crystalline materials present, such as the level of flux and filler. Different clay mineral compositions can severely affect processing properties such as drying shrinkage, cracking and deflocculation characteristics.

Moisture Content: A regular moisture content is important and should be measured, not only for slip calculations, but also to ensure that water is not being purchased in place of the material.

Other key properties include:
- deflocculation demand;
- modulus of rupture;
- fired colour;
- surface area.

Advantages of Material Characterisation

Material characterisation plays a vital role in trouble-shooting, and ensures manufacturers become pro-active rather than reactive to loss reduction, as problem batches are detected early. It also ensures that manufacturers have a flexible attitude to product reformulation, although it does require investment in acceptance test equipment and procedures.

Although suppliers are taking increasing care in the refining of materials, it is inevitable that the clays, in particular, will have variable properties. It is important to understand the effect that variations in the properties of the raw materials may have before they are used, and to adjust the composition accordingly.

By appreciating the requirements placed on raw materials, as well as the properties they impart, an insight into the performance of the production process and subsequent products can be gained.

Close control of raw material properties is important for automated production, loss reduction and higher quality, as the products will possess certain features such as good dimensional stability and colour.

6. MANUFACTURE AND QUALITY MANAGEMENT

In South Africa the use of quality systems in the manufacturing industry is still in its infancy. This is owing to ill-informed perceptions of the client's needs, accompanied by the inept application of quality system principles, which dominated quality-based decision-making. Certainly, lip service had a substantial influence in earlier, and regrettably, even some current thinking on the matter.

In the manufacturing industry, awareness and understanding of quality has improved over the last five years. Unfortunately, some manufacturers have only "gone through the motions" of quality without real commitment and subsequent payback. Those that have implemented coherent, well-structured and cost-effective quality systems have seen decided benefits.

A common perception is that quality management is only applicable to a factory-based type of environment and is totally inappropriate on site. With the necessary attention and planning, however, quality principles on site can be successfully implemented.

Naturally, the design office is equally able to be considered for the application of the principles of quality management.

Local manufacturers are sceptical about applying techniques and principles from other countries to South African situations. The general feeling is that local conditions vary, other priorities exist, quality management costs too much, the current level of labour development is inhibited and the like.

International experience in the field of quality management has recently been focused around a single series of international documents. These are the International Organisation for Standardisation (ISO) series of quality system standards, the ISO 9000 series. It is not widely known that South Africa had a key role in the establishment of the technical committee (TC) at ISO that was responsible for the drafting of the ISO 9000 series of documents. South Africa was one of the first countries in the world to offer certification of quality systems to industry, with local interest and registration growth following closely on the heels of the United Kingdom's British Standards Institute (BSI).

The development of the ISO 9000 standard into a truly global document is apparent when viewed as shown, illustrating those countries that have adopted ISO 9000 as their quality standard. These documents are the major success story at ISO, giving rise to comments such as "one world, one standard". The documents currently making up the ISO 9000 set are given, along with those currently planned and being prepared. A point to note is the fact that the ISO 9000 series constitutes models for quality systems and is therefore extremely flexible in its application. The core concept is that the minimum requirements of each of either ISO 9001, "Model for Quality Assurance in Design/Development, Production Installation and Servicing", or ISO 9002, "Model for Quality Assurance in Production and Installation" are demonstrated to be met in a manner suitable to the implementer.

Significant additions to these standards are those associated with quality improvement, quality consistency and so on. The concepts of quality systems have permeated into all areas of technology, notably also into environmental matters. Currently, one of the newest and largest technical committees of ISO - TC 207 (Environmental Management Systems) is debating the application of ISO 9000 principles in environmental management systems.

To address the future needs of this country and to find answers to all questions facing us is an enormous challenge. I wish to propose a possible way to achieve development along the correct path, namely the quality high road. Some of the key elements involved include:

- Standardisation of manufacturing may be achieved in a variety of ways, one of which is by adherence to codes of practice and other guidelines such as SABS 1449-1996: Specification of Ceramic Wall and Floor Tiles, and the draft specification on adhesives.

- The requirements associated with mark scheme participation are twofold, namely consistent compliance with the specification requirements and adherence to a form of quality system established to ensure that consistency is indeed achieved. The minimum requirement of the quality component is to provide control of quality, but not necessarily to manage it, as previously discussed.

MONO SLIP PREPARATION BALL MILLING

BODY .... DATE...............

CLAY MOISTURE

	SPEC	
HOLFONTEIN	5 - 12	
FELDSPAR	0 - 0.5	
CYCLONES	8 - 12	
PRETORIA	5 - 12	
ORSMOND	8 - 15	

RESIDUE CRUSHED MATERIAL

	SPEC	
FELDSPAR 75 um SIEVE	0 - 4	
SILICA 106 um SIEVE	30 - 40	

DEFLOCULANT		
	STPP	23.00 %
	CERFLUX	0.07 %

SIEVE ANALYSIS OF SPRAY DRIER DUST

	SPEC	NIGHT	MORNING
1000 um	0 - 1		
600 um	2 - 6		
355 um	57 - 67		
250 um	15 - 22		
150 um	8 - 15		
-150 um	1 - 5		
TOTAL			
MOISTURE	6.0 - 6.4		

		MILL NO 3		MILL NO 4			
	SPEC					ARK	TANK
RUNNING TIME	6.5	6.5	6.5	6.5	6.5		
PEBBLE CHARGE KGS	80 KGS						
WATER ADDITION							
LITRE WT (gms/l)	1620-1640						
RESIDUE 63 umSIEVE	5 - 7						
FORD CUP NO4 IN SECS	50 - 80						
TORSION 1ST READING	300 - 320						
2ND READING	280 - 300						
THIX	15 - 30						
PART SIZE DISTRIBUTION +20	15 - 25						
PART SIZE DISTRIBUTION +10	30 - 40						
PART SIZE DISTRIBUTION -10	60 - 70						

Designated control stations.

- *Quality of design*: The key to achieving compliance with client requirements lies in fully understanding what they are. These requirements include design development, technical interfaces, inputs and outputs, verification and changes. Achieving this is neither easy nor straightforward.

JOHNSON TILES BICOTTURA DIPPING CONTROL RECORD

PRODUCT	VENICE	CODE	VC 22	LINE NO		SHIFT		OPERATOR NAME		DATE	

TIME	WATER	1st DIP			2nd DIP			FUME / DISC			PRINT 1	PRINT 2	PRIN3	FIXATIVE	SCREEN No's		
	1.5 g	Density	Viscosity	Tare	Density	Viscosity	Tare	Density	Viscosity	Tare	Weight	Weight	Weight	Weight	1	2	3
6:00																	
7:00																	
8:00																	
9:00																	
10:00																	
11:00																	
12:00																	
13:00																	
14:00																	
15:00																	
16:00																	
17:00																	

SPECIFICATIONS	
Tile Size	200x250
Surface	FLAT

1st Dip	BIC ENGOBE
Density	198g / 100ml.
Viscosity	30-50 seconds
Tare 6x6	9g

2nd Dip	BIC TRANSPARENT
Density	180g / 100ml.
Viscosity	30-40 seconds
Tare 6x6	22g

Fume	
Density	
Viscosity	
Weight	
Atom Pressure/psi	
Fan Pressure/psi	
Belt Speed	

Disc Mottle	
Density	
Viscosity	
Weight	
Pulley Size	
Speed	
Belt Speed	

Print No 1	BIC 6
Screen	DU 995 i
Mesh	P62T GOLD
Batch No	
Print Weight	0.23-0.28g

Print No 2	BIC 9
Screen	DU 995 ii
Mesh	P62T GOLD
Batch No	
Print Weight	0.60-0.65g

Print No 3	
Screen	
Mesh	
Batch No	
Print Weight	

NB. PRINT WEIGHTS MUST BE WEIGHED USING A FIRED MATT WHITE TILE

Fixative	**KIMIFIX 368**
Ratio	0.055556
Tare 6x6	0.5-0.8g

Designated control stations.

A key consideration in design is that sufficient product information is provided by manufacturers to the designer wishing to utilise the product. This includes special requirements, precautions and preparations. Once more, communication is crucial to achieving a quality result.

- *Quality of manufacturing*: It has been said: "The design was a good idea, until someone messed it up by building it". Designers might agree with this, while those in the construction and building field might not.

  It is often said that having a documented quality system on site is not acceptable to site personnel as they hate paperwork (Code of Practice - The Design and Installation of Ceramic Tiling, SABS 0107-1996). Despite this, it is possible to have a well-structured, cost-effective formal system based on a minimum of paperwork for a maximum amount of information recorded and used.

  The onus is on the product manufacturer and the designer to communicate information to the contractor to enable the building project to be completed in accordance with the client's requirements. Again, communication is crucial for success.

  The maintenance activities carried out by contractors should be addressed in any quality system implemented. These activities should naturally relate to routine maintenance and not the rectification of processes incorrectly followed the first time.

- *Total quality*: All of the above points refer in some way to the integration of quality into each phase - design, construction and production. The overall method of relating to quality in all business activities of a company is generally called "total quality".
  The key components of total quality within a company are quality improvement, striving to achieve all client needs, and increased awareness among the staff.

1.4. PRESSED AND GLAZED PROPERTIES
1.4.1. DIALY
1.4.1.1. M.O.R. GREEN, DRIED, GLAZED FOR ALL PRESSES RUNNING
1.4.1.2. TILE MOISTURE FOR ALL PRESSES RUNNING
1.4.1.3. RECORD TILE TEMPERATURE FOR ALL PRESSES RUNNING
1.4.1.4. RECORD SPECIFIC PRESSING PRESSURE FOR ALL PRESSES RUNNING
1.4.1.5. RECOR DRIER TEMPERATURE SETTING FOR ALL PRESSES RUNNING

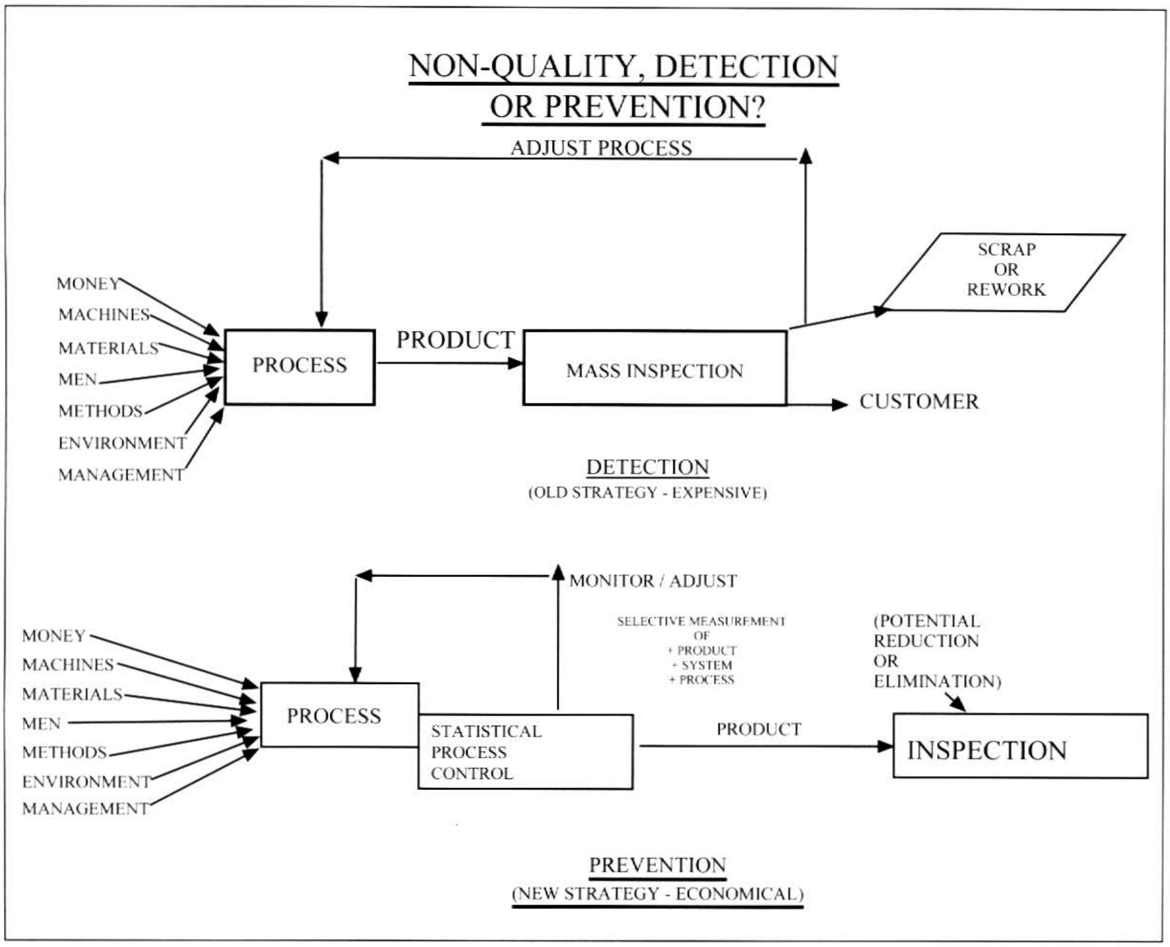
1.5. FIRED PROPERTIES
1.5.1. DAILY
1.5.1.1. DRIED TO FIRED CONTRACTION FOR A TILE FROM EACH KLIN
1.5.1.2. M.O.R. FOR A FIRED TILE FROM EACH KLIN
1.5.1.3. WATER ABSORPTION FOR A TILE FROM EACH KLIN
1.5.1.4. P.E.I. FOR A TILE FROM A KILN ON A ROTATION BASIS
1.5.1.5. BULLERS RINGS FOR EACH KLIN MORNING AND AFTERNOON PLACED LEFT, CENTRE AND RIGHT
1.5.1.6. CRAZING TESTS TO BE DONE FOR EACH KILN

1.5.2. KEEKLY
1.5.2.1. THERMAL EXPANSION TO BE DONE TUE AND THUR

1.5.3. MONTHLY
1.5.3.1. IRREVERSIBLE MOISTURE EXPANSION - SAMPLES TO C.S.I.R.

Pressed and glazed properties.

Productivity and quality go hand-in-hand. The combination of the two concepts into one is called "total productivity quality management", or TPQM.



Quality detection or prevention?

The basic principles of quality management are available for anyone interested in utilising them for improvement of methods, means and materials, and for the saving of money. Some companies have taken up the challenge partially, while others are unaware of the potential advantages waiting to be exploited.

In the near future, with the increase in foreign trade, the implementation of GATT, and the prospect of greater competition from foreign companies in terms of materials and technical and high-level skills inputs, the requirements of quality will dictate how business is conducted. The product design, manufacture and production industry will be well-advised to seriously consider these factors.

It is crucial not to ignore opportunities that may be lost through lack of awareness of what a striving to total, and indeed, global quality can offer.

7. QUALITY OF WORKMANSHIP FOR TILE FIXING

South Africa's productivity rate is one of the lowest in the world. It also seems to increase at a slower rate than it does in those countries which are its major trading partners. The National Productivity Institute has indicated that, over the period 1975 to 1992, labour productivity in manufacturing increased on average by only 0,6 per cent a year, compared to 2,6 per cent in the USA, 4,1 per cent in Japan, 1,7 per cent in Germany, 3,7 per cent in the UK and 5,8 per cent in Taiwan.

In 1989 the then President's Council in South Africa undertook a wide-ranging investigation into productivity in the country. Numerous factors which influence performance were considered.

The council indicated that 85 per cent of the factors which influence the productivity of an organisation can be found in the organisation itself and can largely be controlled by management. The remaining 15 per cent comprises external influences. It is generally accepted that South Africa's lack of management skills and the absence of productivity awareness are important contributing factors to poor productivity performance. The lack of competition in the South African market and insufficient investment in research and development are other factors contributing to poor productivity.

The labour market is often characterised by a confrontational relationship between employers and workers. In many cases there is mutual distrust, which makes productivity bargaining more difficult. In the past, employers have not given enough attention to sharing the benefits of productivity improvements with workers, or addressing any possible effect of productivity improvements on employment, and this has resulted in opposition from unions to productivity bargaining. Employers are also often unwilling to disclose financial and other information for collective bargaining purposes, which makes a joint approach towards productivity improvement and the sharing of the benefits of such improvement difficult.

Social conflict in South Africa is another important factor contributing to low productivity growth. The lack of proper housing, long travelling distances, unsatisfactory health care and nutrition, as well as various other socio-economic factors also play an important role.

A further influencing factor is the skills level of South Africa's workforce, which leaves much to be desired. There is a high rate of illiteracy, and South African employers invest much less in training than do employers in other countries. This has a very negative influence on the country's productivity performance.

Poor workmanship is a very serious problem in the South African ceramics industry. In Europe a ceramic tiler is a qualified, highly skilled artisan. He is paid substantially more per hour than his South African counterpart, but is able to complete a job in a third of the time it takes a South African (with no comebacks).

In the South African contract tile fixing market, however, there are many unqualified or under-qualified people professing to be expert tile fixers. It is very often the untrained tile layer who is contracted to do a job because he is prepared to do it cheaply. He waits outside retail stores in the hope that an unsuspecting homeowner, who has just purchased expensive tiles for his floor, will employ him. In all likelihood he was previously employed by a large tiling contracting concern or even worked as a bricklayer. His technical expertise as far as floor tile installation is concerned is limited - he knows very little about the background to be tiled, or types of adhesives to use in special cases. He believes that he has learned all he needs to know from watching reputable tilers and is hoping to make money quickly.

KNOWLEDGE SELF CHECK		N° 1
DESCRIPTION: INTERPRETATION OF THE DRAWING TO DETERMINE TILING REQUIREMENTS		

DIRECTIONS

1. Evaluate your work by answering the following items.
2. Make a large cross in the appropriate block on the separate Answer Sheet provided. Page 7.
3. Check your answers with those on the Answer key. Pake 8.
4. For those answers missed or incorrect review Instruction Sheet N.°: 1.
5. 100% Mastery must be achieved.

TRUE OR FALSE

SELECT THE CORRECT ANSWER BELOW, AND INSERT A CROSS IN THE APPLICABLE BLOCK ON THE ANSWER KEY

1. The area to be tiled is 1.000 m. x 2.400 m.
2. The tiles to be used are blue and white glazed tiles.
3. The grouting is to be white cement.
4. The tiles are fixed using dagha.
5. The height of the Datum lin is 1.800 m.

PROG:	PT.	DUTY:	F.	TASK:	03.

 Page 6 of 15

Course module contents.

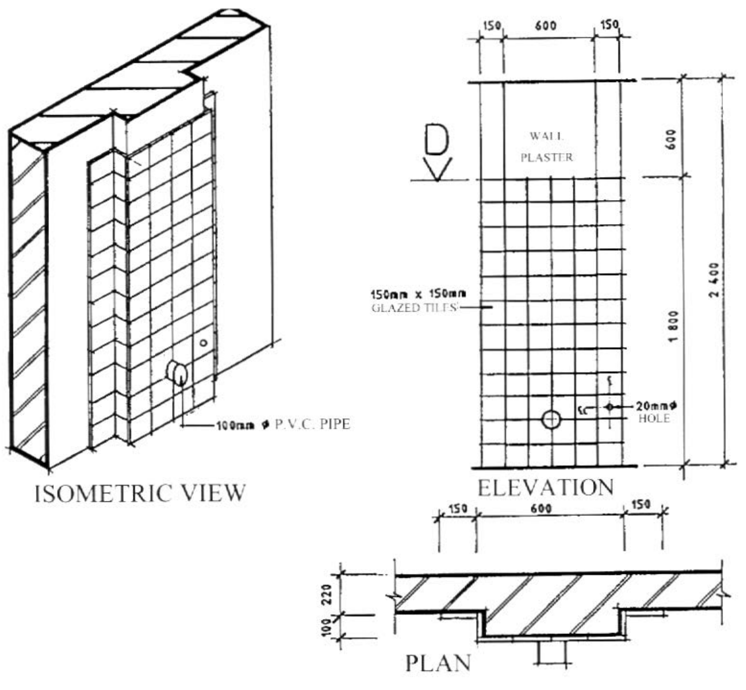
A major problem experienced by the people who hire these untrained labourers is that the job is not done well. Initially, there are no problems. It is only four to five years down the line that failures start to manifest themselves and the homeowner can do nothing about it.

To overcome this problem, the South African Ceramic Tile Manufacturers Association (SACTMA), in close conjunction with the Building Industry Federation of South Africa (BIFSA) and now the Building and Industries Training Board (BITB), works on the upgrading of training manuals and establishment of schools.

Tile fixing courses compiled by SACTMA members are geared to:

- ensuring that suitably qualified, skilled tile fixers, who understand how to properly affix wall and floor tiles, are available in the marketplace;
- providing employment for a number of people;

INSTRUCTION SHEET.		Nº: 1.
LEARNING OBJETIVE. Nº: 1.		LEARNING ACTIVITY. Nº: 1.
DESCRIPTION : INTERPRETATION OF THE DRAWING TO DETERMINE TILING REQUIREMENTS.		



NOTES:

1. 150mm x 150mm Glazed white tiles to be used.
2. Joints to be grouted with proprietary grout.
3. Tiles to be fixed to the wall with tile adhesive.
4. Datum to be 1,800m from the finished floor level.

PROG: PT.	DUTY: F.	TASK: 03.

Course module contents.

- fostering selected emergent entrepreneurs to make a living for themselves and their dependants, but at the same time creating employment opportunities for others;

- providing the tile purchaser easy access to a competent and qualified tile fixer;

- improving the quality of work methods employed by tile fixers in the laying of wall and floor tiles; and

- providing advancement opportunities for the existing employees of tile merchants and outlets.

It is intended that the training will be divided into modular form in the future so that it can be presented countrywide rather than just in Gauteng. The tile fixing portion of the training is approved and recognised by the BITB and a nationally recognised certificate will be presented to successful candidates.

On successful completion of the course, the services which can be provided by the qualified tile fixer will be marketed through merchants and other outlets.

Ceramic manufacturers owe it to themselves and the industry to initiate and maintain meaningful training programmes. In so doing, they will not only improve the standard of workmanship, but also create job opportunities (people taught to lay ceramics will promote the use of ceramics.

8. TILING SYSTEMS AND STANDARDS

Ceramic tiles have been fixed directly into sand/cement mortar beds since time immemorial. The advent of modern building design, however, has resulted in more flexible building systems and fast-track construction techniques, which have increased the need for stronger and more durable and flexible adhesive systems.

As recently as 1970, most ceramic tiles in South Africa were installed by the direct bedding method. Very often tiles only went up to dado height on walls. The plasterer would only render the walls from this height up to the ceiling, and since adhesive systems require a rendered surface, initial problems were experienced with who would pay for the "extra" plaster behind the tiles. Practice soon confirmed that the overall time saved more than compensated for the apparent extra cost.

Today floor to ceiling wall tiling is standard practice and the vast majority of tiles, on both walls and floors, is installed using adhesives. These adhesive systems range from convenient ready-mixed organic binder pastes, through to standard and rapid-setting cement-based powders and sophisticated epoxy-type systems.

The advantages of adhesives over site-batched sand/cement mortars are:

- A successful adhesive system can be found for almost all modern building structures and surfaces;
- Much stronger, longer-lasting and more flexible bonds are achieved;
- Adhesives are much easier to work with (no soaking of tiles is necessary and they are more easily trowelled) and are much quicker;
- The fixing rate is more than doubled, with consequent savings in costs;
- Perfectly consistent quality from factory produced product is achieved (site mixing of mortars is prone to inconsistent sand quality, varying sand/cement ratios, etc.);
- On floors, adhesives are typically 3-6 mm thick, as opposed to a minimum of 40 mm required for direct mortar bedding. This reduces dead load on suspended slabs, thus optimising design; and
- Adhesives allow fixing directly onto background surfaces such as existing tile and vinyl, making renovations easier.

As early as 1969, Harrison and Dinsdale of the British Ceramic Research Association found the following in their long-term tile adhesion clearing house experiment: "An overall comparison of traditional mortar fixatives and thin-bed adhesives is overwhelmingly in favour of the latter".

As tile production technology moves forward and more sophisticated tiles are produced - particularly highly vitrified porcelain-type tiles - the use of adhesives with their enhanced bonding characteristics becomes essential. The extremely low-porosity of these tiles, together with their relatively smooth back surfaces, precludes any hope of a sound mechanical bond using an unmodified cement/sand mortar.

To ensure a consistently high standard of quality in the manufacture of adhesives, leading adhesive manufacturers, in conjunction with the SABS, have begun the formulation of a draft specification for the manufacture of adhesives and grouts.

Main Causes of Tile Installation Failures

Unfortunately, failures of ceramic tiles installations do occur. Although they are limited to less than 0,1 per cent of all tiles installed, the cost of failure can be high and consequent damage enormous. Provided the reasons for failure are understood and due precautions taken, failures need not occur.

The main causes of tile failure are any one or a combination of the following:

- Differential movement not catered for in the system;
- Selection of inappropriate products for the conditions; and
- Poor workmanship on site.

Let's briefly consider these in turn.

Differential movement: One of the most common causes of failure is the build-up of stresses owing to the cumulative effect of differential dimensional damages to a point high enough to cause delamination along the weakest plane. This could occur between the tiles and the fixative, within the fixative itself, or between the fixative and the backing material.

The most important factors contributing to differential movement are:

- Irreversible moisture expansion of ceramic tiles;
- Size changes of backing materials;
- Thermal movements;
- Creep movements of the structure; and
- Other structural movements.

Irreversible moisture expansion of tiles: Reversible moisture expansion and contraction of tiles between wetting and drying cycles or ambient temperatures are relatively insignificant.

Irreversible moisture expansion is the expansion associated with the absorption of moisture in such a way that only elevated temperatures of some 600oC and higher reverse the expansion. The magnitude of irreversible moisture expansion varies from virtually zero for very dense, fully vitrified porcelain-type tiles, to as high as 0,2 per cent and higher for more porous open-bodied tiles. The rate at which this occurs also varies widely for different tiles, but may take years for full expansion to be reached. Naturally, only that expansion which occurs after the tiles have been laid is of significance, and therefore the longer a tile is left to mature before fixing, the better. On floors and exterior facades, tiles should have irreversible moisture expansions of between 0,03 and 0,05 per cent.

Size changes of backing materials: Cementitious materials such as mortars and concrete are subject to initial drying shrinkage which is irreversible and, as in ceramics, occurs over time. An interval, usually at least 28 days, should be allowed between placing the substrate and commencement of the tiling. Reversible movements caused by wetting and drying of mortars can be much higher than that associated with ceramics, and can range from 0,05 per cent to 0,2 per cent between wet and dry, depending on the quality of the mortar. Brickwork, on the other hand, expands in much the same fashion as ceramic tiles.

Thermal movements: Differential movement will be caused by any difference in temperature between the tile face and the underlying substrate. In extreme cases, on external facades for example, the temperature gradient could be as much as 20-30°C in the summer months, which would cause a differential movement of between 0,015 and 0,025 per cent.

Creep movement: Concrete and masonry under sustained loading deform with time. This creep, as the movement is called, causes columns and walls to shorten and beams and suspended slabs to permanently deflect.

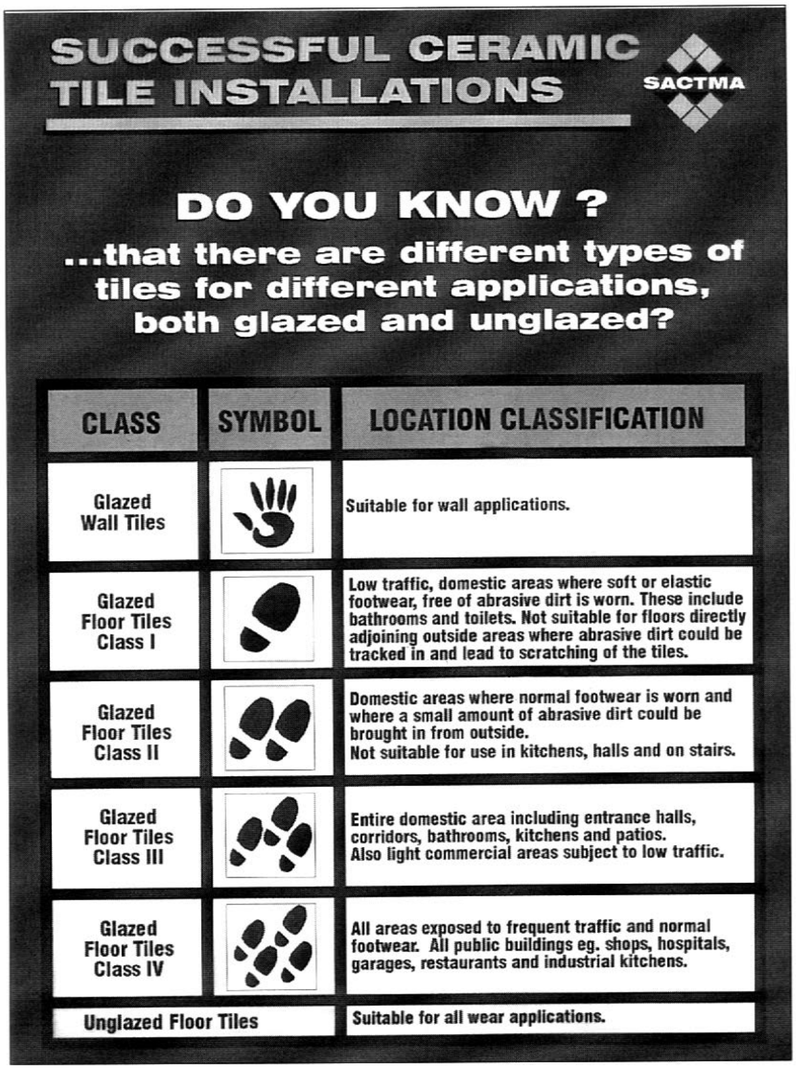
Other structural movements: This could be in the form of settlement of foundations, stress cracks in the structure, or vibration from machinery.

Differential movements are a fact of life. They can and should be limited through judicious choice of materials and careful design. The critical issue here is to cater for the movement of the system by providing movement joints at close enough centres and using an adhesive system with enough plasticity to accommodate it.

Selection of inappropriate products: Choosing the incorrect type of tile for the service conditions can be disastrous. Careful consideration must be given to the expected performance of the tile in terms of traffic requirements, resistance to scratching and abrasion, physical strength and porosity, particularly in external or wet environments.

Similarly, the adhesive and grout system must cater for expected movement, vibration, chemical attack and so on. Naturally, the backing substrates must be suitably designed and specified to accept a tiled finish.

Poor workmanship: Unfortunately, poor workmanship is all too common in South Africa. There is no formal registration of properly trained tiling artisans in the country, unlike in parts of Europe. In fact, in 1990 an estimated 40 per cent of tile installation failures were as a result of poor workmanship. Today this figure has risen to 60 per cent. Other causes, such as moisture expansion, decreased from 50 per cent in 1990 to 30 per cent in 1997.



SUCCESSFUL CERAMIC TILE INSTALLATIONS

SACTMA

DO YOU KNOW ?

...that there are different types of tiles for different applications, both glazed and unglazed?

CLASS	SYMBOL	LOCATION CLASSIFICATION
Glazed Wall Tiles		Suitable for wall applications.
Glazed Floor Tiles Class I		Low traffic, domestic areas where soft or elastic footwear, free of abrasive dirt is worn. These include bathrooms and toilets. Not suitable for floors directly adjoining outside areas where abrasive dirt could be tracked in and lead to scratching of the tiles.
Glazed Floor Tiles Class II		Domestic areas where normal footwear is worn and where a small amount of abrasive dirt could be brought in from outside. Not suitable for use in kitchens, halls and on stairs.
Glazed Floor Tiles Class III		Entire domestic area including entrance halls, corridors, bathrooms, kitchens and patios. Also light commercial areas subject to low traffic.
Glazed Floor Tiles Class IV		All areas exposed to frequent traffic and normal footwear. All public buildings eg. shops, hospitals, garages, restaurants and industrial kitchens.
Unglazed Floor Tiles		Suitable for all wear applications.

Handout available from tile outlets.

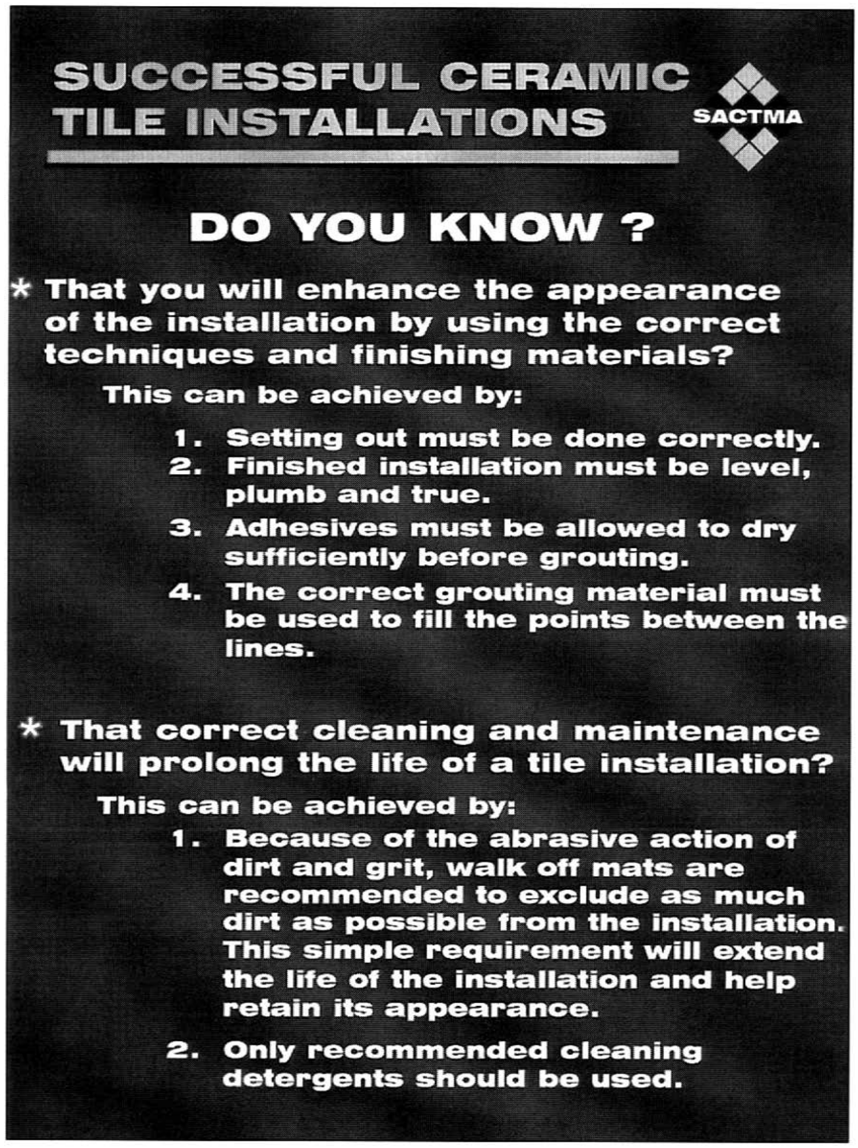
Some of the most common ills of shoddy sitework are:

- Poorly prepared background surfaces;
- Tiling onto green screeds or renders;
- Incorrect application of adhesives, for example, the "five spot" method;
- No movement joints;
- Butt-jointing tiles;
- Subjecting newly laid tiles too early to service conditions.

If the actual cause of the tile failure is unclear, the Mattek division of the CSIR will evaluate the installation and deliver an impartial adjudication.

Successful installation of ceramic tiles

To ensure a long-lasting, durable ceramic tiled finish, the following simple rules must be followed:



Handout available from tile outlets.

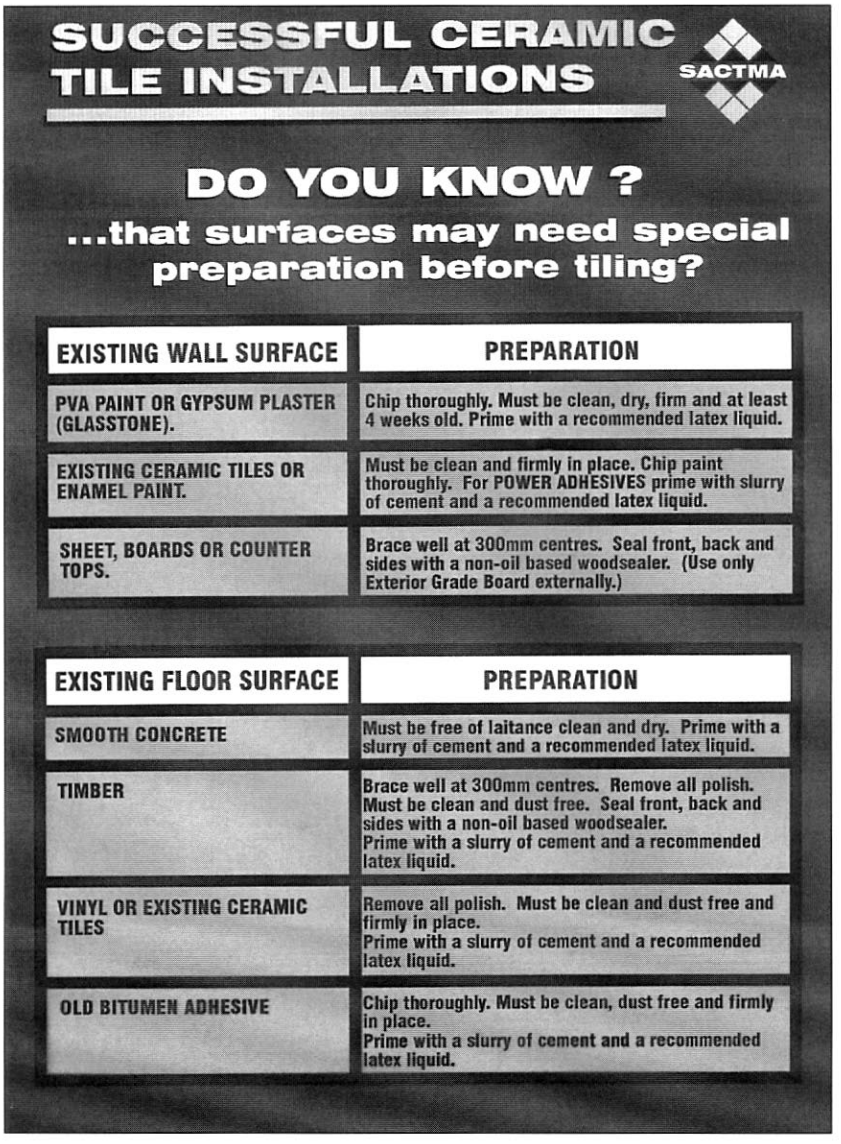
- *Quality products*
  - selection of appropriate tile
  - selection of correct type of adhesive and grout
- *Quality workmanship*
  - properly prepared background surfaces
  - correct application of adhesives and grouts
  - correct bedding of tiles into the adhesive

– limit access onto tile until set

- *Coping with movement*

– allow adequate curing time before tiling

– never butt-joint tiles



SUCCESSFUL CERAMIC TILE INSTALLATIONS

SACTMA

DO YOU KNOW ?

...that surfaces may need special preparation before tiling?

EXISTING WALL SURFACE	PREPARATION
PVA PAINT OR GYPSUM PLASTER (GLASSTONE).	Chip thoroughly. Must be clean, dry, firm and at least 4 weeks old. Prime with a recommended latex liquid.
EXISTING CERAMIC TILES OR ENAMEL PAINT.	Must be clean and firmly in place. Chip paint thoroughly. For POWER ADHESIVES prime with slurry of cement and a recommended latex liquid.
SHEET, BOARDS OR COUNTER TOPS.	Brace well at 300mm centres. Seal front, back and sides with a non-oil based woodsealer. (Use only Exterior Grade Board externally.)

EXISTING FLOOR SURFACE	PREPARATION
SMOOTH CONCRETE	Must be free of laitance clean and dry. Prime with a slurry of cement and a recommended latex liquid.
TIMBER	Brace well at 300mm centres. Remove all polish. Must be clean and dust free. Seal front, back and sides with a non-oil based woodsealer. Prime with a slurry of cement and a recommended latex liquid.
VINYL OR EXISTING CERAMIC TILES	Remove all polish. Must be clean and dust free and firmly in place. Prime with a slurry of cement and a recommended latex liquid.
OLD BITUMEN ADHESIVE	Chip thoroughly. Must be clean, dust free and firmly in place. Prime with a slurry of cement and a recommended latex liquid.

Handout available from tile outlets.

– provide adequate movement joints

– express structural joints through the tile

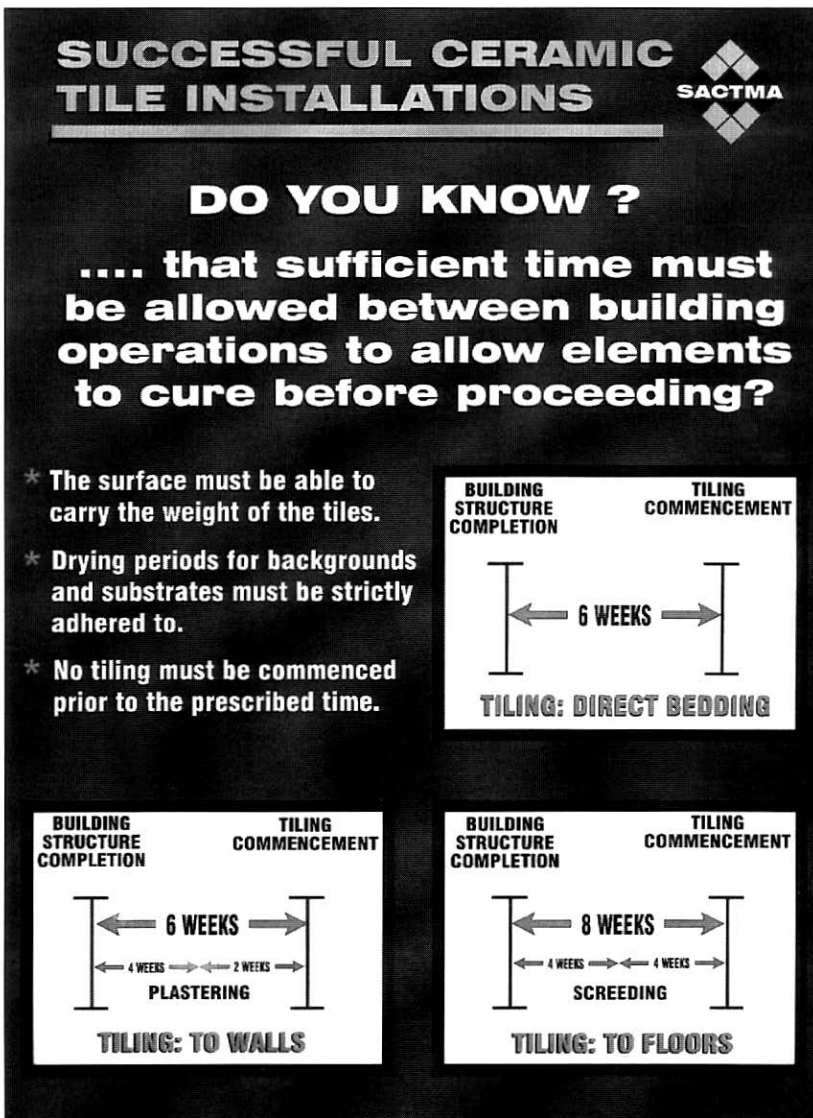
THE MATERIALS AND METHODS SPECIFICATIONS DOCUMENT

All of the above must be fully specified in terms of materials and methods at the design stage. The Code of Practice (SABS 0107: 1996) recommends that this document be prepared for each project and that it forms part of the tender documentation.

This will ensure that all potential tiling sub-contractors base their tender quotations on the same base, making adjudication easier, and secondly, the specification provides a proper standard for monitoring performance on site. Adequate time scheduling is vital.

Successful tiling must be a team effort, beginning at the design stage of the project and ending at handover to the owner.

Ongoing care and maintenance of the tile installation should also form part of this document to ensure that the finish remains good-looking and functional for the full intended life of the installation.



Handout available from tile outlets.

9. CONCLUSION

The second millennium is fast drawing to a close and in this time humankind has constantly striven to improve knowledge and skills. I have been involved in the ceramics industry for only 43 of the past two thousand years. In that time, the advances made in engineering technology, such as tile presses, spray dryers, glaze application and screen printing, as well as those made in the manufacturing process, particularly fast firing, have been phenomenal. Technical problem-solving relating to finished bodies, (for example, moisture expansion) has taken great strides forward.

Although many books have been written on tile installation, failures, improvement of workmanship and other subjects, the attainment of "zero defect" continues to allude us.

I put it to you that the human element is the prime factor in the chain of events leading to failure and this is where the industry's greatest challenge lies.

10. REFERENCES AND ACKNOWLEDGEMENTS

ALSOP, S. B Engineering (Hons), MBA, Project Delivery Manager, Ceram Research, England: *Raw Material Assessment and Control as a Factor in Manufacturing Quality.*

BARRNETT, R. Technical Director, G & W Base Minerals.

BINGLE, P. Executive Director, South African Ceramic Tile Manufacturers Association.

BOWES, A. NHD: Journalism, Communications Consultant, Editing and Desktop Publishing

CROAD, D. BSc Engineering, MBA, Manufacturing Director TAL/Johnson Tiles (Pty) Ltd: *Principles of Ceramic Tiling.*

GEUNS, J. Alpha Carbonates.

JOUBERT, DJP. Pr. Engineering, Manager, Civil Engineering, Assessment Services, South African Bureau of Standards, *Total Quality - How Far Away?*

HECHROODT, Prof O. DSc FSAIMM University of Cape Town.

HUIRAS, A. Managing Director, Interceram.

PURSEY, R. Managing Director, G & W Base Minerals.

ROCHA, M. Dip Civil Engineering (Materials Technology) Head of Division, South African Bureau of Standards.

SMITH, M. BA Chem Project Leader: Council for Scientific and Industrial Research.

VAN DER MERWE, Dr L. Pretoria Technikon, Faculty of Natural Science.

VAN NIEKERK, C. MA (RSC) Design Manager, Johnson Tiles (Pty) Ltd.

VAN DER HORST, D. BA Hons Architectural Ceramics in South Africa.