



# AN INSIGHT INTO VARIOUS PROCESSES OF MAKING TILES AND THEIR TECHNO ECONOMIC COMPARISON

By

<sup>1</sup>**R.Sudhakar Reddy**, Research Scholar, AKS University

<sup>2</sup>**Dr.Sandeep Prasad**, Asst.Professor, AKS University

## Abstract:

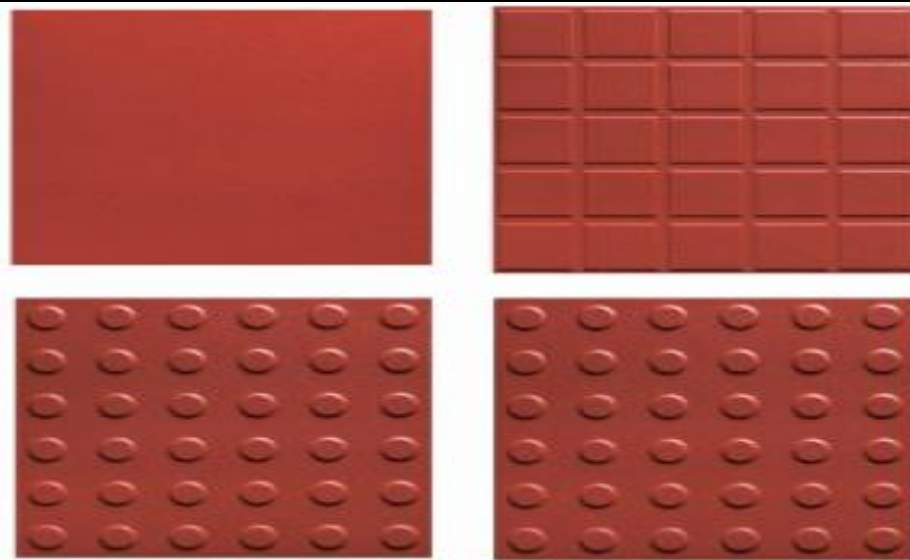
The tile manufacturing industry plays a critical role in modern construction, offering a wide range of materials and designs to meet architectural and functional demands. This paper provides an in-depth exploration of the various processes employed in tile production, including traditional methods such as pressing and extrusion, and advanced technologies like dry pressing and digital glazing. Each method is examined for its material requirements, processes involved and environmental impact. The study also incorporates a techno-economic comparison of these processes, evaluating factors such as capital investment, operating costs, merits and demerits, and place of application. Emphasis is placed on sustainability trends, such as the use of recycled materials and waste minimization. Through detailed analysis, this work highlights the trade-offs between economic viability and technological advancement, providing valuable insights for manufacturers and stakeholders aiming to optimize their production strategies. The findings underscore the importance of balancing cost-efficiency with environmental stewardship to ensure the sustainable growth of the tile industry.

**Keywords:** Clay, Tiles, Quartz, Cement and resins.

## Various processes to manufacture tiles:

### 1. Dry Pressed Tiles (Ceramic or Porcelain Tiles)

1. **Materials:** Clay, feldspar, quartz, kaolin.
2. **Process:**
  - a. **Preparation:** Raw materials are ground and mixed into a fine powder with specific proportions.
  - b. **Moulding:** The powder is placed into metal moulds and subjected to high pressure using hydraulic presses. This compresses the material into tile shape.
  - c. **Drying:** The tiles are dried to remove moisture and improve strength.
  - d. **Firing:** The dried tiles are fired in a kiln at high temperatures (around 1100-1300°C), turning them hard and durable.
  - e. **Glazing and Re-firing:** A layer of glaze is applied for colour, texture, and waterproofing, then re-fired for a durable finish.



## 2. Extruded Tiles (Quarry and Clinker Tiles)

1. **Materials:** Usually natural clay, sand, and additives.
2. **Process:**
  - a. **Preparation:** The clay mix is prepared with water to achieve plasticity.
  - b. **Extrusion:** The wet clay mix is pushed through an extruder, forming a continuous slab or strip. This strip is then cut into individual tiles.
  - c. **Drying:** The tiles are dried slowly to prevent cracks.
  - d. **Firing:** The tiles are then fired in a kiln to achieve their final strength and colour.
3. **Characteristics:** Extruded tiles often have a rustic, rough finish, making them popular for outdoor applications.



## 3. Terracotta Tiles

1. **Materials:** Natural red or brown clay.
2. **Process:**
  - a. **Preparation:** Raw clay is mixed with water and aged to reach a pliable consistency.
  - b. **Hand Moulding or Pressing:** The clay is moulded by hand or pressed into a mould to create the desired shape.
  - c. **Drying:** The tiles are dried slowly to prevent warping.
  - d. **Firing:** Once dried, the tiles are fired at lower temperatures (around 1000°C), giving terracotta its characteristic red-brown colour.

3. **Finishing Options:** Terracotta tiles can be glazed, unglazed, or sealed for added durability and moisture resistance.



#### 4. Cement Tiles

1. **Materials:** Cement, sand, pigments, and water.
2. **Process:**
  - a. **Pigmented Layer:** A mixture of cement, marble powder, and coloured pigments is poured into a metal mould to form the patterned top layer.
  - b. **Cement Layer:** A second layer of cement and sand is added as a base to provide thickness and strength.
  - c. **Pressing:** The tile is hydraulically pressed, binding the layers together.
  - d. **Curing:** Instead of being fired, cement tiles are cured by air-drying in a humid environment for up to a month. This curing process ensures durability and resistance to wear.
3. **Finishing Options:** Once cured, the tiles are polished or sealed to enhance colour and durability.





## 5. Glass Tiles

1. **Materials:** Recycled or raw glass, pigments.
2. **Process:**
  - a. **Melting:** Glass is melted at high temperatures (around 1500°C) until it becomes a molten liquid.
  - b. **Moulding or Cutting:** The molten glass is either poured into molds or rolled out into sheets, then cut into tile shapes.
  - c. **Cooling and Annealing:** The glass tiles are slowly cooled in a controlled environment to prevent cracking.
  - d. **Finishing:** Some tiles are coated with colours or patterns, while others are polished or frosted to create different textures.



## 6. Stone Tiles (Marble, Granite, Slate)

1. **Materials:** Natural stone slabs.
2. **Process:**
  - a. **Cutting:** Large blocks of stone are cut into slabs, which are then sliced into individual tiles.
  - b. **Polishing or Texturing:** Depending on the finish desired, the tiles are polished, honed, or textured (e.g., with sandblasting or flaming) to enhance their aesthetic and functional qualities.
  - c. **Sealing:** Natural stone tiles are often sealed to protect them from stains and moisture.

Each of these methods involves precise processes and careful quality control to ensure the durability, strength, and visual appeal of the final tiles.

### Decorative products made from same raw material:

#### 1. Mosaic Art Panels

1. **Materials:** Ceramic, glass, and natural stone tiles.
2. **Description:** Mosaic panels are crafted by arranging small tiles (called tesserae) into intricate patterns or images. These tiles are cut into shapes and sizes according to the design and then set onto a base panel with adhesive.

3. **Process:** Artists carefully select and position each tile, often using different colours, finishes, and textures to add depth and contrast. Once the design is complete, grout is applied to secure the tiles and fill any gaps, and the panel is polished for a refined finish.
4. **Applications:** Used as decorative wall art in homes, hotels, and commercial spaces, mosaic panels add a vibrant, artistic element.



## 2. Tile Murals

1. **Materials:** Porcelain, ceramic, or glass tiles.
2. **Description:** Tile murals are large-scale compositions, where individual tiles collectively form a cohesive design, such as landscapes, abstracts, or cityscapes. Each tile acts like a "pixel" within the larger image.
3. **Process:** Artists paint or glaze individual tiles, either by hand or with digital printing. Once complete, tiles are fired to set the colors. The mural is installed by arranging the tiles in sequence, sometimes with grout to enhance the visual separation.
4. **Applications:** Commonly used for wall installations in kitchens, bathrooms, and entryways, or as statement pieces in public buildings.



### 3. Decorative Tile Trivets and Coasters

1. **Materials:** Ceramic, porcelain, or cement tiles.
2. **Description:** Tile trivets and coasters serve as functional yet decorative surfaces for hot pots, dishes, and drinkware. These tiles often feature intricate patterns, glazing, or hand-painted designs.
3. **Process:** Small-sized tiles are painted, glazed, or printed with designs. A cork or felt backing is typically added to protect surfaces. Trivets may also have additional heat-resistant coatings for durability.
4. **Applications:** Used in dining and kitchen settings, these items add a colorful, artistic touch to everyday décor.





#### 4. Tile-Based Tabletops

1. **Materials:** Ceramic, mosaic, or natural stone tiles.
2. **Description:** Tiled tabletops transform ordinary tables into decorative furniture pieces. Each tile adds to the table's character, with patterns and colors chosen to match the aesthetic theme.
3. **Process:** Tiles are arranged on a wooden or metal tabletop, with adhesive applied to secure them. Once set, grout is added, and the entire surface is sealed for durability and easy cleaning.
4. **Applications:** Tiled tables are popular in homes, cafes, and restaurants, providing a unique, handcrafted look that elevates the dining experience.

#### 5. Decorative Tile Mirrors

1. **Materials:** Ceramic, glass, or mosaic tiles.
2. **Description:** Tile mirrors feature tile frames that are beautifully designed to highlight the mirror itself. The tiles can be arranged in a pattern, color gradient, or mixed with other materials like metal or wood for a distinctive frame.
3. **Process:** Tiles are selected and arranged around a central mirror in a frame or directly adhered onto the mirror's border. Once set, grout is applied if needed, and the frame is polished or painted to complement the design.
4. **Applications:** Often used in entryways, bathrooms, or as decorative pieces in living rooms, these mirrors add a unique touch to interior decor.

#### 6. Decorative Wall Medallions

1. **Materials:** Marble, porcelain, or glass tiles.
2. **Description:** Wall medallions are circular or geometric tile arrangements that create eye-catching centrepieces. Designs often include elaborate patterns and colors inspired by classic or cultural motifs.
3. **Process:** Tiles are cut into specific shapes and arranged in a radial or symmetrical pattern. Medallions are often assembled in sections, then installed on walls as a complete unit.
4. **Applications:** Wall medallions are popular in foyers, hallways, and lobbies, where they serve as focal points and add a sense of sophistication.



#### 7. Tile Planters and Pots

1. **Materials:** Cement, ceramic, and mosaic tiles.
2. **Description:** These planters and pots feature tiled exteriors that transform regular containers into stylish decor items. Mosaic or small ceramic tiles are often used to create patterns or colourful arrangements.
3. **Process:** Tiles are adhered to the planter surface and then grouted for a seamless look. For mosaic designs, small tiles or fragments are arranged to cover the planter's outer walls.
4. **Applications:** Tiled planters and pots are used both indoors and outdoors, bringing vibrant color and texture to plants and flowers in gardens, patios, and indoor spaces.

## 8. Decorative Backsplash Inserts

1. **Materials:** Ceramic, porcelain, and glass tiles.
2. **Description:** These tiles are designed to add detail and style to kitchen or bathroom backsplashes. Often featuring custom patterns, hand-painted details, or unique textures, inserts complement surrounding plain tiles to create visual interest.
3. **Process:** Inserts are crafted individually or as part of a patterned sheet. They're positioned as accent pieces, either sporadically or in a defined pattern, and installed along with standard tiles.
4. **Applications:** Popular in kitchens and bathrooms, backsplash inserts bring personality and style to a functional space.

These decorative items highlight the adaptability of tile materials, making them versatile choices for both functional and aesthetic home decor products. Each product leverages the qualities of tile materials—such as durability, color variety, and texture—to create visually appealing, durable decor that enhances interior and exterior spaces.



### Objective 3: Techno-economic evaluation of products

#### TECHNO ECONOMIC ASPECTS OF VARIOUS TILES

**Ceramic tiles** are made by mixing and grinding raw materials into a fine powder, and then shaping and drying it. The tiles are then glazed (if needed) and fired in kilns at high temperatures for durability. They also come in an amazing variety of colours and patterns, so you have a plethora of options to choose from. Price starts from Rs.30.

Advantages:

1. Perfect for high-traffic areas as they are generally scratch and stain-resistant
2. Easy to clean and maintain
3. Long-lasting

Place of utility:

1. Walls: Bathrooms, kitchens (backsplashes) and decorative wall installations
2. Outdoor areas: Patios, walkways and pool surrounds
3. Kitchen and bathroom countertops
4. Flooring



Disadvantages:

1. Do not use abrasive cleaners, acids or bleach that can damage the tiles or grout.
2. Do not leave standing water on tiles for extended periods to prevent moisture damage.
3. Do not drop heavy objects on the tiles to avoid cracking or chipping.

### **PORCELAIN TILES:**

Like ceramic tiles, porcelain tiles are made by mixing and finely grinding high-quality raw materials like kaolin clay, feldspar and silica. However, they are fired at higher temperatures (1,200-1,400°C) than ceramic tiles to achieve a dense, durable and water-resistant finish. They are available in various designs, colours and finishes, and can mimic the look of natural stone or wood. Price starts from Rs.200.

Advantages:

1. Resistant to wear, scratches and stains
2. Highly water-resistant and easy to clean and maintain
3. Suitable for both indoor and outdoor applications

Place of utility:

- Ideal for wet areas
- Walls
- Flooring
- Outdoor areas

### **VITRIFIED TILES:**

These are similar to traditional ceramic tiles but include silica in the mix. When these tiles undergo vitrification, the magic happens—the silica and clay blend and melt together, creating a robust, glass-like material within each tile. This special feature not only preserves the tiles' original sheen but also ensures they remain durable even after years of use. . Price starts from Rs.100.

Advantages:

- Available in various finishes including matte, glossy and textured
- Highly durable and resistant to stains, scratches and water absorption
- Modern vitrified tiles often incorporate advanced technologies like digital printing for realistic patterns and designs

Place of utility:

1. Indoor and outdoor flooring
2. Walls and kitchen backsplashes
3. Commercial spaces

## ONYX TILES:

Onyx tiles are crafted from natural onyx stone, formed over thousands of years in limestone caves. Blocks of onyx are extracted from quarries and then sliced into thin slabs using specialised cutting equipment. These slabs are then polished to reveal the stone's unique veining and translucency. Price starts from Rs.300.

### Advantages:

- Have distinct veining patterns
- Hold translucent properties, allowing light to pass through
- Require special care due to their porous nature and susceptibility to scratching and staining

### Place of utility:

1. Stunning feature walls in living rooms, bedrooms and dining areas
2. Onyx's translucent nature makes it perfect for backlit applications
3. Decorative accent features

### Disadvantages:

1. Do not use acidic or abrasive cleaner
2. Avoid dropping heavy objects on onyx tiles
3. Protect onyx from direct heat sources to avoid thermal shock and damage

## VINYL TILES:

Vinyl tiles are manufactured by mixing synthetic materials like PVC resin, plasticisers, stabilisers and pigments. This synthetic flooring material looks like wood and feels like stone. This affordable option is the ideal kind of flooring if you have pets. Price starts from Rs.60.

### Advantages:

1. They are easy to install and are a great option for DIY projects
2. More budget-friendly compared to natural stone or hardwood flooring options
3. Available in a wide range of colours, patterns and styles including wood, stone and abstract designs

### Place of utility:

- Flooring
- Kitchen backsplashes

## MOSIAC TILES:

Mosaic art dates back to ancient civilisations such as the Greeks, Romans and Byzantines, showcasing intricate designs and storytelling elements. These kinds of tiles are made by cutting large sheets of glass, ceramic or stone into smaller pieces using cutting tools or waterjet machines. These smaller pieces, known as tesserae, are then arranged into patterns or designs on a mesh backing or paper face, adhered using adhesives or grout. Price starts from Rs.150.

**Advantages:**

1. Offer endless design possibilities with a wide range of colours, shapes, and textures available
2. Depending on the material, mosaic tiles can be highly durable and resistant to moisture, stains, and wear
3. Creating mosaic art or installing mosaic tiles can have therapeutic benefits

**PLACE OF UTILITY:**

1. Flooring
2. Accent walls
3. Staircases
4. Kitchen backsplashes
5. Bathtub tiles

**TERRAZO TILES:**

These are made by mixing marble, granite, glass, or other aggregates with a cementitious or resinous binder. They allow for artistic expression and customisation with intricate patterns or designs embedded in the flooring or surfaces. Price starts from Rs.200.

**Advantages:**

1. Available in a range of colours and patterns
2. Highly customisable
3. Stronger and more seamless than mosaic
4. Highly durable
5. Resistant to stains and scratches

**PLACE OF UTILITY:**

1. Flooring
2. Stairs
3. Backsplash
4. Countertop
5. Decorative items

**CARPET TILES:**

Carpet tiles are manufactured by cutting large rolls of carpet into smaller square or rectangular tiles. These tiles are then backed with materials like PVC, fibreglass, or vinyl for stability and durability. The carpet fibres can be made from nylon, polyester, wool or other synthetic fibres, depending on the desired characteristics such as softness, stain resistance, or durability. While not very common in India, these kinds of tiles can be used in places that have extreme temperatures. Price starts from Rs.50.



**Advantages:**

1. High resistance to abrasion makes it ideal for use in common areas
2. Cushiony, and hence accident-proof, making it ideal for kids and the elderly
3. High sound and thermal insulation
4. They can be installed without breaking the existing floor

**PLACE OF UTILITY:**

1. Flooring for homes with children and the elderly
2. For sound proofing entertainment rooms and studios

**Disadvantages:**

1. Avoid over-wetting carpet tiles during cleaning to prevent water damage or mould growth
2. Keep direct heat sources like heaters or hot appliances away from carpeted areas to prevent damage
3. Be cautious with sharp objects or high-heeled shoes that can snag or tear carpet fibres

**GLASS TILES:**

Glass tiles are made by melting glass materials, which are then cooled and shaped into tiles. Depending on the desired properties and colours, the glass mixture may include recycled glass, silica sand, and other additives. If you want your space to appear brighter and more spacious, especially in areas with natural or artificial light, glass tiles are a great choice. Price starts from Rs.300.

**Advantages:**

1. Maximum stain-resistance
2. It can provide a more spacious appearance to small rooms
3. Easy to clean
4. It has translucent qualities that allow light to pass through, creating beautiful visual effects

**PLACE OF UTILITY:**

1. Among different types of tiles, glass tiles are great for kitchen backsplash
2. Shower walls
3. Decorative accents on walls, floors, countertops and even furniture surfaces

**MARBLE TILES:**

Marble tiles are natural stone tiles extracted from marble quarries, known for their unique veining patterns and luxurious appearance. Marble tiles retain marble's natural beauty and elegance, making them highly desirable for interior applications where luxury and durability are desired. Price starts from Rs.50

**Advantages:**

1. Available in a variety of colours
2. Looks glam and gorgeous
3. Highly durable and resistant to shattering

4. Offers good insulation

#### PLACE OF UTILITY:

1. Flooring: Marble's natural coolness makes it suitable for flooring in hot climates, providing a refreshing feel underfoot
2. Walls
3. Backsplashes

#### GRANITE TILES:

Granite tiles are created from massive blocks of natural stone, which are carefully extracted from quarries and then sliced into slabs with precision diamond saws. These slabs are polished to reveal the stone's unique patterns and vibrant colours, transforming raw rock into stunning, glossy surfaces. Price starts from Rs.50

#### Advantages:

1. Extremely durable, and resistant to scratches, heat and stains, making them ideal for high-traffic areas and demanding environments
2. Available in a variety of colours and patterns, each tile is unique due to natural variations in the stone

#### PLACE OF UTILITY:

1. Flooring
2. Countertops
3. Wall cladding
4. Outdoor areas

#### KOTA STONE TILES:

Kota stone tiles are another great option for areas with hot temperatures as they remain cool underfoot. Natural Kota stone tiles are quarried from limestone deposits in Kota, India. Available in shades of earthy colours, they offer a natural and rustic appearance. Price starts from Rs.30

#### Advantages:

1. Highly durable and resistant to wear and tear, making them suitable for high-traffic areas
2. Naturally slip-resistant, ideal for both indoor and outdoor use, including wet areas
3. A budget-friendly natural stone option, providing the look of high-end stone without the high price tag

#### PLACE OF UTILITY:

1. Flooring
2. Outdoor areas
3. Staircases
4. Wet areas like bathrooms and swimming pool surrounds

## HARD WOOD TILES:

Hardwood tiles are made from either solid wood or engineered wood. Solid wood tiles are crafted from a single piece of timber, cut to size, and then finished with stains and sealants. Engineered wood tiles are made by bonding a thin layer of hardwood to a high-quality plywood base, providing added stability and resistance to moisture and temperature changes. Price starts from Rs.500.

### Advantages:

1. Hardwood tiles are a popular choice for both traditional and contemporary interiors
2. While durable, hardwood tiles can be susceptible to scratching, denting, and water damage if not properly maintained
3. Hardwood tiles can be used to create various design patterns such as herringbone, chevron, or parquet

### PLACE OF UTILITY:

1. Indoor flooring
2. Accent walls
3. Ceilings

## TRAVERTINE TILES:

Travertine develops a natural patina that adds character and charm to the stone, giving it a timeless appeal that only improves with age. Travertine tiles are made from limestone that is found in natural springs and bring a touch of natural luxury to your space. Price starts from Rs.200.

### Advantages:

1. Travertine tiles remain cool to the touch, making them a comfortable option for hot climates
2. Each travertine tile is unique, featuring distinct patterns, colours, and veining created by natural mineral deposits
3. They are extremely resilient against wear and tear

### PLACE OF UTILITY:

1. Flooring
2. Walls
3. Exteriors

## QUARRY TILES:

Quarry tiles are made from a mixture of natural clay and shale that is extruded into tile shapes. Quarry tiles have been used for centuries, originally in the quarries of Europe, and are still popular for their timeless look and durability. They are a great option for kitchen floor tiles owing to their durability. Price starts from Rs.200.

### Advantages:

Typically available in earthy tones like red, brown, and grey, they have a rustic and natural look, making them a great choice for rustic farm house-style houses.

1. Often have a natural, slip-resistant surface
2. Extremely tough and wear-resistant



**PLACE OF UTILITY:**

1. Perfect for kitchens, hallways and other high-traffic areas
2. Ideal for patios, garden paths and pool surrounds
3. Staircases

**SLATE TILES:**

Slate tiles, with their natural elegance and rugged durability, have been a favourite in both traditional and modern design for centuries. Originating from the ancient depths of the earth, slate brings a unique blend of colours and textures that can transform any space into a sophisticated and timeless environment. Owing to their slip-resistant surface, they make for great bathroom tiling design. Price starts from Rs.100.

**Advantages:**

1. Slate is a natural metamorphic rock composed of clay or volcanic ash, known for its fine-grained texture and layered structure
2. Extremely durable and resistant to scratches, chips, and cracks
3. Has a natural slip-resistant surface

**PLACE OF UTILITY:**

1. Flooring
2. Walls
3. Shower enclosures & stair cases

**Price list for all types of tiles**

<b>Tile material</b>	<b>Cost of tile per sq. ft. (without installation charges)*</b>
Vinyl	₹70
Vitrified	₹120
Granite	₹200
Marble	₹150
Porcelain	₹65
Ceramic	₹60
Natural stone (Kota stone)	₹250
Hardwood	₹770
Laminate wood	₹285
Concrete	₹90
Onyx	₹300
Stone Composite Polymer	₹200

Mosaic	₹150 – ₹400
Terrazzo	₹200 – ₹600
Carpet	₹50 – ₹400
Glass	₹300 – ₹800
Metal	₹200 – ₹600
Travertine	₹200 – ₹800
Quarry	₹150 – ₹400
Limestone	₹150 – ₹600
Terracotta	₹150 – ₹400
Slate	₹150 – ₹500

*\*Note: All prices mentioned above are estimates and cost may vary depending on multiple factors like location, design, finish, etc.*

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