

## Tile and Tile Adhesives

(Partly extracted from "Tile Mantras" a publication of ROFF Tiling Academy, Pidilite Industries Ltd., Mumbai)

Many years ago, tiles were used as a necessity. The type, shape and sizes were all standard. Tiles were meant to perform the basic functions - offer hygiene and waterproof (when the correct adhesive and grout was used), which is essential in bathrooms and kitchens.

Today, with the improvement in technology worldwide, the importance of design and decor has grown manifold. Bathrooms and kitchens have become one of the most popular rooms that people now choose to decorate and have become style statements in themselves. Most people now turn to tiles to create an effect that other accessories find hard to produce.

Tiles are now available in different sizes, colours, textures, materials and designs, giving one the chance to create a unique environment, tailored to one's specific tastes.

Despite these advancements, one of the most crucial aspects i.e. the method for fixing these tiles continues to be old fashioned and usually ineffective, time and labour consuming. As a result the full impact of the beauty of these tiles and the longevity of the flooring is affected.

### Types of Tiles

#### Ceramic Tiles

Most popular for bathrooms and laundries and also suitable for floors in kitchens, entrances, dining rooms, lounges and bedrooms. Ceramic tiles are also durable and can be easily maintained. They are less expensive than porcelain tiles. They are resistant to fire, chemicals and stains, but show less resistance to scratches and cracks as compared to porcelain tiles.

#### Porcelain Tiles

Better quality ceramic tiles, as they are made from finer materials and fired at very high temperatures. As a result they are much more durable, are more commonly used for floors and are more expensive than regular ceramic tiles. Porcelain tiles are also less porous with a water absorption rate of less than 0.5 % and thus can be termed as almost impervious. Their resistance to moisture makes them suitable for both indoor and outdoor applications. This quality of porcelain tiles also makes them more suitable for harsh conditions than ceramic tiles.

Both ceramic and porcelain tiles come in two forms, glazed and unglazed. The glazed ceramic tiles are a bit slippery than the unglazed ones and they are more suitable for wall applications than for flooring. On the other hand, glazed porcelain tiles are less porous and require low maintenance than the unglazed ones.

#### Terracotta Tiles

Made up of fired clay and can be used for indoors or outdoors. They are relatively soft and porous and they need sealing if used indoors.

On the outdoor, they absorb moisture and are best if left uncoated; if coated; white salts become trapped under the sealer.

#### Vitrified Tiles

Made from white clay, heated over high temperatures, which makes them strong and non-porous. These tiles are polished to make them mirror finish; due to which these are used for floors in homes and offices. Vitrified tiles possess much better mechanical strength (MOR), scratch resistance, resistance to acids, alkalies and chemicals, resistance to staining etc compared to marble or natural granite.

#### Marble

The natural stone available in various sizes & colours. However they are unsuitable for kitchens as they stain easily on contact with acids like wine, vinegar etc. Marble is calcium carbonate which is strongly attacked by Hydrochloric acid which is commonly used in toilet & floor cleaning. Marble yellows over extended time duration whereas vitrified tiles retain their colour for decades. Marble laying is very cumbersome and time consuming whereas vitrified tiles may be laid in a matter of hours and put to use after 48 hours.

Marble is comparatively soft material and hence its abrasion resistance is approximately 3 MOH whereas vitrified tiles have an abrasive resistance of 6-7 on MOH scale.

#### Granite

Very hard, resists scratching and needs minimal grouting joints. Used for cladding and flooring. Polished natural granite shows several surface textures. It is suitable for flooring and cladding.

It is necessary to take into consideration both technical and aesthetic aspects of tiles.

### Technical Features of Tiles

The technical features are those necessary for the material's suitability and reliable performance such as uniformity features, structural features, massive mechanical features, surface mechanical features, thermo-hygrometric features, chemical features, and safety features.

Uniformity features determine the suitability of a batch of tiles to perform a "regular" tiled surface, or free of "irregularities" like bumps or dimples, steps between adjacent tiles, irregular joints course.

Structural features refer to the real structure of the material the tile is made of in particular to its porous structure. The tile porosity provides an immediate indication of the water absorption, which at lowest levels with porcelain stoneware. The products with higher levels of water absorption are porous such as terracotta.

### Water absorption

One of the most important of these factors is water absorption. For example, a tile that absorbs significant amounts of water is not suitable for outdoor use. Tiles can be divided into 4 major groups based on their tendency to absorb water such as (i) impervious < 0.5% of water by weight (ii) vitreous > 0.5% but < 3.0% (iii) semi-vitreous > 3.0% but < 7.0% (iv) non-vitreous > 7.0% of water by weight.

These water-absorption characteristics have a major effect on the suitability of tile for different applications.

### Mechanical features

It concerns the load bearing strength (for example the weight of people and furniture on a floor) to which the tiled surface may be exposed. The mechanical features are the bending strength and the breaking stress. The first one concerns the material the tile is made of, and it is directly proportional to the water absorption. The breaking stress is a property peculiar to a finished tile, with its own structure and size. Therefore, it is directly proportional to its thickness. Among these features the impact strength is also important.

### Surface mechanical features

These features refer to the working surface of the tile and they can be associated with the resistance to scratches, wear and deterioration, due to the handling/moving of hard bodies on the surface and in contact with it.

These features are very significant in case of floors. The most important one is the abrasion resistance that provides a measurement of the propensity of a tile to wear down (if unglazed) or to alter its appearance (if glazed) as a result of the above mentioned conditions. As for unglazed tiles, this value tends to increase as water absorption decreases; therefore, porcelain stoneware will have the highest level and the best performance.

Abrasive Wear (ASTM D 2486-00) : 37 cycles per minute over a 10" travel

Resistance to wear of unglazed ceramic tile (ASTM C501-84):  $\geq 500$  by Taber Abrasion

### Thermo-hygrometric features

These features describe the resistance to specific temperatures ("thermo") and dampness ("hygrometric")

conditions, such as thermal shock and frost resistance and for glazed tiles only, crazing resistance. The frost resistance highly depends on the porosity and on the water absorption: the lower the values are, the less the chances of damage by frost will be.

Crazing, in the form of thin cracks of the glaze, can be formed by some building or environmental conditions. The crazing resistance depends on the glaze composition. Some types of glaze run higher crazing risks compared to others. Further thermo-hygrometric features are represented by thermal expansion and dampness expansion, that is to say the measurement of the tile dimensions increase, when submitted to higher temperature and dampness levels.

As regards to thermal expansion, no major differences exist between the various types of tiles, though a slight increase has been noticed in the presence of a great vitreous phase, which means in products with a more compact, vitrified body.

Fire Resistance (ASTM E 84-05) : Flame spread < 15

Accelerated Weathering (ASTM G 155-05a): After 3000 hours:  $\Delta E < 4.5$ , no deterioration, fading or chalking of surface of tile colour

Accelerated Aging (ASTM D 1037-99) : No evidence of cracking, delamination, warpage, checking, blistering, color change, loosening of tiles or other detrimental defects.

### Chemical features

The chemical features are the stain resistance, resistance to household products, acid and alkali resistance.

Chemical Stain Resistance to withstand without discoloration or staining (ASTM D 543-95), 10% hydrochloric acid, urine, saturated calcium chloride, black stamp pad ink, chewing gum, red aerosol paint, 10% ammonium hydroxide, 1% soap solution, turpentine, Urea, 5%, diesel fuel and motor oil.

### Safety features

These features particularly preside over the safety of tiled areas regarding accidental or sanitary risks.

The main safety feature, also very important for outdoor, public and industrial areas, is the slip resistance, which is inversely proportional to the surface friction coefficient.

Slip Resistance (ASTM C 1028-96) for wet/dry Static Coefficient of Friction > 0.80

### Aesthetic features of Tiles

The aesthetic features of tiles are considered based on size, colour and decoration.

## Tile Adhesives

An adhesive is a material used for holding two surfaces together. An adhesive must wet the surfaces, adhere to the surfaces, develop strength after it has been applied, and remain stable.

### Classification as per IS 15477:2004

**Type 1 Adhesive :** Mainly for tiles of standard body composition with apparent porosity greater than 3 percent. These are suitable for most ceramic (that is non-vitrified) tiles and the majority of porous stones and background.

**Type 2 Adhesive :** Mainly for tiles of standard body composition with an apparent porosity less than or equal to 3 percent. Type 2 adhesive will be suitable for vitrified/fully vitrified tiles, dense and large dimension tiles (slabs), and where background and location is especially demanding.

### Classification based on generic types

**Cement based :** A mixture of a hydraulic binder and mineral aggregate (fine sand) with or without, a small amount of organic additives. Produced as a dry blend that is mixed with water immediately before use.

**Polymer based :** A ready-for-use compound of polymeric binding agents (aqueous emulsion or latex) and mineral fillers.

- **Polymer Modified Adhesive :** Enhanced by liquid admixture normally Type 1 adhesive having enhanced adhesion/bonding and flexibility. By addition of liquid admixture resultant adhesive meet the performance criteria of Type 2 adhesive.
- **Highly Polymer Modified Adhesive :** Usually Type 2 adhesives having higher bond strength and flexible characteristics.

**Reactive resin :** The adhesive comprises two or more separate organic components, which polymerise and set when they come into contact. The parts may contain mineral fillers and they are only mixed immediately before use.

### Classification based on usage

1. **General purpose :** For installation of ceramic tile and mosaics in interior area of buildings, where the face of the tiled surface is subjected only to intermitted exposure of water.
2. **Extreme condition :** For installation of ceramic tiles and mosaics in applications where high differential movement occur or where high adhesive strength is required (e.g. cold room, walls, floor subjected to heavy traffic, tiling of flexible substrates).
3. **Water resistance :** For installation of ceramic tiles and mosaics in application where face of the tiled surface is subjected to prolonged exposure of water.

## Selection of Tile Adhesive

Product Description	Single Component Cement based adhesive	Single Component Heavy duty cement based adhesive	Two Component cement adhesive+ binder	Epoxy Adhesives
<b>Flooring (Internal/External)</b>				
Ceramic/Vitrified/ Natural stone on cementitious substrate	Y	Y	Y	N
Ceramic/Vitrified on wooden flooring	N	N	Y	N
New tiles on existing Mosaic/ Ceramic	Y	Y	Y	Y
New tiles on existing Vitrified/ Granite/Marble	N	Y	Y	N
<b>Wall Tiling(Internal/External)</b>				
Ceramic/Vitrified on cementitious substrate up to 10' height	Y	Y	Y	N
Ceramic/vitrified on cementitious substrate more than 10' height	N	Y	Y	N
Natural stone on cementitious substrate up to 10' height	N	Y	Y	N
Natural stone on cementitious substrate more than 10' height	N	N	Y	N
Glass mosaics on cementitious substrate(wet area)	N	N	Y	N
Glass mosaics on cementitious substrate(dry area)	N	Y	Y	N
Ceramic/Vitrified on wooden substrate	N	N	Y	Y
Ceramic/Vitrified tile/Natural stone on Ceramic/ Vitrified tile/ Natural stone	N	N	Y	Y

Ceramic/Vitrified tile/Natural stone on Metal	N	N	N	Y
Inlay of Marble	N	N	N	Y
Metal/Leather/Wood/Glass on tile/Stone	N	N	N	Y
<b>Swimming Pool Tiling</b>				
Ceramic/Vitrified	Y	Y	Y	N
Fully Vitrified(Glass mosaics)	N	Y	Y	N

Y- Yes, N- No

## Properties and Test Methods

Shear and Tensile Adhesion (IS 15477:2004)

Requirements	Type 1	Type 2
Tensile adhesion, Min		
a) Dry conditions	750 N	-
b) Wet conditions	450 N	-
Shear adhesion, Min		
a) Dry conditions 24 h	2.50 KN	4.00 KN
b) Dry conditions 14 days	8.00 KN	10.00 KN
c) Heat aging condition	4.00 KN	5.00 KN
d) Wet condition	4.00 KN	5.00 KN

Compressive Strength (ASTM D1621)	: Min.68.9 kPa
Tensile Strength (ASTM D 1623)	: 117.2 kPa @ 82°C, 65% RH
Water Absorption (ASTM D 2842)	: Max 3.96% by Volume
Water Vapour Permeance (ASTM E 96)	: Max. 152.7 perm pa.s.m <sup>2</sup>
Density (ASTM D 1622)	: 30.6 Kg/ m <sup>3</sup>
Dimensional Stability (ASTM D 2126)	: 1.01 @-40°C, 2 weeks 10.44@70°C,97% humidity, 2 weeks

## Mixing of Adhesive and Grouts

The amount of water and/or liquid admix required for preparing the adhesive should be as stated by the adhesive manufacturer in parts by weight, i.e. liquid to dry powder (if a range of values is given, the average shall be used).

Prepare a minimum quantity of 2 kg of the adhesive in a mixer of the speed settings (140 ± 5) rotations per minute and (62 ± 5) rotations per minute planetary movement.

Carry out the following procedure:

- Pour the liquid into the pan and
- Scatter the dry powder over the liquid
- Mix for 30 s and take out the mixing paddle;
- Scrape down the paddle and pan within 1 min.
- Replace the paddle and mix for 1 min.

Let the adhesive mature in accordance with the adhesive manufacturer's further 15s.

In the case of ready-to-use dispersion adhesives or reaction resin adhesives, the manufacturer's instructions shall be followed.

## Surface Preparation

For effective bonding, the adhesive must intimately wet the surface of each substrate being joined together. In addition, a chemical bond must form between the surface of the adhesive and the substrate. To satisfy these conditions, the surface of the substrate must be clean, reasonably smooth, and chemically receptive to the chosen adhesive.

Surface preparation promotes adhesion by making it possible for the adhesive to wet the actual surface of the substrate, rather than its apparent surface. In many cases, what appears to be the surface is, in reality, a layer of grease, dirt, oil, or some other contaminant.

To a large extent, surface preparation determines how well and for how long a bond will hold. In fact, if the chosen adhesive can withstand the service conditions to which the bond will be subjected, life and service expectancy of that bond will be directly proportional to the degree of surface preparation.

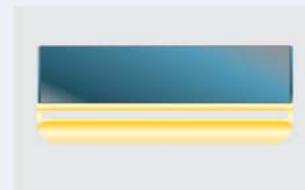
## Tiling Tools



Spatula for applying adhesive.



Notched applicator to spread and rib the adhesive bed.



Rubber squeegee to spread the grout.



Tile cutting machine for cutting hard tiles.



Tile pincers to nibble small pieces of tiles.



Tile scorer to scribe a line on the tile surface where a break is needed.

## Step by step application

### Cementitious Polymer Modified Tile Adhesive



1  
Clean the tiling substrate thoroughly



2  
Mix powder to water in proportion 2.5 part to 1 part by volume



3  
Mix it thoroughly until a lump free paste is achieved



4  
Apply the adhesive paste on a tiling substrate with 2 mm notch trowel



5  
Touch the paste intermittently and if sticks to finger then continue tiling



6  
Start placing glass mosaic sheets with slight twisting action



7  
Continue the tiling



8  
Remove the backing paper after 24 hrs & clean the tiles

### Cementitious Polymer Modified Tile Adhesive on existing Tiles(Non Skid)



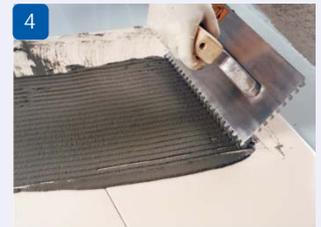
1  
Clean existing tiles thoroughly. Mild acid etching followed by water washing is preferred



2  
Mix powder to water/liquid in proportion 2.5 to 1 part by volume



3  
Mix until a lump free paste is obtained



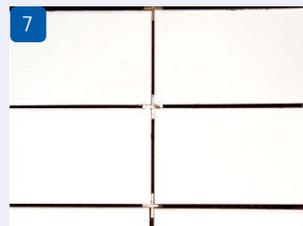
4  
Apply the paste on existing tiles with 3 or 6 mm notch trowel



5  
Touch the paste intermittently and if sticks to finger then continue tiling



6  
Start placing the tiles with slight twisting action



7  
Continue tiling by keeping at least 2mm joints between tiles



8  
Start filling joints by pressing paste firmly

## Heavy Duty Tile Fixing Adhesive

For Vertical Cladding & Tile-on-Tile Applications



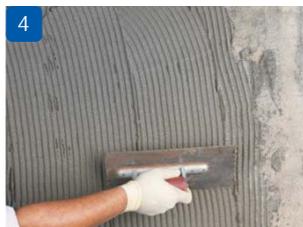
1 Clean the tiling substrate thoroughly



2 Mix powder to water in proportion 3 part to 1 part by volume



3 Mix until a lump free paste is formed



4 Apply the adhesive paste on a tiling substrate with 2 mm notch trowel



5 Touch the paste intermittently and if it sticks to finger then continue tiling



6 Start placing stone tiles

## Precautions

- The tiling substrate should be sound and thoroughly cleaned
- The substrate to be tiled should be dry or at "SSD" (Surface Saturated Dry) condition
- Check the trowelled adhesive paste intermittently
- Always add powder to water/liquid
- Check the uniform bedding behind tiles intermittently
- Allow tiling to cure for 24hrs & do not allow the tiled area subject to traffic for 24 hrs
- Tiling substrate should be wet while working in hot sunny days externally
- Do not put the tiles on skinned (dried) adhesive paste
- Do not wet the tiles for fixing
- Do not spread the adhesive paste more than 1 sq mt at once
- Do not add any cementitious material to tile adhesives

## Tile grouting

Tile grouts are generally of polymer modified cementitious or epoxy resin based. It should be flexible in nature; should accommodate movements and also should not shrink like white cement. It should have a good bond with all types of tiles, thus making joints impermeable to water. In situations where non-toxic, chemical resistant properties for tile joint filler are required especially in food and pharma industry, epoxy resin based is the ideal solution.

1. Grouting should not begin until the tile setting material is properly cured (a minimum of 24 hours).
2. Wipe the tile surface with a damp cloth before grouting.
3. Using a Float, trowel the mixed grout over the surface and into the grout joint, careful to assure all joints are filled fully. Hold the float at a 45° angle to the surface of the tile.
4. As soon as possible, remove excess grout from the tile surface with float held at a 90° angle and moving diagonally across the joints. Strike the joint with the blunt end of a tool-compacting the surface but not digging out the grout.
5. Clean remaining grout from the tile surface as soon as grout firms up enough to be worked without being pulled from the joint by using a Scotch Bright Pad, or a pad of dampened cheese cloth or tile cleaner.

Under extreme heat or low humidity conditions, the floor should be covered with brown Kraft paper to retain moisture. Do not use polyethylene as it may result in uneven drying and discolored joints. The grouted floor must be protected from traffic for 72 hours after installation.



1 Clean the tiling substrate thoroughly



2 Mix it thoroughly until a homogeneous paste is obtained



3 Start filling joints by pressing paste firmly



4 Clean the grouted joints with damp sponge diagonally