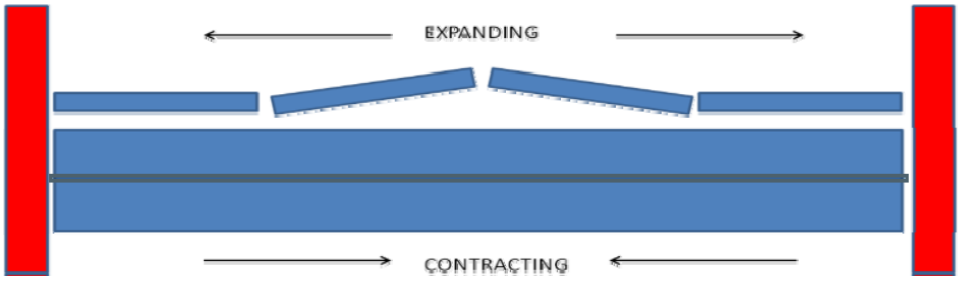
EZEE TILE ADHESIVES
AFRICA'S PREFERRED TILING SOLUTIONS

CAUSES OF TENTING

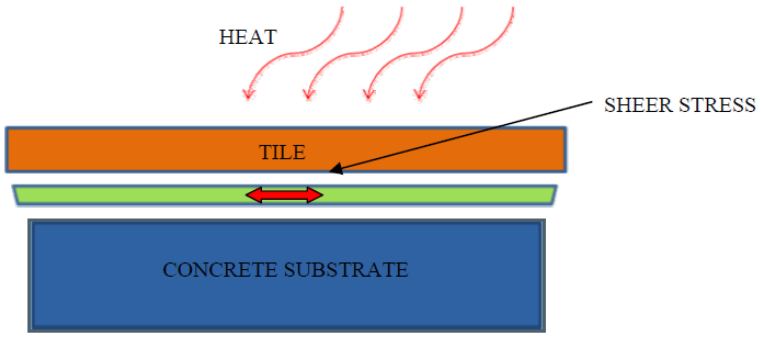
Why do tiles tent?

To understand tenting, one must first appreciate that each of the various components within the flooring system are continuously expanding and contracting and that this movement places constant stress upon the tile adhesive to keep the system together. In a successful application, the sum total of the stresses is weaker than the tensile strength (bond strength) of the adhesive. However, in failed system, these stress forces build up over time to eventually exceed the bond strength of the adhesive. The tiles pop up (or tent) because there are actual changes to the linear dimensions such that the length of the tiles is longer than that of the substrate.



What causes this movement?

The largest source of movement comes from the shrinkage of the concrete substrate as it cures. Internationally accepted values are between 1 mm/meter for a high quality, well designed concrete and up to 3 mm/meter for a lower spec concrete. The amount of shrinkage is determined by a number of factors like the type of cement used, the mix design and the water/cement ratio. As a general rule, the cheaper the mix, the greater the shrinkage. Also, since the rate of contraction slows as the concrete ages, the time between the placing of the concrete and the laying of the tiles is important in determining the stress upon the flooring system. The shorter this period (i.e. in fast track building), the greater the stress on the system.
The stress from the contracting concrete substrate is compounded by the tendency for ceramic tiles to expand. The most common and largest cause is thermal expansion. As the room is heated by the sun or heaters, the ceramic tiles start to expand as they heat up. However, as ceramic tiles are not good conductors of heat the concrete substrate is much cooler and therefore expands at a much slower rate. The SABS standard for locally manufactured ceramic tiles (which meets the AII$_a$ European specification) will, according to international literature, have a thermal linear expansion rate of approximately 0.3 mm/meter.



Another source of expansion is irreversible moisture expansion. This type of expansion is often misunderstood and only occurs when certain types of crystalline structures of clay are present in the body of the ceramic tiles. When these crystals come into contact with water, they react with it and swell which in turn increases the size of the tile. Tiles that are prone to irreversible moisture expansion also have massive problems with the stability of their glaze as they tend to craze i.e. form small cracks on the surface of the tile. As this is huge quality issue for ceramic tile manufacturers, irreversible moisture expansion is very closely monitored and therefore a very rare phenomenon. Tiles that meet the AII$_a$ European specification will have an irreversible moisture expansion of ***less than 0.01 mm/meter*** which negligible when compared to other sources of movement. Since each component moves at different rates and sometimes in opposite directions, the movement creates sheer within the thin adhesive bed. When the sheer force exceeds the tensile strength (bond strength) of the adhesive de-lamination occurs.

What are the factors affecting the bond strength of a tile adhesive?

The maximum bond strength is determined by the mix design of the tile adhesive. The more cement and additives used (i.e. the more expensive), the stronger the bond will be. Bond strength, however, is also proportional to amount of contact between the tile surface and the adhesive i.e. if the maximum bond strength of the adhesive is 1 N/mm^2 and only 50% of the tile surface is in contact with the adhesive due to poor bedding or skinning. Then the actual bond strength will only be 0.5 N/mm^2. Thus poor application technique can dramatically reduce bond strength.

Another important factor is the porosity of the tiles or the substrate. If the porosity is high, moisture is sucked out of the tile adhesive which results in partial hydration of the cement and a weaker strength development of the bond. This is an increasing problem in South Africa with people trying to contain building costs by reducing cement content in concrete floors and plasters. Low cement content equals increased the porosity.
It is important to note that a strong bond is only part of the solution. From a theoretical point of view, the sheer stress in a system with a rigid tile (i.e. a vitrified tile) and a brittle adhesive (i.e. non polymer modified) can go as high as 8 N/mm^2 which is ***eight times higher*** than the bond strength of a top-end European C2 tile adhesive i.e. using more flexible polymer modified adhesive can dramatically reduce the stress in a system.

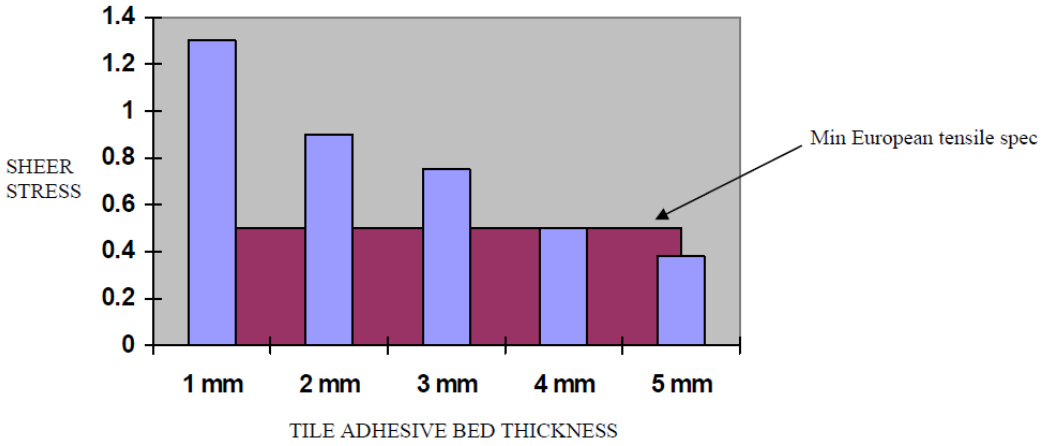
What are the factors that can be manipulated to reduce the sheer stress within a tiled floor to acceptable levels?

As discussed previously the greatest contributor to the sheer stress is the concrete and its rate of shrinkage. The easiest way to counter this is by ensuring the concrete is given sufficient time to cure before tiling. The SABS standard calls for a minimum period of 28 days from the laying of the concrete and tiling. With fast track building this period can often not be adhered to. In this case, the bond strength and the flexibility of the system must be increased to handle the higher stress. The most common methods would be to:

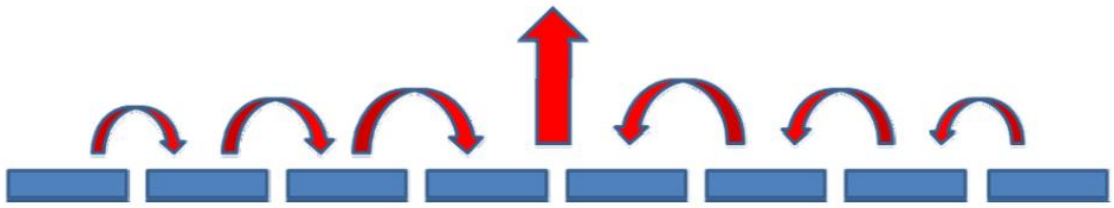
1) Use a high quality flexible adhesive instead of a contractors grade
2) Increase the strength / flexibility of a contractors grade by mixing with a bonding liquid instead of water
3) Apply a basecoat / keying agent slurry to the substrate prior to applying adhesive and tiling

The ambient conditions and characteristics of the installation are important, especially the potential for large temperature fluctuations. Dark coloured tiles on a north facing external balcony will expand and contract significantly more than a light coloured tile in a south facing room.
Temperate fluctuations also explain why winter is known as “popping season” in the South African tile industry. In winter, the difference between the maximum and minimum temperatures is at its highest and consequently tile expansion and contraction is also at its highest. This effect is further compounded by people using heaters, fires and underfloor heating to warm rooms.
The size of the tile is another parameter which affects sheer stress. As the tile size increases so does the sheer stress in the system. This is evidenced by the fact that as the size of tiles has increased in recent years, so has the incidence of tenting. Once a tile is above 500mm x 500mm, the use of a flexible polymer modified adhesive is recommended.
As mentioned earlier the quality of the application is vitally important. A good quality tiler can make a poor quality adhesive work while a poor quality tiler will make the highest quality adhesive fail. As discussed, contact between the tile and adhesive must be as high as possible – no less than 80% of the surface of the tile must be bedded into the adhesive. Another important factor is the thickness of the tile adhesive bed under the tile. Once the bed thickness drops below 4 mm the sheer forces increase above the tensile strength of an entry level European C1 tile adhesive. In the South African context, this is often the result of incorrect trowel choice or excessive bedding by tilers trying to extend the adhesive and maximize the amount of m^2 tiled per bag. The European standard for the application of tile adhesives calls for a thin layer of adhesive to be applied first with the flat side of a notched trowel. Thereafter additional adhesive is applied

and raked with the notch side of the trowel. This procedure ensures that the bed thickness is at least 4 – 5 mm.



Another common error found locally is when the excess tile adhesive has not been removed from between tiles prior to grouting as per the SABS standard. Tile adhesive is relatively hard and it tends to transfer sheer stress from one tile to another. This results in huge sheer in the middle of the tiled room and tenting.



A properly designed grout is softer and more flexible to allow it to act as a cushion to help reduce the transfer of sheer. This is, however, only half the story as sheer stress also increase as the joint width decreases. With butt jointed tiles, 100% of the sheer is transferred from tile to tile but ***less than 10%*** is transferred if the joint width is larger than 4 mm. There is a trend towards smaller joints but clients must be informed that this will increase the risk of an adhesion failure in the project.
One of the more important application practices to reduce sheers forces is the installation of perimeter and intermediate expansion joints. Expansion joints break the transfer of sheer across the floor resulting in lower stresses at the centre of the panels.

Since expansion joints localize failures to within the panels, repair work is quicker and more cost effective as the areas to repair are smaller.

Why the clean break?

In a tenting failure, the ceramic tile usually comes clean off the adhesive bed leaving an imprint of its backing. This is often misinterpreted to be a sign of a poor quality adhesive. It is, in fact, an indication of a high strength but brittle adhesive. The concrete and tile adhesive both have cement as the binder and so they bond very easily together. However, since ceramic tiles are made from clay, the bond between it and the cement in the adhesive is usually fractionally weaker. The point of failure or cleavage plane the will always occur at the weakest point in the system. With a tenting failure, there is a sheering action between the tile layer and the substrate bond which places stress on the tile adhesive layer which in turn, breaks down the adhesive at its weakest point. Hence the observation of the tile coming clean off the adhesive bed.

Another common type of failure is when the adhesive comes clean off the substrate and remains stuck to the tile. Since the cleavage plane is at the weakest point in the bond, this is a clear indication of poor surface preparation (i.e. tiling onto a dusty floor or not applying a basecoat slurry to a steel floated floor).