Winter is popping season for tiles – it's the most common time of the year for ‘tenting’, when tiles seem to magically lift off the substrate for no apparent reason. It's sometimes thought to be the fault of poor quality adhesive – but actually this is not usually the case. More often, changes in temperature, or insufficient curing time for cement substrate are the culprits. In this month’s newsletter, we take a look at this issue in depth.
The forces at work

The materials in tiled flooring - ceramic tiles and cement substrate, for example - undergo expansion and contraction continuously. Since they're made from different substances, they move at different rates.

The forces they experience are linear – in other words, they spread out horizontally in all directions. They put constant stress on the tile adhesive to keep everything together, and under the right circumstances, the bond strength of the adhesive is stronger than these forces. But when the forces are stronger than bond strength of the adhesive, the tiles pop up or ‘tent’. It’s also called disbondment because of the failure of the bond. What’s really happening is that the dimensions of the tiles is actually greater than that of the substrate it’s bonded to. One tile’s edge pushes against the next – soon the tiles have nowhere to go but to pop up.

Adhesive bond strength

When a tile pops up, it often comes clean off the adhesive bed, leaving an imprint. It’s easy to blame poor quality adhesive, but it’s usually an indication of brittle, high-strength adhesive. Cement in the substrate and the adhesive bond more strongly with each other than with the ceramic. If, on the other hand, the adhesive comes off the substrate, it’s usually an indication of poor surface preparation, e.g. tiling onto a dusty floor or not applying a basecoat slurry to a steel floated floor.
Causes of disbondment

- **Concrete shrinkage**
  The most common source of movement is shrinkage of the concrete substrate as it cures. Internationally accepted values for movement are between 1mm/meter for a high quality, well-designed concrete mix and up to 3mm/meter for a lower spec concrete. Cost-cutting measures are usually the culprit for excessive movement – the type of cement, mix design and water-cement ratios are all factors.

  Cost-cutting in the form of lower cement content in concrete floors and plasters increases the porosity of the tiling substrate. Moisture is then sucked out of the tile adhesive, weakening its bond strength.

  Curing times are also a major factor for disbondment. The shorter the period between placing the concrete substrate and laying tiles, the greater the risk. The rate of contraction of concrete is fast in the beginning and slows with time. During fast-track building projects, where there’s pressure to finish within a short timeframe, tiles are sometimes laid before the minimum curing time is up – this puts considerable stress on the system (not to mention the contractor!)

- **Temperature fluctuations**
  Another principal cause of tenting comes from temperature fluctuations in the room. This explains why the winter months are common times for these problems to occur – rooms are heated with electrical heaters, fireplaces and underfloor heating, and cool down again when the heating is off. Since ceramic tiles are poor conductors of heat, and the concrete is much cooler than the surface, the tiles expand faster than the substrate.

  The tendency of curing concrete to shrink and of ceramic to expand when heated can sometimes work together to compound the stresses leading to tenting.

- **Irreversible moisture expansion**
  Irreversible moisture expansion occurs when crystalline structures of the clay bodies of ceramic tiles expand. When the crystals are exposed to water, they react by expanding – usually this is accompanied by crazing (lots of fine cracks) on the glaze. It’s fairly rare for this to happen in tiles thanks to stringent quality control at Ceramic Industries. Our tiles are monitored to make sure their irreversible moisture expansion potential is under 0.01mm/meter, a negligible amount of movement in comparison to the other kinds of expansion/contraction.

- **Inadequate adhesive coverage**
  The bond strength of an adhesive is determined by the amount of cement and bonding agents included in the mix – the more, the stronger (but also, the more expensive the mix.) But it’s important to note that no matter how strong the mix, if there isn’t sufficient coverage, you won’t have sufficient bonding. For example, if the maximum bond strength of an adhesive is 1N/mm² (1 Newton per square mm – a measure of pressure, or force per unit of area), but only 50% of the tile surface is in contact with it because of poor bedding or skinning, the actual bond strength will be only 0.5N/mm².

- **Substrate porosity**
  A highly porous substrate acts like a sponge, sucking the moisture out of the tile adhesive. This weakens the adhesive’s bond strength. Usually this kind of porosity problem happens because of a low cement content in the substrate. Unfortunately, this is becoming more common in South Africa as contractors try to lower costs by reducing the cement content of concrete floors and plasters.
It's important to note that a strong bond is only part of the solution. While standard, non-polymer-modified adhesive can exhibit an very high theoretical bond strength, it may do nothing to reduce sheer stress in the system. On the other hand, using a more flexible, polymer-modified adhesive like Pro Grip Flex can dramatically reduce the stress.

It's crucial to allow sufficient time for concrete to cure – SABS specifies a minimum of 28 days between laying concrete and tiling.

Fast-track building projects often ignore that standard, in which case, additional measures must be taken:
- Apply a keying agent slurry to the substrate
- Use a high-quality, flexible adhesive (not contractors’ grade), or use bonding liquid instead of water in contractors’ grade adhesive to increase strength and flexibility

Make sure the tile adhesive bed is 4 – 5mm thick, and select the right trowel size to achieve this. Anything under 4mm puts the average ceramic tile at risk. You could spread a thin layer with the flat side of the trowel and follow up with additional adhesive raked with the notched side to produce the right thickness. Below you can see the stress placed on the adhesive, according to its thickness.

Preventative measures

- No less than 80% of the surface of the tile must be bedded into the adhesive
- Take care to remove excess tile adhesive between joints before grouting – the adhesive is less flexible than grouting material, which absorbs some of the forces of expansion and contraction. Tile adhesive in the grouting joints means sheer stress is transferred between tiles, and tenting tends to occur in the middle of the room:

![Grouting Joints](image)

- Consider the width of the grouting joints - sheer stress 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 4mm. With the trend towards narrower grout joints, this must be taken into consideration.
- Use expansion joints according to SABS specifications to localize any failures:

![Expansion Joints](image)

- Be aware of the ambient conditions and characteristics of the area of installation, especially the potential for large temperature fluctuations. For example, 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.

![Temperature Effects](image)