The Moisture Sensitivity of Basalt (Bluestone)

Jim Mann
Managing Director
Stone Initiatives MTG
South Australia

Basalt – The Warping Issue

If you were to compile an ABC of Victoria, the letter B would have to stand for basalt (or bluestone). This stone has been commercially quarried in Melbourne and surrounds for over 180 years and could be considered an icon of the state. The popularity of basalt has spread Australia—wide and with this popularity has come a wide range of imported stone types which offer the consumer a broader selection of materials that are similar but in some ways different to local basalt. Some of the differences in these new materials have led to failures and the need to develop new installation practices.

Among the challenges faced by installers has been the propensity of some types of imported basalt to curl or warp upon installation whether laid on a cementitious adhesive or a mortar bed. Before we start to explore the warping phenomenon it is necessary to understand the similarities and differences between typical Victorian basalt and some imported basalt materials.

Formation

Basalt is an extrusive igneous rock type predominantly composed of plagioclase feldspar, pyroxene and olivine with smaller amounts of iron oxides and titanium oxides. Basalt forms at or near the surface and in Australia is typically quarried from volcanic lava flows. During its deposition the expulsion of the molten lava leads to a reduction in pressure allowing dissolved gases to form as fine bubbles within the flow. These bubbles coalesce as they drift upwards within the flow creating larger bubbles most of which are captured within the solidifying stone. The size and distribution of these captured bubbles (vesicles) vary in size throughout the profile of the deposit from less than 1mm to 10mm or more. The appearance of the pores within the stone will also vary depending on the depth and mode of formation of the deposit.

Physical Properties

The table below compares the typical physical properties for ‘typical’ Victorian and imported basalt from countries such as China.

Property	Typical Victorian Basalt	Typical Imported Basalt
Modulus of Rupture – MPa (3-point bending strength)	15 - 19	16 - 22
Bulk Density (kg/m3)	2450 - 2600	2590 - 2900
Apparent Porosity (vol %)	2.5 - 5	1 – 3.5
Total Porosity (vol %)	5 - 12	1.5 - 5
Saturation Coefficient (%)	40 - 50	65 - 70

In the way of explanation, apparent porosity could be described as the volume of pores which will readily absorb water under normal atmospheric conditions while total porosity is determined by ‘forcing’ water into the pores under a vacuum. The saturation coefficient represents the ratio of the apparent porosity compared to the total porosity so a higher saturation coefficient indicates the stone more readily achieves saturation point.

The table shows that the materials typically have a similar bending strength (modulus of rupture) although the imported stone typically has a higher bulk density and lower apparent and total porosity

with a finer pore size which has led to the stone being produced as thin tiles (to ~10mm) while historically Victorian basalt has been produced as thicker flags (30 – 40mm).

Capillaries at Work

The difference between the ranges of saturation coefficients for the two stone types is a crucial issue and can be explained in part by the range in pore size within the two stone varieties. Victorian basalt is typically scoriaceous (frothy) which produces large pores known as vesicles (colloquially known as cats paws) while imported basalt is typically massive with more pores of a finer size. The difference in pore size is important as it affects the way the stone absorbs water due to the stronger capillary action which increases the suction of the stone as shown in Fig 1.

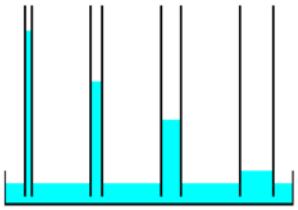

Fig 1: Capillary action at work. The finer the pore throat size the greater ability the water has to rise.

Although the pores within basalt are not usually connected, the passage of water (permeability) through the matrix of the stone is assisted by capillary action with finer pores more readily reaching saturation point (i.e. saturation coefficient near 100%).

In a practical sense the strength of the capillary forces can have an impact on how a tile behaves when it is laid as the speed and distribution of moisture absorbed is governed by permeability and pore size. Figures 2 to 5 show a series of schematic drawings to show how moisture is absorbed by a thin moisture sensitive tile upon laying on a wet adhesive bed.

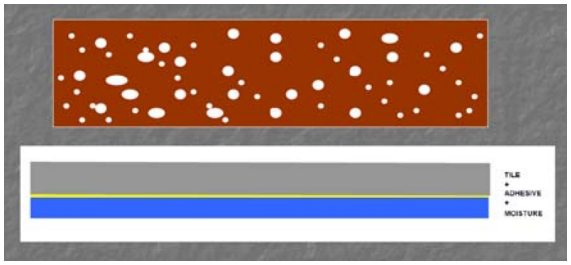

Figure 2: Initial condition of dry tile laid on a wet bed shown below with a magnified view of pores within the tile shown above.

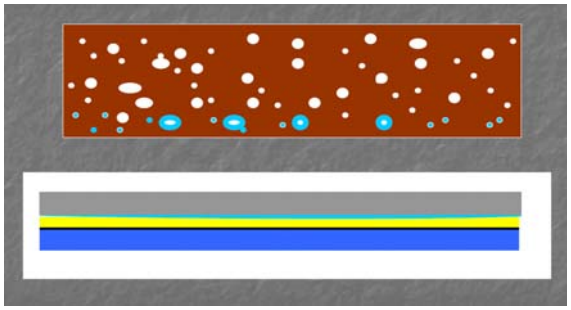

Figure 3: The tile begins to absorb moisture soon after installation.

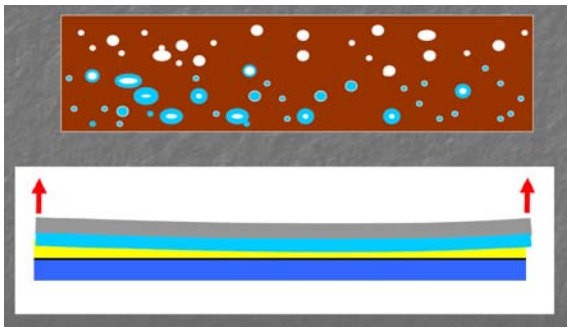

Figure 4: As the tile continues to absorb moisture a differential develops where the lower section of the tile contains pores that are near saturation while the top section is still dry which causes unequal dimensional change which presents itself as warping of the tile.

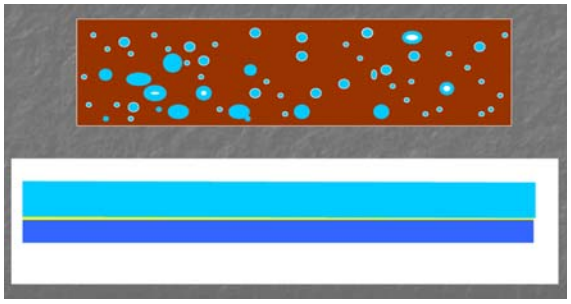

Figure 5: Eventually the tile will achieve a relatively uniform moisture content (depending on thickness) which will result in a consistent rate of dimensional change and absence of any (or minimal) warping.

The warping generally occurs quite quickly but return to equilibrium is a much slower affair as shown in Figure 6.

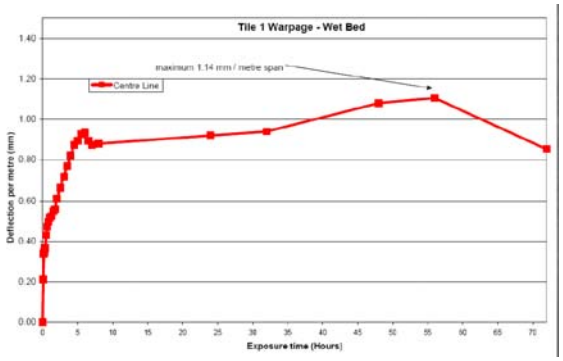

Figure 6: Chart showing deflection of tile surface over time when laid on a wet sand bed.

In Figure 6 we can see that in this instance the majority of the warping occurred within the first five hours. The consequence of the rapid dimensional change is that if the tile is installed with an adhesive sets after five hours it may become fixed in a warped condition unless the stresses are sufficient to cause failure of the adhesive bond between the tile and substrate resulting in a drummy tile.

The other major consequence of the high rate of suction through capillary action is the mobilization of soluble minerals onto the surface of the tile from the adhesive or substrate as shown in Figure 7.

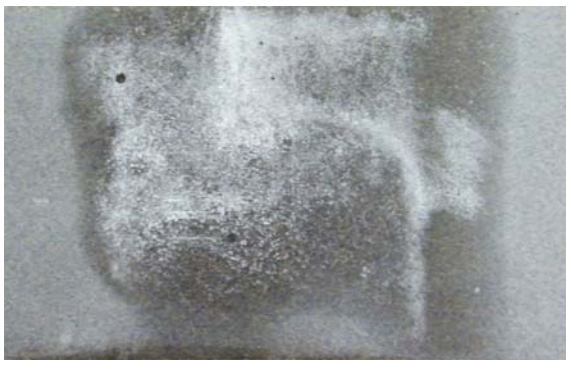

Figure 7: Dense basalt tile exhibiting moisture staining and efflorescence from salts transported through the tile from the substrate.

Solutions

There are numerous approaches to overcoming the challenge of moisture sensitive tiles which involve controlling the material or the method of installation.

Increasing the thickness of the tile provides multiple benefits. Using a thicker tile makes the tile stiffer which reduces the risk that that the tile will warp. An increase in thickness also reduces the likelihood that moisture and soluble minerals will migrate to the surface of the tile.

An added benefit from increasing the thickness is the greater load bearing capacity of the tile. Breaking load increases exponentially with an increase in thickness – double the thickness and the breaking load increases fourfold.

The plan size of the tile also has an effect on any apparent warping. A tile that has a length to width ratio of 1: 1 will appear to warp much less than a tile with a ratio of 3: 1 or greater (see Figure 8).

Figure 8: Comparison of warping of a 1:1 and 3:1 tile in plan and cross section view. Minimizing the length to width ratio reduces any apparent warping.

Tiles with a mid-brown or grey tonality such as basalt are highly sensitive to colour changes from contaminants and moisture especially on finely finished surfaces (e.g. honed). The use of surface finishes with a coarser texture such as sawn or sandblasted are more forgiving as they tend to hide minor blemishes.

Careful selection of the installation method is crucial for all types of tile especially when the material may be moisture sensitive. The choice of the correct adhesive is vital to a successful installation. Rapid setting cement based systems which achieve an early set and a significant portion of their tensile strength in a short period of time can reduce any warping that may occur.

Two-part high strength non-water based adhesives are also an alternative and involve adding a powder (Part A) is added to a proprietary liquid (Part B) to provide a rapid set adhesive which also minimises excess moisture. Epoxy adhesives specifically designed for moisture sensitive stone are also available and these provide a very high strength rapid-set fixing system especially suited for challenging areas such as swimming pool surrounds, bathrooms and external wall cladding.

Six-sided sealing of tiles with some types of penetrating sealers dramatically reduces the uptake of moisture into a tile which can improve stability, reduce staining and improve durability. It is very important to determine compatibility between the sealer and adhesive to ensure the adhesive bond is not affected.

Know Your Stone

In all aspects of our daily life we are bombarded by innovations and new products and the stone industry is no different. As we are exposed to new stone types it is important to understand their strengths and limitations and to learn how they behave in different environments. The popularity of basalt has to some degree been marred by the issue of warping and is in part due to using old practices on new products. For the industry to grow it is important that all aspects of the industry, the quarry, the tile shop and adhesive manufacturers stay informed and work together to reduce the mysteries within stone and provide the consumer with a low risk product.