December 21, 2011

Tileletter

Tagline here.

Shrinkage Leads to Indent Fractures in Stone

December 14, 2011 By Tileletter

Natural stone tile continues to grow in popularity despite reduced consumption due to the soft economy. Materials used to install these tiles continue to change. As products and their usage change, so must you change to stay current with industry standards and the manufacturer-recommended applications of these products.

Shrinkage is not new. In fact, it's expected to occur within setting materials. What has changed is that much more stone is being installed today, over different substrates and substrate conditions For instance, crack-isolation membranes – rare years ago – are much more common today. There are also a variety of membrane types with different properties and requirements.

Also, installers today tend to use much thicker application of thin-set mortar to compensate for irregular substrates, instead of correcting the substrates' irregularities before installing tile. There are many more polymer/latex-modified thin-set mortars being used now rather than the standard dry-set thin-set mortars. All of these changes produce shrinkage and less resistance to shrinkage, resulting in a condition in stone known as "indent fractures."

The phenomenon of indent fractures is much more frequent today. An indent fracture is a spider web-like fissure typically found in softer stones such as limestone and travertine, but is also seen in marbles and even some granites. It typically runs through one or more tiles and will branch off in different directions. Indent fractures are not easy to see; typically they can only be seen from an angle when light reflects off them. If you run your hand over the indent fracture you can't feel it because there isn't an actual crack or separation in the stone surface. If you put a straight edge over the indent fracture and shine a flashlight from the back of the straight edge, the light shines through at the fracture, indicating a low spot. Indent fractures can develop into an actual crack separation if the stone is subjected to enough movement, stress from deflection, or due to lack of movement joints.

The culprit

I have investigated numerous stone tile applications with this indent-fracture condition. The common denominators in each case are typically excessively-thick, polymer-modified thin-set mortar installed over a membrane of some sort. It also occurs where a bonded mortar bed wasn't bonded to its substrate and was applied very wet and rich and in cases where the wire reinforcement for a non-bonded mortar bed was at the bottom of the mortar bed rather than suspended within the mortar bed.

What we found in our investigations was that the combination of excessively-thick thin-set mortar over a resilient membrane allowed the indent fracture to occur. The total force of shrinkage resulting from thicker applications of thin-set mortar will impart greater stresses in the stone than a thinner application, causing more deformation (strain) or shrinkage. This is compounded if the thin-set is also installed over a resilient membrane, because the membrane isn't as effective in restraining the thin-set mortar as a rigid concrete substrate would. Instead, the thin-set mortar under the stone dries in a manner similar to a dry lake bed, with compression within some areas of the thin-set that results in tension in other areas, creating cracking in the thin-set. The crack then works its way up through some of the stone, but does not appear as a crack at the surface.

This condition is further compounded when a stone is installed over a membrane, since the moisture within the thin-set mortar can't be absorbed by the substrate. The moisture can only escape through the stone or the grout joints. Of course the thicker the thin-set, the more moisture the stone is subjected to. This causes it to expand, resulting in more stress and deformation.

Wet-set mortar

Indent fracturing can occur when tile is installed over a wet-set mortar bed application particularly if it is over fat mud (very wet) which creates much more shrinkage, particularly if the mortar mix is very rich (higher ratio of cement to sand). If the mortar is placed over a membrane, as the mortar shrinks the membrane isn't restraining the shrinkage. If the membrane isn't properly attached to its substrate then it can further reduce the amount of resistance on the mortar bed or the thin-set. On a non-bonded mortar bed over cleavage membrane, wire reinforcement is required to minimize the shrinkage. If the wire reinforcement is left out or placed at the bottom of the mortar bed, then it can't do its job of mitigating shrinkage and avoiding indent fractures. Dry-pack mortar has very little moisture for the stone to absorb, so shrinkage is much less.

Recently I was involved in devising some experiments to reproduce indent fracturing in a testing laboratory. We substantiated that the thicker application of thin-set mortar created more stress and strain, and application over a resilient membrane contributed to deformation by not fully restraining the thin-set as it would if bonded to a rigid surface. It was determined that the fractures were the result of tension within the thin-set mortar at those points.

Indent fractures didn't develop right away, but took a week or more to develop and eventually halted. Cracking initiated within the thin-set and traveled up through the bottom of the tile. Based on Pythagorean triangular geometry, an indent can be explained by the bottom of the stone shortening from deformation caused by the thin-set shrinkage, resulting in the crack. The top surface of the stone is drawn down at the crack location resulting in the indent (low point).

Avoiding indent fractures

So what can you do to avoid indent fractures? First, follow thin-set mortar manufacturers' recommendations for

their products. ANSI now has defined the differences between a medium-bed and thin-bed thin-set mortar, indicating their limitations. A thin-bed mortar cannot be used any thicker than 1/4" or less than 3/32" after the tile is embedded. A medium-bed mortar cannot be any thicker than 3/4" thick after the tile is embedded. ANSI further states that the medium-bed mortar is not intended to be used in truing or leveling underlying substrates or the work of others, but only to accommodate the irregularities within a tile.

Make sure you adjust your substrate to meet ANSI A108 flatness requirements. Then use thin-bed mortar, limiting the thickness to 1/4." Use a rapid-setting thin-set to help minimize the extent of shrinkage since it cures faster. A membrane with less resilience can also help to restrain the thin-set mortar if it is properly attached. Use dry-pack mortars for wet-setting stone on floors to limit the amount of shrinkage and the amount of moisture to which the stone is subjected. Make sure your wire reinforcement is suspended within one-third to one-half the thickness of the mortar bed for non-bonded applications to help minimize shrinkage.

Bottom line: if you want to avoid problems, follow industry standards.

 Ceramic Tile Consultant, Donato Pompo CTC CSI CDT MBA is the founder of Ceramic Tile and Stone Consultants (CTaSC). Donato has over 30 years of experience in the ceramic tile and stone industry from installation to distribution to manufacturing of installation products. CTaSC provides services in forensic failure investigations, quality control for products and installation methods, including writing specifications, training programs, testing, and on-site quality control inspection services. CTaSC is a professional consulting company comprised of expert tile and stone consultants, accomplished ceramic tile and stone installers, architects, engineers, general contractors, construction scientists and other industry specialists conveniently located throughout the US and Canada. Reach Donato at www.CTaSC.com or e-mail at Donato@CTaSC.com or by calling 866-669-1550.

Filed Under: Business & Technical Articles

Want to reduce the risk of ceramic tile failures?

November 28, 2011 By Tileletter