ARTICLE REPRINT
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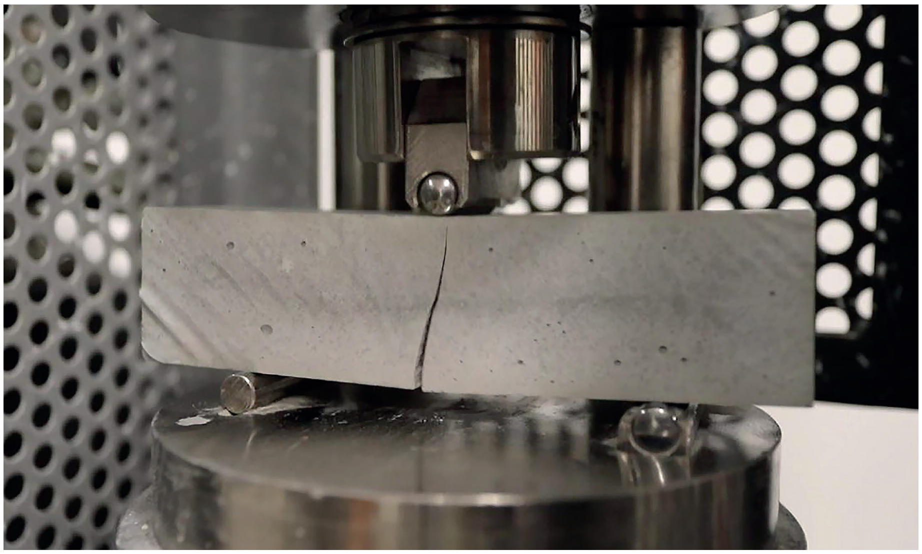
Rapid Set

CONSIDER AN OVERLAYMENT'S TENSILE AND FLEXURAL STRENGTH



The downward force from the top causes the bottom of the prism to fail in tension during this ASTM C348 Test performed at the CTS laboratory.

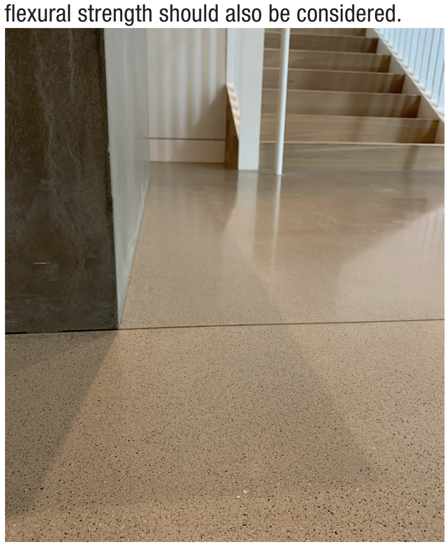
"When addressing cracking concerns, it's important to understand how cracks result and how different types of strength can contribute to crack resistance and durability.

Compressive strength — the ability of a material to withstand being compressed or pushed together — is often used to determine mortar and concrete's quality. This makes sense for floors and overlayments as the primary forces applied to them are downward, compressive loads from traffic, equipment or anything affected by the force of gravity.

However, when it comes to decorative overlayments, which are typically installed between 3/8 and 1/2 inch thick, crack resistance is also critical. When addressing cracking concerns, it's important to understand how cracks result and how different types of strength can contribute to crack resistance and durability.

In overlay mortars, compressive strength is tested by ASTM C109 – Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (www.astm.org/Standards/C109). The test essentially measures how much force can be applied to a cube with a 4-square-inch surface area before the cube breaks. This allows the user to calculate the pounds per square inch (psi) of the mortar.

Usually, standard concrete is between 3,000 and 5,000 psi. According to the International Polished Concrete Institute (IPCI), the preferred concrete mix design has a minimum compressive strength of 3,500 psi (http://www.ipcionline.org/index.cfm?fuseaction=polishedConcrete.specifications). A polished overlay should meet or exceed the concrete substrate's compressive strength. However, an overlayment's tensile and flexural strength should also be considered.



This office lobby in Austin, Texas, is finished with Rapid Set® TRU® SP. The high-performance, self-leveling architectural topping has undergone extensive testing of its comprehensive, tensile and flexural strengths to provide a more comprehensive analysis of its overall performance when it comes to cracking.

CONSIDER OTHER TWO STRENGTHS

Tensile strength — the ability to resist being pulled apart — is often measured by ASTM C307 – Standard Test Method for Tensile Strength of Chemical-Resistant Mortar, Grouts and Monolithic Surfacings (www.astm.org/Standards/C307).

Flexural strength — the ability to withstand flexing or deflection when a load is applied — is measured by ASTM C348 – Standard Test Method for Flexural Strength of Hydraulic-Cement Mortars (www.astm.org/Standards/C348).

ASTM C348 is a three-point bending test where the specimen fails on the side opposite to the side where force is being applied. The side that fails is stressed in tension, so flexural strength can really be considered another measurement of tensile strength.

Concrete and other cementitious products traditionally have very high compressive strength and much lower tensile strength. The rule of thumb is that portland cement concrete has a tensile strength that's about 10% of the compressive strength, but that percentage varies based on the mix design. Producers can adjust the strength by varying the doses of chemical additives in the mix.

There are many reasons cementitious, polishable overlayments may crack — such as drying shrinkage, plastic shrinkage, substrate movement or flexing, and reflective cracking from existing joints or cracks. Ultimately, a surface crack is caused when the forces of tension within the material exceed the material's ability to resist that force, i.e., tensile strength. A crack relieves the tensile stress in the overlay.

WHY CARE ABOUT MOE?

When a force is applied to a material, it will have some amount of nonpermanent deformation and will rebound to its original shape when the force is removed. The Modulus of Elasticity (MOE) is defined as the ratio of force or stress to that nonpermanent deformation or strain. Rigid or brittle materials have a high MOE, and flexible or ductile materials have a low MOE.

In mortar and concrete, MOE is measured by ASTM C469 – Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression (www.astm.org/Standards/C469). In this test, a cage is mounted to a cylinder that measures how much the cylinder is deformed due to an applied load. The strain is the change in length divided by the total length of the cylinder.

Figure 1 shows stress versus strain curves for different self-leveling overlayments. Since the MOE is a ratio of stress over strain, the slope of each line is the MOE. The yellow line has a very steep slope, indicating high MOE and a very rigid mortar, while the black line represents a mortar that's more flexible and is more likely to bend slightly before breaking.

This is important when considering tensile stresses that may lead to cracking at the surface. Materials with a very high MOE may have high compressive strengths but they are more susceptible to cracking because they're so rigid. Materials with a lower MOE bend slightly rather than crack when faced with tensile stresses.

IN CONCLUSION

To ensure decorative overlayments achieve performance and aesthetic expectations, compressive, tensile and flexural strengths must be evaluated as a whole. Compressive strength measures a material's ability to resist forces from traffic and equipment, as well as resist the impact from dropped items. Tensile and flexural strengths measure the material's ability to resist forces that can lead to cracking.

Long-term durability and toughness can't be predicted by compressive strength alone. Evaluating compressive, tensile and flexural strengths together provides a more comprehensive analysis of overall performance. This holistic approach will help architects and specifiers meet and exceed performance and aesthetic expectations in polished overlay designs.

ABOUT THE AUTHOR

Matt Sambol, manager of flooring and polymer systems at CTS Cement, has been with the company since 2002. He oversees product development, testing and field support for the Rapid Set TRU® Flooring System, which includes the polishable self-leveling overlayment products. He can be reached at msambol@ctscement.com.

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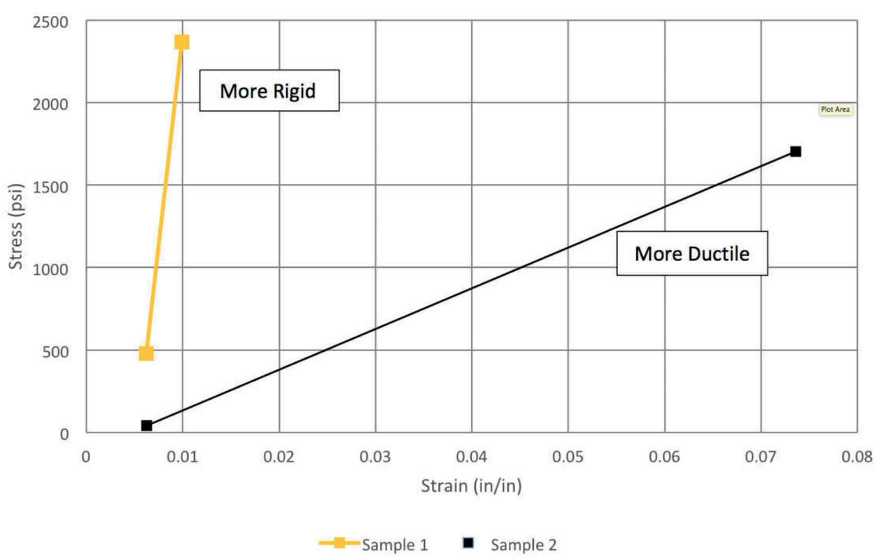

Self-Leveling Overlayments
Stress vs. Strain Curves
Figure 1: Stress vs. strain curves comparison for various levelers