Surface Preparation for Shotcrete Repairs

by Denis Beauprè

Surface preparation is an important element of the repair process, both with shotcrete and cast-in-place concrete. It covers a large scope, including concrete removal, saturation of the substrate, the use of bonding agents (rare with shotcrete), and cleaning of the surface. These operations are influenced by the local conditions (surface position: vertical or overhead, the presence of reinforcement) and are very important for both the short- and long-term bond strength and, thus, the repair integrity. When all steps involved in surface preparation are considered, it is obvious that these operations represent a large part of the repair cost and may reach up to 50% of the total repair cost. For this reason, it is important not to neglect surface preparation.

The subject of surface preparation is not fully understood. The information presented in this technical tip is based on my experience in shotcrete research and practice over the past 15 years. It should be viewed as my personal understanding of the subject at the present time. What follows could change as research progresses.

There are several schools of thought regarding surface preparation. Some subjects are still being discussed and constitute the hot issues. Among the most controversial are: the use of a bonding agent, saturation of the substrate, and preparation between layers of shotcrete. Concrete removal is a less contentious subject.

Concrete Removal

The most common way to remove concrete has been the use of a pneumatic chipping hammer. In the past 10 years, the use of hydromilling has become increasingly popular. A summary of the results from a 10-year-old study on shotcrete bonding (Talbot et al. 1994) was presented in the second issue of *Shotcrete* (V. 1, No. 2, May 1999). In terms of concrete removal, hydromilling was found to be very effective as was the use of a chipping hammer, followed by sandblasting. It was also shown that the use of sandblasting alone (when no demolition was needed) helped produce an excellent and durable bond. Usually, properly applied shotcrete produces a bond in excess of 1.5 MPa (around 200 psi) in direct tension.

Use of a Bonding Agent

Bonding agents are not typically used in shotcrete repair. It might be interesting to discuss why they aren't. The reason is simple: while shotcreting, the first layer of material that sticks to the substrate surface is a fully consolidated layer of a relatively low water-cement ratio (w/c) material. Moreover, this layer is always followed by the application of the bulk of the shotcrete repair material, without having time to set. This is almost the perfect description of how bonding agents (at least cement-based ones) should perform. Therefore, shotcrete usually bonds completely to a substrate without the requirement of a bonding agent.

Degree of Saturation

Identifying the necessary degree of saturation of the substrate or answering the eternal question "wet or dry?" (not the shotcrete process but the state of the receiving surface) is not easy. To solve this, many agencies have different requirements on how long the surface must be kept wet prior to shooting. Strictly from the point of developing a good bond, Fig. 1 shows data from shear bond tests performed on two different moisture conditions: dry and saturated surface dry (SSD). Each dot represents the bond strength of particular repairs for both conditions. Because there are more dots above than below the dotted line, it means that, on average, the bond strength is higher for the repairs performed on the dry surface than on the SSD surface.

From these data, it appears that the degree of saturation is not very critical and, in most cases, a dry surface is better. However, one must keep in mind that these repairs have been performed on a clean surface in a laboratory. In practice, the reason

for requiring a predampened surface (or SSD) is that is ensures that the surface has been "cleaned" before shooting. Of course, no free water should be left on the surface: air blowing is always necessary subsequent to wetting the surface. Excess water on the surface results in a high water-cement material ratio (*w*/*cm*) and, hence, a reduction in bond strength at the critical interface between the substrate and shotcrete.

Conclusions

The shotcrete process inherently provides a good bond. Poor bonds, however, have been observed when shooting on nonsandblasted surfaces, on dusty surfaces, or on curing compounds. If these situations are avoided, and if the shotcrete is not allowed to sag or debond in the green state (common when shooting too thick of layers on overhead surfaces), good bond results should be achieved.

If specifications calling for bond strengths higher than 2 MPa (around 300 psi) are encountered, it might be wise to use silica fume; greater surface preparation will only help a little. Specifiers should be warned that requiring more than 1.5 MPa direct tensile bond strength is very demanding. This should only be done for special purposes and not as a general requirement. If safety is a concern, use mechanical anchors and wire mesh; do not specify higher bond strengths because it is too risky.

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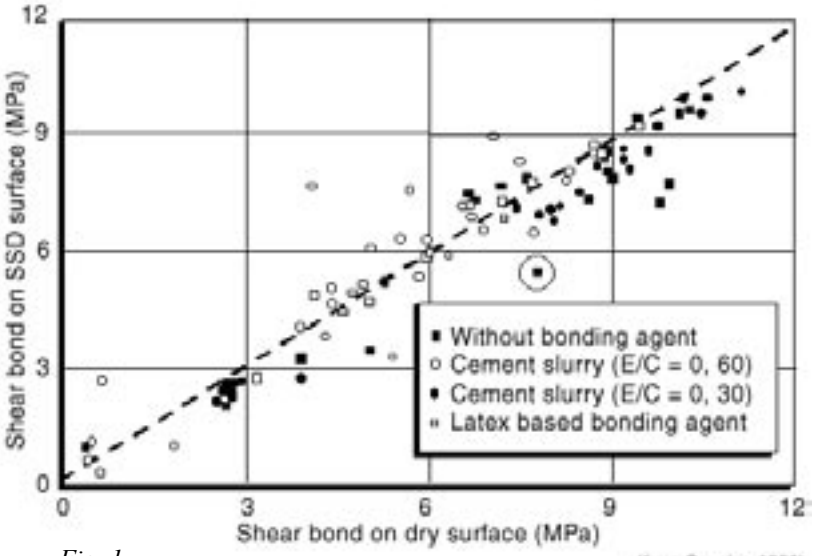

Fig. 1