Surface Preparation for Shotcrete Repair

By Simon Reny

When placing shotcrete in a concrete repair application, one cannot overstate the importance of the bond between the shotcrete and the concrete substrate. This bond is a critical factor in determining the overall performance and durability of a repair. Research has demonstrated that bond strength between the concrete substrate and the concrete repair, whether it is shot or cast in place, is directly related to the quality of the surface preparation, as demonstrated by Talbot et al.[1] Good surface preparation requires correct concrete demolition practices and properly cleaned surfaces. This Technical Tip briefly covers the best of these techniques for preparing the receiving surface of a shotcrete repair. The first section will cover demolition of the deteriorated concrete. The second section will treat the surface-cleaning requirements. The third segment will explain quality control testing of the surface preparation.

Concrete Demolition

Concrete structure rehabilitation requires proper removal of deteriorated concrete to a sound concrete substrate before the surface preparation takes place. Qualified personnel must first determine the deteriorated concrete area and mark the surfaces to be repaired. It is recommended, but not mandatory, to saw cut the perimeter of any concrete sections to be repaired, and feather edging should be prohibited. The saw-cut perimeter separates the repair area from sound concrete. The depth of the saw cut also determines the minimum thickness of the repair. To prevent further damage to the sound concrete and ensure long-term performance of the repair, hydrodemolition (refer to Fig. 1) is the preferred concrete demolition method, as it is most effective in preventing the concrete substrate from further damage, such as microcracking, that often results from using impact hammers. It is strongly recommended to conduct a test on a concrete sample that best represents the project conditions before the project begins to calibrate the pressure of the hydrodemolition equipment to obtain the desired results. It is also acceptable to use other methods, such as jackhammering, but the equipment used should be selected to minimize the potential damage by microcracking of the substrate.

Fig. 1: A concrete surface after hydrodemolition

Surface Cleaning

After the concrete removal process is completed, it is recommended that all exposed concrete surfaces be cleaned with a high-pressure water blast or with wet sandblasting, as dry sandblasting can be a safety hazard in some areas (refer to Fig. 2). This statement does not apply in the case of the hydrodemolition surface preparation method because this method provides the same result as water or sandblasting.

It is important to differentiate high-pressure water *blasting* and normal high-pressure water *washing*. High-pressure water blasting characteristics are considered to be as effective as wet sandblasting and are capable of cutting into the concrete surface. Depending on the concrete substrate quality the required pressure can vary between 3000 and 7000 psi (21 and 48 MPa). Normal high-pressure water *washing* requirements can be defined as follows: pressure (2200 psi [15 MPa]) and flow (5.3 gal./min [20 L/min]).

High-pressure water washing is mandatory for the last cleaning procedure before shotcreting

Fig. 2: High-pressure water blasting the concrete substrate after concrete removal with a jackhammer

starts, even when hydrodemolition is used. Although this procedure may seem redundant, it is a crucial step to ensure good quality bond between the substrate and the shotcrete repair by removing any microfractured concrete, dust particles, debris, and loose sand. This procedure is specified by the Ministry of Transportation of Quebec.[2] In addition to the cleaning procedures, it is also recommended that adequate prewetting of the concrete substrate is performed before shotcreting (refer to Fig. 3). This procedure has been described by Dufour et al.[3] Concrete substrates should be in a saturated surface-dry (SSD) condition immediately prior to the shotcrete application.

Bonding agents are never recommended when using the shotcrete process. Firstly, it is not necessary, as the shotcrete process provides excellent bond by itself. Secondly, if the bonding agent is not installed properly or the shotcrete material placement is delayed and the bonding agent dries out before the repair material is placed, the bonding agent will act as a bond breaker. Thirdly, it is another step added to the repair process. The more steps one adds to the repair process, the greater an opportunity for mistakes to happen. Finally, it will also create two layers where there could be potential for debonding instead of only one, which also increases the risk of failure. These comments on bonding agents are also reported in the Report Number MERL 12-17.[4]

Surface Preparation Testing

Evaluating the quality of surface preparation and ultimately the durability of bond is a critical factor in determining the quality of a repair. At the beginning of a major project, a qualification test of the repair method should be conducted. A representative surface area should be prepared with the selected technique and repaired with the chosen repair method. After a certain period of

Fig. 3: A worker prewetting the concrete substrate

time (for example, 28 days) after the repair is complete and the shotcrete has developed adequate strength, a pulloff test (refer to Fig. 4 through 6) should be conducted according to ICRI Technical Guideline No. 210.3-2004.[5] A proper bond should be typically higher than 145 psi (1 MPa), as reported in ACI 506R-05[6] but this value can vary depending on the substrate to repair, as mentioned in the Report Number MERL 12-17.[4]

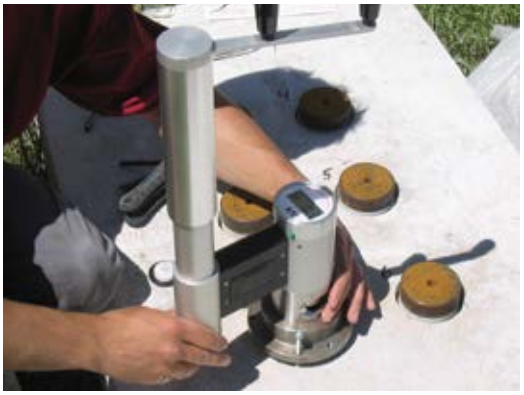

Fig. 4: A pulloff test being conducted on a test panel (photo courtesy of the Centre de recherche sur les infrastructures en béton (CRIB))

Fig. 5: Extracted cores after pulloff tests (photo courtesy of the CRIB)

Fig. 6: A hole after a core has been extracted during a pulloff test

The values obtained during the qualification of the repair method should be treated as a reference for the rest of the project. To assure quality during the project, surface preparation should be tested by repeating the pulloff test periodically.

Conclusion

A strong, durable bond is critical to a successful concrete repair. Surface preparation is a key element to achieving a strong, durable bond, but other aspects should not be neglected, as they also play a significant role in bond performance. Curing, carbonation, material selection, exposure, and load transfer, among many other factors, can influence the bond of any repair system.

References

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