Total Surface Selective Removal of Concrete Utilizing Hydrodemolition

By: Patrick Martens, P.E., Supervising Bridge Inspection Engineer (Missouri DOT)

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As an engineer with the Missouri Department of Transportation, spending over 26 years in field bridge maintenance and inspection, I have had the chance to participate in the evaluation of many products and processes related to bridge repairs. Without question though, one of the most fascinating processes I have encountered is the process of hydrodemolition, especially as it relates to bridge deck restoration. It is a process that has unlimited potential in changing the course of bridge deck preservation – and it has in numerous states already.

The technology is believed to have first been developed for use on bridges in Italy in the early 1980's, but it was the Swedish National Road Administration (SNRA) who aggressively pursued it as a process in the mid-80's for addressing their aging and rapidly deteriorating concrete structures. The process was introduced into the United States in 1979 on bridge deck patching type projects, but has continued to evolve through the years, especially as it is used in bridge deck restoration. In particular, a process known as "fast track" hydrodemolition is now a very practical and cost effective process to attack aging bridge decks and prolong their life.

Hydrodemolition is a method of removing unsound concrete that utilizes direct impact of a water jet through a combination of pressure and water flow. While the term hydrodemolition implies "destruction by water" it is essentially a restoration type process when performed under a controlled setting. When performed as a "fast track" operation, the robot is calibrated to *selectively remove* all deteriorated concrete across the entire bridge deck surface during a single pass of the equipment. It is the *selective removal* aspect of the "fast track" hydrodemolition process that is critical to the success of the operation.

Selective removal is defined as the capacity to remove all deteriorated or unsound concrete during the "fast track" hydrodemolition process, independent of the depth to which damage has infiltrated the slab. This means all weakened concrete (or concrete less than a certain pre-established strength) is only removed and all good concrete is left in place.

The underlying success to the fast track process is found within the surface preparation, and in particular, the selective removal that occurs with all deteriorated concrete in order to achieve the ideal bonding surface. A properly prepared surface, by hydrodemolition, has the other added benefits of the absence of micro-cracking; leaving reinforcing steel that is cleaned and left with no damage; and, of most importance, providing a surface substrate that will result in an enhanced bond strength aided by the surface roughness. The bond is critical in the success of the overlay. Plus, hydrodemolition obviously has the major advantage of removing large quantities of concrete in a relatively short period of time, which means production is greatly increased and less manual labor is required.

The demolishing effect of a hydrodemolition robot can be controlled to a desired level of removal, ranging from a surface scarification to deeper penetration cutting. This all starts with the calibration process. There are four key components to manage that are part of the calibration process of the hydrodemolition robot, to insure desired results are achieved for selective removal. This includes finding the correct pressure setting and water flow rate, determining the speed of the cutting head of the robot, and setting the desired step of the unit to insure that every square inch of the deck is uniformly attacked. All these features work together in a manner that provides consistent, repeatable results that are necessary to effectively remove all unsound concrete in a selective manner.

The most important of these components in attaining selective removal is correct pressure. While proper pressure is critical in the success of selective removal, a misconception is that if a certain level of pressure is good, more pressure must be better. In fast track hydrodemolition the goal is to achieve selective removal of concrete with a single pass that is achieved with the ideal pressure, flow rate, machine step and jet speed. There is a point at which too much pressure though can push the operation past selective removal of concrete and into a total removal process (removal of good concrete), and that is not desirable in the process. Likewise, higher pressures can have the reverse effect of not removing all deteriorated concrete due to the cutting speed. The water flow rate is probably the least important factor in the selective removal process. The production rate of the operation is a by-product of the water flow.

The SNRA established a series of tests in the mid 1980's for the purpose of proving that selectivity was being achieved with hydrodemolition equipment. This was done using slabs with varying indentations and depths, and cast with high design strength (5700 psi) concrete and lesser strength (2850 psi) concrete (to simulate deteriorated concrete). Jets with ranges from 14,000 psi to 17,000 psi were found to be the most acceptable in removing the lesser strength concrete within the general outline of the test slabs, verifying that the process was indeed selectively removing inferior concrete.[1] In other words, the best range to achieve selective removal is between 14,000 psi and 17,000 psi.

From an owner's standpoint, the overall quality that is achieved with selective removal is important from an economic standpoint. Traditional (and archaic) concrete removal specifications call out sounding and mechanical removal of deteriorated concrete with jackhammers. Typically, this would include removing good concrete too, as specifications often require the removal of all concrete to a prescribed depth below the reinforcing bars. With the selective removal process, essentially only that concrete which is deteriorated is being removed with a single pass of the hydrodemolition robot. This minimizes the amount of patching material required.

Insuring that unsound concrete is selectively removed enhances the success of the bond of the new latex concrete overlay, and improves the chances of a maintenance free surface for the owner for many years to come. There is no need to remove any additional concrete to get below the reinforcing steel, provided that there is no debonding of the concrete interface with the reinforcing steel. The superior surface profile that is the result of hydrodemolition, when utilized in conjunction with the latex material, provides sufficient bond for the new latex

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[1] Medeot, R. 1989. "History, Theory and Practice of Hydrodemolition." IN: Vijay, M.M., and Savanick, G.A. (eds.). *Proceedings of the 5th American Water Jet Conference, August 29-31, 1989, Toronto, Canada*, p. 99-110. Ottawa, Ont.: National Research Council of Canada ; St. Louis, MO: U.S. Water Jet Technology Association. http://www.wjta.org/images/wjta/Proceedings/5TH_WATERJET_CONF_889_RR.PDF

concrete to the deck. Latex not only adheres very well to a properly prepared hydrodemolished surface, but it can be placed (as thin as 1 ½”) over the entire deck surface in a single, monolithic pour. It also works well in variable depth situations when poured monolithically as an overlay, without premature cracking due to changing depths, provided proper curing is performed.

From an agency standpoint fast track hydrodemolition is a win-win proposition. If an agency takes the appropriate steps to drawing up proper specifications the results are fair for the owner and contractor. Hydrodemolition and latex concrete can each be bid separately per square yard based on the design for both the depth of cut desired, and the nominal concrete overlay thickness specified. Where deteriorated concrete is removed to depths that are beyond the anticipated removal limits, any excess latex material poured can then be paid per the actual volume used, beyond the plan quantity. The excess material is set at a fixed, pre-arranged price within the contract, for the cost of the material only. This is very important to protecting the bridge owner against costly overruns that could occur should the deck deterioration be much more than anticipated.

In the United States, fast track hydrodemolition is a proven technique for bridge deck rehabilitation. The next step in understanding the importance of the selective removal process, however, as it relates to fast track hydrodemolition, is education. State agencies are becoming more aware of the value in hydrodemolition, but often the mechanism to getting the ideal results – which is essentially selective removal – is not well understood. This is borne out with inconsistent or poorly written specifications, which lead to inferior results, not just in the end product in the field, but in substantial overruns (that can easily be controlled). By further educating DOT’s and other agencies in understanding the importance of how fast track hydrodemolition can save time and money on jobs, the power of selective removal can be realized.

The development of uniform specifications is important. For some reason each state sees a need to ‘reinvent the wheel’ to developing their own hydrodemolition specifications, when in fact there are already good specifications that have been developed by several states. This includes states such as Pennsylvania, Indiana, and North Carolina, who have served as leaders in implementing this process. It is important that other state agencies take advantage of this ground work that has been done for them already.

Ultimately, when the job is completed, and the proper specifications and methods of payment are utilized for removal and replacement materials, the result is a durable, long lasting and maintenance free surface that an owner can expect to get upwards of 25 years of service life. Plus, there is the added benefit of control over the tax dollars expended. In turn, that can result in a savings realized which can be used to further stretch out funds for additional bridge preservation projects.