Public works

A core strategy for effective and environmentally friendly utility cuts and repairs

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Abstract The keyhole coring and reinstatement process, like microsurgery in the medical field, enables utility crews to cost-effectively locate underground infrastructure or perform repair or maintenance work on underground infrastructure from the road surface through an 18-inch-diameter 'keyhole' cored through the pavement, thereby avoiding more costly, disruptive and inherently more dangerous excavation methods. It results in a permanent, almost invisible, perfectly matching, waterproof pavement repair which can extend the performance life of asphalt and concrete pavements and significantly reduce traffic delays and inconvenience to the public. Keyholes are smaller than conventional utility cuts and less destructive of the pavement as a load-bearing system. They will not sink, allow infiltration of groundwater or become potholes. There is no noise or vibration from jack hammers or pavement breakers used in conventional utility cuts to disturb the neighbours or damage the surrounding pavement and roadbed. The reinstated core will support a wheel load of 50,000lbs (22,680kg) — five times the AASHTO H-25 standard in just 30 minutes. It is a reliable, field-proven process with zero reported failures in more than 15 years and over 50,000 successful corings and reinstatements in tough urban climates. It is also an environmentally sensitive technology which eliminates the need for new paving materials and the disposal of old, by reusing the same materials that were used to build the roadway to repair it after excavation. The coring and reinstatement process reduces the carbon footprint of utility cuts and pavement repair using this process to one-sixth of that generated by conventional means and avoids the consumption of millions of tons of asphalt paving materials and the disposal of millions of cubic feet of asphalt spoil every year in utility cut repairs.

Keywords: *keyhole technology, utility cut repair, keyhole coring, pothole, road repair, pavement excavation and repair*

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INTRODUCTION

Providing and maintaining a smooth and safe riding surface on roads and streets is a major challenge for highway agencies and municipal transport officials, particularly when the road is the main corridor for utilities, and when utility cuts, needed to access and repair underground infrastructure, are poorly repaired afterward.

Utility cuts are made in pavements to install and repair gas, communications, water and wastewater infrastructure. They are also made to locate potential conflicts when doing horizontal directional drilling or to map existing infrastructure during subsurface utility engineering (SUE). This is called 'potholing' or 'daylighting', in which the underground utility is exposed by vacuum excavation through a small hole cut through the pavement. Once the inspection work has been completed, if the repair is not done properly, the repaired pavement will settle relative to the original pavement or crack and allow groundwater to penetrate into the subgrade. It is this groundwater that is the most common cause of pavement failures and potholes. If the repair is done properly, no groundwater penetrates, and one can perform 'potholing *without potholes*'.

How one makes the pavement cut is also important. Jackhammers and backhoes disturb not only the original pavement, but also the base course and subgrade soils around and below the cut to a distance of two to three feet (0.6–1m) beyond the limits of the actual trench. This additional area is termed the 'zone of influence' (see Figure 1).

Research conducted by the National Research Council of Canada and the Region of Ottawa-Carleton[2] found that improperly restored utility cuts can reduce pavement life by up to 50 per cent and have a cost impact of from $4.32 per square metre for pavements resurfaced more than ten years prior to the trenching, to as much as $23.78 per square metre for pavements that were resurfaced less than two years before.

Because it is considered to be in the public interest for utilities to use the right of way of public roads and streets when it does not interfere with the primary highway purpose, municipalities cannot arbitrarily prohibit utilities from installing or gaining access to their buried plant, even under newly constructed, repaved or 'protected' streets.

UTILITY CUT PERMITS AND RESTORATION PROCEDURES

While they cannot prohibit access, municipalities can, and do, seek to impose conditions on access in their utility cut permits that will allow them to recover reasonable administrative costs and compensation for actual or future damage, and to prescribe conditions and specify processes for repair and restoration.

But a regime of fees and arbitrary procedures may not be the best answer. Rather than simply increasing the street cut fees that they charge for presumptive pavement damage caused by utility cuts, or requiring slurry treatment or costly mill and overlay of all utility cuts, municipalities need to be more selective in the use of this powerful regulatory device. The result could be a situation in which the municipalities and their citizens end up with a cleaner environment, a better performing road system, and reduced traffic congestion and delay. And all this begins with the pavement cut permit.

Last year, an estimated 3.6 million pavement cut permits were issued at the municipal level across North America to facilitate the repair or installation of infrastructure, or to conduct SUE work in planning future infrastructure work. While these permits also cover extensive trenching and other large open pit projects, it is estimated that between 20 and 25 per cent, or approximately 800,000, are of the smaller utility cut variety in respect of

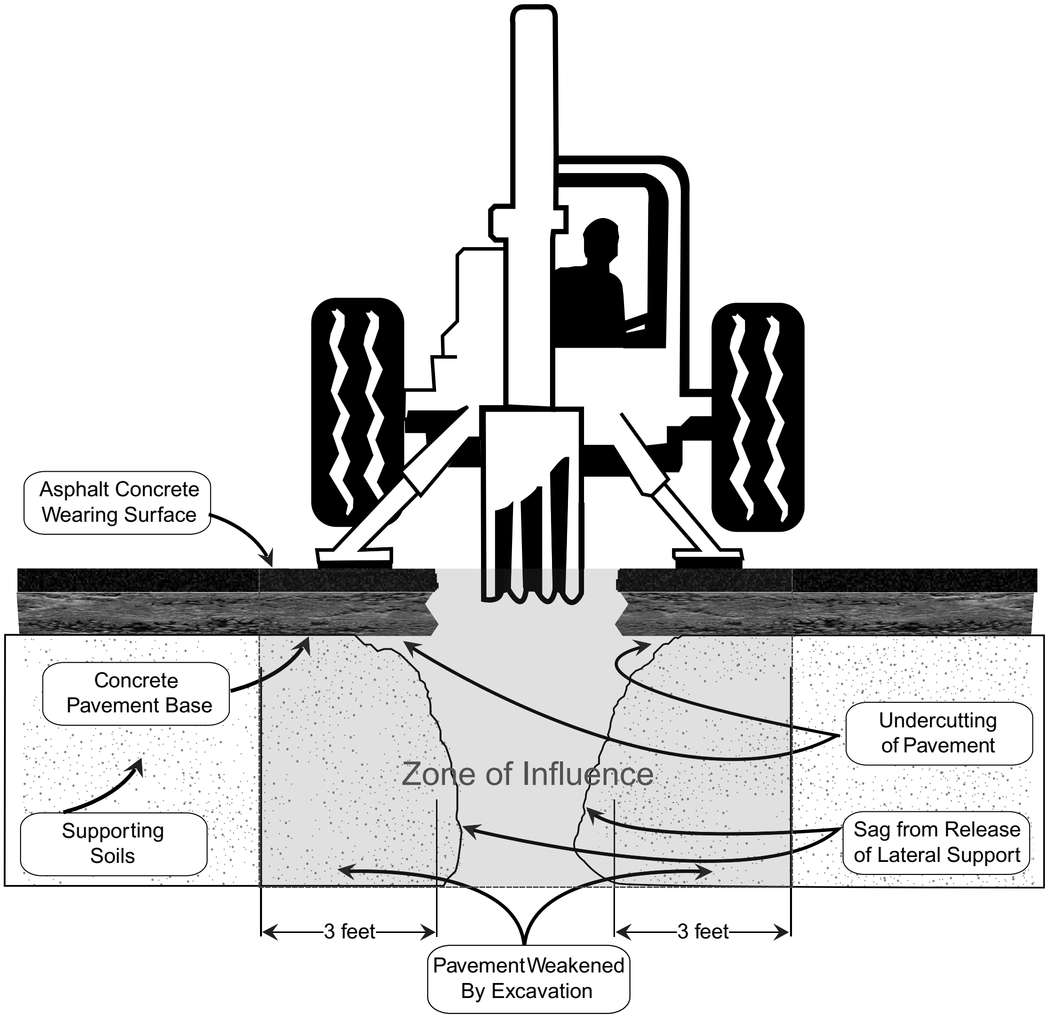

Figure 1: Zone of influence is the area around the excavation that is susceptible to slippage or collapse resulting from external surface load from vehicles, plant or excavated material at or near the excavation. (Original illustration University of Iowa[1])

work that could be performed through an opening no larger than two feet by two feet or two feet by three feet.

These cuts may start out to be small, but by the time one has applied the mandatory one- or two-foot (0.3–0.6m) T-section cut-backs required in many jurisdictions when permanently repaving or restoring the road surface, one has increased the size of the paving restoration (and disposal requirements) from four to six square feet ($0.36–0.54m^2$) to an area of 20–42 square feet ($1.8–3.78m^2$) of asphalt, eight to ten inches (20–25cm) deep. That is between one and two-and-a-half tons (0.9–2.25 tonnes) of old paving material that needs to be disposed of, and an equal amount of new paving material brought in to repair the road. Applied against the number of utility cuts of this size permitted each year, that would amount to almost two million tons of hot-mix asphalt (HMA) and an equivalent amount of spoil that had to be trucked away.

Spurred on by the spiralling cost of petroleum-based pavement products that consume vast amounts of energy to produce and emit large quantities of greenhouse gases in their production and transportation, momentum is building for sustainable solutions that encourage more environmentally friendly technologies in transport infrastructure construction and maintenance. These technologies can reduce the consumption of new paving materials and the disposal of old materials, and can directly reuse and recycle existing materials in the repair and maintenance of road systems. One of these environmentally friendly technologies is keyhole coring and reinstatement.

KEYHOLE TECHNOLOGY

Emulating a procedure practised by laparoscopic surgeons for years, keyhole technology is a process of excavating a small, precisely controlled, hole in the right of way to allow utilities to gain access to their buried infrastructure and repair it more safely from the surface using long-handled tools. It can also be used to identify the exact location of buried utilities to avoid damaging them during horizontal directional drilling or boring, and as part of SUE in the planning and design stages of highway construction. Vacuum excavation is used to remove the soil to expose the buried plant.

More recently, as shown in Figure 2, to facilitate vacuum excavation and location of infrastructure that is buried under paved surfaces, a rotary coring device has been adapted to core a small (up to 18in (45.7cm) diameter) hole through the pavement. The core or coupon of pavement is extracted and set aside to allow vacuum excavation to expose the underground plant. After the underground work has been completed and the hole backfilled to the base of the pavement, the same core of pavement that was removed earlier can now be bonded back into the roadway with a special bonding agent as a permanent repair. No pavement spoil is created, no new paving materials are required to repair the road surface, and the road can be safely reopened to traffic again within 30 minutes of the repair, thus reducing traffic congestion and public inconvenience.

Not only can the road be reopened sooner after the original excavation — at least an hour sooner than with conventional restoration methods — but, because the initial keyhole repair is ‘permanent’, there is no need subsequently to shut down traffic again for two to three more hours for permanent pavement repairs. This can mean an average reduction in road closing duration from three to four hours which, if

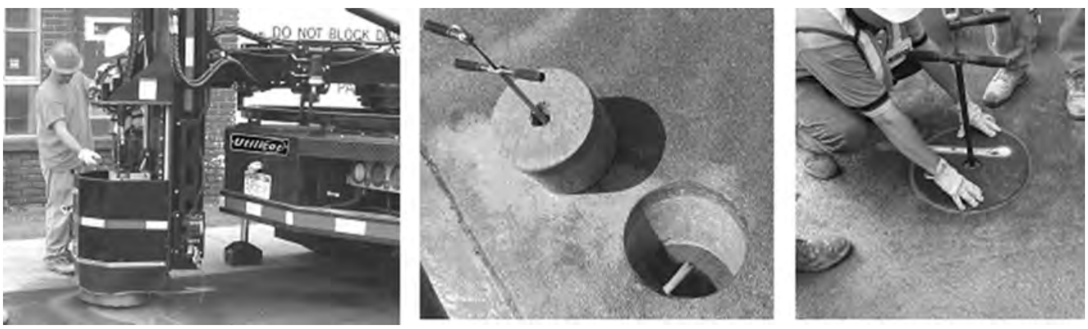

Figure 2: (Left) Rotary coring unit cores 18in (45.7cm) diameter core; (centre) core is removed and set aside. Vacuum excavation (not shown) is used to expose the infrastructure; (right) after the work has been completed, the core is replaced and bonded back into the pavement as a permanent repair

extended nationwide to each of the approximately 800,000 small hole utility cuts performed in our streets every year, could have a major impact on local traffic and the environment.

For example, if the process had been used in all 800,000 cases, where it was practical to do so, work-zone congestion could have been reduced nationwide by about two million hours of delay and would have meant savings of more than 1.3 million gallons (494,000L) of otherwise wasted fuel.[3] Add to that the reduction in consumption and disposal of paving materials and reduced pollution levels associated with the evaporation of volatile organic compounds from new-laid pavement, and one has a prescription for both huge economic savings and significantly reduced environmental impact.

REDUCED CARBON FOOTPRINT

Keyhole coring and reinstatement technology can also have an environmentally positive impact on utility construction and highway maintenance operations. The coring and reinstatement process significantly reduces the carbon footprint of utility cuts and pavement repair and minimises the atmospheric emissions of greenhouse gases by simplifying and shortening the maintenance and repair process, and by reducing the consumption of millions of tons of asphalt paving materials and the disposal of millions of cubic feet of asphalt spoil every year in utility cut repairs.

The utilisation of traditional open-cut methods for the installation or repair of underground utilities has been common practice for many years. Today, utility operators are being tasked with the requirement of selecting a suitable construction method that not only offers the most economical solution, but also minimises impact to the environment and reduces the carbon footprint of utility repair and maintenance operations.

Keyhole coring and reinstatement, in conjunction with other trenchless technology methods, offer an environmentally sensitive alternative for installing and connecting new gas, water and telecommunications utilities and rehabilitating existing infrastructure. The use of several different types of construction equipment, including jackhammers, concrete saws, backhoes, dump trucks, vacuum excavators, asphalt and cement delivery vehicles and pavement compactors, during open-cut construction and repair invariably results in considerably higher greenhouse gas and other emissions into the atmosphere compared with keyhole methods, which have minimal on-site equipment requirements: a coring unit, a vacuum excavator and a hand-held pogo tamper compaction device.

Not only does keyhole coring and reinstatement use fewer pieces of equipment than conventional excavation and restoration but, because it reuses the same core of pavement to permanently repair the roadway after the underground work has been performed, there is no spoil to be disposed of and no need for additional paving materials. The production of these paving materials — concrete and asphalt — is the second largest source of US carbon dioxide emissions after fossil fuel consumption.

Moreover, because the keyhole core reinstatement is a permanent repair, there is no need subsequently to close the road again to remove and replace a temporary asphalt pavement patch with a permanent repair, thereby avoiding the emission into the atmosphere of additional volatile organic compounds from newly laid asphalt pavement.

As shown in Figure 3, excluding the substantial energy consumption and carbon emissions involved in the actual production, delivery and application of new asphalt concrete to conventional pavement repairs,[4] the carbon footprint from conventional

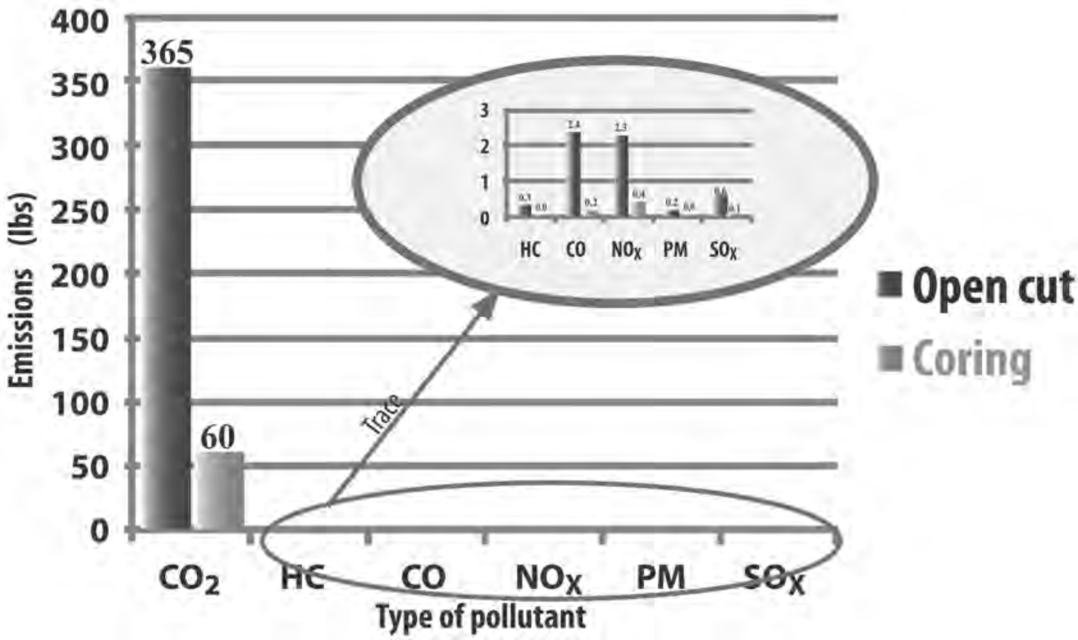

Figure 3: This chart, applying the carbon footprint calculator tool, eCalc[5] to engine emissions (CO_2, CO, NO_x, VOC, SO_x) from the equipment used in the excavation and repair process, shows that equipment used in the conventional open cut and restoration process generates 365lbs (165kg) of CO_2 compared with only 60lbs (27kg) of CO_2 for the equipment used in the keyhole coring and reinstatement process

open cut procedures was found to be six times greater than that generated by the coring and reinstatement option — 365lbs (165kg) of CO_2 vs 60lbs (27kg) of CO_2.

BETTER PAVEMENT REPAIR

The coring and reinstatement process also results in a better pavement repair, less damage to the remaining roadway and a waterproof mechanical joint that restores the road to the load-sharing capability that existed prior to the excavation. It also eliminates the potential for groundwater penetration, which is the major cause of potholes.

Attempts to use tack-coats or crack-sealants to create a waterproof, permanent joint between new asphalt and the original paved surface have limited success. Unlike bonding materials specifically designed for the process, such as Utilibond, which have high levels of adhesive and cohesive strength that can actually create a mechanical joint between the two surfaces, these tack-coats and sealants, as well as other common grouting materials, fail because there is virtually no adhesive or cohesive strength in the materials. As their names suggest, they are either 'sealant' or 'grouts' that fill the void between the two surfaces — but only as long as they remain in place undisturbed.

But that is not the nature of an active roadway which is designed to flex, absorb and transfer the vehicle wheel-load pressures along its length. Sealants applied at the perimeter of the patch and to the over-cuts of conventional pavement saws at the corners only achieve waterproof integrity as long as they remain intact and completely fill the kerf or void. Because the vertical joint between the two asphalt layers is inherently weak, it is susceptible to flexing, which causes the grouting material to pull away from one side or the other or, in the case of sealants, to be squeezed out by the action of traffic. This gap or opening allows groundwater to penetrate into the sub-surface where, today, it is acknowledged to be the leading cause of premature pavement failure and potholes.

Even the geometry of conventional repair procedures is suspect. The almost universal requirement that utility cut repairs be rectangular in shape and formed with straight edges running parallel or at right angles to the traffic flow can actually make the situation worse. The rectangular shape causes pressure to concentrate in the corners, which leads to cracks in the repaired section, permitting the infiltration of groundwater. A circular keyhole has no corners and, thus, no pressure cracks will develop. The requirement that the lines of the repair be oriented in the direction of the traffic flow may help to make the repair 'look neat', but structurally can lead to differential pressures or wheel loads on either side of the cut which help to expel the sealant and open the cut. Thus, the preoccupation with rectilinear pavement restoration geometry, mandated in most jurisdictions, may be more of a problem than a solution.

As shown in Figure 4, size also matters. The smaller and more precise excavation and permanent repair of a keyhole core requires no subsequent paving or milling and overlay, performs better and is much more aesthetically pleasing than the larger rectangular road cuts.

T-section cut-backs, in which the existing asphalt is cut back from between 12 and 24in (30.5–61cm) beyond the original excavation and the pavement removed prior to the installation of new HMA, in addition to adding significantly to the cost of restoration, are of little help.

Not only is a second cutting required, but what began as a two-foot by three-foot (0.3–0.6m) opening, with a two-foot cut-back, now becomes a six-foot by seven-foot (1.83–2.13m) opening, which increases the area that must be restored sevenfold — from 6 square feet to 42 square feet (0.54–3.78m^2). This means that seven times as

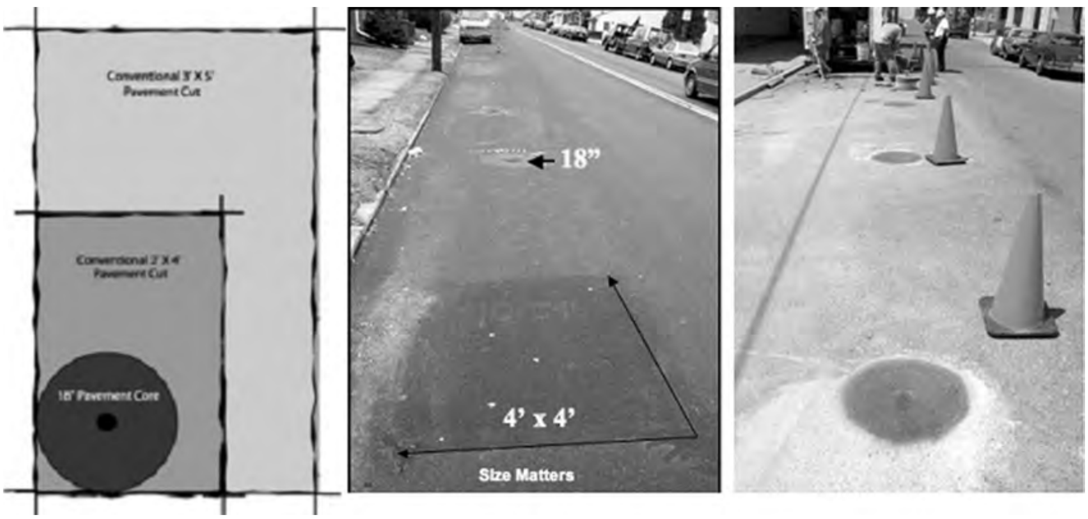

Figure 4: Size matters. (Left) An 18-inch-diameter circular keyhole is less than half the size of a standard two-foot by four-foot cut and, because it is circular, has no corners in which to develop pressure cracks. (Centre and right) The large conventional repair of a two-foot by two-foot utility cut with a one-foot cut-back all around (making the area to be repaired four feet by four feet) is much more intrusive that the 18-inch keyhole behind or the series of keyholes on the right

much sound pavement has to be removed and disposed of, and seven times as much new HMA must be provided to complete the restoration.

Proponents of the cut-back theory argue that the additional cost and effort are justified because it can add structural strength to the repair and provide a better seal against water intrusion. But, while both are admirable objectives, there is no evidence to suggest that either is achieved by the cut-back.[6]

Structural strength is supposedly gained by some kind of bridging effect. But bridging strength is normally not found in a visco-elastic material such as asphalt. Moreover, laboratory research done on full-size cuts, using servo-hydraulic equipment capable of providing millions of repetitions of heavy wheel loads, found that it was poor soil compaction that was the overwhelming cause of settlement or deflection, and that poor soil compaction was not in any way mitigated by the cut-back.[7]

As far as moisture penetration is concerned, the cut-back is supposed to reduce this by creating a more complex path for the water to follow. But this too seems doubtful, especially from a process that actually increases the potential for infiltration by extending the perimeter of a two-foot by three-foot (0.3–0.6m) cut, with a two-foot cut-back, from 10 linear feet to 28 linear feet (3–8.5m) — almost three times as long. If one of the problems sought to be overcome by this process is the failure to devise a reliable and long-lasting method of sealing the crack between the patch and the remaining pavement, it is difficult to see how trebling the length of the area of potential failure can have a salutary effect on the repair.

CORING AND REINSTATEMENT HAS BEEN FIELD PROVEN OVER 15 YEARS

The coring and reinstatement process was developed and field proven in the City of Toronto, where it was ultimately accepted and approved as a permanent pavement repair after monitoring the performance of thousands of reinstated cores in city streets from 1988 to 2003. To date, more than 50,000 cores have been cut and reinstated in North America, with zero reported failures.

As part of the proof, Golder Associates, an internationally respected science and engineering firm was retained to monitor the development of the pavement coring and reinstatement process and to evaluate a broad range of potential bonding products. Among the evaluation criteria for the selection of the appropriate bonding material were: fast setting and rapid strength gain to minimise traffic disruption; high bond strength to exceed AASHTO standards (safety factor) and to create a long-lasting, mechanical joint with the remainder of the pavement; low shrinkage to ensure the waterproof integrity of repair; high flowability to ensure complete coverage with no voids; convenient mixing and use characteristics to ensure uniform and consistent application; a wide range of operating temperatures to extend use of the process; and non-hazardous impact on crews and public.

In addition to these prescriptive performance characteristics, the bonding agent needed to achieve an effective coupling or 'structural bonding' between the core and the pavement in such a manner that the road would regain its design ability to share and transfer the effect of traffic loading from one section to another. This is a 'hot-button' issue for those who are responsible for maintaining the road systems.

The Golder study spanned the period 1992–1996 and encompassed a series of field trials and laboratory tests on more than 20 potential bonding materials. It resulted in the selection of a single process, cementitious bonding compound (now Utilibond), which had been specially designed for the process. Golder continued to monitor the effectiveness of the process for a period of ten years and in April 2003 reported that:

> 'The lab trials and previous demonstrations on the rotary cutting method have shown that the pavement coupon has been bonded into the slab in such a manner that the loads of traffic are effectively transmitted to the remaining intact slab. Based on trials carried out at our testing laboratory in Whitby and our in-field performance observations, we are satisfied that the equipment, procedures and materials [including Utilibond] developed and used by Enbridge Gas Distribution over the last 10 years will ensure satisfactory long term performance of pavement reinstatement.'[8]

This study is the only ten-year longitudinal study to evaluate the effectiveness of a road reinstatement process by monitoring the degree of coupling between the undisturbed road structure and the newly restored utility cut (see Figure 5).

Subsequently, from 2000 to 2003, these impressive results were independently confirmed by testing by the Joint Utility Cut Study led by the National Research Council of Canada and the United States Army Corps of Engineers. A report on the results of a Field Investigation conducted in Toronto, Ontario, between October 2001 and April 2003,[9] which monitored and compared the performance of the excavation and restoration procedures involved in a conventional trench excavation and a cored and reinstated keyhole, did find that the keyhole repair outperformed the conventional rectangular utility cut by a substantial margin.

Surface and subsurface data collected from sensors embedded in both excavations and visual observations over the 18-month test period revealed that the restored keyhole performed better and caused less damage to the road system than the conventional rectangular utility cut performed with a road saw and backhoe and restored in a conventional manner with newly poured concrete and newly laid asphalt.

Figure 5: To test the effectiveness of the bond, Golder cut satellite core samples through the kerf of previously reinstated cores. These samples (right) showed perfect and complete bonding or adhesion of the Utilibond to both the surface of the core or coupon and the surface of the remaining pavement, as well as excellent 'cohesion' through the joint itself. The light grey line in the photograph is Utilibond, showing excellent bonding of the asphalt–concrete core (central area) to the undisturbed pavement (outer layer) with complete infilling of voids in pea gravel (bottom). The core, which is directly in the wheel path of a transit lane of this arterial road, showed no deflection from the time it was first reinstated in September 1995 (left) to December 2002 (centre) notwithstanding the fact that, during the seven-year interval, more than 145,000 transit buses and 13 million commercial and other vehicles have passed directly over the keyhole with no apparent weakening or other degradation of the reinstated core or the adjacent road system or paved surface

Specifically, settlement and deflection had occurred along the wheel path in the conventional repair, and the material used to seal the joint had been lost through the action of traffic shortly after its application. These failures allowed the joint between the road and the repaired section to open and was considered to be the most likely cause of higher than normal levels of moisture at the bottom of the open cut compared with the keyhole cut.

By comparison, the keyhole repair showed no distress, remained level with the road profile, and performed well throughout the life of the experiment, with no signs of cracking or separation in the bonding compound surrounding the core.

The smaller footprint of the keyhole was also credited with reducing the level of wheel-load stress transmitted to the underlying sections of the roadway compared with the standard cut, and the circular shape minimised the potential for the propagation of pressure or stress cracks in the corners of the repair.

Based on these findings, the Report on the Toronto Field Investigation concluded that the keyhole coring and reinstatement process was an effective restoration technique that should be encouraged whenever feasible to minimise the need for opening large trenches in the future.

> 'The keyhole cutting and restoration technique that was evaluated in the Toronto field experiment indicates that the process is practical and effective in reducing the potential for damaging the road. It is recommended that the keyhole application be encouraged whenever proven feasible.'

FAST STRENGTH GAIN (30 MINUTES) WHICH SUPPORTS 50,000LBS FORMS BASIS OF TORONTO STANDARD

The fast strength gain and overall bond strength performance of Utilibond was independently confirmed in 2003 by testing at the Newmark Civil Engineering Laboratory of the University of Illinois at Urbana Champaign (UIUC).[10] The comparative testing of three commercially available bonding materials concluded that:

> 'The Utilibond material was the only bonding material that demonstrated satisfactory performance in the 30 minute tests [where it gained sufficient strength to support a single wheel load of more than 50,000lbs (22,680kg)]. Since all three materials ultimately achieve high safety factors against core punch out, it is reasonable to emphasise attributes of performance such as rapid set time and workability. Rapid set time and workability are meaningful attributes in the field application, and effectively differentiate the performance of bonding materials for reinstatement of cores.'

In May 2009, the bond strength of Utilibond was tested by Construction Technology Laboratories (CTL), an American Association of State Highway and Transportation Officials (AASHTO) approved testing facility, as part of the certification process for the Illinois Department of Transport. In their test of Bond Strength Using the Slant Shear Method (ASTM C 882), CTL reported that the fracture pattern revealed in the tests indicated that the bond formed by Utilibond was actually stronger than the pavement itself.[11]

The UIUC findings, together with the results of the Joint Utility Cut Study form the basis of the approval of the process by the City of Toronto and its promulgation in November 2007. TS 4.70: Construction Specification for Keyhole Excavation and Permanent Reinstatement of Keyhole Cores[12] is the first comprehensive set of acceptance and performance standards for the keyhole coring and reinstatement process in North America.

The Standard is far reaching and comprehensive. The maximum diameter of the core is specified to be 460mm or 18 inches, but, with prior approval of the city, larger cores up to 610mm or 24 inches in diameter, or overlapping cores, may also be cut. This is important, because some locates may be a little off or a larger opening may be required to perform the repair work (see Figure 6).

The minimum depth of asphalt or flexible pavements in which the process may be employed is fixed at 100mm or four inches. There is no thickness limitation on other types of pavement or sidewalks. The Standard also requires that the core be cut with equipment that is capable of accurate vertical adjustment, to ensure that the core is cut in an alignment perpendicular to the horizon.

A central part of the Standard establishes minimum performance criteria for the high-strength bonding material to be used to bond the keyhole core or coupon back into the pavement. To be approved, the bonding material must be capable of generating a waterproof bond that, within 30 minutes of application at 70°F (21°C), achieves an equivalent traffic loadable condition at least two times greater than the AASHTO H-25 standard or 30,000lbs (13,600kg).

In the event that the keyhole cut cannot be reinstated within 24 hours, or a temporary covering is required to restore traffic flow, the Standard mandates the use of a circular steel road plate, fitted with a

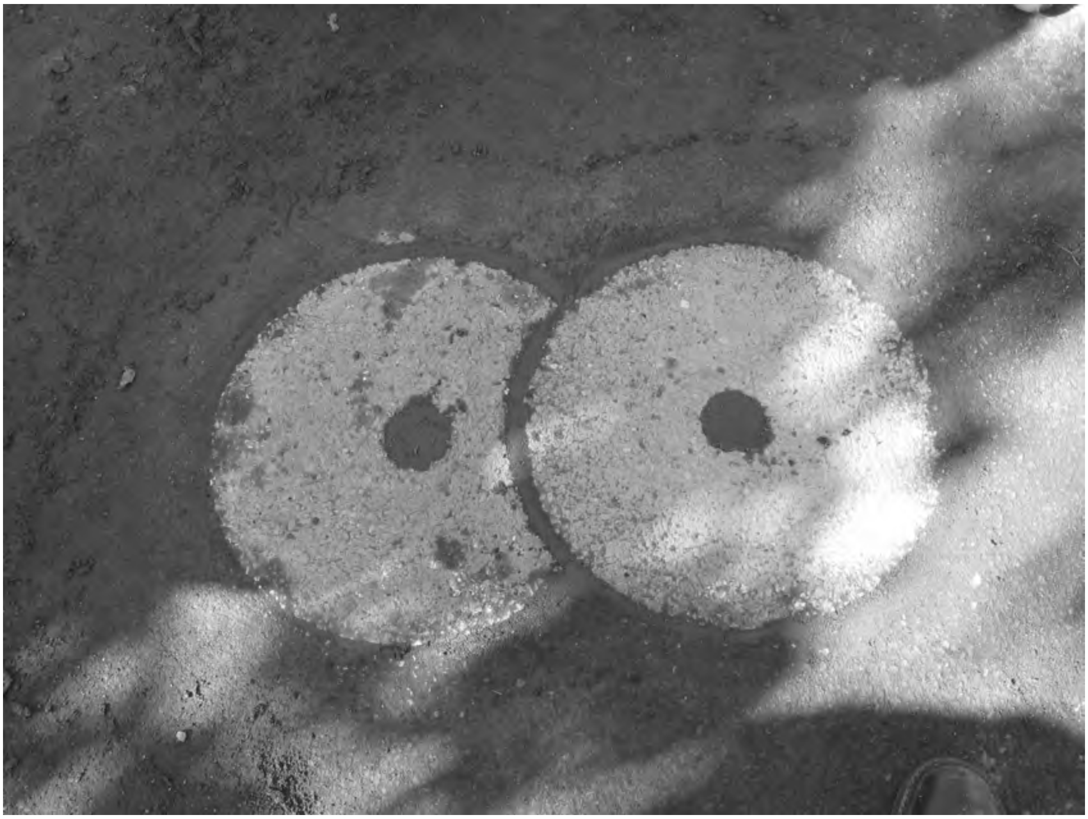

Figure 6: Sometimes two cores may be better than one. For example, a locate may be slightly off or a larger opening may be required to make the repair or properly locate and identify the infrastructure. In that case, a second or overlapping core may be cut to expose the infrastructure. When the work has been completed and the excavation backfilled, the two cores can be reinstated as a permanent repair using the same technique as for a single core

Figure 7: View: Bathurst Street in Toronto, looking north. Keyhole cores are cut to identify potential conflicts during HDD and temporarily capped with a circular road plate which allows traffic to flow uninterrupted on this busy thoroughfare while directional drilling takes place

collar which, when inserted into the keyhole, will prevent the hole cover from tipping, tilting, bouncing or spinning out of the hole in all kinds of traffic conditions.

These road plates, which weigh about 40lbs (18kg) and are easily handled by one person, allow the road to be reopened again to traffic while other aspects of the work are being performed. This results in better scheduling of operations and less inconvenience for the public.

For example, as shown in Figure 7, in the City of Toronto, Enbridge Gas Distribution needed to tie in a new four-inch (10cm) gas main laid down the west side of a busy arterial street to services in residences and businesses on the east side, using directional drilling. Before the drill pits were dug through the sidewalk on the west side, a series of five cores were cut in the roadway along the intended drill paths to 'pothole' and identify the exact location of potential north–south conflicts which included a 24-inch (61cm) water main, an eight-inch (20cm) water main, a six-inch (15cm) gas line and two electrical and telephone lines running under the sidewalk on the east side of the street.

In order to make the most efficient use of the drilling crew's time, the cores were cut and the conflicts exposed by vacuum excavation in advance of the drill shots, and road plates inserted to allow the road to be kept open to traffic. When all the keyholes in two or three blocks had been dug, the directional drill arrived on scene and began its work of safely completing the connection. A core reinstatement crew followed up backfilling and reinstating the cores and the entire project of more than 4.5 miles (7.24km) was completed in this manner. Except for very brief periods of time, at least two lanes of traffic remained open at all times.

CONCLUSION

The coring and reinstatement process has been field proven and is currently employed in North America and the UK by more than 30 leading gas and other utilities and their contractors. It saves both time and money for everyone involved, consumes far less energy and raw materials than conventional repair methods, reduces harmful emissions to the atmosphere, results in shorter and fewer road closings, is more convenient for the travelling public and the neighbours and causes less damage to the road system and the environment than conventional excavation methods do.

Rather than jackhammers, pavement-breaking devices and backhoes, which disrupt or damage the adjacent pavement structures, the excavation is accomplished with the surgical precision of a pavement-cutting saw. The circular geometry of the cut eliminates the possibility of corner pressure cracks which typically plague conventional rectangular pavement repairs and are the major cause of infiltration of groundwater, which ultimately results in potholes.

The process uses the very same materials used to build the original roadway to permanently restore the utility cut in an environmentally friendly way. No pavement spoil is created, no additional paving material or resources are consumed, and no volatile organic compounds or other harmful emissions escape to the atmosphere. Most important is the fact that this is a quick, cost-effective and easy permanent repair, which allows the road to be safely reopened to traffic again within just 30 minutes of completion of the underground work and requires no subsequent road closing to carry out a permanent repair.

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