Stop cutting corners

Keyhole technology, a core strategy for effective and environmentally-friendly utility cuts and repairs

BY MARSHALL POLLOCK

As complex as public infrastructure systems are, they have one common denominator: Over time and with use they will wear out and must be replaced. Many are buried underground and are difficult to access, inspect and maintain. As such, they are "out of sight and out of mind" or literally invisible. However, roads and public thoroughfares are not and their failure is evident.

Along with this need for highway agencies and municipal public works officials to work to maintain a smooth and safe running surface, there exists an equally demanding and essential requirement on gas, communications, water and wastewater utilities, who own or operate the thousands of miles of infrastructure buried beneath those roads, to cut through them to reach and repair or replace their aging infrastructure as it fails or nears the end of its useful life.

In addition, these cuts are also used to locate potential conflicts or obstructions when performing horizontal directional drilling or to map existing infrastructure during subsurface utility engineering (SUE). Once the underground work has been completed, if the excavation is not restored properly, the repaired pavement will settle or crack and allow groundwater to penetrate into the subgrade where it can cause premature pavement failure. For this reason every municipality seeks to regulate this kind of excavation through a system of permitting.

Utility cut permits

Last year, the City of Toronto issued more than 38,000 of these utility cut permits. It is estimated that, in total, municipalities in Canada and the U.S. issue more than 3.6 million of these road cut permits every year.

Some of these are for major trenching projects and others are for small holes used for minor utility repairs or to identify the location of underground infrastructure when directional drilling or for road design and planning. The Gas Technology Institute estimates that between 20 to 25 percent, or about 800,000 of those permits, are of the small hole variety measuring no more than four square feet (0.37 cubic metres) or so. These could be candidates for a made in Canada technology – keyhole coring and reinstatement – that have been cost-effectively used in hundreds of municipalities across North America for almost 25 years.

Keyhole technology

Keyhole technology is a process of excavating a small, precisely controlled, circular hole in the right-of-way to accurately locate buried infrastructure or to gain access to that infrastructure to install or repair it more safely from the surface of the road using long handled tools.

After the underground work has been completed, and the excavation 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 and no new paving materials are required to repair the road surface. The road can be safely reopened to traffic within 30 minutes of the repair, thus reducing traffic congestion and public inconvenience.

Not only can the road be reopened sooner but there is no need to subsequently shut it down again for permanent pavement repairs. This results in a further reduction of road closure time (and public inconvenience) of between two to three hours. In this way keyhole coring and reinstatement can reduce the duration of utility cut repair by an average of three to four hours over conventional methods.

A better, safer and less intrusive excavation method

Keyhole technology not only saves time and is safer for the workers but it can actually help to extend pavement life.

Jackhammers, pavement breakers and backhoes not only disturb the neighbours as they chop through the pavement but they can damage pavement and subgrade soils – well beyond the extent of the excavation itself – both around and below the cut.

Even the geometry of conventional pavement excavations makes little sense. The almost universal insistence by municipal authorities that utility excavations and repairs be rectangular in shape and formed with straight edges running parallel or at right angles to the traffic flow can actually contribute to pavement failure.

Basic mechanics teaches that the rectangular shape of a conventional utility cut allows pressure from traffic to concentrate in the corners of the repair. This pressure can be at least four times greater than in the rest of the structure and is the cause of the diagonal cracks that form in the corners of the pavement abutting the repaired section. Because a circular keyhole has no sawing over-cuts or corners in which pressure cracks can form, it eliminates a major access point for groundwater that can lead to premature pavement failure.

Size also matters. Laparoscopic surgeons have known for years that smaller and more precise incisions are better for the patient. The recovery period is shorter, the incision heals faster and as it is the incision that leaves a smaller scar, and


Left: Rotary coring unit cores 18-inch (457 mm) 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.

the entire operation costs less. The same holds true for keyhole pavement cuts. The smaller and more precise excavation causes minimal damage to the road system, can be repaired much faster and leaves a smaller footprint that is almost invisible. Because a reinstated keyhole core is a permanent repair and requires no subsequent paving or milling and overlay, it costs less, performs better and is much more environmentally friendly than conventional rectangular road cuts.

Other conventional restoration methods like T-section cutbacks also do not make much sense. As practiced in many jurisdictions, a T-section cutback involves the cutting and removal of the existing layer of asphalt from between 12 and 24 inches (30.5 and 61 cm) beyond the original excavation, prior to the installation of the new asphalt surface.

Proponents of the T-section cutback argue that the additional cost and effort are justified because it can add to the structural strength of the repair and provide a better seal against water intrusion. However, there is no evidence to suggest either is achieved by the cutback.

They also say that structural strength is enhanced through a "bridging effect." However, little if any bridging strength is found in a visco-elastic material like asphalt. Moreover, laboratory research done on full-size cuts, using equipment capable of providing millions of repetitions of heavy wheel loads, found that, whatever the cause of settlement or deflection, it was not in any way mitigated by the cutback.

The cutback theory is also supposed to reduce groundwater penetration by creating a more complex path for the water to follow. Yet the cutback itself actually increases the potential for infiltration by significantly increasing the perimeter of the cut. For example, the perimeter of a two-foot (0.6 m) by three-foot (0.9 m) excavation, with a two-foot cut-back, grows from 10 linear feet (3 m) to 28 linear feet (8.5 m) – almost three times as long – through which groundwater will inevitably pass when the material used to seal the joint is expelled by the action of traffic.

Continued on page 18

Field proven and laboratory tested

Keyhole coring and reinstatement is not a "flash in the pan" technology. It has been field proven and laboratory tested for more than 25 years and boasts more that 350,000 successful cuts and reinstatements in thousands of municipalities in North America and Europe.

It was developed in Canada where Golder Associates, an international engineering firm, worked with Enbridge Gas Distribution to perfect the system in the 1990s. Following the specifications of the Metropolitan Toronto Transportation Department, Golder tested more than 20 core bonding compounds until it found one that met all of the requirements, including: rapid strength gain to minimize traffic disruption; superior bond strength that exceeded AASHTO wheel load standards for safety; and the capability to form a long lasting, mechanical, waterproof joint with the remaining pavement – as well as being safe and easy to use. The result was Utilibond, that has now become the industry standard for core reinstatement.

In 2002, after monitoring the process for more than 10 years, Golder reported:

"The lab trials and demonstrations of 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 [these] trials we are satisfied that the equipment, procedures and materials developed and used by Enbridge Gas Distribution over the last 10 years will ensure satisfactory long term performance of pavement reinstatement."

At the same time, the National Research Council of Canada and the U.S. Army Corps of Engineers on behalf of a number of North American cities, utility companies and U.S. state departments of transportation undertook a joint study on the *"Restoration of Utility Cuts"* to develop a guide for best pavement restoration practices based on sound engineering principles.

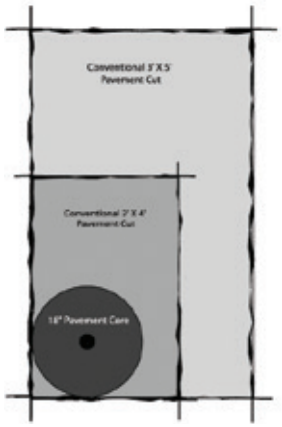
As part of this study, a Field Experiment was conducted in Toronto using two cut sections – a conventional transverse trench and a keyhole. Both the conventional cut and the keyhole were instrumented to monitor traffic-induced stresses and moisture conditions in the lower layer of the excavations. After placement of sensors in the sand layer surrounding the buried pipe, unshrinkable fill was poured into both excavations and brought up to the level of the base of the pavement.

Monitoring of the excavations during the three-year period of the study from 2001 to 2003 noted:

"There were noticeable failures in the repair of the conventional cut. The conventionally repaired joint between the road and the cut opened. The location of this joint separation coincided with visible settlement in the trench along the wheel path. The material used to seal the joint was lost under the action of traffic as a result of shear flow or pullout of the sealant and there are indications that the sand cover and surrounding clay in the conventionally restored cut were exposed to higher than normal levels of moisture (compared with the keyhole)."

"There were no defects noted in the keyhole cut. The keyhole section established on October 2001 continued to perform well throughout the life of the experiment. The surface of the restored keyhole remained at level with the road profile. The grout [Utilibond] surrounding the AC/PCC plug remained intact (no cracking or separation) and the surface and subsurface data … revealed that the restored keyhole performed well and resulted in no damage to the road."

The report concluded that: "Keyhole construction and restoration technique produced an effective result that should be encouraged whenever feasible to minimize the need for opening large trenches in the future."



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 & 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 than the 18-inch keyhole behind it, or the series of keyholes on the right.

As a result the City of Toronto approved the process and in 2007 established the Construction Specification TS 4.70 for keyhole excavation and permanent reinstatement of keyhole cores that has guided utilities and their contractors in the execution of their work ever since.

Other utilities across North America have followed suit, and keyhole coring and reinstatement is fast becoming the excavation process of choice among utilities and their contractors interested in an environmentally friendly and cost-effective way to perform their work in city streets, without cutting corners.

Utilicor Technologies Inc.

Marshall Pollock is the president & CEO of Utilicor Technologies Inc., manufacturer of keyhole coring equipment and Utilibond permanent core bonding compound.