UTILICORING:
A UNIQUE CORING AND PAVEMENT RESTORATION PROCESS

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ABSTRACT:

This paper discusses Utilicoring™, a unique pavement excavation and restoration technology. This technology was developed and field-proven over the last ten years by Enbridge Consumers Gas. This process facilitates utility access to underground plant and is a key cost-saving element in the growing utility maintenance trend to “keyhole” technology, which allows crews to cost-effectively perform repair or maintenance work on underground pipe or other buried plant from the road surface without resort to more costly, disruptive and inherently more dangerous excavation methods. It also has direct application to other utility service and trenchless operations including test holes and daylighting for directional drilling, inspection holes for pipeline integrity and subsurface utility engineering.

Introduction

Underground service repair is one of the most disruptive operations in city streets. Not only is there major traffic disruption during excavation and repair, but also the repair itself may give rise to poor pavement performance and be a source of ongoing maintenance for the municipality. The Consumers Gas Company Ltd. (now Enbridge Gas Distribution) has over the last twelve years worked to develop less intrusive keyhole repair technologies employing, among other things, a rotary cutter and improved pavement reinstatement techniques including a proprietary bonding compound called **"*Utilibond*™"**.

Figure 1.*The Utilicor coring unit operates through a complete 270º arc, allowing the truck to be positioned on the shoulder or off the traveled surface to minimize traffic disruption.*

Rotary coring neatly and accurately cuts through all types of paved surfaces and facilitates utility access to underground plant. It is a key cost-saving element in the growing utility maintenance trend to "keyhole" technology, which allows crews to cost-effectively perform repair or maintenance work on underground pipe or other buried plant from the road surface without resort to more costly, disruptive and inherently more dangerous, excavation methods. It also has direct application to other utility service and trenchless operations including: test holes, service drops and shallow splice pits for the telecommunications and cable industry, daylighting and test holes and bore-gel blow-out holes for directional drilling and inspection holes for pipeline integrity and SUE.

The technology, as shown in Figure 1, involves a very robust, purpose-built, rotary cutting unit that works through a complete 270º arc (patent pending) that quickly and cost-effectively cores an 18" diameter hole through asphalt, asphalt-concrete and reinforced concrete road systems and sidewalks to enable crews to vacuum excavate, and view subsurface activity or repair underground plant from the road surface using long handled tools. After the repair has been completed, the hole is backfilled to the level of the base of the pavement and the core or "coupon" that was originally cut from the pavement, is reinserted back into the road surface where it is permanently bonded by a special proprietary adhesive (*Utilibond*™) which creates a bond stronger than the original pavement. According to tests conducted at the University of Illinois Urbana-Champaign, the bonded core has sufficient strength to support the combined weight of five transit buses (50,000 lbs.) – five time the AASHTO H-25 standard -- and allows the road to be opened to traffic within 30 minutes of the repair. (Lange 2003)

A win-win process

Rotary coring and reinstatement is a cost-effective, "win-win" process that offers significant cost savings and other benefits to gas and other utilities, their contractors, their crews, their clients and their communities.

The utility or contractor saves money. The rotary coring and reinstatement process dramatically reduces paving budgets and saves up to $1,000 per hole over traditional pavement cut and repair methods (Table 1). Because it is a faster, less intrusive process, it results in fewer complaints from municipalities about unsightly road cuts, sunken patches or weakened or failed roads and can be a source of positive community relations. It is a reliable, field-proven process with ZERO reported failures in more than 10 years and thousands of successful corings and reinstatements in tough urban climates. (Golder 2003)

Table 1. Cost Advantages of Utilicoring

Activity	Conventional Road Cut*	Utilicoring Process
Road cut with concrete saw	$375	$0
Break out by backhoe & disposal	$175	$0
Set up and rotary cut (estimated)	$0	$200
Vacuum excavation	$100	$100
Backfilling after repair	$100	$100
Permanent reinstatement of the core	$0	$100
Temporary surface patch/repair	$100	$0
Permanent pavement repair	$150	$0
Road Rehabilitation Fee	$500	$0
Total	**$1,500**	**$500**
Costs based on actual results at Enbridge, MichCon & Nicor. Specific results may vary.		

One-stop, same-day coring and pavement reinstatement means improved logistics for both the utility and its contractors with simplified crew scheduling, no temporary patching or repaving and no repeat site visits. Directional drillers are able to locate and verify potential underground conflicts in minutes and permanently reinstate the pavement immediately after drilling. Its ten year, proven track record, supported by independent engineering reports and test data, helps gain quick approval for the process from municipalities and other highway authorities or DOTs.

Simpler and safer for the crews. Easy and simple to operate, the coring unit is physically less demanding than other methods and eliminates the need for jack-hammers, hand-digging and backhoes. It lets the crew work smarter and safer and reduces potential for workplace injury. The reinstatement process is also simpler. Easy opening, pre-measured plastic pails mean no more awkward measuring and mixing from fragile paper bags. Just add water to the line on the pail, stir and pour into the hole.

The community also benefits. Faster, one-step permanent pavement repair means reduced traffic disruption with fewer and shorter road closings. The road can be open for traffic just 30 minutes after the repair. This means better relations with the traveling public and residents – both of the constituencies most affected by utility roadwork. The less intrusive, more precise pavement coring and reinstatement process also means less structural damage to the road system, longer pavement life and reduced maintenance that saves millions of tax dollars. Of equal importance is the fact that the pavement repair exactly matches the composition of the original roadway from which the core was extracted. Once the core is bonded in place with *Utilibond*™, the road regains its original performance characteristics. (Golder 2003)

Utility cuts and pavement performance

Improperly restored utility cuts can affect pavement performance and contribute to deterioration and reduced pavement life. Keyhole technology procedures and rotary coring and reinstatement processes are designed to minimize the impact of utility cuts on roadways and other paved surfaces by reinstating the paved surface to the operating condition that preceded the repair.

Pavement design: Pavements are designed as systems to share the vertical wheel load laterally across the paved surface, thereby reducing the vertical pressure on the sub-grade. The following diagram (not to scale) illustrates how pavements are designed to carry load and the difference in performance characteristics between roads that have been cut and repaired in the conventional manner and those that have employed the rotary coring and reinstatement process.

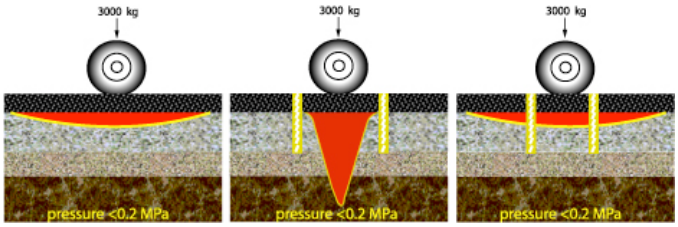

Figure 2. *Utility cuts reinstated with Utilibond restore the ability of the road to perform as a system and share the surface load laterally as originally designed, thereby minimizing damage to the sub-grade.*

The illustration on the left shows the normal uncut road with the surface load distributed through the pavement (the red area) in a lateral fashion, as postulated in conventional road design theories.

The center illustration shows the result of a conventional utility cut repair where the edge of the repair has not properly bonded to the remaining pavement and the road has not been reinstated as a system. In this case the surface load is not transmitted laterally beyond the perimeter of the cut, with the result that the pressure (the red area) is concentrated vertically downward directly into the sub-grade where it can result in more rapid deterioration of the roadway. In extreme cases, the pavement cut repaired in the conventional way, may actually "float" free of the rest of the surface resulting in surface cracking and spalling which can allow surface water to infiltrate the sub-grade.

Finally, the illustration on the right shows the results of a utility cut reinstated with *Utilibond*™. In this case the core and the balance of the pavement have been reintegrated into a *load-bearing system*, capable of laterally transmitting the surface load across the original cut lines to the remainder of the roadway. The reinstated roadway is again capable of performing in accordance with the original pavement design specifications. (Golder 2003)

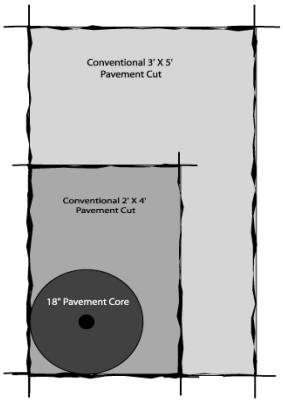

Figure 3. *18" circular core is 80% smaller than conventional rectangular utility cuts.*

Geometry: The circular shape or geometry of the cut is also important. Square or rectangular utility cuts after repair tend to concentrate stress in the corners causing corner cracking which can allow surface water to infiltrate the paved surface and undermine the road. There are no corners in a circular hole. No corners -- no cracks.

Size: Surgeons have recognized the importance of size in the medical field for years now. Smaller is better. Laparoscopic surgery is less intrusive and causes less trauma and tissue damage to the patient, which leads to a shorter recovery period. The smaller incision also heals faster and leaves a smaller scar. It is also cheaper because it consumes fewer resources in the hospital and has less impact on the patient during recovery.

All of these factors apply to rotary-cored keyholes in roadways. The hole is smaller and more precise, with no trauma from pounding jackhammers and backhoes. The neat, almost invisible circular keyhole excavation is also more aesthetically pleasing and is less than a quarter of the area of a conventional

2ft. x 4ft. rectangular road cut (Figure 3). From both a performance and aesthetic point of view, the smaller the footprint the better.

Faster, simpler restoration: Because the original pavement core is re-used, restoration is completed in one step and much faster than by conventional means. The precision cutting and permanent bonding to the remaining pavement of the core effectively reinstates the load bearing capacity of the roadway to its original design parameters and the circular geometry and the lack of over cutting at the corners eliminates the potential for stress cracking and the penetration of ground water.

Because the keyhole process is faster and more efficient and requires fewer resources -- in terms of equipment, manpower, scheduling and call-backs -- and because traffic is restored much more quickly than with conventional methods -- the cost to both the utility and the community is much less than with other methods.

Environmentally friendly: Because there is no pavement spoil to be disposed of and no temporary patching compounds with volatile organic compounds (VOC's) to escape into the atmosphere, the process is also more environmentally friendly than conventional methods. The absence of jack-hammers and back-hoes also means less mess during and after the excavation and reduced noise and disruption for neighbors.

The Bonding Compound

While there are a variety of coring tools available, including truck-mounted, trailer-mounted and skid steer-mounted coring units, the key element in the pavement reinstatement process, is the bonding compound used to restore the repaired roadway.

To be effective it must be able to bond the core to the remaining intact slab of pavement in a manner that allows the road to again perform as a system and to share the effect of traffic loading. It must also generate sufficient bond strength to quickly meet relevant AASHTO standards and allow the road to be opened to traffic as soon as possible.

Figure 4. *Utilibond is safe and easy to use – just add water, mix and pour into hole.*

Utilibond™ is a specially formulated and engineered bonding compound designed to be used for permanently reinstating pavement cores in asphalt and concrete roads, sidewalks and other paved surfaces.

Utilibond™ is a non-toxic, fast-setting, high-strength, waterproof bonding agent that comes in two colors – Aged Asphalt and Natural Concrete. Once it is mixed with the prescribed quantity of water and poured into the back-filled hole (Figure 4), the core is reinserted into the pavement. This causes the Utilibond to flow up around the outside of the core, completely filling the base, kerf and central pilot hole, encapsulating the core and bonding it to the remaining slab of pavement. Any excess bonding material is then cleaned up from the road surface with a trowel or shovel before it hardens and the core is allowed to set up for 10 to 15 minutes and gain sufficient strength to meet or exceed AASHTO H-25 standards. The rapid set and strength gain of *Utilibond*™ allows the road to be safely opened to traffic in just 30 minutes.

Utilibond™ was developed and field-proven over 10 years by the Consumers Gas Company (now Enbridge Gas Distribution), one of North America's oldest and largest local gas distribution companies with over 1.5 million customers, as part of its innovative rotary coring and keyhole pavement reinstatement program.

Testing by Golder Associates (1992-2002)

In June 1992, Enbridge retained Golder Associates, a highly respected international engineering firm that provides science and engineering consulting services in support of environmental, industrial, natural resources, health and civil engineering projects. Golder was asked to provide consulting and testing services in the development of a new pavement reinstatement system following rotary cutting of the pavement for gas service repairs using keyhole repair technology. That work encompassed a series of field trials and laboratory tests on a broad cross section of potential bonding materials undertaken over the period 1992 to 1996. (Golder 2003)

Figure 5. *Pavement core reinstated in bus lane with Utilibond in 1995 still in perfect condition seven years later in 2002.*

Ten years later, in October 2002, a follow-up study was commissioned to confirm previous results and to update performance data on the current version of *Utilibond*™, which is the third generation of the proprietary bonding compound originally selected for the process.

As in previous phases, the *Utilibond*™ compound was evaluated based on a punching shear type laboratory test that was designed to simulate the loading conditions in the field. Loads in the laboratory were compared to the loads expected in the field by comparing the bonded area tested in the field to that in the laboratory. Based on that conversion, the loads were compared to the AASHTO H-25 loading standard. Under that loading scheme the *Utilibond*™ tests confirmed that the repaired core reached the AASHTO standard of 44.5 kN per tire within half to three quarters of an hour and continued to strengthen to a safety factor in excess of 15 times the AASHTO standard within 5 hours. (Golder 2003)

The study also confirmed that over the ten year period that the Rotary Coring and Reinstatement process had been successfully employed in more than 3000 utility cut repairs in streets and sidewalks in Toronto, under a wide variety of climatic conditions, there have been no recorded failures. Many of these reinstatements occurred in major arterial routes with high traffic volumes (Annual Average Daily Traffic greater than 20,000 vehicles), which included transit bus routes with high pavement loadings. (Golder 2003)

Figure 6. *Satellite core samples taken through bonded area of reinstated core show effective coupling.*

Several of these sites, including one originally excavated and reinstated in August 1995 (Figure 5), have been regularly monitored and found to be without any apparent weakening or degradation of the reinstated core or adjacent road system or paved surface, notwithstanding the fact that in the intervening eight year period more than 145,000 transit buses and more than 13 million commercial and other vehicles have passed directly over the repaired keyhole.

Core samples taken at the site (Figure 6) demonstrate effective coupling between the core and the remaining slab of pavement. Light gray line is Utilibond showing excellent bonding of asphalt-concrete core (central area) and undisturbed pavement (outer layer) with complete infilling of voids in pea gravel (bottom).

The Golder 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.

According to Golder Associates:

"Effective coupling is achieved where the road will share the effect of traffic loading, as postulated in conventional road design theories. 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. In addition, the investigation of former trials over a number of years indicates that the repair technique continues to perform well. Based on this successful performance, the City of Toronto has approved the Utilicor™ pavement restoration technique as a permanent reinstatement." (Golder 2003)

"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." (Golder 2003)

Testing by University of Illinois (2003)

More recently, in July 2003, the performance of *Utilibond*™ was again tested and compared with two other bonding compounds currently being experimented with in California and Pennsylvania. These tests were undertaken by Professor David A. Lange, Ph.D., P.E., FACI of the Department of Civil Engineering at the University of Illinois at Urbana-Champaign. (Lange 2003)

The objective of Rotary Coring and Reinstatement technology, and that of its competitors, is to cost-effectively and permanently restore a pavement to its pre-excavated condition and allow it to accept normal traffic loads as soon as possible after the repair. As a result, the tests focused both on absolute bonding strength as well as on the time taken for the various bonding compounds to achieve sufficient strength to meet or exceed AASHTO standards.

The AASHTO Guide for Design of Pavement Structures is used for concrete pavement design in the United States and other countries. The AASHTO Guide converts a mixed traffic stream of different axle loads and axle configurations into an equivalent number of 18-kip single axle loads. An appropriate load condition to consider is the AASHTO H-25 loading with a maximum axle load of 40,000 lb. supported by four tires. A worst case loading occurs when a 10,000 lb. single tire load is positioned on the center of the reinstated core. So, for the purposes of the tests, the ability and time taken to achieve a bonding strength capable of supporting a load of 10,000 lbs. (i.e. the equivalent single axle load on one tire) was a critical factor.

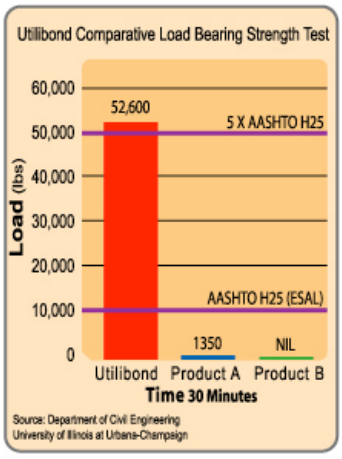

Figure 7. *Ultra-fast strength gain of Utilibond allows it to support more than 50,000 lbs in 30 minutes.*

Dr. Lange used a variety of standard test methods including those adapted from ASTM C882-99 and ASTM C109, as well as a nonstandard "Core Punch Out Test" to simulate field performance of the bonding materials.

The core bond area is calculated by multiplying the circumference of the core by the pavement depth. In the field, an 18 inch diameter core in an 8" pavement would have a bond area of 454 in^2. The average bond shear stress under the tire load would be 10,000/425 = 22 psi. Thus, the bond strength required to resist punch out of a core is relatively modest when compared to the capacity of the bonding materials after curing which is more than 100 psi. In other words, all three bond materials *ultimately* reached bond strengths in excess of that required to resist punch out (i.e. at least 22 psi) but the study concluded that only the *Utilibond*™ material was capable of achieving that strength within half an hour.

Actually, the tests showed that the *Utilibond*™ material achieved an average punch out safety factor of 4 to 5 times the AASHTO standard at the 30 minute test time, i.e. a comparative load bearing factor equivalent to more

that 50,000 lbs. The other two products (dubbed Product A and Product B) did not achieve measurable or sufficient strength gain until at least one hour in one case and two hours in the other (see Figure 7).

The test report concluded that "the *Utilibond*™ material excelled consistently as a rapid set material, and achieved the highest punch out loads at all test times," and that while all three bonding materials proved capable of achieving high safety factors in the core punch out test *over time*, only the *Utilibond*™ material demonstrated satisfactory performance in the 30 minute tests. Given the proposed application, it was Dr. Lange's opinion that this substantial time differential represented a *significant difference in performance* and that "rapid set time and workability are meaningful attributes in the field application, and effectively differentiate the performance of bonding materials for reinstatement of cores." (Lange 2003)

In other words, to both the utility and the municipality (which owns the road), "Time is money". *Utilibond*'s rapid hydration and ultra-fast strength-gain at normal temperatures allows repaired roadways to be opened to traffic in just 30 minutes.

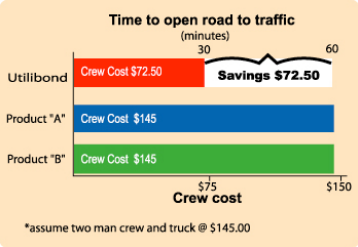

Figure 8: *Utilibond lets you open the road 30 minutes sooner and saves more than $70 in crew cost per utility cut.*

As can be seen in Figure 8, this results in additional savings of over $70 in crew costs per utility cut compared to other products that can take more than an hour to gain sufficient strength to meet AASHTO H-25 load bearing standards. It also means that a road reinstated with *Utilibond*™ can be opened to traffic sooner and public inconvenience greatly reduced

Utilibond™ has other advantages. It provides a perfect waterproof seal every time, and a bond that is stronger than the original pavement – exceeding AASHTO standards by 5 times in only thirty minutes.

The precise, circular Utilicor cut is not only much smaller and more aesthetically pleasing than conventional utility cuts but it also eliminates corner stress cracks and leaks (a constant problem with conventional rectangular road cuts), adding years to pavement life.

Like other aspects of the innovative keyhole technology program supported by GTI, of which effective and timely reinstatement of the road surface is a significant cost-saving element, *Utilibond*™ can be a win-win solution for utilities and municipalities alike.

In addition to Enbridge Gas Distribution, which has used the process for twelve years in Canada, and Robert B. Somerville, one of Ontario's largest pipeline and utility contractors, Rotary Coring and Reinstatement is currently being used in Michigan by MichCon Gas, in Maryland by Baltimore Gas & Electric, in Pennsylvania by UGI and PECO Energy, in Illinois by Nicor Gas, in Oregon by NW Natural, in California by Southern California Gas, in the District of Columbia, Virginia and Maryland by Washington Gas and in Texas by TXU Gas.

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