TECH NOTE

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REPAIR OF UTILITY CUTS WITHIN INTERLOCKING CONCRETE PAVEMENTS

North American cities have thousands of utility cuts made in their streets each year. Figure 1 shows a daily occurrence in most cities: repairs to underground utility lines for water, sewer, gas, electric, steam, phone, fiber-optic, or cable services. A sample is given below of the number of annual utility cuts in a few cities.

Billings, Montana	650–730
Boston, Massachusetts	25–30,000
Chicago, Illinois	120,000
Cincinnati, Ohio	6,000
Oakland, California	5,000
San Francisco, California	10,000
Seattle, Washington	10–20,000
Toronto, Ontario	4,000

THE COSTS OF UTILITY CUTS

The annual cost of utility cuts to cities is in the millions of dollars. These costs can be placed into three categories. First, there are the initial *pavement cut and repair costs*. These include labor, materials, equipment, and overhead for cutting, removing, replacing, and inspecting the pavement, plus repairs to the utility itself. Costs vary depending on the size and location of the cut, the materials used, waste disposal, hauling distances, and local labor rates.

Second, there are *user* costs incurred as a result of the repair. They include traffic delays, detours and denied access to streets by users, city service and emergency vehicles.

User costs depend on the location of the cut. A repair blocking traffic in a busy center city will impose higher costs and inconvenience from delays than a cut made in a suburban residential street. There are downstream costs to users from utility repairs such as lost productivity due to delays, and damage to vehicles from poor pavement riding quality. While these losses are difficult to quantify, they are very present.

The third cost is subtle and long term. It is the *cost of pavement damage* after the repair is made. Cuts damage the pavement. Damage can range from negligible to substantial, depending on the quality of the reinstated area and the condition of the surrounding pavement. The damage reduces pavement life and shortens the time to the next rehabilitation. The need to rehabilitate damaged pavements earlier, rather than when normally required, has costs associated with it.

Several studies have demonstrated a relationship between utility cuts and pavement damage. For example, streets in San Francisco, California, typically last 26 years prior to resurfacing. A study by the City of San Francisco Department of Public Works demonstrated that asphalt streets with three to nine utility cuts were expected to require resurfacing every 18 years (1). This represented a 30% reduction in service life compared to streets with less than three cuts. Streets with more than nine cuts were expected to be resurfaced every 13 years. This represents a 50% reduction in service compared to streets with less than three cuts.

Figure 1. Repairs to utilities are a common sight in cities, incurring costs to cities and taxpayers.

The report concludes that while San Francisco has some of the highest standards for trench restoration, utility cuts produce damage that

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extends beyond the immediate trench. “... even the highest restoration standards do not remedy all the damage. Utility cuts cause the soil around the cut to be disturbed, cause the backfilled soil to be compacted to a different degree than the soil around the cut, and produce discontinuities in the soil and wearing surface. Therefore, the reduction in pavement service life due to utility cuts is an inherent consequence of the trenching process.”

A 1985 study in Burlington, Vermont, demonstrated that pavements with patches from utility cuts required resurfacing more often than streets without patches. Pavement life was shortened by factors ranging between 1.70 and 2.53, or 41% to 60% (2). Research in Santa Monica, California, showed that streets with utility cuts saw an average decrease in life by a factor of 2.75, or 64% (3). A 1994 study by the City of Kansas City, Missouri, notes that “street cuts, no matter how well they are restored, weaken the pavement and shorten the life of the street.” It further stated that permit fee revenue does not compensate the city for the lost value resulting from street cuts (4). A 1995 study by the city of Cincinnati, Ohio, showed that damage to the pavement extends up to three feet (1 m) from the edge of properly restored cuts (5).

$$\text{Annual cost of pavement damage from utility cuts to one category of streets (local, collector thoroughfare, etc.)} = \text{Annual cost of resurfacing streets damaged by utility cuts} - \left[\text{Annual cost of resurfacing streets damaged by utility cuts} \times \left(\frac{\text{Number of years of life remaining before resurfacing streets with utility cuts}}{\text{Expected years of life before resurfacing if there are no utility cuts}}\right)\right]$$

Where the:

$$\text{Annual cost of resurfacing streets damaged by utility cuts} = \left(\text{percent of all resurfaced streets that are damaged by cuts}\right) \times \left[\text{Total annual cost of resurfacing all streets} \times \left(\frac{\text{Total miles (km) of streets resurfaced that year of one category (local, collector thoughfare, etc.)}}{\text{total miles (km) of all streets resurfaced in that year}}\right)\right]$$

A damage fee would be derived by dividing the annual cost of resurfacing a particular category of street damaged by utility cuts by the number of years of life expected from those streets. The fee would be higher if a street to be cut had been recently resurfaced, and lower for a street that is about ready for resurfacing.

Table 1—Annual cost of pavement damage from utility cuts (4).

The cost of pavement damage includes street resurfacing and rehabilitation to remedy damage from cuts. Permit fees charged by cities to those making cuts often do not fully account for pavement damage after the cut pavement is replaced. Some cities, however, are mitigating the long-term costs of pavement cuts by increasing fees or by charging a damage fee. They seek compensation for future resurfacing costs to remedy pavement damage. The rationale for fees to compensate for early resurfacing can be based on the following formula in Table 1.

REDUCING COSTS WITH INTERLOCKING CONCRETE PAVEMENTS

Life cycle analysis comparisons between asphalt, cast-in-place concrete and interlocking concrete pavements (ICP) show ICP have lower maintenance costs (6). Several of the benefits inherent to ICP that lower maintenance costs also help reduce pavement cut and repair costs, and the associated user costs, as well as reduce long term pavement damage including the associated fees to rehabilitate them.

a. Ease of paver removal. Tools exist to assist with the removal of the first few pavers; once the area is opened, the extraction of the remaining pavers is very simple – reference *Tech Note PAV-TEC-006*. Cost savings occur because saw-cutting equipment or pneumatic jack hammers typically used for monolithic pavements like asphalt or poured concrete are not required for surface layer removal.

b Ability to reinstate pavers. The extracted pavers can be stacked to the side and then reinstated, eliminating the need for the purchase of replacement surfacing materials.

c. Reduction in Waste Material. Reinstating the same pavers creates additional saving in haulage of waste material from the site, and disposal (landfill) costs. Replacement materials also do not need to be hauled to the site.

d. No delay for curing. User costs due to traffic interruptions and delays are reduced because the reinstated concrete pavers require no curing onsite; they can handle traffic immediately after reinstatement.

e. Maintaining site aesthetics. With many projects, concrete pavers are originally used to help define the character of these areas, with the character influencing property values and taxes. Reinstated concrete pavers preserve the aesthetics of the street or sidewalk surface. There are no patches to detract from the character of the neighbourhood, business district or center city area. Conversely, visible patches with other materials will detract from the aesthetics and likely result in requests for earlier area restoration.

f. Modular characteristics. Since interlocking concrete pavements are modular and not monolithic, they do not suffer the same accelerated wear from cuts.

Any break in monolithic pavement, e.g., joints, cuts or cracks, normally shortens pavement life because the continuity of the material is broken as shown in Figure 7. In contrast, the joints of the modular units in interlocking concrete pavements maintain structural continuity.

Figures 2, 3, 4, 5 and 6 show the process of repair and illustrate the continuity of the paver surface after it is completed. The reinstated units are knitted into existing ones through the interlocking paving pattern and sand filled joints. Besides providing a pavement surface without cuts, the joints distribute loads by shear transfer. The joints allow minor settlement in

Figure 2. After compaction of the base, bedding material is screeded. Edge restraints would typically be required to prevent the pavers from moving during disassembly and reinstatement.

Figure 3. Once smoothed and joined with undisturbed materials at the opening perimeter, the bedding receives concrete pavers.

Figure 4. Reinstatment using the same pavers continues following the existing herringbone paving pattern.

Figure 5. The final paver is inserted, the reinstated area compacted, joints filled, and compacted again. There are not cuts or damage to the pavement surface.

the pavers caused by discontinuities in the base or soil without cracking.

When pavers are reinstated on a properly compacted base, there is no damage to adjacent, undisturbed units. Unlike asphalt, concrete pavers do not deform, because they are made of high strength concrete. The need for street resurfacing caused by repeated utility cuts is eliminated because concrete pavers are not damaged in the reinstatement process. In addition, the use of low density concrete fill can help reestablish the broken continuity of the base and subgrade. This reduces the likelihood of settlement and helps eliminate damage to the pavement.

Therefore, long term costs of pavement damage from utility cuts to interlocking concrete pavement can be substantially lower when compared to monolithic pavements. This makes interlocking concrete pavement cost effective for streets that will experience a number of utility repairs over their life. Furthermore, lower costs from less damage can mean lower fees for cuts when compared to those for cutting into monolithic pavements.

CONSTRUCTION RECOMMENDATIONS WHEN REINSTATING PAVERS

Excavation of the base and soil must be within the limits of the removed pavers, and care must be taken to not undermine the adjacent pavement. Trench excavation, bracing, shoring, and/or sheeting should be done in accordance with the local authority. Equipment should be kept from the edges of the opening as loads may dislodge pavers around the opening. Excavated soil and base materials should be removed from the site. The trench should be kept free from standing water. *Tech Note PAV-TEC-006 – Operation and Maintenance Guide for Interlocking Concrete Pavements* provides additional guidance on repairs to utility cuts.

Unshrinkable fill being poured into a trench is shown in Figure 8. The fill flows into undercuts providing additional support, and in places where the soil or base has fallen from the sides of thetrench. These places are normally impossible to completely fill and compact with aggregate base or backfill material.

There are many mixes used for low-density concrete fill (7)(8)(9). Proprietary mixtures include those made with fly-ash that

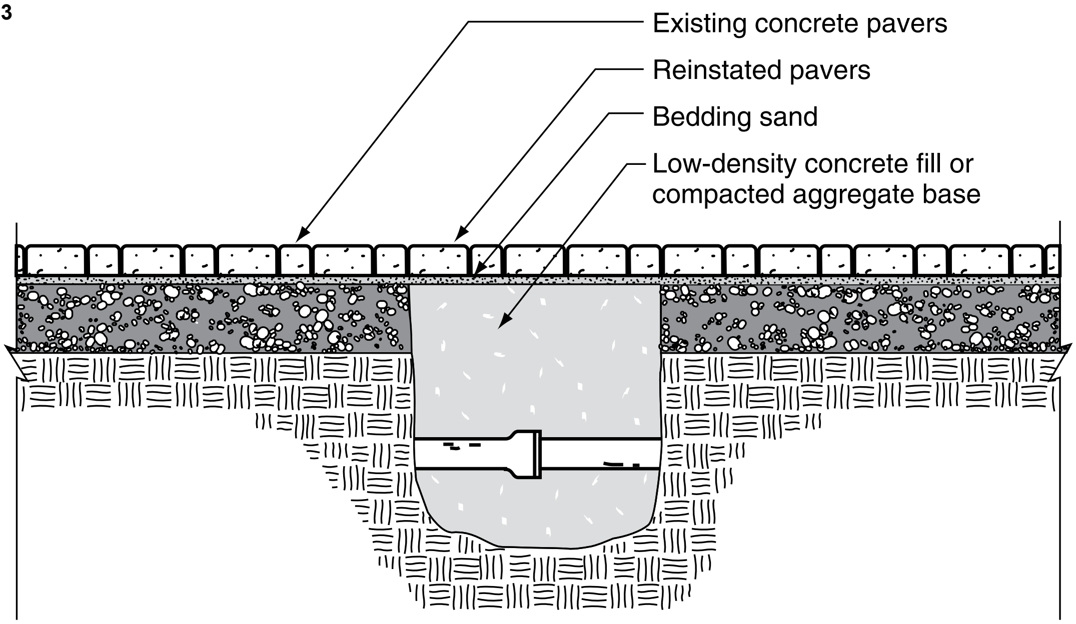

Figure 6. Cross section of reinstated utility cut into interlocking concrete pavement.

harden rapidly. Others are made with cement. A recommended mix can be made with ASTM C150 Type I Portland cement (or Type 3 for winter repairs), or CAN3-A23.5-M type 10 (or type 30 Portland cement). The slump of the concrete should be between 8 and 12 in. (200 and 300 mm) as specified in ASTM C143 or CAN3-A23.2.5C. When air entrainment is required to increase flowability, the total air content should be between 4 and 6% as measured in ASTM D6023 *Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material (CLSM)* or CAN3-A23.2-4C. Air content greater than 6% is not recommended as it may increase segregation of the mix.

A strength of 10 psi (0.07 Mpa) should be achieved within 24 hours. The maximum 28 day compressive strength should not exceed 50 psi (0.4 Mpa) as measured by ASTM C39 or CAN3-A23.2-9C. Cement content should be no greater than 42 lbs/cy (25 kg/m^3). The low maximum cement content and strength enables the material to be excavated in the future. Mixes containing supplementary cementing materials should be evaluated for excessive strength after 28 days.

Repaired utility lines are typically wrapped in plastic prior to pouring the low density fill. This keeps the concrete from bonding to the lines and enables them to move independently. When the fill is poured, it is self-leveling. It should be poured to within the thickness of the paver, plus 20 mm (thickness of the bedding layer once compacted), of the riding surface; for example, with a 3.125 in. (80 mm) thick concrete paver, the fill would be 4 in (100mm) from the surface

Bedding sand can be installed when the concrete is firm enough to walk on, generally within a few hours after placement. The bedding sand should be as hard as available and should conform to the grading requirements of ASTM C33 or CSA A23.1. *Mason sand, limestone screenings or stone dust should not be used.* The sand should be moist, but not saturated or frozen. Screed the bedding with 1 in. (25 mm) diameter screed pipe. Remove excess sand from the opening.

Since the low-density concrete fill is self-leveling, it will create a flat surface for the bedding sand. In most cases, there will be a slope on the surface of the street. The flowable fill can be screeded to slopes while stiffening. Drain holes at lowest elevations can be cut into the curing material using a metal can. This can be done when the material supports walking but has not yet completely cured. The approx 2 in. (50 mm) diameter holes are filled with washed pea gravel and covered with geotextile to prevent ingress of bedding sand. Adjustments to the thickness of the bedding sand may be necessary for the finished elevation of the pavers to follow the slope on the surface of the street. This can be accomplished by adjusting the height of the screed pipes.

Concrete pavers, if being replaced, should be at least 3.125 in. (80 mm) thick and meet ASTM C936 or CSA A231.2. They should be delivered in strapped bundles and placed around

Figure 7. Pavement damage from settlement and shrinkage of cold patch asphalt.

Figure 8. Low density concrete fill (unshrinkable fill) poured into a utility trench from a ready-mix concrete truck.

the opening in locations that don't interfere with excavation equipment or ready-mix trucks. The bundles should be covered with plastic to prevent water from freezing them together. The bundles need to be placed in locations close to the edge of the opening. Most bundles have several rows or bands of pavers strapped together. These are typically removed with a paver cart. The paver bundles should be oriented so that transport with carts is done away from the edge of the pavement opening.

Rectangular concrete pavers [nominally 4 in. by 8 in. (100 mm x 200 mm)] should be placed against the cut asphalt sides as a border course. No cut paver should be smaller than one third of a unit if subject to tire traffic.

Place pavers between the border course in a 90 degree herringbone pattern (Figure 12). Joints between pavers should be between $^1/_{16}$ and $^3/_{16}$ in. (2 to 5 mm). Compact the pavers with a minimum 5,000 lbf (22 kN) plate compactor. Make at least four passes with the plate compactor. A small test area of pavers may need to be compacted to check the amount of settlement. The bedding sand thickness should be adjusted in thickness to yield pavers no higher than $^1/_8$ in. (3 mm) above the edge of the undisturbed pavers.

Spread and compact sand into the joints. The joint sand is typically finer than the bedding sand, and should conform to the grading requirements of ASTM C144 or CSA A179. The joints must be completely full of sand after compaction. Remove excess sand and other debris. The pavers may be painted with the same lane, traffic, or crosswalk markings as any other concrete pavements. Plastic markings are not recommended. Light colored pavers can be used for pavement markings. This can save re-painting costs.

REFERENCES

Refer to the latest published ASTM and CSA standards and CMHA Tech Notes.

ASTM–American Society for Testing and Materials International, Conshocken, PA. www.astm.org

CSA–Canadian Standards Association, Rexdale, ON. www.csagroup.org

CMHA–Concrete Masonry and Hardscapes Association, Herndon, VA. www.MasonryAndHardscapes.org

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Sources for additional information on low-density flowable fill include the Cement Association of Canada and the American Concrete Institute offers publication 229R-13, report on “Controlled Low Strength Materials (CLSM)”.

Figure 1 is from iStock.com and Figure 8 is courtesy of Gavigan Contracting Ltd., London, Ontario.

ABOUT CMHA

The Concrete Masonry & Hardscapes Association (CMHA) represents a unification of the Interlocking Concrete Pavement Institute (ICPI) and National Concrete Masonry Association (NCMA). CMHA is a trade association representing US and Canadian producers and suppliers in the concrete masonry and hardscape industry, as well as contractors of interlocking concrete pavement and segmental retaining walls. CMHA is the authority for segmental concrete products and systems, which are the best value and preferred choice for resilient pavement, structures, and living spaces. CMHA is dedicated to the advancement of these building systems through research, promotion, education, and the development of manufacturing guides, design codes and resources, testing standards, and construction practices.