Comparison of Utility Cut Impacts on Pavement Performance

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This report uses US Customary units. It is also available in SI units.

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GLOSSARY OF ABBREVIATIONS

AASHTO	- American Association of State Highway and Transportation Officials
ACPA	- American Concrete Pavement Association
ASCE	- American Society of Civil Engineers
ASTM	- American Society for Testing Materials
FHWA	- U.S. Federal Highway Administration
GPR	- Ground Penetrating Radar
HMA	- Hot Mix Asphalt
ICP	- Interlocking Concrete Pavement
ICPI	- Interlocking Concrete Pavement Institute
LCC	- Life-Cycle Cost
LCCA	- Life-Cycle Cost Analysis
PCC	- Portland Cement Concrete
PCI	- Pavement Condition Index

Executive Summary

In North America, the majority of utilities such as water, storm sewer, gas, cable and telephone etc. are located within the municipal roadway right-of-way and generally beneath the roadway surface. Utilities agencies are permitted to access their infrastructure as needed to complete additional connections and repairs to their utilities. This requires removal and replacement of the pavement and subgrade in the area of the utility cut. The removal and replacement of materials is generally completed by the utility or in some cases by the municipality who then charges the utility for the construction work.

The patched pavement is considered a defect when condition ratings are completed during pavement management inspections. This detracts from the overall condition of the pavement as well as increasing pavement maintenance costs during the remainder of its service life. Estimates of the reduction in service life ranged from a few years to over 10 depending on the frequency and severity of the defects.

ASTM Standard D6433 *Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys* assesses the impact of defects such as utility cuts on the overall condition of hot mixed asphalt (HMA) and concrete pavements. The Pavement Condition Index (PCI) procedure uses the distress type, extent and severity to calculate the PCI of the pavement. For patching and utility cut patching, the areas of patched pavement are rated in terms of severity in accordance with the criteria in the standard and the sum of the areas of patched pavement are divided by the area of pavement surveyed to obtain the distress density in terms of a percentage of pavement area. Using the distress density and severity, the deduct value is obtained from the deduct curve set out in the standard. The deduct value is subtracted from a perfect pavement of 100 to determine the PCI for the pavement section. For example, if 5 percent of the pavement is patched with a condition severity of medium, the deduct value for the section would be 22 which results in a PCI of 78. A PCI of 78 would be representative of a municipal pavement with an age of about 12 years. This example demonstrates the impact of utility cuts on the life of monolithic pavements.

ASTM Standard E2840 *Standard Practice for Pavement Condition Index Surveys for Interlocking Concrete Roads and Parking Lots* outlines the procedures for assessing the impact of defects such as patching and utility cuts on the overall condition of interlocking concrete roads and parking lots. The standard assesses the impact of patching for interlocking concrete pavement is much less pronounced than for HMA pavement because the surface can be reinstated to similar conditions before the utility cut. A distress of 5 percent of medium severity patching results in a deduct value of 2 which results in a PCI of 98 which is representative of a municipal pavement with an age of about 1 to 2 years. While the impact of utility cut patching can be substantial for HMA and Portland cement concrete (PCC) pavements, a properly completed utility cut repair for an interlocking concrete pavement can have little to no impact on the future performance of the pavement.

Pavement maintenance and rehabilitation action plans were developed for ICPI as a part of the life-cycle cost comparison tools for municipal roadway pavements. In order to demonstrate the life-cycle cost impact of utility cuts on HMA pavements, the maintenance and rehabilitation action plans for a an HMA surfaced pavement with medium strength subgrade and minor collector bus route traffic were selected. The base plan represents a pavement without utility cuts. The plan was then modified to reflect a reduction in service life of the initial construction and future rehabilitation treatments based on the impact of utility cuts. In addition, it was assumed that while some agencies use controlled density backfill (unshrinkable concrete fill), most agencies backfill utility cuts with the original natural soil and/or dense graded aggregate base. As the backfill can be difficult to properly compact because of the relatively small size of utility cuts, location of utility and proximity to undisturbed, compacted materials, some undermining of the adjacent pavement and settlements may occur. Future maintenance may consist of partial or full-depth removal of the asphalt followed by levelling of the granular base and replacement of the asphalt layer(s). In other cases, maintenance consists of simply adding more asphalt onto the settled area defining the patch. For interlocking concrete pavements (ICP), maintenance typically consists of removal of the pavers, joint and bedding sand, aggregate base, and soil subgrade, if needed. After utility repairs, the subgrade and base are reinstated and compacted. This is followed by levelling of the granular base and replacing bedding sand, the existing pavers and new joint sand are installed and compacted. While the pavers and bedding sand in the undisturbed adjoining and reinstated areas are fairly consistent in material quality and compacted density, this is not the case at the *interface* of the undisturbed and reinstated soil subgrade and base. Therefore, activities and costs for future maintenance of patched utility cuts was added to the base maintenance and rehabilitation plans assuming some settlement of the patched areas will occur for ICP as well as for HMA pavements.

The analysis was completed for a discount rate of 4 percent and analysis period of 50 years. The results of the analysis are shown in the following table.

Pavement Type	NPW of Cost (with Utility Cuts)	NPW of Cost (without Utility Cuts)	NPW Difference
HMA	$ 324,322	$ 175,924	$ 148.398
ICP	$ 120,325	$ 67,875	$ 52,450
		Net Difference (HMA vs ICP)	**$ 95,948**

The results of the utility cut impact analysis show a net savings of $ 95,48 per 2 lane-mile ($ 9.09/ft^2) for the total life-cycle present worth of costs for ICP when compared to the impact of utility cuts on the performance of HMA pavements.

The impact of utility cuts on the performance and total life-cycle costs of HMA pavements is substantial when compared with ICP. This is due to additional use of materials over the course of 50 years as well as labor costs. The analysis results show that a HMA pavement with utility cuts can have an almost 200 percent higher life-cycle maintenance and rehabilitation cost than an ICP pavement with utility cuts. Due to its monolithic nature, the impact of utility cut patching can be substantial for HMA pavements. Since ICP is modular in nature, a properly completed utility cut repair for an ICP can have little required maintenance and almost no impact on the future performance of the pavement. This can provide a significant life-cycle cost benefit for ICPs. In addition, the use of flowable fill offers an extra measure of long-term stability and risk reduction of settlement should an agency prefer this option.

1. Introduction

In North America, the majority of utilities such as water, sanitary/storm sewer, gas, electric, communications cable/fiber, telephone, etc. are located within the municipal right-of-way and generally beneath the roadway surface. Likely from economy and habit, municipalities have used monolithic pavements for decades over utility lines that will inevitably require repairs or relocation during their lifetimes which often stretch longer than the life of the pavement surface.

Utility agencies are permitted to access their systems as needed to make upgrades, additional connections and repairs. This requires removal and replacement of the pavement and subgrade in the area of the utility cut. The removal and replacement of materials is generally completed by the utility or in some cases by the municipality who then charges the utility for the construction work. Some municipalities have studied the reduction of pavement life from utility cuts and have included those costs in fees charged to utility companies to obtain permits to make pavement cuts.

Most municipalities have rigid specifications for utility cuts and pavement restoration [1]. However, in most cases, the pavement restoration does not achieve the same quality as the original pavement as shown in Figure 1-1 and Figure 1-2. In some cases, this may be due to lack of enforcement of specifications in the field.

Figure 1-1. Poor Quality Restoration Resulting in Settlement and Alligator Cracking.

Figure 1-2. Poor Quality Restoration Resulting in Settlement, Cracking and Asphalt Segregation.

Unlike HMA surfaced pavements, the surface of an ICP can be removed and replaced using the same material [2]. The pavers can be removed, stacked, and then replaced in the utility cut area once the utility repairs are completed as shown in Figure 1-3.

Figure 1-3. Utility Cut Repair of Interlocking Concrete Pavement.

The cut and patched monolithic asphalt or concrete pavement is considered a defect when condition ratings are completed during pavement management inspections. This detracts from the overall condition of the pavement as well as increasing pavement maintenance costs during the remainder of its service life [3]. Estimates of the reduction in service life ranged from a few years to over 10 depending on the frequency and severity of the defects.

ASTM D6433 *Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys* assesses the impact of defects such as utility cuts on the overall condition of flexible and rigid pavements. The impact of patching and utility cut patching on the pavement condition index for HMA pavements is shown in Figure 1-4. The Pavement Condition Index (PCI) procedure uses the distress type, extent and severity to calculate the PCI of the pavement. For patching and utility cut patching, the areas of patched pavement are rated in terms of condition severity in accordance with the criteria in the standard. The sum of the areas of patched pavement are divided by the area of pavement surveyed to obtain the distress density in terms of a percentage of pavement area. Using the distress density and severity, the deduct value is obtained from the deduct curve shown in Figure 1-4. The deduct value is subtracted from a perfect pavement rated at 100 to determine the PCI for the pavement section. For example, if 5 percent of the pavement is patched with a severity of medium, the deduct value for the section would be 22 which results in a PCI of 78. A PCI of 78 would be representative of a municipal pavement with an age of about 12 years.

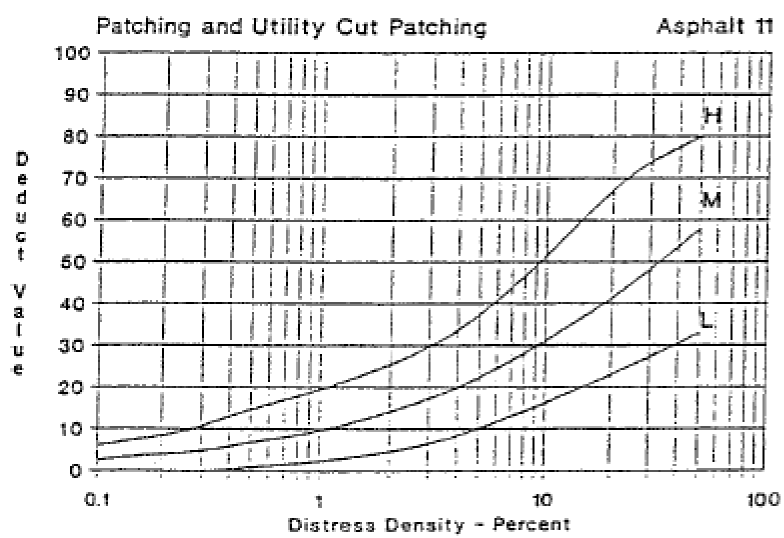

FIG. X3.16 Patching and Utility Cut Patching

Figure 1-4. Deduct Curves for Patching and Utility Cut Patching – HMA Pavement [4].

ASTM E2840 *Standard Practice for Pavement Condition Index Surveys for Interlocking Concrete Roads and Parking Lots* [5] outlines the procedures for assessing the impact of defects such as patching and utility cuts patching on the overall condition of interlocking concrete roads and parking lots. Figure 1-5 shows the deduct curves for ICP. From the figure, it can be seen that the impact of patching for ICP is much less pronounced than for HMA pavement because the surface can be reinstated to similar conditions before the utility cut. Using the same example from above, 5 percent of medium severity patching results in a deduct value of 2 which results in a PCI of 98 which is representative of a municipal pavement with an age of about 1 to 2 years. While the impact of utility cut patching can be substantial for HMA pavements, a properly completed utility cut repair for an ICP will have very little impact on the future performance of the pavement. However, as all pavements requirement maintenance it has been assumed that the interlocking concrete pavement will require some paver resetting and levelling and joint sand replacement after completion of the utility cut restorations.

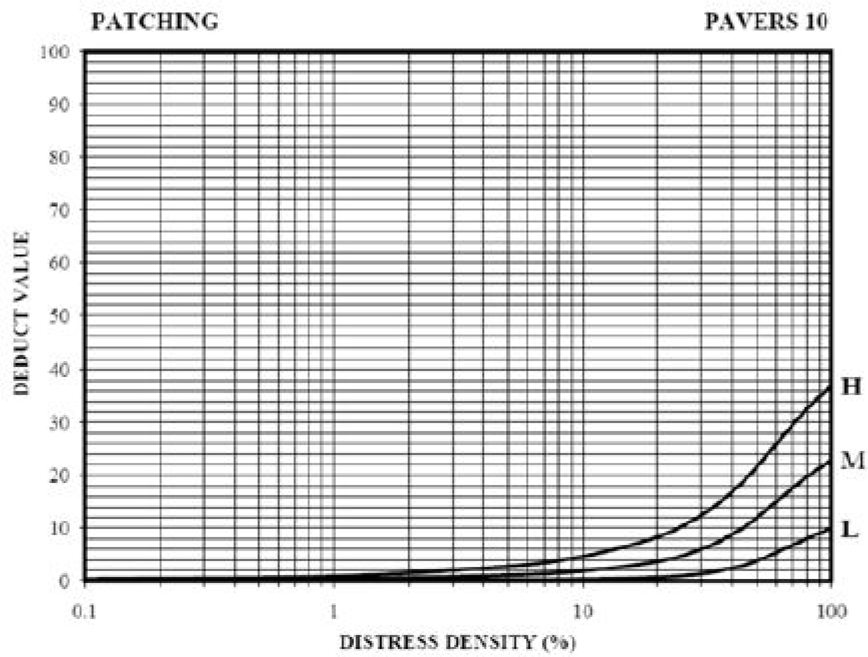

FIG. X3.10 Patching (10)

Figure 1-5. Deduct Curves for Patching – Interlocking Concrete Pavement [5].

2. Pavement Performance Impact of Utility Cuts

Calculating the cost impact of utility cut repairs can be very complicated. Some of the elements that could impact the cost of utility cut repairs include:

- Pavement type (flexible (HMA), rigid (PCC) or composite (HMA over PCC)). PCC and composite pavements are typically designed to last longer than flexible HMA surfaced pavements.
- Roadway classification and traffic. Low traffic pavements such as subdivision roads are not subjected to substantial truck and bus traffic which results in less damage to the pavement. Arterial and collector roads are subjected to heavy traffic and in the urban environment and generally have more utilities under the roadway.
- Age of the roadway. Utility cuts in new roadways have to last longer than those completed in pavement closer to the end of their service life.
- Quality of repairs. Some agencies have strict specifications and procedures for the restoration of utility cuts. Others permit utilities to complete their own repairs which can lead to inconsistency in the quality of repairs especially when municipal inspection is absent.
- Number of utilities with assets under the roadway. In older communities, some of the utilities such as electricity, telephone, etc. are above ground resulting in fewer utilities under the roadway.
- Number of utility cuts. In the urban environment there can be many utilities under the roadway requiring access by many different utility providers. The complexity of assigning costs to individual utilities can be complex depending on the number and type of utility cuts.

Utility cuts completed early in the life of a pavement will have a more significant impact on the performance of a pavement than those completed near the end of the pavement's life-cycle. As such, some agencies reduce the fees charged to utilities for older, more degraded pavements. More frequent and extensive utility cuts (Figure 2-1) will likely increase the surface distress and roughness of the pavement requiring earlier rehabilitation action than pavements with only a few utility cuts.

Figure 2-1. Example of an Extensive Longitudinal Utility Cuts.

3. Cost Impact of Utility Cuts

Potential methods of determining the impact of utility cuts on the performance of municipal pavements include:

1) **Accounting Method:** This method uses standard accounting straight line depreciation to compare the depreciated value of the roadway asset based on service life. The service life would typically consist of the time between initial construction/rehabilitation and the end of service when reconstruction is necessary. The calculations include the initial value of construction, maintenance and rehabilitation over the full life-cycle of the pavement. For a typical municipal roadway section (e.g., city block), this would also account for 1 to 3 rehabilitation treatments before reconstruction is required. Comparing the depreciated value of a typical pavement with and without utility cuts can provide the cost impact of utility cuts. As noted below, this method is more suitable for assessing the average cost of damage done across a network of pavement sections.

2) **Network Value Method:** This method is similar to the accounting method except that in place of the straight-line depreciation, the pavement performance models are used to determine the value of with and without utility cut pavements to determine the cost impact

of utility cuts. This method is more suitable for use with a network of pavement sections rather than one or two road sections.

3) **Maintenance and Rehabilitation Supplement Method**: This method only includes the maintenance and rehabilitation costs over the full life-cycle of the pavement. The initial construction costs are ignored as they would be spent regardless of whether or not the pavement has utility cuts. A maintenance and rehabilitation plan for a pavement without utility cuts is compared to the revised maintenance plan of a pavement with utility cuts to determine the additional maintenance costs and reduction in pavement life incurred due to the presence of utility cuts. This method can also account for additional maintenance costs as well as the reduction in life of future treatments due to the presence of utility cuts. This method is suitable for use with a network of pavements or individual sections within the network.

In a 2009 study completed for the City of Toronto [6], pavement condition data was gathered for roadways with and without utility cuts to determine the impact of utility cuts on the degradation of pavements. A total of 94 sections of roadway of similar construction consisting of 2,635 segments were surveyed using ground penetrating radar (GPR) and a detailed pavement surface distress survey. The GPR survey determined if a utility cut was located beneath a surface patch or if the surface patch was from a regular pavement maintenance operation only. An example of the results of the GPR testing shows a reflection of a utility cut in Figure 3-1.

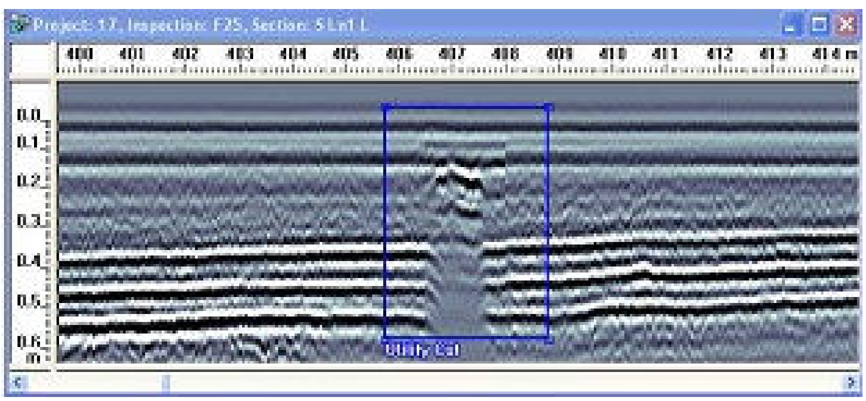

Figure 3-1. GPR Cross Sections showing a Utility Cut Reflection.

The pavement sections were then separated into segments with utility cuts and segments without them. Detailed pavement surface condition inspections were then completed for each of the segments. The surface distresses were then used to calculate the pavement condition index (PCI) of each segment. The weighted average PCI of all segments was found to be 75.6 for pavements without any utility cuts and 71.4 for those with utility cuts. The study indicated that utility cuts reduce the life of a typical municipal pavement in Toronto by 5.5 percent. Over a 25-year initial service life, this represents a service life loss of 1.4 years. This is represented by the pavement performance curve for local and collector roadways shown in Figure 3-2.

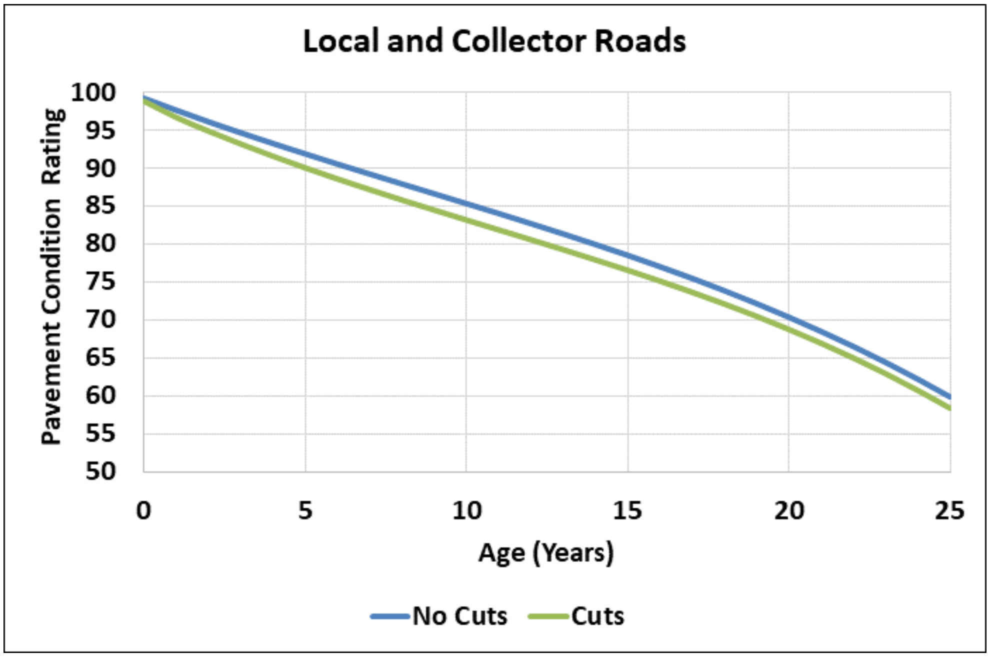

Figure 3-2. Pavement Performance Curves for Local and Collector Roads.

The findings of the study were used to develop a utility cut pavement degradation fee that is charged to utilities to represent the loss of value of road life to the municipality. The 2020 pavement degradation fees charged for various pavement ages and roadway classifications are shown in Table 2-1.

Table 2-1. City of Toronto Pavement Degradation Fees for Flexible Pavement for 2020 (ft²).

Pavement Age	Roadway Classification	
	Local Roadway	Collector
0-15	$ 4.60	$ 3.90
16-30	$ 3.69	$ 3.11
31-45	$ 2.76	$ 2.30

For the purpose of this analysis, the pavement degradation fees shown in Table 2-1 were not used directly but rather, the maintenance and rehabilitation plan timing for the hot mixed asphalt (HMA) pavement was adjusted based on the pavement performance curves shown in Figure 3-2. No adjustment was made to the ICP lifecycle as the ICP can be removed from the repair area and then reinstated to their original condition in accordance with *ICPI Tech Spec 6, Reinstatement of Interlocking Concrete Pavements*.

The analysis assumes that the initial utility cut and restoration have already been completed to the required specifications. While some agencies use controlled density backfill (unshrinkable fill), most backfill utility cuts with the original natural soil and/or dense graded aggregate base. Since the backfill can be difficult to properly compact because of the relatively small size of utility cuts, some undermining of the adjacent pavement and settlements may occur. Maintenance may consist of partial or full-depth removal of the asphalt followed by levelling of the granular base and replacement of the asphalt layer(s). For ICP, maintenance would consist of removal of the pavers, bedding sand, subgrade and granular base. Then replacing the subgrade and base, followed by levelling and final compaction of the base, finishing with replacement of the bedding sand, pavers, and joint sand.

Future maintenance of the utility cuts was added to the base maintenance and rehabilitation plans assuming that some settlements of the patched areas will occur for both the HMA and ICP surfaced pavements. The additional cost to maintain the utility cuts includes the following assumptions:

- Utility cuts are made in the pavement beginning at a pavement age of 5 years.
- The area of the pavement subjected to utility cuts is 2 percent beginning in Year 5 with an additional 2 percent added every 10 years.
- The initial life of the utility cut restoration is 10 years.

The process and costs of completing utility cut maintenance in HMA and ICP pavements is described in the sections below.

3.1 Utility Cut Maintenance for Asphalt Pavement

The process of completing a utility cut and restoration for an HMA pavement includes:

- Set up a traffic control zone as required by road agency standards and regulations.
- Sawcut the edges of the asphalt to be to replace, remove and dispose of the HMA, for the full depth of the repair area, then make utility repairs.
- Level the base and top up as necessary and compact.
- Place base course asphalt using a small asphalt spreader and compact.
- Place surface course asphalt using a small asphalt spreader and compact.
- Rout and seal the joints between the repair area and surrounding HMA.

The typical equipment required includes, personal protective equipment (PPE), shovels, small backhoe, rake, pick, broom, portable saw, plate compactor for the asphalt, truck or trailer to haul-off debris, hot mix asphalt and delivery truck, portable router, crack sealing equipment including trailer kettle and hot poured rubberized asphalt.

3.2 Utility Cut Maintenance for ICP Pavement

The general; process of completing a utility cut and restoration for an ICP pavement includes:

- Set up a traffic control zone as required by road agency standards and regulations.
- Scrape and remove much of the sand from the joints around a single paver using a metal putty knife, pry the paver upwards using two flathead screw drivers or a custom-built paver extraction tool.
- Remove pavers from the area to be excavated and a few courses more. Restrain surrounding pavers along the perimeter of the undisturbed edge. Remove and store pavers necessary to complete the repair, address any base issues adding additional granular base if necessary.
- Place and screed the new bedding sand such that when placed, the pavers will be at least 1/8 in. 3/16 in. above the adjacent paver surface to account for settling during compaction.

- Compact the pavers using a minimum 5,000 lbf. plate compactor. Fill the joints with sand and compact again to seat the joint sand. Continue to fill and compact sand into joints until full. Remove excess sand from the repair area.

The typical equipment needed includes PPE, a metal putty knife, two flat head screwdrivers, temporary paver restraints, shovels, rake, pick, truck or trailer to haul-off debris bedding/joint sand, wooden or metal bedding sand screed, plate compactor and a broom and/or leaf blower.

3.3 Comparative Cost of Utility Cut Maintenance

The comparative unit costs to complete the utility cut maintenance activities outlined in Sections 3.1 and 3.2 are shown in Table 3-2. The cost data for HMA utility cut repairs is the average cost for utility cut restorations from City of Toronto 2020 contracts. The cost for ICP utility cut maintenance activities is from industry estimates adjusted for inflation to 2020 prices.

Table 3-2. Comparative Cost of Utility Cut Restoration for HMA and ICP.

Pavement Type	Utility Cut Maintenance Cost ($/ft^2)
HMA	$ 5.10
ICP	$ 4.20

4. Example Maintenance and Rehabilitation Supplement Method Calculation

The maintenance and rehabilitation supplement method calculation can be applied to any pavement type or classification. The calculation is based on the whole life maintenance and rehabilitation plan for the pavement. In 2020, ICPI commissioned the development of interlocking concrete pavement (ICP) life-cycle cost comparison tools [7]. The tools focused on municipal roadways including the following elements:

- Typical pavement designs for ICP, HMA and PCC pavements for 3 subgrade support categories and 4 levels of traffic.
- Development of life-cycle performance models;
- Representative construction, maintenance and rehabilitation costs over an analysis period of 50 years.
- Preparation of life-cycle cost tools in the form of MS Excel spreadsheets and a sensitivity analysis including discount rates and the cost of ICP versus HMA surfaced pavements.

4.1 Maintenance and Rehabilitation Plans for HMA

The pavement maintenance, rehabilitation and action plan for an HMA surfaced pavement with medium strength subgrade and minor collector bus route traffic is shown in Table 4-1 .

Table 4-1. No Utility Cuts Pavement Maintenance and Rehabilitation Action Plan (HMA)

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity per 2-lane mile	Price per unit of quantity	Cost	Net present worth
10	Rout and seal, ft/mile (ft)	1300	1300	$ 1.50	$ 1,950	$ 1,317
10	Spot repairs, mill 1.5 in/patch 1.5 in, % area (ft²)	2	2534	$ 3.25	$ 8,237	$ 5,564
15	Spot repairs, mill 1.5 in/patch 1.5 in, % area (ft²)	10	12672	$ 3.25	$ 41,184	$ 22,868
20	Mill HMA, in (ton)	1.5	1199	$ 16.35	$ 19,598	$ 8,944
20	Resurface with HMA Surface, in (ton)	1.5	1208	$ 110.00	$ 132,896	$ 60,652
25	Rout and seal, ft/mile (ft)	2600	2600	$ 1.50	$ 3,900	$ 1,463
30	Spot repairs, mill 1.5 in/patch 1.5 in, % area (ft²)	5	6336	$ 3.25	$ 20,592	$ 6,349
35	Mill HMA, in (ton)	1.5	1199	$ 16.35	$ 19,598	$ 4,966
35	Full depth asphalt base repair, % area (ft²)	10	12672	$ 4.20	$ 53,222	$ 13,487
35	Resurface with HMA Surface, in (ton)	1.5	1208	$ 110.00	$ 132,896	$ 33,678
40	Rout and seal, ft/mile (ft)	2600	2600	$ 1.50	$ 3,900	$ 812
43	Spot repairs, mill 1.5 in/patch 1.5 in, % area (ft²)	5	6336	$ 3.25	$ 20,592	$ 3,813
48	Mill HMA, in (ton)	3.5	2797	$ 16.35	$ 45,728	$ 6,960
48	Resurface with HMA Binder, in (ton)	2	1573	$ 105.00	$ 165,122	$ 25,131
48	Resurface with HMA Surface, in (ton)	1.5	1208	$ 110.00	$ 132,896	$ 20,226
50	Residual value (negative cost)				-$ 286,456	-$ 40,308
Total Maintenance and Rehabilitation Cost					**$ 515,857**	**$ 175,924**

In order to assess the impact of utility cuts on this maintenance and rehabilitation plan, the plan was revised based on the following assumptions:

- Life-cycle analysis period of 50 years.
- Discount rate for net present worth of costs of 4 percent.
- The cost to complete the initial utility cut is the same for both HMA and ICP pavements.
- Utility cut maintenance includes 2 percent of the pavement surface in Year 4 and is increased by 2 percent every 10 years through the analysis period.
- The presence of utility cuts reduces initial construction service life of HMA by 2 years.
- The service life of future maintenance and rehabilitation activities are all adjusted to reflect the 2-year reduction in service life.
- General quantities of maintenance and rehabilitation activities remain the same.

The adjustments to the maintenance and rehabilitation plan to account for utility cuts in asphalt pavement is shown in Table 4-2.

Table 4-2. Utility Cut Adjusted Pavement Maintenance and Rehabilitation Action Plan (HMA)

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity per 2-lane mile	Price per unit of quantity	Cost	Net present worth
5	ICP Utility Cut Restoration, % area (ft2)	2	2534	$ 4.20	$ 10,644	$ 8,749
10	Rout and seal, ft/mile (ft)	1300	1300	$ 1.50	$ 1,950	$ 1,950
10	Spot repairs, mill 1.5 in/patch 1.5 in, % area (ft^2)	2	2534	$ 3.25	$ 8,237	$ 5,564
15	Spot repairs, mill 1.5 in/patch 1.5 in, % area (ft^2)	10	12672	$ 3.25	$ 41,184	$ 22,868
15	HMA Utility Cut Restoration, % area (ft2)	4	5069	$ 5.10	$ 25,851	$ 14,354
18	Mill HMA, in (ton)	1.5	1199	$ 16.35	$ 19,598	$ 9,674
18	Resurface with HMA Surface, in (ton)	1.5	1208	$ 110.00	$ 132,896	$ 65,601
22	Rout and seal, ft/mile (ft)	2600	2600	$ 1.50	$ 3,900	$ 1,646
25	HMA Utility Cut Restoration, % area (ft2)	6	7603	$ 5.10	$ 38,776	$ 14,546
26	Full depth asphalt base repair, % area (ft^2)	5	6336	$ 4.20	$ 26,611	$ 9,598
30	Mill HMA, in (ton)	1.5	1199	$ 16.35	$ 19,598	$ 6,042
30	Full depth asphalt base repair, % area (ft^2)	10	12672	$ 4.20	$ 53,222	$ 16,409
30	Resurface with HMA Surface, in (ton)	1.5	1208	$ 110.00	$ 132,896	$ 40,974
34	Rout and seal, ft/mile (ft)	2600	2600	$ 1.50	$ 3,900	$ 1,028
35	HMA Utility Cut Restoration, % area (ft2)	8	10138	$ 5.10	$ 51,702	$ 13,102
36	Spot repairs, mill 1.5 in/patch 1.5 in, % area (ft^2)	5	6336	$ 3.25	$ 20,592	$ 5,018
40	Mill HMA, in (ton)	3.5	2797	$ 16.35	$ 45,728	$ 9,525
40	Resurface with HMA Binder, in (ton)	2	1573	$ 105.00	$ 165,122	$ 34,393
40	Resurface with HMA Surface, in (ton)	1.5	1208	$ 110.00	$ 132,896	$ 27,681
43	Rout and seal, ft/mile (ft)	2600	2600	$ 1.50	$ 3,900	$ 722
43	Spot repairs, mill 1.5 in/patch 1.5 in, % area (ft^2)	5	6336	$ 3.25	$ 20,592	$ 3,813
45	HMA Utility Cut Restoration, % area (ft2)	10	12672	$ 5.10	$ 64,627	$ 11,064
50	Mill HMA, in (ton)	1.5	1199	$ 16.35	$ 19,598	$ 2,758
50	Resurface with HMA Surface, in (ton)	1.5	1208	$ 110.00	$ 132,896	$ 18,700
50	Residual value (negative cost)				-$ 152,494	-$ 21,458
Total Maintenance and Rehabilitation Cost					**$ 1,024,424**	**$ 324,322**

4.2 Maintenance and Rehabilitation Plans for ICP

The pavement maintenance and rehabilitation and action plan for an ICP surfaced pavement with medium strength subgrade and minor collector bus route traffic is shown in Table 4-3.

Table 4-3. No Utility Cuts Pavement Maintenance and Rehabilitation Plan (ICP)

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity per 2-lane mile	Price per unit of quantity	Cost	Net present worth
8	Replace cracked pavers, % area (ft^2)	2	2534	$ 6.00	$ 15,206	$ 11,111
18	Replace worn/rutted pavers wheelpath, % area (ft^2)	5	6336	$ 11.15	$ 70,646	$ 34,873
28	Replace cracked pavers, % area (ft^2)	2	2534	$ 6.00	$ 15,206	$ 5,071
38	Replace worn/rutted pavers wheelpath, % area (ft^2)	5	6336	$ 11.15	$ 70,646	$ 15,916
48	Replace cracked pavers, % area (ft^2)	3	3802	$ 6.00	$ 22,810	$ 3,472
50	Residual value (negative cost)				-$ 18,248	-$ 2,568
Total Maintenance and Rehabilitation Cost					**$ 176,268**	**$ 67,875**

The adjustments to the maintenance and rehabilitation to account for utility cut maintenance in ICP pavement is shown in Table 4-4.

Table 4-4. Utility Cut Adjusted Pavement Maintenance and Rehabilitation Plan (ICP)

Years after initial construction	Description of pavement layer, Amount (Quantity)	Amount	Quantity per 2-lane mile	Price per unit of quantity	Cost	Net present worth
5	ICP Utility Cut Restoration, % area (ft^2)	2	2534	$ 4.20	$ 10,644	$ 8,749
8	Replace cracked pavers, % area (ft2)	2	2534	$ 6.00	$ 15,206	$ 11,111
15	ICP Utility Cut Restoration, % area (ft^2)	4	5069	$ 4.20	$ 21,289	$ 11,821
18	Replace worn/rutted pavers wheelpath, % area (ft^2)	5	6336	$ 11.15	$ 70,646	$ 34,873
25	ICP Utility Cut Restoration, % area (ft^2)	6	7603	$ 4.20	$ 31,933	$ 11,979
28	Replace cracked pavers, % area (ft^2)	2	2534	$ 6.00	$ 15,206	$ 5,071
35	ICP Utility Cut Restoration, % area (ft^2)	8	10138	$ 4.20	$ 42,578	$ 10,790
38	Replace worn/rutted pavers wheelpath, % area (ft^2)	5	6336	$ 11.15	$ 70,646	$ 15,916
45	ICP Utility Cut Restoration, % area (ft^2)	10	12672	$ 4.20	$ 53,222	$ 9,112
48	Replace cracked pavers, % area (ft^2)	3	3802	$ 6.00	$ 22,810	$ 3,472
50	Residual value (negative cost)				-$ 18,248	-$ 2,568
Total Maintenance and Rehabilitation Cost					**$ 335,935**	**$ 120,325**

4.3 Comparison of Maintenance and Rehabilitation Plans for HMA and ICP

The net present worth of the HMA and ICP pavement with and without the impact of utility cuts on the pavements is shown in Table 4-5.

Table 4-5. Summary of Cost Analysis for Utility Cut Impact ($/2-lane mile)

Pavement Type	NPW of Cost (with Utility Cuts)	NPW of Cost (without Utility Cuts)	NPW Difference
HMA	$ 324,322	$ 175,924	$ 148.398
ICP	$ 120,325	$ 67,875	$ 52,450
		Net Difference (HMA vs ICP)	**$ 95,948**

The results of the utility cut impact analysis show a net savings of $ 95,948 per 2 lane-mile ($ 9.09/ft^2) for the total life-cycle present worth of costs for ICP when compared to the impact of utility cuts on the performance of HMA pavements.

5. Conclusions

The impact of utility cuts on the performance and total life-cycle costs of hot mixed asphalt (HMA) pavements is substantial when compared with interlocking concrete pavements (ICP). The analysis results show that a HMA pavement with utility cuts can have an almost 195 percent higher life-cycle maintenance and rehabilitation cost than a pavement without utility cuts. While the impact of utility cut patching can be substantial for HMA pavements, a properly completed utility cut repair for an ICP will have very little required maintenance and no impact on the future performance of the pavement. This can provide a significant life-cycle cost benefit for ICPs.

6. References

1. City of Toronto. *Construction Specification for Utility Cut and Restoration – TS 4.60*, Engineering and Construction Services Division, Standard Specifications for Road Works, Toronto, Ontario, 2014.
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4. ASTM. *Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys, D6433-18*, West Conshohocken, Pennsylvania, 2018.
5. ASTM. *Standard Practice for Pavement Condition Index Surveys for Interlocking Concrete Roads and Parking Lots, D3840-11 (2019)*, West Conshohocken, Pennsylvania, 2019.
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