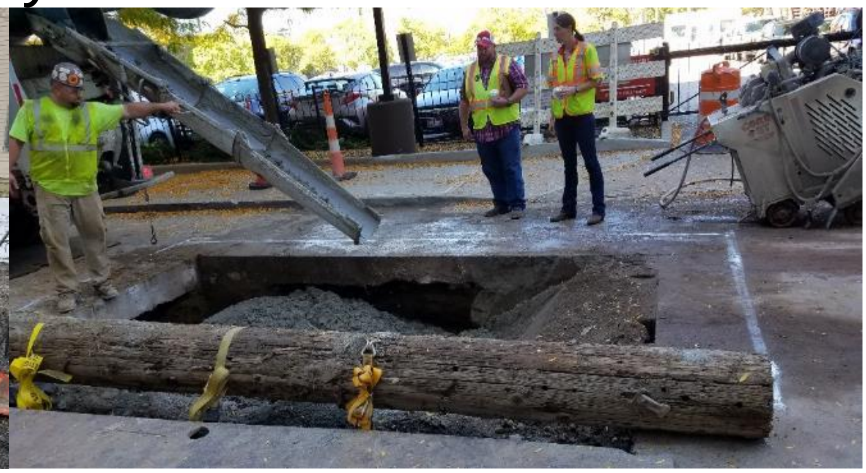
Best Practices for Pavement Restoration of Open Cut Utility Installations/Repairs on Local Roadways in Ohio



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16. Abstract
Local public agencies often face the challenge of repairing their pavements after the installation or repair of subsurface utilities in the roadway. While minimizing the need to disturb the in-service pavements through advanced planning and coordination with other planned roadway work is ideal, open utility cuts are often unavoidable. The performance of a repair is influenced by a number of factors such as backfill materials, compaction of the backfill, season in which it was completed, and compaction of the asphalt surface.

The primary objective of this research was to identify the best practices for pavement restoration of open cut utility installation on local roads in urban areas to ensure low cost and long-term performance. As part of this study, a literature review was completed, local agencies across Ohio and surrounding states were surveyed to collect information pertaining to current practices for pavement restoration of open utility cuts, and follow up interviews were conducted with local transportation officials in Ohio to gather additional information related to their standards and practices, and field sites were visited to select sites for detailed evaluation. A field and laboratory evaluation was conducted on three poor performing repairs and three good performing repairs in each of three cities in Ohio: Cleveland, Columbus, and Dayton. A matrix of best practices was developed which identifies best practices as defined by the literature, local transportation agency officials, and identified from field evaluations.

17. Key Words
Low traffic volume, county, township, city, best practices, utility cuts in pavement, repair of pavement

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3

NOTE: Volumes greater than 1000 L shall be shown in m^3.

Symbol	When You Know	Multiply By	To Find	Symbol
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(°F-32)/9 or (°F-32)/1.8	Celsius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2 or psi	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celsius temperature	1.8°C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2 or psi

* SI is the symbol for the International Symbol of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

Best Practices for Pavement Restoration of Open Cut Utility Installations/Repairs on Local Roadways in Ohio

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Final Report
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1 Project Background

There are an estimated 3.6 million road opening permits issued nationwide each year (Jarnecke and Pollock, 2017). While minimizing the need to disturb the in-service pavements through advanced planning and coordination with other planned roadway work is ideal, open utility cuts are often unavoidable. As a result, local public agencies face the challenge of ensuring pavements are repaired properly after the installation or repair of subsurface utilities in the roadway. The process of open utility cuts can result in a weakening of the foundation of the pavement, decreasing the expected life of the pavement section [Schaefer et al., 2005]. Furthermore, the repaired pavement has been observed to degrade at a quicker rate than the surrounding pavement. The performance of a repair is influenced by a number of factors such as backfill materials, compaction of the backfill, season in which it was completed, and compaction of the asphalt surface, to name a few. Therefore, there is a need to develop a best practices matrix which can be used to improve the long-term performance of for pavement repair of open utility cuts.

2 Research Context

Utility cuts in pavements are typically used to inspect, install or repair buried infrastructure such as communication or electrical cables, drainage, pipelines, sewer or water lines. The opening of the pavement, utility work, and replacement of the pavement results in an inconvenience to the traveling public due to delays, noise, and if the repair is not done properly, the resulting loss in ride quality. Furthermore, open utility cuts have been shown to cause premature deterioration of the repaired cut and the pavement beyond the cut (Bodocsi et al., 1995). The performance of a repair is influenced by a number of factors such as backfill materials, compaction of the backfill, season in which it was completed, and compaction of the asphalt surface, to name a few. Additionally, the pavement repair at the utility cut may experience functional or structural failure due to inadequate compaction of the soil, aggregate base, or asphalt repair; loss or lack of load transfer in a concrete repair; frost heave in the wet/freeze zone; and other factors.

Schaefer et al. (2005) identified three primary modes of failure: settlement in the patch, rising or humping of the patch, and failure of the surrounding pavement. Settlement, or a low spot in the patch, is typically caused by either, or the combination of, poor compaction of natural subgrade or other backfill materials which have been exposed to wet or frozen conditions or the use of unsuitable backfill materials (Schaefer et al., 2005).

Various types of cuts have been used to improve performance, while minimizing the area of the pavement to be repaired. There are three basic types of open utility cut trenches in pavements, as shown in Figure 1. A vertical or U-cut consists of a trench cut for the repair of the subsurface utility followed by placement of new pavement material the same width as the trench cut. The T-repair or T-section and sometimes referred to as a cutback, requires that in addition to the initial cut made to access the utility, a second saw cut is made to remove all or partial depth of the existing pavement material beyond the width of the trench. The third type is similar to the T-repair, however in addition to removal or cutback of the pavement material, unbound material such as granular base and/or subgrade to a specified depth is also cutback beyond the initial trench width.

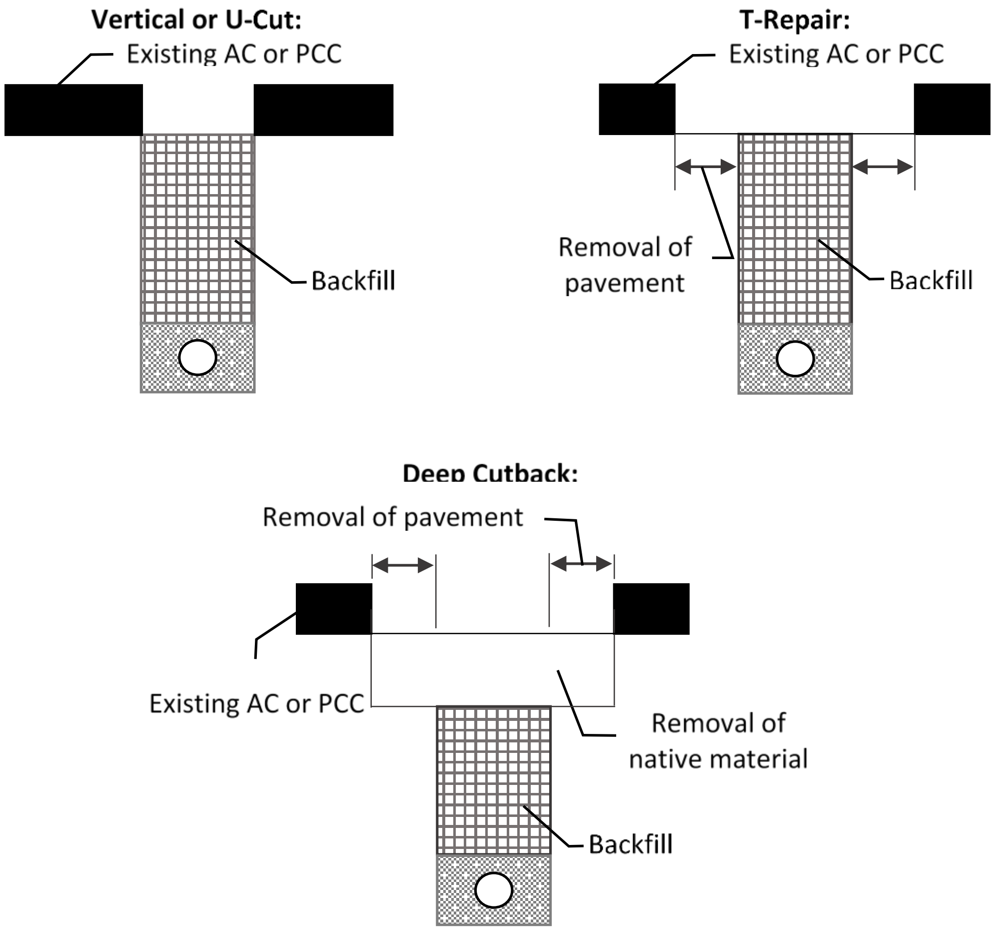

Figure 1 Type of open utility cut repairs.

Todres (2000) identified the two primary reasons for using T-repair as sealing against infiltration of water from the top and structural strength. Suleiman et al. (2010) found T-repairs performed better than deep cutback repairs in terms of settlement despite reduced deflections in the deep cutback repairs under falling weight deflectometer (FWD) testing in the zone of influence. However, in a review of best engineering practices for utility cuts in asphalt pavements, Todres (2000) argues T-repairs are costly in terms of labor, material and environmental costs, due to the increase in pavement removal which can be at most nearly three times an area without cutback of existing asphalt, and the need for a second sawcut.

Guidance for controlling and reducing the frequency of utility cuts is provided by Wilde et al. [2002]. The researchers recommended policy and technology methods to control or reduce utility cuts. Policy strategies include incentives, fees, and regulations. Incentives can be used to encourage trenchless technology (e.g. guided boring, auger boring, microtunneling, pipe bursting, etc.) where applicable, use higher quality material for repairs, make smaller or less damaging cuts, and coordination with other utility companies to share trenches and/or resources. Incentives may be in the form of waiving inspection fees or permits, and decreasing or eliminating fees associated with repairs. Examples of strategies using fee based policies include fees for pavement degradation, appropriate permit fees, lane rental fees, bonds, and penalties for non-compliance [Wilde et al., 2002].

Although there has been a range of research completed in the area of utility cuts, there has not been an effort to compile this information into a best practices matrix applicable to large local agencies subjected to Ohio conditions.

2.1 Objectives

The primary objective of this research was to identify the best practices for pavement restoration of open cut utility installation on local roads in urban areas to ensure low cost and long-term performance. It is expected this work will be an essential step for determining degradation rates of various pavement repair methods in the future. Additionally, a matrix of best practices was developed for pavement restoration techniques for open cut utility installation.

2.2 Tasks

To fulfill the objectives listed above, the following tasks were undertaken:

1. Conduct a literature search. A literature search was conducted to help identify current best practices and new and emerging technology for pavement restoration of open utility cuts. Relevant information identified from the literature search was included in the synthesis of current practices and new and emerging technology. Additionally, the literature search was used to help identify current best practices for inclusion in the matrix of best practices.
2. Issue survey and summarize responses. A survey was issued to local agencies across Ohio and surrounding states to collect information pertaining to current practices for pavement restoration of open utility cuts.
3. Interviews with local transportation officials and field site visits. Local agencies in Ohio were selected for a follow-up phone interview to gather additional information related to their standards and practices for restoring pavement in open utility cuts. Based on those interviews, three agencies were selected for a follow-up in-person interview and field site visits.
4. Field and laboratory evaluation of selected sites. Field testing was conducted to capture properties associated with repairs having good and poor performance. Laboratory evaluation was conducted as needed on samples collected in the field.
5. Create a synthesis of current practice and new and emerging technology. Information related to current practices and new or emerging technology related to pavement restoration of open utility cuts gathered from the literature search, survey, and interviews were utilized to develop a synthesis.
6. Develop matrix of best practices. Results of Tasks 1 through 4 were used to develop a matrix of best practices.
7. Prepare final report. A technical report was written which summarized findings, drew conclusions, and documented results. The synthesis of current practice and new and emerging technology was included in the final report. The matrix of best practices was included in the final report as well.

3 Research Approach

3.1 Literature Search

A comprehensive literature search was conducted to help identify current practices for pavement restoration of open utility cut installations.

3.2 Local Agency Survey

To learn current practices for repair of open utility cuts of large local agencies (population greater than 25,000), a survey was developed. The survey was issued to LTAP offices in states which have a wet-freeze climate as identified in the Long-Term Pavement Performance (LTPP) program and subgrade soils similar to Ohio subgrade. As shown in Figure 2, the most predominant surface soil texture in Ohio is a silt loam (NASA, 2017). Therefore, the LTAP office in the following states were contacted: Ohio, Missouri, Illinois, Indiana, Kentucky, West Virginia, Pennsylvania, and New York.

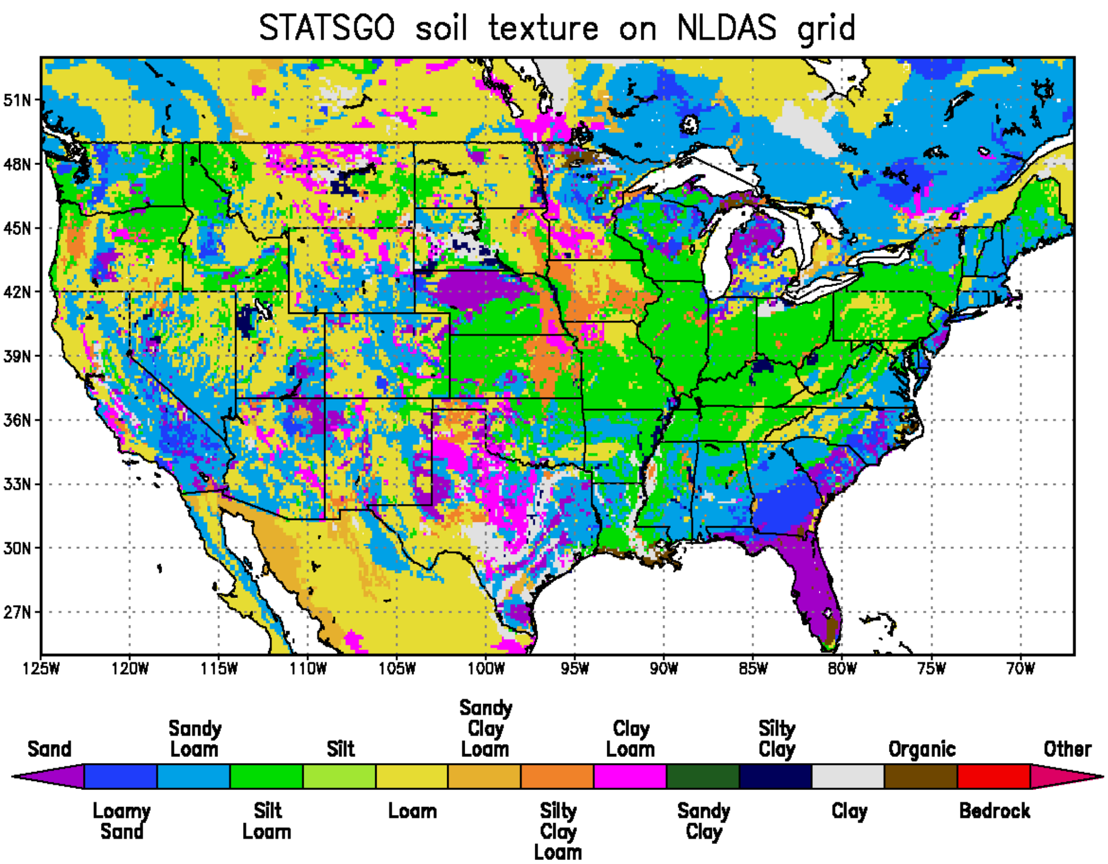

Figure 2 Predominant Soil Texture in the continental United States (NASA, 2017).

A survey was developed and is shown in Appendix B. Survey questions were developed to focus on standard methods of repair, materials, and policy used in local agencies for open utility cut repairs. Through the literature search previous research studies which conducted surveys were identified such as the work by Schaefer et al. (2005) and Mohamed et al. (1999). Such surveys helped to serve as a basis for the development of the survey conducted in this study. Once completed, the survey was sent to the Technical Advisory Committee (TAC) for approval prior to distribution.

The survey was developed in both pdf format and in an online format using the Qualtrics platform. A copy of the survey in pdf form and a link to the online survey was distributed via email to LTAP offices in all eight states on November 20, 2017 for distribution to large local urban agencies (with population greater than 25,000) with a requested completion date of December 22, 2017. Due to the proximity to the holidays and some LTAP offices indicating they had not received the email, the requested completion date was extended to January 12, 2018. Survey participants could complete the survey online, or by completing the pdf form and emailing or mailing the completed survey to the research team.

3.3 Interviews with Local Transportation Officials and Field Site Visits

3.3.1 Phone Interviews

A sample of large local urban agencies in Ohio were selected from the survey responses for a follow-up phone interview to gather additional information related to their standards and practices for restoring pavement in open utility cuts. The intent of the phone interviews was to clarify survey responses, collect additional details related to current practices for repair of open utility cuts, and identify agencies for follow-up detailed interviews, site visits, and field testing. Phone interview questions and a summary of the responses are provided in Appendix C.

Tabulated in Table 1 are the agencies interviewed, type of agency, region of the state for each agency, and date of the interview. Interviewees were provided with a list of questions prior to the phone interview so they could review the questions and prepare for the phone call.

Table 1. Ohio Local Agencies Interviewed by Phone

Name of Agency	Agency Type	Area of state	Date of interview
City of Columbus	City	Central	3/7/2018
City of Akron	City	Northeast	4/18/2018
City of Cleveland (Engineering & Construction)	City	Northeast	5/18/2018
City of Cleveland (Water Department)	City	Northeast	4/17/2018
City of Cleveland (Streets Department)	City	Northeast	5/23/2018
City of Lakewood (City Engineer) and City of Lakewood (Public Works)	City	Northeast	3/22/2018
City of Wooster	City	Northeast	3/27/2018
Lake County Engineer	County	Northeast	3/8/2018
City of Findlay	City	Northwest	3/30/2018
Northwestern Water and Sewer District	Water & Sewer	Northwest	3/21/2018
City of Dayton	City	Southwest	3/19/2018

Based on survey responses, agencies were selected for phone interviews. A variety of agencies were selected, with focus on agencies in northern Ohio. It had been planned to conduct phone interviews with 10 agencies, however after receiving survey responses and reaching out to agencies, it was elected to conduct 11 interviews with nine agencies. This was due in large part to the fact that while one office in an agency may develop the standards and specifications of the repairs and oversee permits of repairs, repairs are also being conducted by city forces in other offices such as public utilities (e.g. water and sewer). For example, multiple offices within the City of Cleveland, the agency with the largest number of open utility cuts each year, were interviewed.

3.3.2 In-person Interviews and Site Visits

Based on the phone interviews, three agencies were selected for a follow-up in-person interview and field site visits. These agencies were also selected for field and laboratory evaluation of existing repairs of open utility cuts. The three agencies were selected based on the predominant pavement types in their jurisdiction, number of open utility cuts performed each year, the type of repair (vertical cut, or T-repair) specified in their standard, and the backfill material allowed. The three agencies selected for in-person interviews, field site visits, and field evaluation were City of Cleveland, City of Columbus, and City of Dayton.

In-person interviews were conducted in conjunction with a visit to each of the three cities for field site visits. Site visits were conducted to look at existing repairs of open utility cuts with a range of ages and performance. Prior to conducting the interview and site visit, the research team requested a list of at least six repairs performing poorly and six repairs performing well for the pavement type of interest, and at least three repairs on other pavement types. Although those identified as performing poorly exhibited distresses such as localized depressions, cracking around the edge of the repairs, and minor rises, no sites were encountered that had experienced structural failures (i.e. wheel track cracking, pumping of subgrade material through cracks, differential settlement of repair relative to existing pavement). Based on interviews and surveys conducted it is known that repairs which have failed have been observed, however in many cases agencies were not able to easily track or identify those repairs. The sites on the city's list of poor and well performing repairs were visited before or after the in-person interviews. Three well performing and three poor performing sites were chosen in each city for field and laboratory evaluation.

In-person interviews were conducted to further clarify previous information collected through the survey and phone interviews, to identify possible best practices, to identify possible reasons the identified repairs may be performing well or poorly, and to coordinate field evaluations. As part of the in-person interview, the research team also inquired as to what characteristics defined poor and good performance. Four in-person interviews were conducted, as shown in Table 2.

Table 2 List of In-person Interviews Conducted

Agency	Interviewees	Date of Interview
City of Cleveland	Dave Weglicki, Section Chief of Permits and Sidewalks Bob Chaplain, Inspector, Bureau of Sidewalks	10/10/2018
City of Dayton	David Escobar, Senior Engineer, Division of Civil Engineering Dave Weinandy, Chief Engineer, Construction	9/27/2018
City of Columbus	Dwayne Byrum, Construction Inspector	1/11/2019
City of Columbus	Tim Huffman, Manager, Water Distribution Engineering	1/11/2019

Additionally, as feasible, the research team observed repairs being conducted. Repairs of open utility cuts, depending on the size of the cut and the agencies standards, may span several days. Therefore, only portions of repairs could be observed. In the City of Cleveland, observations were made during the repair of a large open utility cut on a concrete pavement for the repair of a sanitary sewer line. The research team observed placement of the backfill material and sampled low-strength mortar being placed. In the City of Dayton, their standards dictate all initial repairs are performed as temporary repairs, and the utility or contractor return to complete the permanent repair. While visiting City of Dayton, the research team observed the placement of the permanent pavement surface for an open utility cut for a gas service line on an existing asphalt pavement.

3.4 Field and Laboratory Evaluation of Selected Sites

Tasks performed during the field evaluation included:

1. Measured patch and pavement dimensions
2. Photographed site to document condition of pavement and repair
3. Measured longitudinal profile of the pavement and repair through the centerline of the repair and transverse profile through the center of the repair to evaluate ride quality of the repaired area
4. Measured pavement stiffness/response with the falling weight deflectometer

5. Cored pavement and repair to determine pavement layer thickness and collect samples for laboratory testing.

The cities of Cleveland and Columbus required a permit to work on city right-of-way. Both granted the research team a blanket permit. A permit was not required in the City of Dayton

The week prior to the planned field evaluation, the Ohio Utility Protection Service (OUPS) was contacted. Ohio law required OUPS be contacted no less than 48 hours before, and no more than 10 days when excavation or drilling is planned near a utility. OUPS is a one call service which notifies underground utilities located in the area of work. These utilities mark the location of their respective utility on the pavement prior to the planned work.

Maintenance of traffic (MOT) was coordinated with the city. MOT typically consisted of signs and cones. Flag people, with paddle stop/slow signs, were used as necessary.

After MOT was in place, the dimensions of the repair were measured. A line for FWD and dipstick measurements was marked on the pavement using a chalk line and locations for FWD tests and cores, as shown in Figure 3, were marked on the pavement using paint. Photographs of the repair and markings were taken to document test locations and condition of the repair and pavement. Valve and manhole covers, utility markings on the pavement in response to the OUPS notice, etc. were noted in order to identify the utility repaired.

Figure 3 Example of chalk line and core layout.

Profile of the pavement was collected along the centerline of the lane using a FACE Dipstick 2200 profiler, as shown in Figure 4. The centerline, rather than a wheel path, was chosen because this was assumed to be the “as constructed” profile, unaffected by traffic, and would show any changes in road profile due to settlement or heaving. Dipstick measurements were typically began 25 ft (7.62 m) from the edge of the repair and continued to approximately 25 ft (7.62 m) on the opposite side of the repair. The dipstick measurements were then continued back to the original starting point along the same chalk line. The transverse profile of the centerline of the repair was also measured with the dipstick.

Figure 4 FACE Dipstick profiler used to collect profile along center of the lane.

Upon completion of the dipstick measurements FWD tests at four drop heights corresponding to target loads of 6000 lbs (26.7 kN), 9000 lbs (40.0 kN), 12,000 lbs (53.4 kN), and 15,000 lbs (66.7 kN), using a JILS FWD, shown in Figure 5. Typically, tests were conducted at three locations within the pavement repair and two each on either side of the repair, as shown in Figure 6. Locations within the pavement repair were near the middle of the repair, and just inside the edge of the repair on each side. Testing outside of the repair were conducted near the boundary, at approximately two to three feet from the edge and at a distance far enough away the material would be undisturbed by the open cut. Distances between test locations were determined on a case-by-case basis. Measurements were collected in both directions.

Figure 5 JILS FWD.

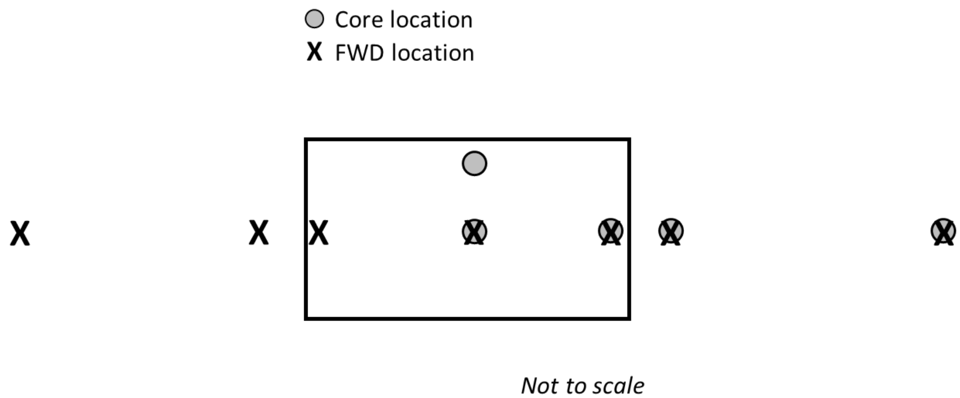

Figure 6 Schematic of test layout

Coring, as shown in Figure 7, was conducted at five locations at each site to observe the cross-sections of the existing pavement restoration and existing pavement. Typically, three pavement cores were collected within the boundary of the repair, and two outside, as shown in the testing schematic. Observations of each core were used to help characterize the performance of each site. Thicknesses of each core were measured. Samples of the granular or stabilized base were collected using a core bit or hammer driven soil core sampler, as shown in Figure 8. Base material sampled was sealed in tubes or bags and transported to the laboratory for determination of moisture content and visual determination of color and grain size. Upon completion of the sampling, holes were repaired in accordance with the requirements of the respective city.

Figure 7 Coring of existing pavement.

Figure 8 Sampling of base or backfill material.

Laboratory testing was conducted on the collected cores to evaluate quality of construction. The laboratory testing is described in later subsections.

3.4.1 FACE Dipstick Analysis

The FACE software generates a text file of elevation, in inches, for each step, in this case, every 12 inches. The data were copied to an EXCEL worksheet where the data were plotted. Figure 9 is an example of the plot for 66 South Sperling Avenue. The blue line is the up measurements and the orange line is the return measurements. As shown in the Figure, there is a slight drift in the data which was typical for all sections. The manual for the dipstick provides a procedure for correcting the data by applying an equal correction to each measurement. The procedure resulted in a plot which was the average of the measurements at a point.

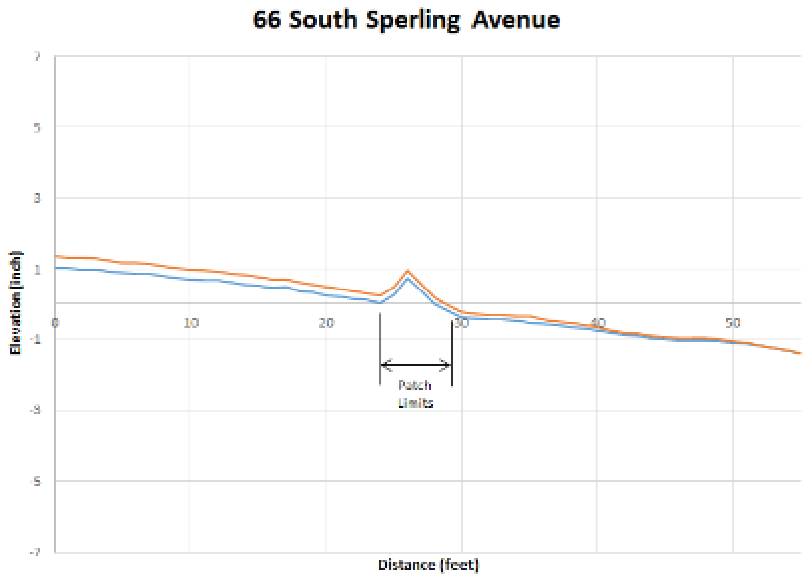

Figure 9 Example of longitudinal profile measurements from FACE Dipstick.

The dipstick also provided an estimate of IRI. The values calculated were unreasonable, some values being as high as 950 in/mile (15.0 m/km). These high estimates were most likely due to the length measured being too short to determine a reasonable IRI. Therefore, the plots were used to visually determine if the repairs have heaved or settled, or if there was settlement at the repair boundaries.

From the dipstick measurements, the total deviation, maximum dip and maximum hump were determined for each repair. The average values among the repairs were plotted relative to the type of repair (vertical or T-repair) and backfill material (granular or LSM), as shown in Figure 10. The average total deviation as well as the average maximum dip and hump for T-repairs were comparable for repairs backfilled with granular material and LSM. Differences are noted in averages of the total deviation and maximum dip between the vertical repairs using granular or LSM backfill. For the three vertical repairs backfilled with granular material, the average total deviation and average maximum dip were greater than the average total deviation and average maximum dip for all other combinations of repair and backfill material. While this may indicate there is a tendency towards settlement for vertical repairs backfilled with granular material, there are too few repairs of each combination to truly draw conclusions on this topic.

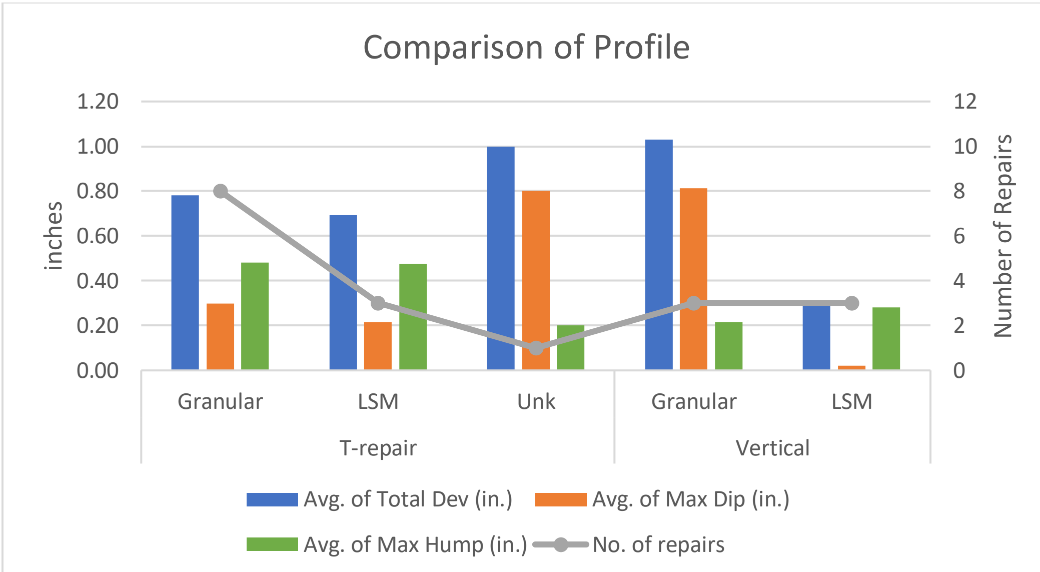

Figure 10 Comparison of average profile characteristics by repair type and backfill material used.

3.4.2 FWD Analysis

A properly repaired open utility cut would be expected to have a service life equal to or greater than the surrounding pavement. In addition, the repair should be sufficiently long enough to encompass all subgrade material weakened by the utility break or by excavation to repair the utility. Deflection data collected by the falling weight deflectometer (FWD) can be utilized to analyze the pavement structure and subgrade. Typically, layer modulus values are backcalculated from the data however, the results obtained from this process can be highly variable, especially when the layers being analyzed vary in terms of material type and thickness. An analysis of pavement stiffness, i.e. the load divided by deflection, can achieve the goal of comparing the structure capacity of the repair to the surrounding pavement. Stiffness values were normalized relative to the stiffness measured at the center of the repair as this location can be easily compacted and not affected by conditions (water infiltration, weakening due to excavation, etc.) at the boundaries of the repair. Normalization of the stiffness allows comparisons within and between sections.

FWD data were normalized using the following procedure:

- Stiffness was determined by dividing the measured load at test location by the deflection collected at the sensor located at the center of the load plate
- Stiffness was normalized relative to the repair for a location by dividing the stiffness at an FWD test location by the stiffness at the center of the repair (typically FWD location 4).

The value for normalized stiffness at the center of the repair will always be 1.00. Values higher than 1.00 indicate the pavement structure at that location is more stiff than the center of the repair. A value lower than 1.00 indicate the pavement structure at that location is less stiff than the repair.

FWD measurements can also be used to determine the modulus of the material used for the base under the repair. Equation 1, from section 5.4.5 of the 1993 AASHTO Guide for Design of Pavement Structures (AASHTO, 1993) was used to directly estimate base resilient modulus.

$$M_R = \frac{0.24P}{d_r r} \qquad \text{Equation 1}$$

Where,
M_R = backcalculated subgrade resilient modulus, psi
P = applied load, pounds
d_r = deflection at distance r from the center of the load, inches
r = distance from center of load, inches

3.4.3 Laboratory Testing

3.4.3.1 Asphalt Concrete

Where asphaltic material was used in the pavement restoration, bulk specific gravity (BSG) and maximum specific gravity (MSG) were determined in the laboratory to characterize the in-place density of the three cores sampled within the restoration. BSG was determined for each core in accordance with AASHTO T 166 and MSG was determined in accordance with AASHTO T 209 using all three cores sampled within the restoration to characterize the in-place density of the material.

3.4.3.2 Concrete

When concrete pavement was used in the pavement restoration, compressive strength tests was conducted on the collected cores. The intent was to conduct compressive strength tests on controlled low-strength mortar when used as a backfill material however, samples cemented sufficiently for testing could not be obtained. Instead, base samples from repairs where controlled low-strength mortar was reportedly used were examined with a Leica Zoom 2000 microscope to confirm particles were cemented. Concrete was recovered from the repair at all six locations in Cleveland and from the site located at 1576 Old Leonard Avenue in Columbus. All solid cores were trimmed to a height equal to two times the diameter and the compressive strength determined in accordance with AASHTO T 22.

3.4.3.3 Base and subgrade material.

Moisture content of base and subgrade sampled was determined in accordance with AASHTO T 265. The color and grain size of the material was visually observed. A Leica Zoom 2000 microscope was used to assess if particles were cemented.

4 Research Findings

4.1 Best Practices Matrix

Best practices identified during the literature search, surveys, interviews, and field evaluations were compiled into the best practices matrix shown in Table 3.

Table 3 Best practices matrix for repair of open utility cuts.

Item	Source	Best Practice
Backfill material	Literature Search	• For uniform stiff support of the pavement restoration it is recommended low-strength mortar (LSM) should be used.
	Survey/Interviews/Site Visits	• Survey showed about equal number of agencies allow LSM that allow granular material. • Site visits showed lack of quality control and quality assurance on LSM. It is recommended samples of LSM be collected at time of placement to ensure proper curing. It is recommended material tickets also be collected at time of placement to ensure material meets specifications. • Where granular material is used, agency specifications should be followed to ensure material is not saturated and is compacted properly.
	Field Evaluations	• Based on field evaluations no significant difference was found between granular material and LSM relative to stiffness.
Pavement material: Concrete	Literature Search	• It is recommended the concrete patch be dowelled to the existing pavement where concrete pavement thickness is greater than or equal to 7 in. (175 mm), otherwise dowels are not recommended.
	Survey/Interviews/Site Visits	• When plain concrete is exposed, replace entire slab. • Match existing concrete pavement thickness.
Pavement material: Brick	Survey/Interviews/Site Visits	• Replacing brick with brick pavers maintain the historical aesthetics of the neighborhood, although it is costly and time consuming. Using dyed and stamped concrete may be used as an alternative.
Pavement material: Asphalt	Field Evaluations	• Based on examination of extracted asphalt cores, in many repairs it appeared asphalt was placed in one lift in the repair and had relatively high air voids in the repair. Therefore, it is recommended placement and compaction of asphalt is inspected to ensure adherence to standard and adequate compaction of the material.
Pavement material: Concrete composite and rigid brick composite	Survey/Interviews/Site Visits	• Utilize a concrete base in the repair, placed at least to height of existing concrete to prevent heaving of repair.
Pavement material: Brick composite	Survey/Interviews/Site Visits	• Agencies interviewed repaired brick composite with either a concrete or asphalt base. Insufficient projects were available to verify performance.

Item	Source	Best Practice
Repair method	Survey/Interviews/Site Visits	• The repair area was minimized with keyhole repairs. Consideration needs to be given to the condition of the existing pavement as well as the backfill material used.
	Field Evaluations	• No significant differences were found between stiffness in those repairs made with a vertical and those with a T-repair. Therefore, either repair method should provide sufficient structural performance. • It was found vertical repairs with granular backfill had the greatest average total deviation and average maximum dip among all combinations of repair type and backfill material evaluated. While this trend was observed, there were not enough repairs in each category to draw statistically significant conclusions as to which combination has the greatest tendency towards settlement.
Construction	Literature Search Survey/Interviews/Site Visits	• Where asphalt is used in the surface of the repair, it is recommended that crack sealing be applied by the overband method to the joint to prevent water infiltration and reduce raveling. • Saw cut pavement to provide clean square joints for the permanent pavement restoration of the repair.
Extent of repair	Survey/Interviews/Site Visits	• Removal of any saturated unbound material is necessary. Limits of the excavation may have to be expanded to ensure saturated material is completely removed and adequate compaction can be achieved. • Several agencies required the use of pavers to pave asphalt full lane width for large or long repairs. Definition of large varied from city to city, with the smallest being 100 square feet. • If the repair is within three feet of the curb or lane line, the repair should be extended to the curb, or the entire slab should be replaced.
Temporary/emergency repairs	Survey/Interviews/Site Visits	• Use concrete, cold mix, or asphalt for temporary repairs. If weather does not permit the use of asphalt use either concrete or cold mix for temporary repair. If cold mix is used, replace cold mix with asphalt as soon as hot mix asphalt is available. If asphalt is preferred as the permanent surface, utilize a bond breaker (plastic, etc.) between the permanent concrete base and temporary concrete surface. Replace concrete with asphalt when it is suitable to do so.
Quality Assurance	Survey/Interviews/Site Visits	• Sufficient staff is needed to provide inspection on a significant portion of open utility cut repairs.

Item	Source	Best Practice
		• Repairs of publicly owned utilities should be subjected to the same specifications as privately owned utilities; therefore, repairs completed by agency forces should also be inspected. • It is recommended the contractor be required to contact the agency prior to critical points in the repair including placement of backfill and asphalt in order for the inspector to be present. For enforcement, it is recommended a non-compliance clause be included in the permit such that if the contractor is non-complaint a warranty is placed on the repair. • Utilize RFID tags in temporary repairs, where asphalt or cold patch has been placed, to ensure the permanent repairs have been performed and to identify responsibility parties in the event of failure. • Utilize RFID tags in permanent repairs where asphalt is placed, to identify responsibility parties in the event of failure and for enforcement of warranties, if applied.
Administration/Policy	Literature Search	• Establish a contractor pre-qualification process. Only issue permits to prequalified contractors.
	Survey/Interviews/Site Visits	• Require permits to perform open utility cut work in the right-of-way. • Sufficient staff is needed to oversee permitting process and to track permits. • The agency and utility companies should share capital improvement program plans with one another to coordinate planned work to minimize need to perform open utility cuts on new pavement. • The agency should establish a moratorium policy to minimize open utility cut work on new pavement and to ensure expected service life of existing pavement. • Fees should be set to recover the costs associated with permitting and inspection.
New and emerging technology	Survey/Interviews/Site Visits	• Trenchless technology minimizes the area of the repair. Consideration should be given to local ordinances and density of utilities in the area.

5 Conclusions

Based on the work completed in this study, the following conclusions can be made:

- Due to the lack of detailed records, the research team was highly reliant on the list of repairs provided by the agencies. As a result, the sites selected for evaluation did not encompass a wide range of distresses. Furthermore, agencies do not have a method to track repairs that were constructed without a permit. Such repairs are more likely to have not met specifications and therefore, more prone to failure.
- FWD deflections were measured at three well and three poor performing repairs in each of the three cities. Repairs were selected from a list of those provided by each agency. Based on results from this limited study, FWD deflections indicated the stiffness in the repair was typically as stiff or greater than the stiffness found in the existing pavement. Therefore, it can be expected that for the repairs evaluated, they will have a service life equal to the existing pavement.
- Although, the use of T-repair was identified as a current practice in some literature, other literature supports the idea that T-repair requires additional saw cutting and material, without providing the perceived benefit of structural support or prevention of water infiltration.
    - Results from the field evaluations conducted in this study indicated there was no significant difference between stiffness determined from FWD deflections on those repairs where T-repair was required and on those repairs where vertical cut was required.
    - Base moisture content was found to be higher in field evaluations conducted in City of Columbus which requires a vertical repair than base moisture content in other cities where T-repair is required. However, it could not be determined if this was due to the repair method alone.
- For the repairs constructed with a heat weld evaluated in this study, the joint of the repair had reflected through the heat weld. Therefore, it may not be effective in reducing water infiltration.
- Many agencies required sealing the joints of asphalt surfaced repairs. This will help to prevent water infiltration and reduce raveling. When used as a preventive maintenance treatment, crack sealing has been shown to extend the life of pavements in Ohio (Rajogopal, 2011), it can be assumed this benefit would apply to utility cut repairs as well. However, water infiltration will only be prevented for as long as the crack seal is maintained.
- Based on the results of the literature search, surveys, interviews, site visits, and field evaluations, a matrix of best practices was developed for the repair of open utility cuts, and if implemented, should improve the performance of open utility cut repairs.

6 Recommendations

The best practices matrix identifies best practices as defined in the literature, local agency personnel, and identified from field evaluations. Many of the practices can be implemented with minor changes to current procedures or specifications. The information gathered from the survey and interviews are subjective, with limited verification by site visits. The research team recommends the identified best practices be adopted by local agencies as a specification, policy, or procedure after local verification.

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8 Appendix A: Results of Literature Search

8.1 Introduction

Utility cuts in pavements are typically used to inspect, install or repair buried infrastructure such as communication or electrical cables, drainage, pipelines, sewer or water lines. There are an estimated 3.6 million road opening permits issued nationwide each year (Jarnecke and Pollock, 2017). Local Public Agencies often face the challenge of repairing their pavements after the installation or repair of subsurface utilities in the roadway. While minimizing the need to disturb the in-service pavements through advanced planning and coordination with other planned roadway work is ideal, open utility cuts are often unavoidable. The opening of the pavement, utility work, and replacement of the pavement also results in an inconvenience to the traveling public due to delays, noise, and if the repair is not done properly, the resulting loss in ride quality. Furthermore, open utility cuts have been shown to cause premature deterioration of the repaired cut and the pavement beyond the cut (Bodocsi et al., 1995). The performance of a repair is influenced by a number of factors such as backfill materials, compaction of the backfill, season in which it was completed, and compaction of the asphalt surface. Additionally, the pavement repair at the utility cut may experience functional or structural failure due to inadequate compaction of the soil, aggregate base, or asphalt repair; loss or lack of load transfer in a concrete repair; frost heave in the wet/freeze zone; and other factors.

8.2 Type of Utility Cut Repair Failures

Schaefer et al. (2005) identified three primary modes of failure: settlement in the patch, rising or humping of the patch, and failure of the surrounding pavement. Settlement, or a low spot in the patch, is typically caused by either, or the combination of, poor compaction of natural subgrade or other backfill materials which have been exposed to wet or frozen conditions or the use of unsuitable backfill materials (Schaefer et al., 2005). Settlement in the repaired area also allows for water to pool in the surface which can exacerbate existing settlement. According to Schaefer et al. (2005) a rise or hump in the repaired area under winter freeze/thaw conditions is often a result of frost action. Frost heave, a form of frost action and a result of the formation of ice lenses, occurs when the following exist: frost susceptible soils (soil with significant amount of fines), temperatures below freezing, and water in the pavement structure (from high groundwater table, infiltration, underground aquifer, or water held within voids of fine-grained soils) (Pavement Interactive, 2018). Lastly, the pavement adjacent to the repaired area can settle and fail, eventually leading to failure of the patch itself. According to Schaefer et al. (2005) this typically occurs when the soil in the existing pavement adjacent to the repair has been weakened by the excavation for the repair. The weakened area around the utility cut excavation is called the “zone of influence,” as shown in Figure 11.

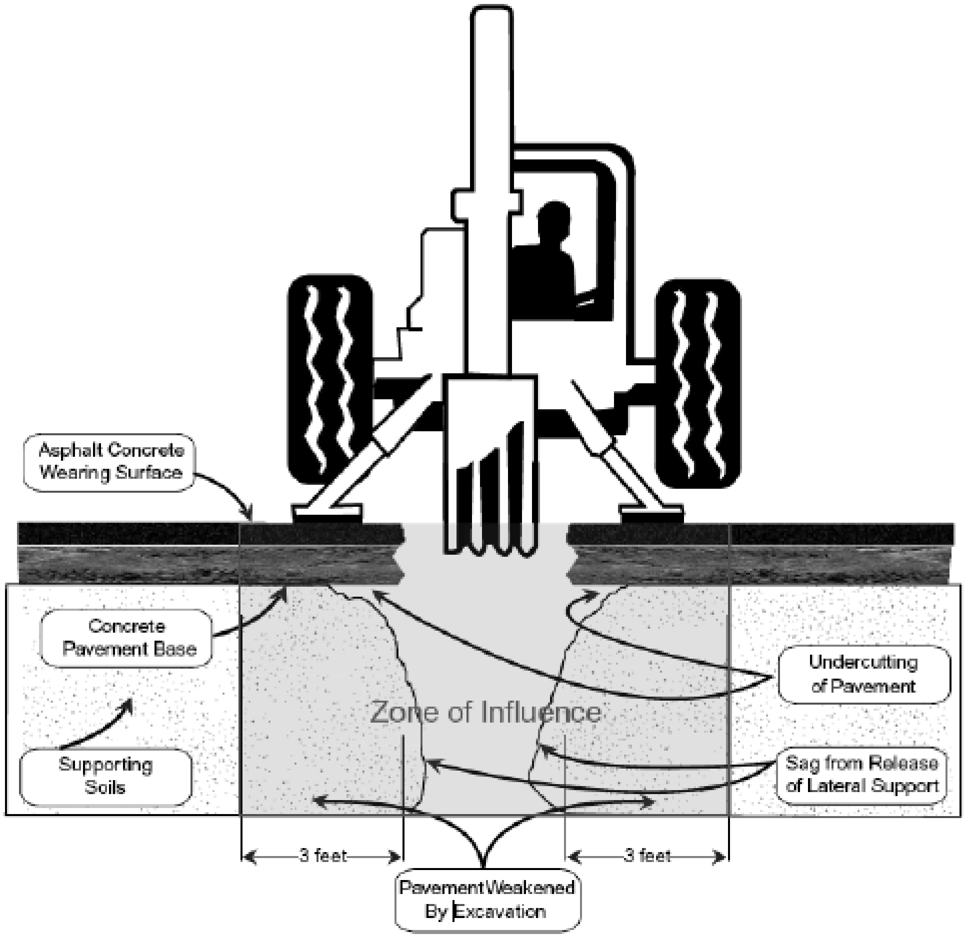


Figure 11 Zone of Influence (Schaefer et al., 2005)

8.3 Type of Open Utility Cut Repairs in Pavements

According to the FHWA Field Guide on Utility Cuts in Paved Roads (1996), trench widths should be the width of the utility plus a minimum of 18 in. on each side and the width of the cut be kept as narrow as possible to minimize the size of the pavement patch. Various types of cuts have been used to improve performance, while minimizing the area of the pavement to be repaired.

There are three basic types of open utility cut trenches in pavements, as shown in Figure 12. A vertical or U-cut consists of a trench cut for the repair of the subsurface utility followed by placement of new pavement material the same width as the trench cut. The T-repair or T-section and sometimes referred to as a cutback, requires that in addition to the initial cut made to access the utility, a second saw cut is made to remove all or partial depth of the existing pavement material beyond the width of the trench. The third type is similar to the T-repair, however in addition to removal or cutback of the pavement material, unbound material such as granular base and/or subgrade to a specified depth is also cutback beyond the initial trench width. To distinguish from the T-repair, the third type of cut is referred to as a deep cutback in this literature review.

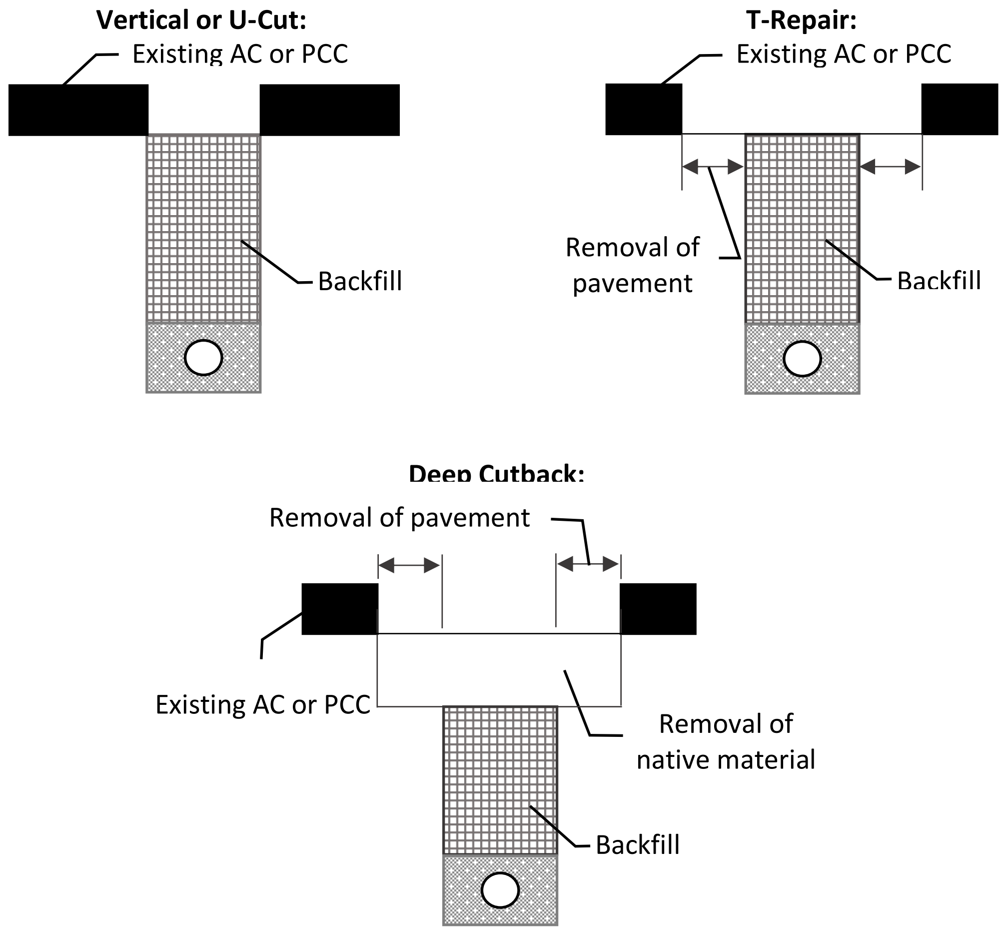


Figure 12 Type of Open Utility Cut Repairs in Pavements.

For concrete pavements or where a concrete base is used in the repair, the FHWA Field Guide (1996) points out that the pavement cut is typically wider and longer than the trench so the concrete spans the trench and is supported by undisturbed soil, such as a T-repair or deep cutback repair.

A recent study titled, sought to identify current practices for utility cut restoration among state agencies (Kumar et al., 2019). Results of the survey showed 13 of the 19 state agencies surveyed required an additional cutback of the pavement surface to achieve a T repair. The extent of the required cutback varied from 1 to 4 ft. on either side of the initial trench.

In a review of best engineering practices for utility cuts in asphalt pavements, Todres (2000) discusses T-repairs (also referred to as cutback). Todres argues such practices are costly in terms of labor, material and environmental costs, due to the increase in pavement removal which can be at most nearly three times an area without cutback of existing asphalt, and the need for a second sawcut. The two primary reasons for using T-repair were identified as sealing against infiltration of water from the top and structural strength. (Todres, 2000)

In addressing the notion that T-repair methods for asphalt pavements can act as a seal, preventing moisture penetration, Todres (2000) points out the effectiveness of creating a more complex path in reducing moisture penetration is unknown. Todres notes the claimed benefit is bought at the cost of an increased perimeter around the trench in which water may enter.

In regards to the structural strength, Todres (2000) reasons it is "gained by a bridging effect" and asphalt concrete, being a visco-elastic material, cannot provide beam strength and instead will "relax to follow the underlying contour," thereby settlement due to poor soil compaction cannot be mitigated by using a T-repair. To support this, Todres points to a 1991 laboratory study (Mangolds and Carapezza) which found good soil compaction was a significant factor in avoiding settlement and poor soil compaction was not mitigated by use of a T-Repair. Todres further points to field studies. Todres (2000) summarizes one study (Maxim Technologies, 1995) which also addressed the effect of repair type on performance. In Hawaiian Gardens, California sixteen utility cuts were made in the wheelpath of a heavily trafficked lane to study the effect of backfill density, and repair configuration (standard or T-repair) on the performance of utility cut repairs. A comparison, albeit limited, between hot mix asphalt concrete and cold mix asphalt concrete was also conducted. Based on results from monitoring the repairs over two years during which time deflections were measured with an FWD and profile measurements were made, no significant difference in performance was found between standard repairs and T-repairs surfaced with hot mix asphalt concrete. On the topic of repair configuration for asphalt pavements, Todres ultimately concludes "the best cut performance can be anticipated from straight-sided cuts and repairs" where the repair materials and thicknesses match the surrounding pavement as close as is practical (Todres, 2000).

Introduced as part of a study on reducing settlement in utility cut repairs in Iowa (Schaefer et al., 2005) (there referred to as a cutback), the deep cutback was further investigated in a follow-up study (Suleiman et al., 2010) (in which it was referred to as a T-Section). In the follow-up study six trenches were excavated in which two followed the description for T-repair used herein, and the remainder were a deep cutback trench. In addition to the type of repair, granular backfill materials and the use of structural geogrids were also explored. Based on the performance of the six trenches, Suleiman et al. (2010) found T-repairs performed better than deep cutback repairs in terms of settlement despite reduced deflections in the deep cutback repairs under falling weight deflectometer (FWD) testing in the zone of influence. Ultimately Suleiman et al. (2010) concluded the increased effort and resources required of deep cutback repairs does not yield improved performance. Where T-repairs are used as opposed to deep cutback repairs, Suleiman et al. (2010) recommended a minimum of 2' of pavement be removed around the perimeter of the initial trench cut and the soil be recompacted before new pavement is placed.

8.4 Pavement Materials

Patching material for utility cuts often includes the use of like material, i.e. asphalt for flexible pavement and concrete for rigid pavement. When patching concrete pavement with concrete, the American Concrete Pavement Association (ACPA, 2014) recommends the pavement be removed 6 to 12 in (0.15 to 0.3 m) beyond the planned utility cut and flowable fill or compacted granular material be used to backfill the utility cut. ACPA recommends the concrete patch be dowelled to the existing pavement if the pavement thickness is greater than or equal to 7 in (175 mm), otherwise dowels are not recommended.

One method used for asphalt repair is the "T" section, where an additional 6 to 12 in (0.15 to 0.3 m) or more of the asphalt pavement is removed on either side of the utility cut, as shown in Figure 12, to key the repair and delay seepage of water into the pavement foundation (Schaefer et al., 2005 and Todres, 2001).

The Interlocking Concrete Pavement Institute has developed a system for repairing utility cuts using concrete pavers (ICPI). Proprietary materials such as polymerized cold mix, etc., have also been developed for patching utility cuts, especially in the wet/freeze area where cold temperatures or wet weather prevent the use of conventional asphalt or concrete mixes. The use of conventional repairs, as well as the proprietary materials, are well documented in NCHRP synthesis 463 (McDaniel et al., 2014). Several states are investigating the use of precast concrete panels for pavement repair, including a system with removable panels that allow access to underground utilities (TRB AFD70, 2017).

8.5 Backfill Materials

Schaefer et al. (2005) reported poor performance around utility trenches is often due to improper backfill placement such as poor compaction, or material that is too wet or dry. They also reported the use of controlled low strength material (CLSM) eliminates future settlement that results when using soil backfill materials. CLSM does not require compaction, however, it does have a higher initial cost than soil or granular backfill material.

Additional information is provided on CLSM, also referred to as flowable fill or controlled density fill (CDF) in a later subsection.

8.6 Repair Performance

Many methods have been used to measure the "performance" of a patch of a utility cut. Guthrie et al. [2015] utilized the measurements from the dipstick, straightedge, and light weight deflectometer along with a cracking survey to determine pavement condition index (PCI) and present serviceability index (PSI) for their test sections. Schaefer et al. (2005) used the nuclear density gage, dynamic cone penetrometer (DCP), and Clegg hammer to monitor the quality of construction during the patching of a utility cuts in Iowa while Vidokovich et al. (2010) used an elevation survey and falling weight deflectometer for long term monitoring of the effectiveness of the same repairs. In addition, installed instrumentation to monitor temperature, pressure, moisture content, and settlement. Nichols, Vallerga & Associates (2000) used PCI and deflection measurements to determine fees for utility cuts in the City of Seattle. To measure the quality of the material used for backfill, Griffin and Brown (2011) looked at unconfined compressive strength, density and hardening time when evaluating flowable fill.

A study by Nichols, Vallerga, and Associates (2000) for the city of Seattle found asphalt and composite pavement sections with utility cuts had an average PCI of 14 and 7 points lower than the respective pavements without utility cuts. However, they found there was no statistical difference in the performance of concrete pavements with and without utility cuts. Deflection measurements were taken with a falling weight deflectometer (FWD) on the repair, 2 ft (0.6 m) off the patch, and 10 ft (3 m) off the patch. For asphalt pavements, based on the deflection measurements, an additional 1.6 in (40 mm) of asphalt, on average, would be needed to restore the patched area structurally to the unpatched area. Only 4 of the 10 tested concrete sections were adversely affected by the repair and the effect was not consistent. For the composite sections, an average of 1.5 to 1.7 in (38 to 43 mm) of asphalt would be needed to make the patched area equal to the unpatched area structurally, depending on assumed interface bonding condition.

Guthrie et al. [2015] investigated the effect of utility cuts on remaining service life (RSL) of flexible pavements in Springville City, located in northern Utah. Functional classification, age at time of cut, and age at time of testing were considered. Pavement life was quantified in terms of PCI and PSI. The researchers found the utility cut resulted in a reduction of 22.6 and 1.3 for PCI and PSI, respectively. In turn, this resulted in a reduction of predicted pavement life of 18.7 and 50.0 years, based on PCI and PSI, respectively.

8.7 New and Emerging Technology

Wilde et al. (2002) discussed the use of available trenchless technology to reduce the number of pavement cuts. Methods discussed include:

- Horizontal directional drilling, or guided boring
- Auger and slurry boring
- Pipe jacking and microtunneling
- Impact moling and ramming, or thrust boring
- Pipe bursting.

Dawson et al. (2017) discussed additional new technologies including:

- Infrared repair, where infrared heat is used to soften the asphalt to allow blending and compaction of the existing and repair asphalt in the repair area.
- Precast concrete pavement that is pre-fabricated and installed during the original construction or during repair.
- Keyhole excavation in which the utility to be repaired is accessed thru a circular core hole, typically 18 to 24 in (0.45 to 0.6 m) in diameter, and vacuum excavating the base and subgrade. The core is reinstalled and bonded in place when work is completed. Additional details and benefits of this technique are provided in Jarnecke and Pollock (2017).

Kumar et al. (2019) conducted interviews with state and local agencies engineers to determine reasons for utility cut repair failures and to make recommendations for mitigate failures. One recommendation was to utilize radio frequency identification (RFID) tags to easily identify the party responsible for a repair. The RFID tags store information such as the date of the repair, the utility contractor responsible, This is especially helpful when an emergency repair is needed or when failures occur in the repair. This technology has been implemented in the City of Dayton.

8.8 Policy

Guidance for controlling and reducing the frequency of utility cuts is provided by Wilde et al. (2002). The researchers recommended policy and technology methods to control or reduce utility cuts. Policy strategies include incentives, fees, and regulations. Incentives can be used to encourage trenchless technology (e.g. guided boring, auger boring, microtunneling, pipe bursting, etc.) where applicable, use higher quality material for repairs, make smaller or less damaging cuts, and coordination with other utility companies to share trenches and/or resources. Incentives may be in the form of waiving inspection fees or permits, and decreasing or eliminating fees associated with repairs. Examples of strategies using fee based policies include fees for pavement degradation, appropriate permit fees, lane rental fees, bonds, and penalties for non-compliance (Wilde et al., 2002).

Procedures for determining fees are provided by Nichols, Vallerga, and Associates (2000), Mouaket and Capano (2013), and Lakkavalli et al. (2015). Regulation based policies included restricting trenching in newly resurfaced pavements for a period of time, enhanced inspection and enforcement, and requiring the repair meet quality standards.

Kumar et al. (2019) also recommended implementing a requirement that contractors be prequalified. This would help ensure work meets agency standards. Additionally, Kumar et al. (2019) states this would provide a method for screening contractors with a history of failed repairs.

8.9 Flowable Fill Used in Pavement Utility Cut Repair Work

Differential settlement between backfilled trenches and surrounding areas has been a problem for many years. Flowable fill was developed to attend to the problem during the 1970's. The American Concrete Institute (ACI) set up Committee 229 to develop guidelines/specifications for and promote this new material. Flowable fill has been used to many field applications including utility trench backfills, structural fills, insulating fills, isolating fills, abandoned mine void fills, and foundation improvements.

Flowable fill is a common technical term used for grout materials that are derived by mixing Portland cement, fine aggregate, and water. Flowable fill are also referred to as 'Controlled Low-Strength Material (CLSM)', 'Controlled Density Fill (CDF)', soil-cement slurry, unshrinkable fill, Quikrete, and K-Krete. In some cases, locally available industrial waste by-product (ex. fly ash, bottom ash), that has some cementitious abilities, is also blended in to reduce the amount of cement needed. There are two classes of fly ash generally available – class C and class F. Class C fly ash is produced by burning subbituminous coals. Class F fly ash results when combusting bituminous coals. Class C fly ash contains more free lime CaO and thus more cementitious. Class F fly ash often serves as a low-cost filler material.

Chemical admixtures are often added to the blend of main ingredients to improve the flowable fill's setting time and/or flowability. What separates flowable fill from conventional soil fill is that flowable fill is self-compacting and self-leveling (does not need to be compacted in lifts by compaction equipment) and void-filling. What separates flowable fill from regular concrete is that its fast setting time and its 28-day compressive strength being lower than 1.2 ksi (8.3 MPa).
When it comes to flowable fill, key engineering characteristics and properties include the following:

- Setting time
- Flowability
- Compressive strength
- Long-term excavatability (or removability)

Flowable fill was developed as an easy-to-produce and easy-to-apply material that can transition from its initial viscous liquid state to a hardened state relatively quickly. The setting time of flowable fill is often arbitrary defined as the time needed to gain a compressive strength of at least 50 psi (345 kPa) and dictated by its mix design. The setting time of flowable fill typically ranges from 1 to 5 hours.

Flowable fill is supposed to flow without experiencing material segregation problem. This ability is critical for filling voids that exist surrounding the excavated trench. Flowability of fresh flowable fill is typically measured by the standard cylinder flow test. A good flowable fill material has a spread of 8 to 12 inches (203 to 305 mm), according to ACI.

Compressive strength of flowable fill is measured by running the unconfined compression test on hardened cylinder specimens. This is typically done at the age of 28 days, to be compatible with concrete. It is believed that materials having relatively high compressive strength possess good bearing capacity (to support the pavement layer and live loads).
The long-term excavatability has been an issue for flowable fill. This is because any grout material that sets up quickly has potentials to eventually become as solid/hard as concrete. The excavatability is considered to be influenced by maximum aggregate size, compressive strength, and the type of equipment used. According to ACI (2008), flowable fill should remain excavatable as long as its maximum compressive strength stays within 100 to 200 psi (689 to 1,378 kPa). Brewer (1990) proposed a concept

of 'Removability Modulus (RE)' to quantitatively address the excavatability of flowable fill. The RE is defined as …

$$RE = \frac{104(UW)^{1.5}(\sigma_{30})^{0.5}}{10^6}$$

where
UW = unit weight (lb/ft^3);
σ_{30} = 30-day compressive strength (lb/in^2).

Brewer stated that the RE value of less than 1.0 indicates that the material is excavatable. The RE value for hard clay and concrete (compressive strength 3 ksi or 21 MPa) may be 1.00 and 10.3, respectively. Brewer (1991) subsequently came up with the concept of 'Removability Factor (RF).' The aim of the RF is to determine how easily a material can be excavated by correlating the characteristics of flowable fill and the equipment used. The RF is defined by …

$$RF = \frac{5.27TJ\left[1 + \left(\frac{IP - D^3}{\sqrt{IPD}}\right)\right]}{UW(A)}$$

where
T = equipment type (see Table 4 for values);
J = cutting edge used (see Table 4 for typical values);
I = impact factor (see Table 4 for typical values);
P = power factor (see Table 4 for typical values);
D = direction of excavation (see Table 4 for typical values);
UW = unit weight (lb/ft^3);
A = area under the stress-strain curve (lb-ft) = 0.0094 x (compressive strength in lb/in^2)$^{1.4}$.

Table 4 Typical Values of Parameters Associated with Removability Factor

Equipment Type	Cutting Edge	Impact Factor	Power Factor	Direction
Hand Tool (10)	Blade (50)	Low (10)	Low (1)	Along Trench (2)
Air Spade (30)	Tooth (100)	Average (20)	Average (5)	Across Trench (1)
Backhoe (50)	Point (150)	High (30)	High (10)	
Clam Bucket (20)				
Dragline (25)				

Brewer stated that removability and the RF value are related as – Very easy to remove (RF = 80 to 100), Fairly easy to remove (RF = 60 to 80), Somewhat difficult to remove (RF = 40 to 60), Extremely difficult to remove (RF = 20 to 40), and Almost impossible to remove (RF = 0 to 20).

8.9.1 ODOT Specifications

ODOT has in its standard specifications on CLSM in CMS Item 613 (low strength mortar backfill). ODOT permits three different standard mix designs for CLSM, as summarized in Table 5. Table 6 provides gradation specifications for the fine aggregate used to prepare flowable fill. The aggregate must be fine enough to float in any of the CLSM mixtures. Type 1 mix is derived from cement, fly ash, sand, and water. Type 2 mix is similar to a weak concrete, consisting of cement, sand, and water. It tends to be stiff without adding an air entrainment agent. Type 3 differs from the other two, since it contains no cement.

Table 5 Standard Mix Designs for Low Strength Mortar Materials (ODOT, 2018)

	Type 1 Mix [see note 1]	Type 2 Mix	Type 3 Mix

Portland Cement	50 lb/yd^3 (30 kg/m^3)	100 lb/yd^3 (59 kg/m^3)	NA
Fly Ash (Class F)	250 lb/yd^3 (148 kg/m^3) [See note 2]	[See Note 3]	1,500 lb/yd^3 (890 kg/m^3)
Fly Ash (Class C)	0	0	500 lb/yd^3 (297 kg/m^3)
Fine Aggregate [4]	2,910 lb/yd^3 (1,726 kg/m^3)	2,420 lb/yd^3 (1,436 kg/m^3)	0
Water	500 lb/yd^3 (297 kg/m^3)	210 to 300 lb/yd^3 (125 to 178 kg/m^3)	850 lb/yd^3 (504 kg/m^3)
Notes	1: An air-entrainment agent specifically developed for the low-strength mortar may be added. 2: Class F fly ash in Type 1 mix may be replaced with Class C fly ash. The alternate mix design must be approved by ODOT. 3: Air entrainment (up to 25%) is used in Type 2 mix, instead of Class F fly ash. 4: The amount of fine aggregate is for the saturated-surface-dry condition.		

Table 6 Gradation Requirements for Fine Aggregate (ODOT, 2018)

Sieve No	Opening	% Passing by Mass	Sieve No	Opening	% Passing by Mass
3/8”	9.5 mm	100	30	0.60 mm	20 to 60
4	4.75 mm	90 to 100	50	0.30 mm	7 to 40
8	2.36 mm	65 to 100	100	0.15 mm	0 to 20
16	1.18 mm	40 to 85	200	0.075 mm	0 to 10

ODOT commonly specifies CMS Item 613, Low Strength Mortar Backfill to fill around conduits. ODOT often requires fly ash ingredients to possess relatively low LOI (weight loss upon ignition) values. Unburned carbon is tied to the LOI issue. The low-LOI requirement is because high-LOI (LOI above 3%) fly ash has been known to inhibit the ability of air entrainment agents.

8.9.2 Relevant Studies

During the literature review, the following three studies surfaced. In each of the studies, flowable fill was evaluated comprehensively as a utility trench backfill material both in the laboratory and in the field. None of the studies mentioned varied trench excavation configurations.

Meade at al. (1993) of Kentucky Transportation Center conducted a detailed study about flowable fill. Prior to the study, flowable fill had been used as a trench backfill material for utility repairs by some municipalities, but not by the Kentucky Department of Transportation (KDOT). The study involved laboratory testing of cured flowable cylinders, monitoring of flowable fill performance at two sites, evaluation of the removability concept proposed by Brewer (1991), and cost comparisons between flowable fill and conventional backfill.

Few problems were observed while placing overt 3,000 cubic yards (2,294 m^3) of flowable fill at the first site, where several hundred feet (hundred meters) of 18 to 30 inch (457 to 762 mm) diameter cross drain pipes were backfilled. The mix prepared at a nearby concrete plant consisted of 50 lbs. (23 kg) of cement, 300 lbs. (136 kg) of fly ash, 2,750 lbs. (1,250 kg) of sand, and 583 lbs. (265 kg) of water. The material flowed well and filled voids. After one hour of curing, the fill was covered with a dense aggregate material. An asphalt concrete patch was placed within two days. Bleeding of water was noticed on the surface of the fill within 10 minutes. They speculated that this bleeding helped the material become densified. A backhoe was able to remove flowable fill placed at the first site at the age of 150 days, when the unconfined compression strength was 220 psi (1.52 MPa). Its strength was 85 psi (586 kPa) at the age of 28 days. At the second site, where ten old 30 to 42 inch (762 to 1,067 mm) diameter cross drains were replaced, flowable fill was placed with sand bags holding down the pipes. The mix consisted of 40 lbs. (18 kg) of cement, 300 lbs. (136 kg) of Class F fly ash, 2,750 lbs. (1,250 kg) of sand, and 500 lbs. (227 kg) of water. Air entrainment agent was added to provide the air content of about 10%. Initially poured flowable fill was dry, did not bleed water, and did not flow around pipes. Addition of water was necessary to resolve the problem.

A few cross drain pipes at the two sites were instrumented with pressure cells. One pipe received the sensors at the top and bottom, while another pipe had two pressure cells position at the haunch and invert. Pressure readings registered by the top and bottom sensors during the flowable fill placement decreased by 50% to 60% upon hardening of the flowable fill. The cell positioned at the haunch registered always much lower pressures (due to uplifting pressure).
Static live loads were applied over the pipe sections instrumented with pressure cells, when the flowable fill was about 3 weeks old. While applying a 14.6-kip (65-kN) axle load, the sensor at the crown hardly responded to the load. The sensor at the invert registered small (up to 3.3 psi or 23 kPa) increases in its pressure reading.

In the Kentucky Transportation Center study, flowable fill samples were also tested extensively in the laboratory. Below are some of their findings …

- Moisture content and moist unit weight centered around 10% and 126 lb/ft^3 (19.8 kN/m^3).
- Volumetric shrinkage of cylinder samples varied from 0.5% to 5.1% (average 3.1%).
- At the age of 28 days, the unconfined compression strength ranged from 36 to 150 psi (248 to 1,034 kPa).
- Flowable fill material was fairly impermeable, having hydraulic conductivity value ranging between 1 x 10^{-7} and 5 x 10^{-5} cm/s.
- Triaxial compression tests yielded an average internal friction angle of 39° and cohesion of 3.6 psi (25 kPa).
- Resilient modulus of hardened cylinder samples was close to 40 ksi (276 MPa).

At the end of the study, they noted that …

- Flowable fill appears to be an effective trench backfill material.
- When trench dimensions are the same the use of flowable fill can be slightly more expensive. However, the reduced trench width makes flowable fill equivalent to conventional aggregate backfill.
- The removability concept formulated by Brewer appears to be useful reasonable. Some parameter values are subjective and difficult to estimate. An improvement can be made by using the actual long-term compressive strength instead of the 28-day strength.

Masada and Sargand (2000) investigated the feasibility of installing flexible pipe system using flowable fill for ODOT. The study examined engineering properties and field performance of the flowable fill mixes designated in ODOT's CMS Item 613. The study consisted of four phases – literature review, laboratory testing, field demonstration tests, and engineering analyses/computer simulations. Cost analysis was added as a minor component at the end. The laboratory phase examined properties of the three mixes at different ages by performing the flowability test (ASTM D-6103), time for hardening test (ASTM C-403), unconfined compression strength test (ASTM C-39), direct shear test (ASTM D-3080), triaxial compression test (ASTM D-4767), and resilient modulus test (AASHTO T-294). Table 7 summarizes the laboratory test results.

Table 7 Laboratory Test Results Obtained in Ohio University Study

	ODOT Type 1 Mix	ODOT Type 2 Mix	ODOT Type 3 Mix
Unit Weight (pcf)	131.1 (20.6 kN/m^3)	116.8 (18.3 kN/m^3)	101.8 (16.0 kN/m^3)
Flowability (in)	9.9 (251 mm)	7.0 (178 mm)	13.4 (340 mm)
Hardening Time - Penetration Resistance (psi)	200 in 2 to 3 days 400 in 3 to 4 days 600 in 8 to 9 days 1,000 in 10 to 11 days Max. 1.6 ksi @ 14 days	200 in less than 1 day 400 in 1 to 2 days 600 in 2 days 1,000 in 3 to 4 days Max. 1.5 ksi @ 5 days	200 in 0.5 to 0.75 days 400 in 2 to 2.5 days 600 in 7 to 8 days Max. 600 psi @ 8 days
Unconfined Compression Strength (psi)	3 (20.7 kPa) @ 2 days 10 (69.6 kPa) @ 7 days 18 (126 kPa) @ 28 days 22 (149 kPa) @ 90 days 19 (131 kPa) @ 1 year	5 (34.5 kPa) @ 1 day 10 (67.6 kPa) @ 2 days 18 (124.1 kPa) @ 7 days 35 (238 kPa) @ 28 days 35 (242 kPa) @ 90 days 36 (245 kPa) @ 1 year	15 (102 kPa) @ 2 hrs 42 (286 kPa) @ 2 days 44 (306 kPa) @ 4 days 41 (285 kPa) @ 28 days 50 (343 kPa) @ 90 days 48 (331 kPa) @ 1 year
RE	0.67	0.78	0.69
Direct Shear Test	ϕ = 29°, c = 0.8 psi @ 2 hrs ϕ = 34°, c = 4.3 psi @ 1 day ϕ = 34°, c = 3.8 psi @ 2 days	ϕ = 28°, c = 0.3 psi @ 2 hrs ϕ = 29°, c = 3.8 psi @ 1 day ϕ = 20°, c = 8.0 psi @ 2 days	ϕ = 26°, c = 0.0 psi @ 2 hrs ϕ = 25°, c = 9.8 psi @ 1 day ϕ = 21°, c = 12. psi @ 2 days
Triaxial Compr. Test	ϕ = 29°, c = 0.8 psi @ 2 hrs ϕ = 34°, c = 4.3 psi @ 1 day ϕ = 34°, c = 3.8 psi @ 2 days	ϕ = 28°, c = 0.3 psi @ 2 hrs ϕ = 29°, c = 3.8 psi @ 1 day ϕ = 20°, c = 8.0 psi @ 2 days	ϕ = 26°, c = 0.0 psi @ 2 hrs ϕ = 25°, c = 9.8 psi @ 1 day ϕ = 21°, c = 12. psi @ 2 days
Resilient Modulus (or Dynamic modulus)	3.6 to 4.8 ksi @ 1 day 6.9 to 8.7 ksi @ 2 days 7.6 to 8.2 ksi @ 7 days	4.5 to 7.0 ksi @ 1 day 6.2 to 6.4 ksi @ 2 days 7.5 to 8.8 ksi @ 7 days	2.3 to 2.5 ksi @ 1 day 3.3 to 4.4 ksi @ 2 days 3.4 to 4.8 ksi @ 7 days

[Note] UCS = Unconfined Compression Strength; RE = Removability modulus; ⍰ = angle of internal friction; and c = cohesion. 1 psi = 6.894 kPa.

According to the test results, ….

- The unit weights of the three ODOT mixes corresponded to low to medium dense soils. Type 3 mix was the lightest, and Type 1 the heaviest.
- Flowability was marginal for Type 2 mix, moderate for Type 1 mix, and high for Type 3 mix.
- Type 3 mix had the fastest hardening rate, while Type 1 exhibited the slowest setting time. However, Type 3 did not become hardened as much as the other two mixes.
- Due to the hardening behaviors described above, Type 1 and 2 mix specimens could not be tested for UCS until the second or third day. Type 3 specimen was able to be tested within only 3 hours.
- Type 3 mix possessed the highest UCS at any curing age.
- During the first 90 days of curing, Type 1 and 2 mixes shared similar UCS characteristics.
- At the age of 90 days, Type 3 mix possessed a UCS of 41 psi (283 kPa), opposed to Type 1 (18 psi or 124 kPa) and Type 2 (34 psi or 234 kPa).
- The removability modulus (RE) values of the three ODOT mixes were less than 1, meaning that they should all remain excavatable. This was confirmed for Type 2 and 3 mixes during the field test phase.

- According to the direct shear test results, the internal friction angle had a tendency to remain about the same over time while cohesion grew with age.
- The resilient (or dynamic) moduli of the ODOT mixes at early ages were comparable to those of loose to medium dense soils.
- Linear relationships could be generally observed between the penetration resistance (PR) values and strength test results for each ODOT mix.

Based on the laboratory test results, ODOT Type 2 and 3 mixes were utilized in the field test phase. Table 8 summarizes some basic data compiled on the two mixes used in the field. By comparing Tables 7 and 8, it can be stated that the mixtures prepared by commercial suppliers were very different from the mixtures prepared and tested in the lab. The commercial versions were heavier, set faster, and had higher strengths. It was speculated that the commercial versions had more Portland cement content and the sand used was drier.

In the field, each flowable fill material was used to backfill a 20-ft (6.1-m) long, 30-inch (762-mm) diameter corrugated HDPE pipe within a trench area. The trench was 22 inches and 12 inches (559 and 305 mm) wider than the pipe's outside diameter for Type 2 and Type 3 mixes, respectively. The pipe and the flowable fill were both instrumented with sensors to collect useful performance data. Many insights were gained during the field demonstration phase, some of which are summarized below ....

- Potentials for pipe floatation diminished by using sand bags and placing the flowable fill in a few lifts.
- The flowable fill did not generate high hydration heat during the curing time.
- Backfilling the flexible pipe with flowable fill induced little deflections and strains to the pipe.
- Hydrostatic pressure that initially existed around the pipe disappeared completely as the flowable fill hardened.
- Structural responses of flexible HDPE pipe installed in a hardened flowable fill were much less than those of the same pipe installed in a dense granular soil backfill.
- Each flowable fill material used was able to flow well and fill every void that existed within the trench, including the underside of the pipe and in between the pipe's corrugation ribs.
- Type 2 mix placed in the field was removable by standard construction equipment at the age of 6 months. It was relatively easy to excavate the Type 3 mix 10 days after its placement.

Table 8 Data on Flowable Fill Materials Used in Field Demonstration Tests

	ODOT Type 2 Mix	ODOT Type 3 Mix
Commercial Supplier	Hocking Valley Concrete (Athens, OH)	Greensboro Corp. (Columbus, OH)
Unit Weight (pcf)	126.3 (19.9 kN/m^3)	133.2 (21.0 kN/m^3)
Flowability (in)	8.0 (203 mm)	12.0 (305 mm)
Hardening Time - Penetration Resistance (psi)	14 psi (96.5 kPa) @ 0.5 hours 36.8 psi (253.7 kPa) @ 1.2 hours 282 psi (1.94 MPa) @ 3.5 hours 1,500 psi (10.3 MPa) @ 15 hours 1,830 psi (12.6 MPa) @ 17 hours	27 psi (186.1 kPa) @ 0.25 hours 38 psi (262.0 kPa) @ 0.33 hours 129 psi (889.3 kPa) @ 0.55 hours 284 psi (1.96 MPa) @ 0.70 hours 980 psi (6.76 MPa) @ 13 hours 1,353 psi (9.33 MPa) @ 37 hours 1,368 psi (9.43 MPa) @ 61 hours
Unconfined Compression Strength (psi)	23.1 psi (159.3 kPa) @ 1 day 17.2 psi (118.6 kPa) @ 2 days 33.4 psi (230.3 kPa) @ 4 days	18.0 psi (124.1 kPa) @ 0.7 days 29.6 psi (204.1 kPa) @ 1.6 days 28.4 psi (195.8 kPa) @ 3 days

Table 9 on the next page compares the ODOT 304 and the two standard CLSM mixes in terms of cost and other aspects. It is commented here that the cost effectiveness of using CLSM may not be obvious in a small utility cut project.

Griffin and Brown (2011) investigated the use of flowable fill as a rapid airport runway pavement repair material. They evaluated eleven (two from a local ready-mix plant, nine from commercial companies that are specialized in flowable fill) blends and found flowable fill to be an ideal backfill material in rapid pavement repair work especially when concerns exist for site accessibility, and equipment & material availability. In their study, flowable fill mixtures were tested both in the laboratory and in the field. The laboratory testing phase examined all the blends in terms of initial flowability, setting time, 28-day unconfined compression strength, unit weight, and calculated Removability Modulus (RE).

Their laboratory test results are summarized in Table 10 below. Blends 1 and 2 were prepared by a local concrete mixing plant. Blend 3 is by a company that produces flowable fill products for pavement projects. Blends 4 through 6 were by the second company that is specialized in utility backfill materials. Blends 7 and 8 were produced by the third company. The remaining three blends were marketed as ‘Quikrete’ by two different companies for utility and pavement projects. Comments on the test results are added to the table. At the end of the lab testing, only five of the eleven blends tested (Blends 1, 2, 4, 5, and 7) appeared to be suitable for utility trench projects. This was largely based on the ACI definitions and the RE criterion set by Brewer.

Table 9 Cost & Other Comparisons (Masada & Sargand, 2001)

Item	ODOT 304	ODOT Type 2 Mix	ODOT Type 3 Mix
General availability	Available from local construction material suppliers	Available from local concrete mixing plants	May not be readily available in some areas
Delivery method	Regular dump truck	Regular concrete mixer vehicle	Regular concrete mixer vehicle or customized truck
Placement method	Spread loose in 8-10 in. lifts, watered, and then compacted by equipment	Poured gradually into utility trench	Poured gradually into utility trench
Labor needed	Two workers @ $80/hr; and soil compaction equipment, 3 hrs -- $540 total	One worker, 2 hrs @ $40/hr -- $80 total	One worker, 2 hrs @ $40/hr -- $80 total
Testing needed	Soil density & moisture content	Flowability, Time for hardening, Unit weight & unconfined compression strength -- $500 total	Flowability, Time for hardening, Unit weight & unconfined compression strength - $500 total
Curing Time	None	2-3 hrs	2-3 hrs
Unit price (per yd^3)	$16.60	$ 45.00	$ 50.00
Delivery time	Short (locally available)	Short (locally available)	Varies
Delivery charge	Included in unit price	Included in unit price	Included in unit price
Total Cost *	$640.00	$850.00	$880

[Note] * The total cost estimated for a volume of 6 cubic yards. 1 inch = 25.4 mm.

Table 10 Laboratory Test Results (Griffin & Brown, 2011)

Blend	Flowability	Setting Time	Unit Weight	28 Strength	RE	Comments
1	9.5 in	6.0 hrs	126 pcf	110 psi	1.5	Longest setting time
2	11 in	4.0 hrs	128 pcf	140 psi	1.8	2nd longest setting time
3	15 in	0.5 hrs	132 pcf	1,070 psi	5.2	Very high RE value
4	NA	1.75 hrs	108 pcf	60 psi	0.9	Best RE value
5	NA	1.25 hrs	112 pcf	170 psi	1.6	
6	NA	0.75 hrs	128 pcf	640 psi	3.8	High RE value
7	9.5 in	0.75 hrs	104 pcf	500 psi	2.5	
8	10.5 in	0.5 hrs	102 pcf	2,140 psi	4.9	Lean concrete; High RE value
9	8 in	0.5 hrs	NA	1,890 psi	NA	Lean concrete
10	4 in	2.75 hrs	110 pcf	180 psi	1.6	Poor flowability
11	6.5 in	1.75 hrs	124 pcf	520 psi	3.3	Poor flowability poor; High RE value

[Notes] Blends 1 & 2 were prepared by local concrete mixing plants. Others were marketed as special backfill grouts for pavement and utility projects. 1 inch = 25.4 mm. 1 pcf = 0.157 kN/m^3. 1 psi = 6.894 kPa.

They tested seven of the eleven blends (Blends 1, 2, 4, 5, 6, 8, and 10) and an aggregate material in the field. Each fill material was placed into a trench having an area of 3 ft x 9 ft (0.91 x 2.74 m) and a depth of 3 ft (0.91 m). After a 7-day curing period, the trench area was capped with a 6-inch (152-mm) thick concrete pavement layer. Subsequently, the sections were subjected to 2,000 passes of a simulated single-wheel Boeing aircraft loading of 44.9 kips (200 kN). They were periodically tested by the Falling Weight Deflectometer (FWD) and evaluated visually during the load testing. Table 11 lists various time requirements that are demanded during the placement of each utility cut backfill material. Table 12 presents the FWD test results, and estimated cost figures are summarized in Table 13.

Table 11 Construction Time Associated with Choice of Backfill Material

Blend	Mixing Time (hrs)	Placing Time (hrs)	Hydration Time (hrs)	Hardening Time (hrs)	Total Construction Time (hrs)
Aggregate	0.00	6.50	0.00	0.00	6.50
1	0.17	0.08	0.00	6.00	6.25
2	0.17	0.08	0.17	6.00	6.25
4	0.00	0.33	0.17	1.75	2.25
5	0.00	0.33	0.17	1.25	1.75
6	0.00	0.33	0.00	0.75	1.25
8	0.08	0.08	0.00	0.83	1.00
10	0.08	0.08	0.00	2.58	2.75

Table 12 FWD Impulse Stiffness Modulus Results for Utility Cut & Patch Sections

Blend	Initial	11 Load Passes	96 Load Passes	776 Load Passes	2,000 Load Passes
Aggregate	964	622	161	---	---
1 (utility cut)	3,221	2,798	2,435	2,035	2,228
2 (utility cut)	2,253	2,573	2,110	1,688	1,768
4 (utility cut)	2,104	1,809	1,163	879	1,011
5 (utility cut)	2,187	2,268	1,687	1,539	1,989
10 (utility cut)	2,518	2,557	1,991	1,991	1,714
6 (utility patch)	3,189	---	---	---	2,860
8 (utility patch)	2,691	---	---	---	2,194

[Note] All FWD impulse stiffness modulus values are in the unit of kips/inch. 1 kip/inch = 0.11 kN/m.

Table 13 Estimated Cost Comparisons

Blend	Total Time (hrs)	Unit Material Cost (per yd^3)	Labor Cost (per yd^3)	Equipment Cost (per yd^3)	Total Cost (per yd^3)
Aggregate	6.50	$12.00	$353.21	$280.00	$645.20
1	6.25	$66.00	$339.63	$136.50	$542.13
2	6.25	$75.00	$339.63	$136.50	$551.13
4	2.25	$435.00	$122.27	$238.66	$795.92
5	1.75	$435.00	$95.10	$225.27	$755.36
6	1.25	$435.00	$30.54	$95.27	$560.51
8	1.00	$400.00	$24.43	$102.08	$526.51
10	2.75	$283.00	$149.44	$312.11	$744.54

[Note] 1 yd^3 = 0.764 m^3.

Referring to the above three tables, they made the following comments …

- Total construction time to backfill a utility trench area can be reduced substantially by choosing a commercialized flowable fill product, since it requires much less time for mixing, placing, grading, and hardening.
- Under the repeated load applications, the FWD impulse stiffness modulus value declined by only 20 to 30%
- A utility trench cut area filled with a good flowable fill can withstand many passes of heavy axle load without losing its stiffness. In contrast, the area that received the aggregate fill settled significantly under the first 96 passes.
- Material costs for the aggregate and the flowable fills produced by ready-mix plants were lower compared to those produced by the companies specialized in flowable fills. However, faster setting time and reduced labor and equipment requirements reduced the overall costs of using the specialized flowable fill closer to the option of utilizing less expensive backfill materials.

At the end of the study, they stated that flowable fill reduces the potential for premature failure, reduces construction time, and reduces total project cost by 5 to 40% while increasing repair performance. Additional remarks made in this study are listed below …

- Flowable fill can serve as an ideal material when narrow utility trench cut areas need to be backfilled quickly and there are some issues identified with soils.
- The RE equation is easy to use. However, it appears to be on the conservative side. Materials with RE values up to 1.8 were excavatable in the field.
- The RE calculation should be based on the ultimate compressive strength, not on the 30-day compressive strength. Compressive strength of flowable fill tends to keep increasing until the age of about one year.

Lastly, a couple of short paragraphs may be needed to caution engineers and field personnel about the use of flowable fill in cold weather and very wet soil conditions.

Most flowable fill mixes contain some amount of Portland cement. As true for most concrete mixes, the cement does not hydrate well when the air temperature is below 5 degrees C (42 degrees F). So, the fill should not be placed unless the temperature is at least above this level. If the fill must be poured in less-than-ideal temperature conditions, an insulation blanket must be used to keep the fill somewhat warm while it is maturing/hardening.

Saturated ground/trench condition is another tough situation for flowable fill materials. The ponding water should be removed/pumped out as much as possible before placing the flowable fill. The fill will obviously displace most of the water (since it is much heavier), but some of the standing water will get into the fill and negatively influence its initial mix design. One counter measure is to pour a bit drier fill material (with reduced amount of water) into the trench and mix the standing water and the dry mix together quickly to arrive at something that is close to what it should be.

9 Appendix B: Local Agency Survey

9.1 Development and Distribution

To learn current practices for repair of open utility cuts of large local agencies (population greater than 25,000), a survey was developed. The survey was issued to LTAP offices in states which have a wet-freeze climate as identified in the Long-Term Pavement Performance (LTPP) program as shown in Figure 13 and subgrade soils similar to Ohio subgrade. As shown in Figure 14, the most predominant surface soil texture in Ohio is a silt loam (NASA, 2017). Therefore, the LTAP offices in the following states were contacted: Ohio, Missouri, Illinois, Indiana, Kentucky, West Virginia, Pennsylvania, and New York.

Figure 13 Map of LTPP Climate Zones in the continental United States (Li et al., 2015).

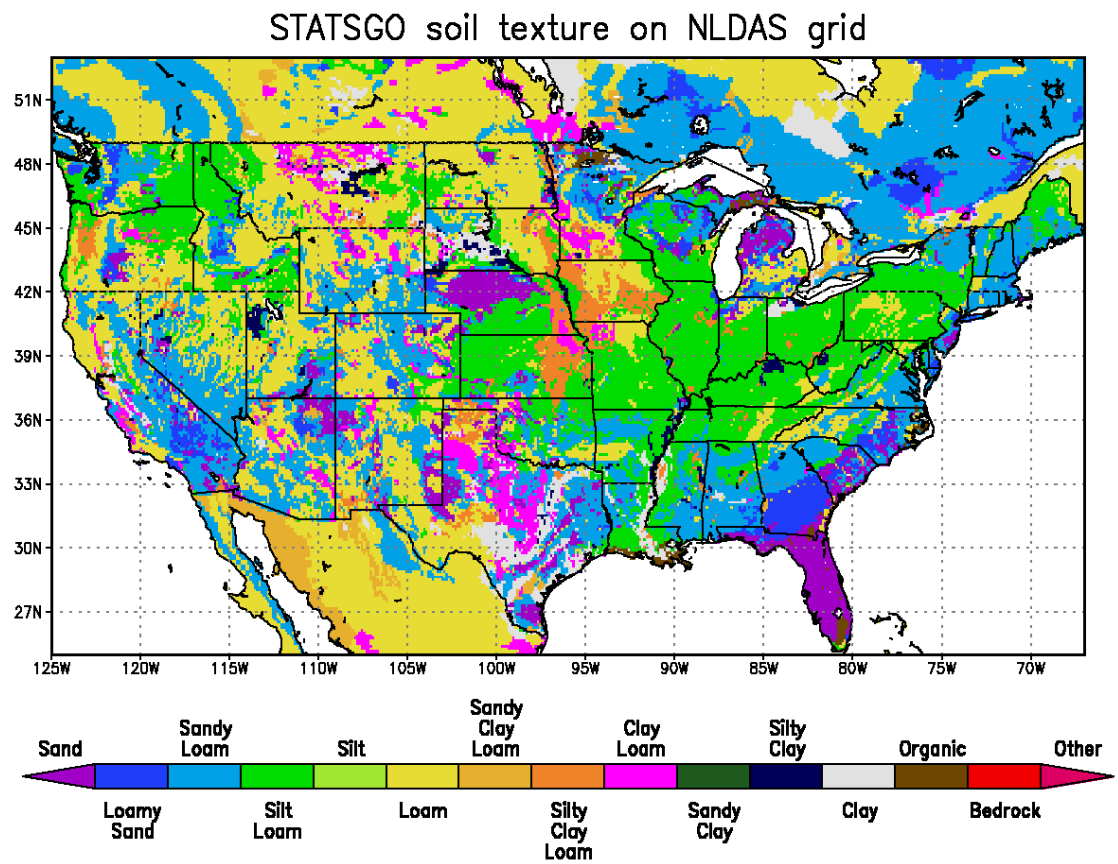


Figure 14 Predominant Soil Texture in the continental United States (NASA, 2017).

A survey was developed and is shown in later in this Appendix. Survey questions were developed to focus on standard methods of repair, materials and techniques used in local agencies for open utility cut repairs. Through the literature search previous research studies which conducted surveys were identified such as the work by Schaefer et al. (2005) and Mohamed et al. (1999). Such surveys helped to serve as a basis for the development of the survey conducted in this study. Once completed, the survey was sent to the TAC for approval prior to distribution.

The survey was developed in both pdf format and in an online format using the Qualtrics platform. A copy of the survey in pdf form and a link to the online survey was distributed via email to LTAP offices in all eight states on November 20, 2017 with a requested completion date of December 22, 2017. Due to the proximity to the holidays and some LTAP offices indicating they had not received the email, the requested completion date was extended to January 12, 2018. Survey participants could complete the survey online, or by completing the pdf form and emailing or mailing the completed survey to the research team.

9.2 Summary of Survey Results

Despite reaching out on multiple occasions to LTAP offices in all eight states (Ohio, New York, Pennsylvania, West Virginia, Kentucky, Indiana, Illinois, and Missouri) responses were only received from large local agencies (population greater than 25,000) in Ohio, as shown in Figure 15, below. A total of 37 responses were received which are tabulated in this Appendix under Survey Responses.

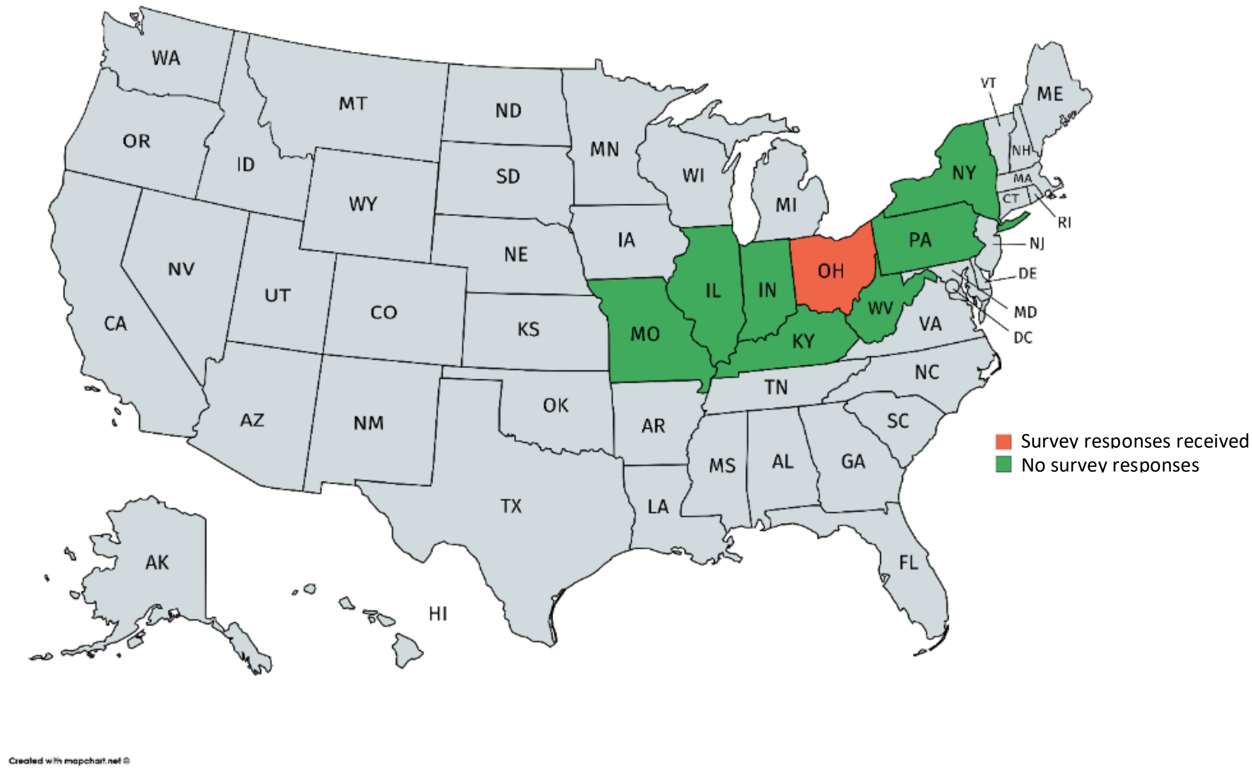


Figure 15 Location of survey distribution and responses

Multiple responses were received from four cities: City of Dayton, City of Findlay, City of Lakewood, and City of Newark. Additionally, a representative from the Ohio Department of Transportation in District 4 also responded to the survey. The breakdown of the responses by agency type is shown in Figure 16. The four cities with multiple responses were counted only once in the figure below.

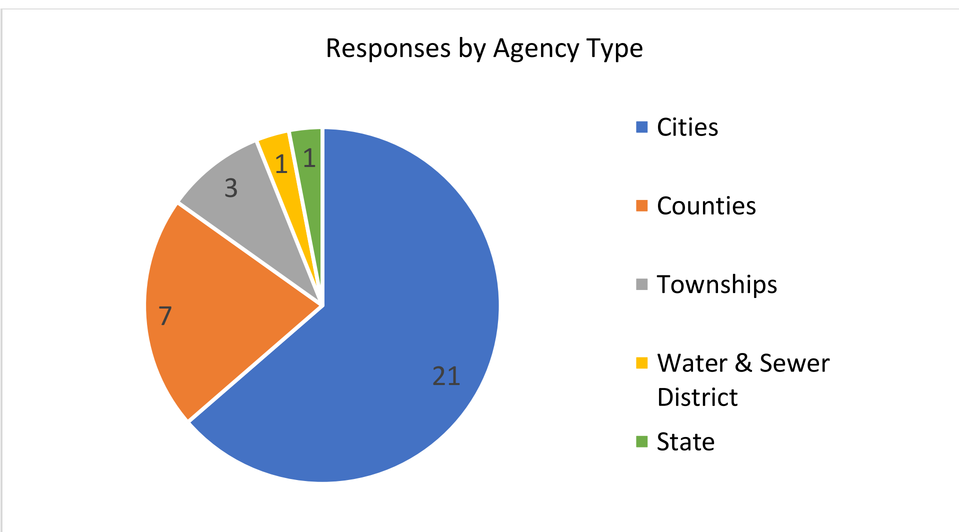


Figure 16 Distribution of survey responses by agency type

In analyzing the results of the survey, one response from the City of Findlay was excluded as only a small portion of the survey had been completed. For City of Newark and City of Dayton, two responses were received for each, although only one of the two responses was completed in its entirety the responses were received from different offices in each city. Therefore, both responses were included in the analysis. Similarly, City of Newark submitted two responses, both fully complete, but representing two different offices within the city, therefore, both responses were included in the analysis. Responses from ODOT were excluded as this study focused on pavement restoration for local agencies. Several agencies did not provide responses beyond the first question under standard method of repair. Furthermore, few agencies completed the survey in its entirety, therefore the total number of respondents varies from question to question.

Relevant results are summarized below by the following topics: general information, standard method of repair, performance, construction, and policy.

9.2.1 General

As shown in the figure below, most responses indicated their agency has less than 100 cuts per year, on average. Three agencies: City of Dayton (Construction Bureau), City of Cleveland, and City of Columbus indicated more than 1,000 open utility cuts are performed each year on average on their roadways. City of Cleveland reported the highest number of open utility cuts, at 10,000 per year.

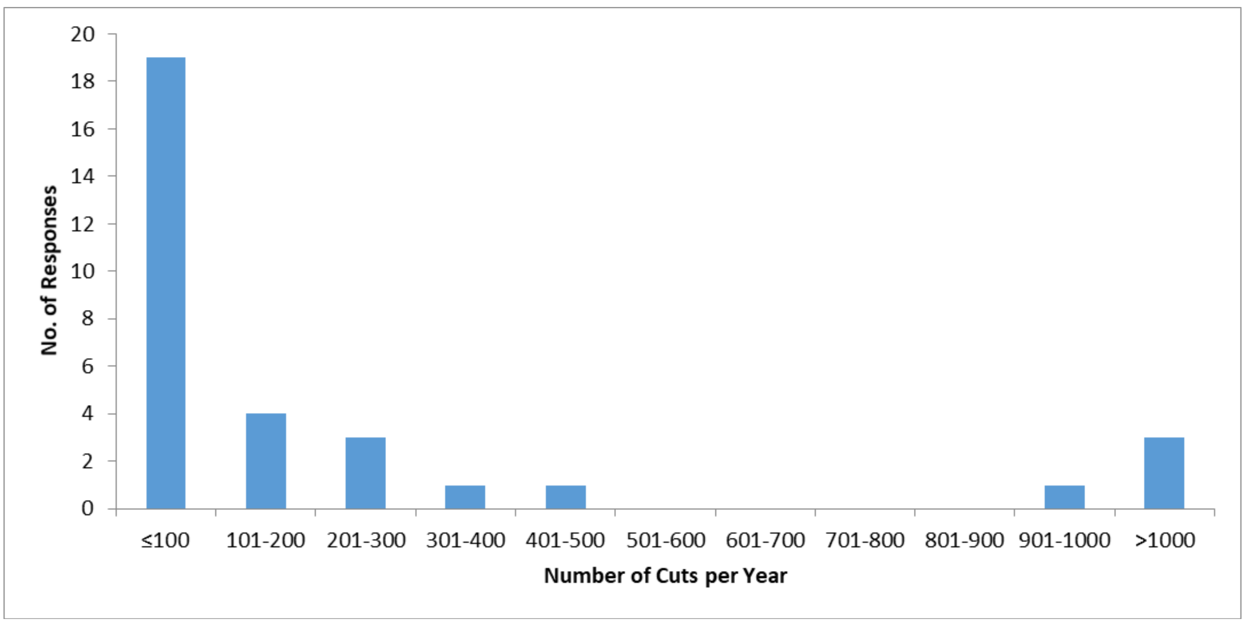


Figure 17 Survey results, summary of number of open utility cuts performed each year

9.2.2 Standard Method of Repair

Of the 35 responses included in the analysis, only 2 agencies, City of Newark Street/Traffic, and Violet Township indicated they did not have a standard method of repair. One agency, Montgomery County Engineers Office provided the following description: "Sawcut all edges. Compacted granular backfill. Hot mix asphalt to match existing pavement thickness. Edges sealed with hot AC sealer." Although the remaining participants indicated their agency has a standard method of repair not all of them provided the standard or a link to retrieve the standard.

Participants were asked if their standard method of repair provide satisfactory results for each pavement type (asphalt, concrete composite, brick, brick composite, rigid brick composite). For the survey concrete composite pavements include those with a concrete base and asphalt surface, brick composite pavements include brick over granular base with an asphalt surface, and rigid brick composite pavements include brick over a concrete base with an asphalt surface. Agencies were asked to respond, “Yes”, “No”, or “N/A”, where “N/A” indicates it is not applicable (they do not have that pavement type in their jurisdiction). As indicated by the table below, most agencies believe their standard method of repair does provide satisfactory results for the repair of open utility cuts.

Table 14 Number of responses indicating standard method of repair provides satisfactory results

Type of Pavement:	**Asphalt**	**Concrete**	**Concrete Composite**	**Brick**	**Brick Composite**	**Rigid Brick Composite**
Response	**Number of responses**					
Yes	26	21	17	10	10	9
No	1	0	1	0	0	0
N/A	0	4	7	13	13	14
No response	8	10	10	12	12	12

In looking at the materials used in repair of open utility cuts, survey participants were asked what type of backfill material is allowed per their standard method of repair. A total of 27 responses were received for this question. Several agencies indicated more than one backfill material is allowed. Participants were provided with options for backfill material type of native material, granular material, controlled low-strength mortar (CLSM), or other. As shown in the table below, the majority of agencies allow granular material or CLSM. One agency indicated that in addition to CLSM and native material, ODOT Item 304 is also allowed.

Table 15 Backfill material allowed, number of responding agencies.

Native material	Granular Material	CLSM	Other
2	21	22	1

Survey participants were also asked to report the permanent pavement surface based on the existing pavement type. Agencies could report more than one pavement surface for each existing pavement type. A total of 27 responses were received for this question.

Table 16 Number of responses for each permanent pavement surface based on existing pavement

Existing Pavement Type	Permanent pavement surface				
	Asphalt	Concrete	Brick	Stamped Concrete	Other
Asphalt pavements	26	3	0	0	0
Concrete pavements	4	20	0	0	0
Concrete composite pavements	15	6	0	0	2
Brick	3	4	8	2	0
Brick composite pavements	8	5	2	0	1
Rigid brick composite pavements	6	4	2	0	2

9.2.3 Performance

Most agencies reported utility failures occur most often in the winter. This is expected due to freezing temperatures that can lead to water main breaks and other failures.

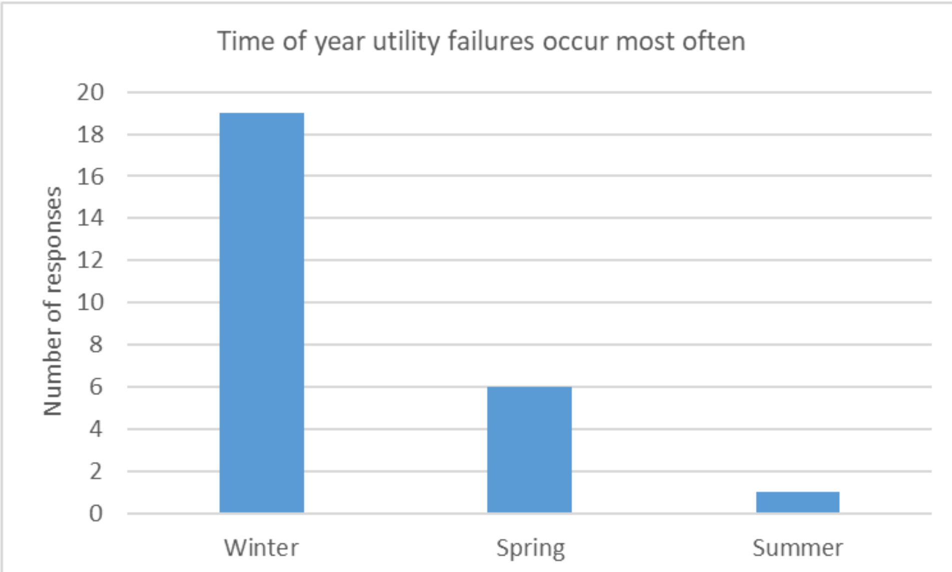


Figure 18 Time of year utility failures are most likely to occur.

In looking at the expected service life for repairs of open utility cuts, survey participants reported a range of values for each pavement type, as shown in the table below. One agency provided the indicated they expect repairs on all pavement types to last "until resurfacing occurs." The most frequent range of service lives reported are shown in bold font for each pavement type below. For the three most common pavement types, asphalt, concrete, and concrete composite, the most frequent expected service lives reported were 5 to 10 years, 15 to 20 years, and 5 to 10 years, respectively.

Table 17 Expected service life of open utility cut repairs

Existing pavement type	Expected Service Life (yrs)						No. of
	≤5	>5 and ≤10	>10 and ≤15	>15 and ≤20	>20 and ≤25	>25	Responses
Asphalt	6	**10**	2	3	2	0	23
Concrete	2	4	3	**6**	2	0	17
Concrete composite	3	**5**	1	2	1	0	12
Brick	1	2	1	**4**	1	0	9
Brick composite	0	**5**	0	1	1	0	7
Rigid brick composite	0	**3**	0	1	1	0	5

When asked how premature failure of repairs of open utility cuts are defined, agencies largely indicated settlement or depressions in the repair. Two participants indicated lack of adequate compaction in the backfill material, one of which stated this leads to failure in the wearing course. One participant indicated poor compaction in the asphalt defined premature failure. Poor compaction in the backfill material often leads to settlement in the repair. Other distresses such as opening of the joint or cracking around the joint, alligator cracking, raveling, or debonding characterize premature failure of open utility cut repairs.

Agencies were also asked to report the approximate percentage of repairs that have experienced pavement performance problems based on the existing pavement type. For asphalt pavements, responses ranged from 2% to 100%. Values reported for concrete pavements ranged from 0% to 50%. Similarly, responses indicated percent of repairs with performance problems on concrete composite pavements among the responding agencies ranged from 0% to 50% reported. Ranges for brick pavements ranged from 0% to 75%, whereas values for brick composite and rigid brick composite ranged from 0% to 10%. It should be noted that a reported value of 0% may indicate an agency simply does not have that pavement type in their jurisdiction.

When asked what may be causing these performance problems survey participants provided a range of responses. However, the most frequent cause stated was inadequate compaction of the backfill. Coinciding with this, agencies also indicated the cause was related to backfill materials in which improper or inadequate materials are used; one participant provided an example of frozen gravel being used for backfill. Several responses were related to the lack of preparation of the repair or poor workmanship. This includes failing to identify the extent of the damage, such that underlying layers are saturated in the surrounding area. It also includes failure to perform the specified overcut for a T-repair or perform the repair according to the agency's standard. Other causes reported included pavement materials, such asphalt temperature too cold at placement, improper compaction of the asphalt, and inadequate lift thickness of asphalt. Other causes included the lack of crack sealant at repair joint, or water infiltration at the joint. One survey participant pointed to the failure of the repair being inspected during restoration.

Agencies were asked to select criteria used to judge the performance of restorations of open utility cuts. Once selected, agencies were then asked to rank them in order of importance with number one being the most important. Compiled in the table below are the number of responses for which each criterion was ranked number one. As shown, the profile of the restored surface was reported as the most important criterion for judging performance by the largest percentage of respondents.

Table 18 Primary criterion for judging performance of restoration of open utility cuts

Primary Criterion	No. of Responses
Profile of restored surface (settlement/hump)	17
Public complaints	7
Crack width	1
Extent of cracking around the cut	0
Other	0

9.2.4 Construction

When asked if they have quality control/quality assurance (QC/QA) requirements for the restoration of open utility cuts, 50% of the survey participants indicated they do have QC/QA requirements, with the remaining 50% indicating they do not. Of the 13 survey participants that indicated they have QC/QA requirements, 10 provided descriptions of their requirements. The most frequently reported requirement was inspection of the restoration, with seven of the 10 indicating their agency inspects the repair. Two respondents indicated a warranty is in place, with one respondent stating the warranty is a lifetime warranty and the other stating it is a one-year warranty. Two respondents reported the use of their standards and/or construction and material specifications. One respondent indicated compaction testing of the subgrade is completed by a geotechnical service. Lastly, one survey participant reported the use of RFID tags embedded in the asphalt for identification purposes, presumably to coincide with their lifetime warranty.

Of the 13 responses stating their agency has QC/QA requirements for the restoration of open utility cuts, only one indicated the requirement are not effective in assuring a quality repair. This survey participant reported the use of inspection and engineering standards for their QC/QA requirements.

Survey participants were also asked to report the approximate percentage of pavement restorations of open utility cuts that are inspected at the time of restoration. While only seven participants reported inspection as a QC/QA requirement, 24 survey participants reported a percentage of restorations inspected. As shown in the table below, the most frequent range reported was less than 25% of the pavement restorations, followed by 75% to 100% of restorations inspected.

Table 19 Percent of pavement restorations inspected at time of restoration

Range of Percent Inspected	No. of Responses
≤25%	8
>25% and ≤50%	4
>50% and ≤75%	5
>75% and ≤100%	7

Survey participants were asked to select the types of open cut repair methods that have been used in their jurisdiction. Methods of repair of open cuts are described in the figure below. The most frequent open cut repair type reported was a T repair, followed by a cutback, as shown in the figure below. A cutback and T repair open cut are similar; however, they differ by the removal of unbound materials beneath the pavement materials.

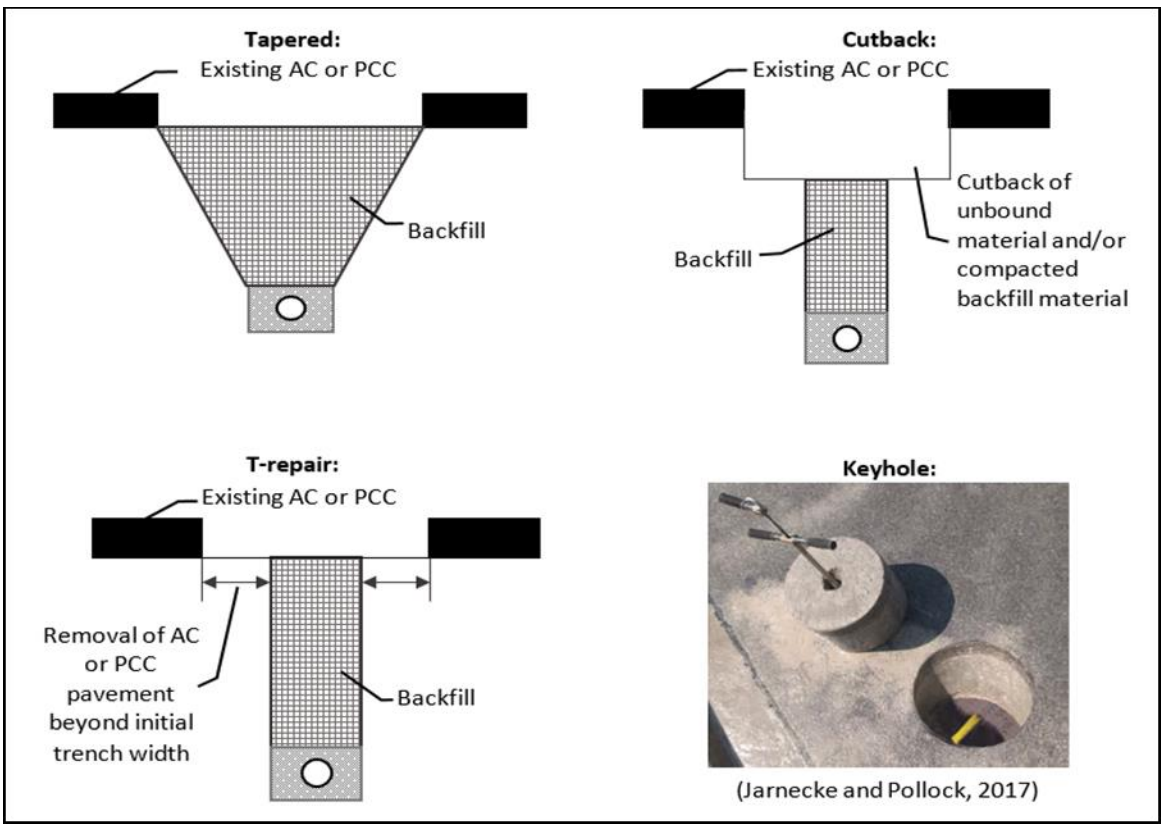


Figure 19 Methods of repairs.

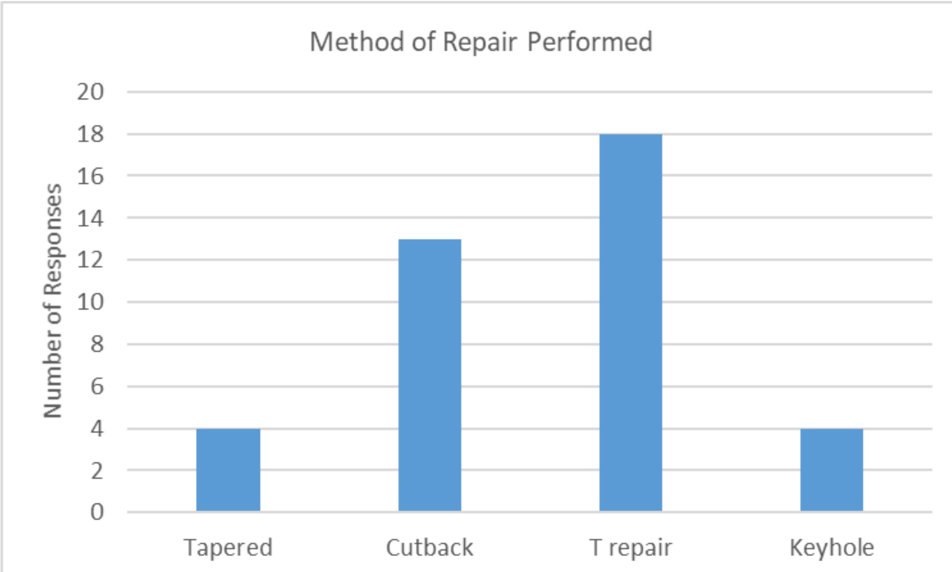


Figure 20 Methods of repairs of open cuts performed.

Survey participants were asked to select the factors that influence their decision on repair procedure and/or material used. They were also asked to rank the top three factors in order of importance, with number being the most important factor. Two participants identified "other" as the primary factor that influences their decision. They reported "other" as time and staffing, and type and condition.

Table 20 Primary factor that influences decision on procedure/material for repair

Primary factor	No. of Responses
Traffic volume	6
Time of the year	4
Past performance or procedure/material	4
Other	2
Age of existing surface	1
Time to next resurfacing	1
Cost	1

9.2.5 Policy

The survey sought to also collect information related to fees, tracking and management of repairs, as well as the use of moratorium policies to limit damage to new pavements. Agencies were asked to describe how utility cuts are permitted and tracked. Generally, responses fell into one of four categories, as shown below. Seven respondents indicated their agency uses an electronic method such as software, GIS, or updated spreadsheets to track utility cut repairs. The same number of respondents indicated some type of permit is issued but did not provide information on tracking of the repairs. Two respondents indicated tracking of the cuts was by an individual, either in the permit office, or by the inspector.

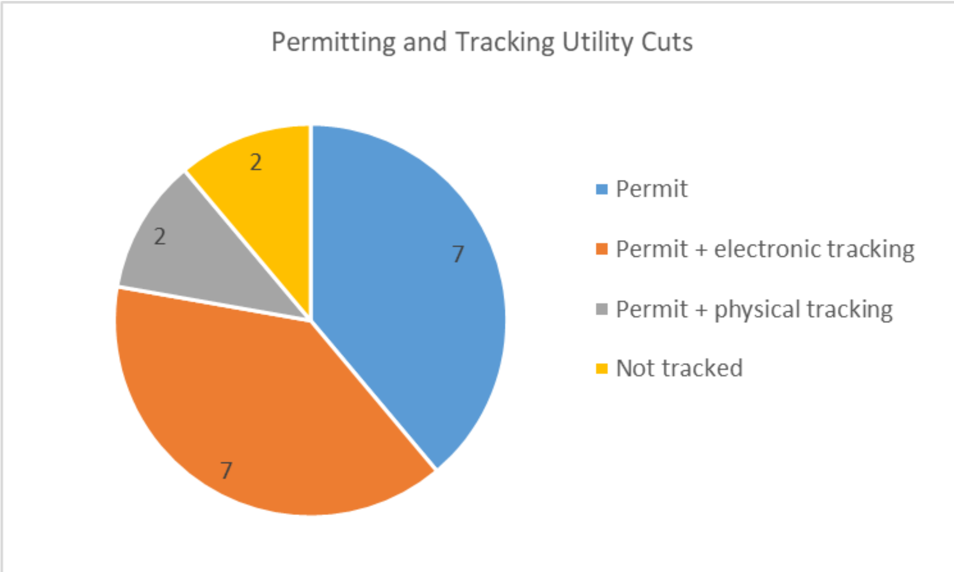


Figure 21 Permitting and tracking of utility cuts.

Inquiries related to types of fees assessed for utility cuts were also made. As shown in the figure below, most agency assess a permitting fee. Three respondents utilized bonds or inspection fees. One agency assesses a cash or performance bond based on extent of the repair and requires the contractor have $10,000 license and have a permit bond on file with the agency. Similarly, one agency assesses a permit bond on extent. One agency requires fees for inspection of the repair.

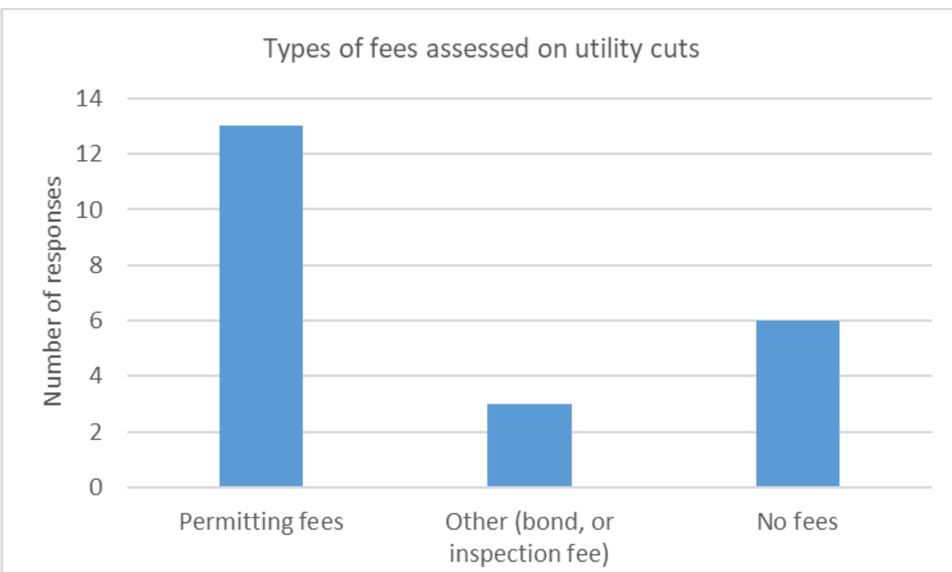


Figure 22 Types of fees assessed.

Agencies were asked if a moratorium on utility cuts was placed following the construction or resurfacing of a pavement. The majority (67% of respondents) indicated a moratorium was used, while the remaining one third do not have a moratorium policy. The durations of the moratorium reported ranged from 30 days to the lifetime of the pavement. The range of the most frequent duration reported was three to five years.

Lastly, agencies were asked if they were satisfied with their current methods of managing utility cuts. The majority (13 responses) indicated they were satisfied and 7 respondents, or approximately 35%, indicated they were not. Of those unsatisfied, six provided ways their process could be improved. Half of these agencies indicated they would employ inspections or provide more staff for inspections. One response indicated they would improve the tracking of contractors and coordination of visual inspection. Similarly, another response indicated improvements would be made in "tracking, inspection, follow up, cost recovery." One indicated they would have additional staff for administering and overseeing permits and inspections of restorations. One respondent described the need for a set procedure to ensure utilities would be held responsible for inadequate work. Lastly, one agency simply indicate there is currently no procedure for managing utility cuts.

9.3 Survey Questions

"Best Practices for Pavement Restoration of Open Cut Utility Installations/Repairs on Local Roadways in Northern Ohio"

Sponsored by Ohio Research Initiative for Locals

Purpose of the Survey

Local Public Agencies face the challenge of repairing their pavements after the installation or repair of subsurface utilities in the roadway. While minimizing the need to disturb the in-service pavements through advanced planning and coordination with other planned roadway work is ideal, open utility cuts are often unavoidable. Pavement restoration of open cut utility installations and repairs often result in shortened service life relative to surrounding, undisturbed pavement sections.

This survey will take approximately 30 minutes to complete. The purpose of the survey is to collect information about pavement restoration of open cut utility installation or repair from practitioners in urban areas with similar climatic conditions as northern Ohio.

This survey will assist with the research goal of identifying the best practices for pavement restoration of open cut utility installation on local roads in urban areas to ensure low cost and long-term performance. We are specifically seeking responses from municipalities with population greater than 25,000.

Please complete the survey by **December 22, 2017**.

You may access the online survey at the following link:
https://ohio.qualtrics.com/jfe/form/SV_02ENKGCFMtKsrCl

If you are unable to complete the online survey, you may email an electronic copy of your completed survey to Dr. Mary Robbins at robbinm1@ohio.edu or mail a hard copy to**:**

Dr. Shad Sargand
Civil Engineering
Stocker Center 231
1 Ohio University
Athens, Ohio 45701

General

Name: ____

Title: ____

Agency: ____

City, State: ____

Phone #: ____

Email address: _______________________________________

1. May we contact you if we have follow-up questions?

   ☐ Yes
   ☐ No

2. Do you represent a municipality with a population greater than 25,000?

   ☐ Yes
   ☐ No

   If you answered yes, please proceed with the survey.
   If you answered no, we appreciate your time. You have completed the survey.

3. Approximately, what is the population of your municipality?

   ____

4. What is the approximate number of open utility cuts performed on your roads, on average, per year?

   ____

5. Please provide the approximate distribution (% of total) of open utility cuts by utility type:

   ____% Water and sewer
   ____% Electric
   ____% Cable
   ____% Gas
   ____% Telecommunication
   ____% Other: ____________________

6. Please provide the type of pavement in your jurisdiction by indicating the approximate amount of each pavement type as a percentage of total roadway network.

   ____% Asphalt
   ____% Concrete
   ____% Gravel
   ____% Concrete composite (concrete with asphalt surface)
   ____% Chip seal
   ____% Brick
   ____% Brick composite (brick over granular base with asphalt surface)
   ____% Rigid brick composite pavements (brick over a concrete base with an asphalt surface)?
   ____% Other: ________________________

7. What is the predominant subgrade soil type in your jurisdiction?

   ☐ Fine-grained (soils that drain slowly such as silt, clay, silty clay)
   ☐ Granular (soils that drain quickly such as gravel, sand, silty or clayey gravel, silty or clayey sand)

Standard Method of Repair

1. Does your agency have a standard method of repair for utility cuts?

☐ Yes
☐ No

If you answered no to question 1, please proceed to question 8.

If you answered yes to question 1, and you have specifications and/or standard drawings you would be willing to share with us, please send any documents by mail or email to the addresses above. Or please provide below a web address where we may access them or a description of the method.

Description:
____
____
____
____
____
____

Web address: ___________________________

2. Does your standard method provide satisfactory results? Please answer Yes, No, or N/A for each pavement type.

Pavement Type	Yes	No	N/A
Asphalt pavements			
Concrete pavements			
Concrete composite pavements (concrete with asphalt surface)			
Brick			
Brick composite (brick over granular base with asphalt surface)			
Rigid brick composite (brick over concrete base with asphalt surface)			

3. What type of backfill materials are allowed?

☐ Native material
☐ Granular material
☐ Controlled low-strength mortar
☐ Other: _________________________________

4. What pavement material is used as a temporary pavement surface, and how long is the patch typically left in place? Please provide duration next to selected material (select all that apply).

☐ No temporary pavement surface is allowed
☐ Asphalt: ______________________
☐ Concrete: ____________________

☐ Brick: ______________________
☐ Other (please specify type and duration): ______________________________

5. For utility cut repairs of each pavement type, what is the permanent pavement surface of the repair?

Pavement Type	Asphalt	Concrete	Brick	Stamped Concrete	Other
Asphalt pavements					
Concrete pavements					
Concrete composite pavements					
Brick					
Brick composite pavements					
Rigid brick composite pavements					

6. Do you have a different specification for seasonal repairs or emergency repairs?

☐ Yes
☐ No

If you answered yes, please send the specifications and/or standard drawings to the mail or email address at the beginning of the survey, or provide a web address where we may access them. Or please provide a description of the method below.

Description:
____
____
____
____
____
____

Web address: ___________________________

7. Is cold weather protection required for curing of concrete?

☐ Yes
☐ No
☐ N/A

8. If you do not have a standard method, who decides the method to be used? (Check all that apply)

☐ Agency (e.g. municipal engineer)
☐ Utility company
☐ Contractor

☐ Other: _________________

Performance

1. What time of the year do utility failures occur most often?

   ☐ Winter
   ☐ Spring
   ☐ Summer
   ☐ Fall

2. What is the expected service life, in years, of a utility cut repair for each pavement type in your jurisdiction?

   Asphalt: _____ Concrete composite (concrete with asphalt surface: _____
   Concrete: _____ Brick: _____
   Brick composite (brick over granular base with asphalt surface): _____
   Rigid brick composite (brick over concrete base with asphalt surface): _____
   Other (please specify type and duration): __________________________________

3. How would you define a premature failure of a pavement restoration of an open utility cut?
   ____
   ____
   ____

4. Have you experienced premature failures? Select Yes or No for each pavement type in your jurisdiction, and select the approximate age they typically occur.

Pavement type	Have you experienced premature failures?			Typically, at what age?
	Yes	No	N/A	Please provide age:
Asphalt pavements				______________
Concrete pavements				______________
Concrete composite pavements (concrete with asphalt surface)				______________
Brick				______________
Brick composite (brick over granular base with asphalt surface)				______________
Rigid brick composite (brick over concrete base with asphalt surface)				______________

5. For each existing pavement type, approximately what percentage of repairs have experienced pavement performance problems?

   ____% of repairs on Asphalt
   ____% of repairs on Concrete
   ____% of repairs on Concrete composite (concrete with asphalt surface)

____% of repairs on Brick
____% of repairs on Brick composite (brick over granular base with asphalt surface)
____% of repairs on Rigid brick composite (brick over concrete base with asphalt surface)
____Other: ______________________

6. What, in your opinion, is causing the problem?
____
____
____
____
____
____

7. How is performance evaluated? (Check all that apply)

☐ Visual Inspection
☐ Direct measurement, please specify: ________________
☐ Non-destructive testing, please specify: ________________
☐ Other, please specify: _______________________
☐ Performance is not evaluated

8. What criteria do you use to judge performance? Check all that apply and of those selected, rank your top three based on importance, by writing in "1", "2" or "3" on the adjacent line.

Select all that apply:	Rank the top three:
☐ Profile of the restored surface (settlement/hump)	____
☐ Crack width	____
☐ Extent of cracking around the cut	____
☐ Public complaints	____
☐ Other, please specify: ___________________	____
☐ None	

9. Have you noticed a difference in performance between utility cuts made in the wheel path and those made between or outside the wheel path?

☐ Yes, please describe:
____
____

☐ No

Construction

1. Please indicate the percentage of total repairs completed by each of the following:
   - ____% Agency
   - ____% Utility company
   - ____% Contractor
   - ____% Other (please list) ________________________________

2. Do you have quality control/quality assurance requirements for open utility cut restoration?
   - ☐ Yes, please describe:
     ____
     ____
   - ☐ No

3. If you answered yes, are the requirements effective in assuring a quality repair?
   - ☐ Yes
   - ☐ No

4. What percentage of pavement restorations of utility cuts are inspected at the time of the restoration?

   ____

5. Is any testing of the materials done at the time of restoration?
   - ☐ Yes, type of tests:
     ____
   - ☐ No

6. What factors influence your decision on repair procedure/material? Check all that apply and of those selected, rank the top three factors by writing in "1", "2", or "3" on the adjacent line.

Select all that apply:	Rank the top three:
☐ Traffic volume	____
☐ Age of existing surface	____
☐ Time to next resurfacing	____
☐ Time of year	____
☐ Past performance of procedure/material	____
☐ Cost	____
☐ Other, please specify: ___________________	____

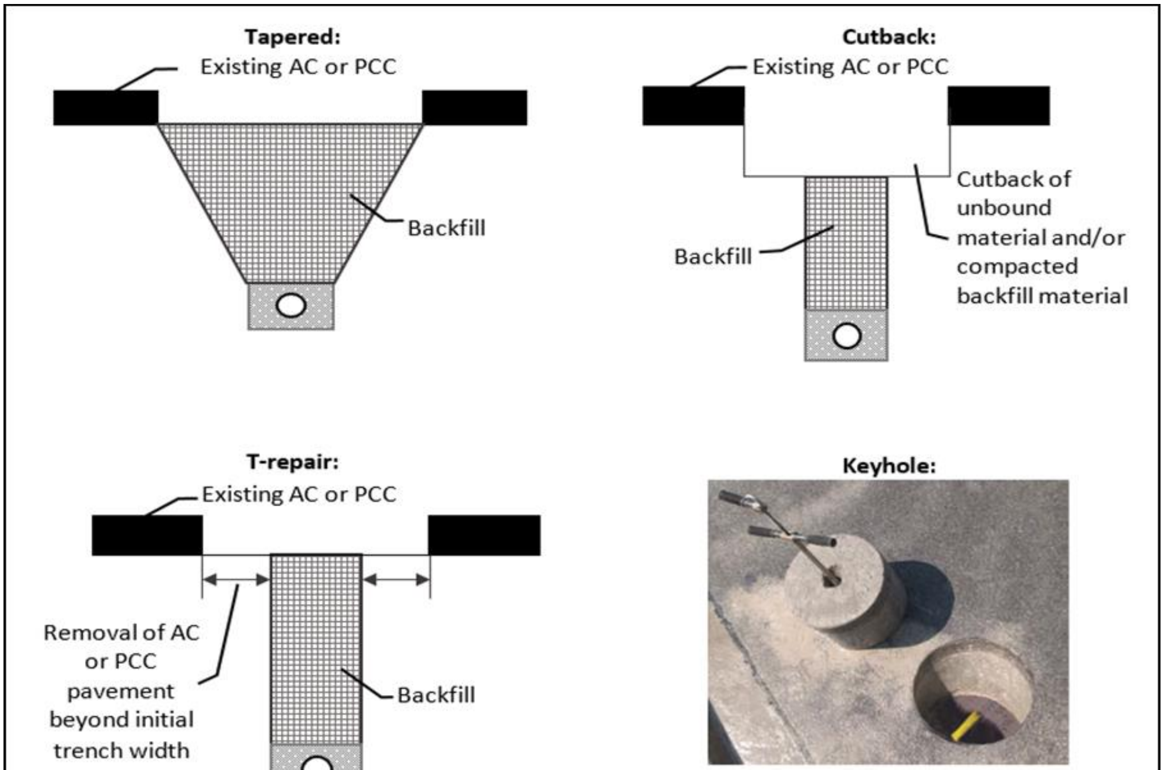
7. How is backfill material compacted? Please select all that apply and indicate type. Also, please indicate if the equipment provides adequate compaction.

Compaction Equipment	Select all that apply	Does it provide adequate compaction?		
		Yes	No	N/A
Vibrating plate, type: ___________________________				
Tamper, type: ___________________________				
Roller, type: ___________________________				
Other: ___________________________				
None				

8. Has any of the following techniques been used in your jurisdiction? See image below for description. (Check all that apply)

☐ Tapered
☐ "T" repair
☐ Cutback
☐ Keyhole
☐ Other, please describe:

____
____
____
____
____



(Jarnecke and Pollock, 2017)

9. If the T-repair technique is used, what is the typical distance beyond the initial trench width that the existing pavement material is removed?
____

10. If the cutback technique is used, what is the depth of subgrade removed?
____

11. If the cutback technique is used, what is the typical lateral distance from the edge of the trench that is removed?
____

12. For each pavement type in your jurisdiction, what is the typical restoration of open utility cuts? Please provide the following for the typical restoration of each pavement type: technique, backfill material, average life (in years), estimated average cost (per sq. yd.)

Pavement type	Typical Technique (e.g. T repair, or cutback)	Backfill material (e.g. native material, or controlled low-strength mortar)	Average Life (yrs)	Average Cost ($/sq. yd.)
Asphalt	________________	__________________	______	______
Concrete	________________	__________________	______	______
Concrete composite	________________	__________________	______	______
Brick	________________	__________________	______	______
Brick composite	________________	__________________	______	______
Rigid brick composite	________________	__________________	______	______

13. Has trenchless technology (e.g. boring, pipe bursting, etc.) been used in your jurisdiction to install utilities? If yes, please list those used and for which utility they were used.

☐ Yes: ____
☐ No

14. Please describe the procedures/materials typically used during low temperature conditions (indicate if the method is temporary)

____
____

15. Please describe the procedures/materials typically used during wet conditions (indicate if the method is temporary)

____
____

Policy

1. How do you track and permit utility cuts? Please describe the process, or you may provide web address if process is described on agency website:

____
____
____

2. What fees are assessed on utility cuts?

☐ Permitting fee
☐ Pavement degradation fee
☐ Other __________________
☐ No fees are assessed

3. Where can we find the fee schedule assessed in your municipality? Please provide a web address below, if available.

____

4. Are you satisfied with your methods for managing utility cuts?

☐ Yes
☐ No, please describe what needs to be improved:
____
____

5. Does your agency place a moratorium on utility cuts following the construction or resurfacing of a pavement? If so, what is the duration of the moratorium?

☐ Yes, duration: ______________
☐ No

THANK YOU FOR SUPPORTING THIS IMPORTANT EFFORT

You may access the online survey at the following link:
https://ohio.qualtrics.com/jfe/form/SV_02ENKGCFMtKsrCl

If you are unable to complete the online survey, you may email an electronic copy of your completed survey to Dr. Mary Robbins at robbinm1@ohio.edu or mail a hard copy to**:**

Dr. Shad Sargand
Civil Engineering
Stocker Center 231
1 Ohio University
Athens, Ohio 45701

9.4 *Survey Responses*

Name	Job Title	Name of Agency	Email Address	Affiliation	Approximately what is the population of your municipality?	What is the approximate number of open utility cuts performed on your roads, on average, per year?
Michael Vinay	Director of Public Service	City of Barberton	mvinay@cityofbarberton.com	City	26500	150
Rob Nicolls	City Engineer	City of Middletown	robertn@cityofmiddletown.org	City	50000	100
Lawrence W. Fulton	Chief Deptuy Engineer	Summit County Engineer	lfulton@summitengineer.net	County	542000	we dont permit open cuts of pavement
Joe Beno	Public Works Director	city of Lakewood	joe.beno@lakewoodoh.net	City	52000	100
Nick Gorris	Deputy Engineer	Geauga County Engineer's Office	ngorris@co.geauga.oh.us	County	99,000 - County	25
John Rice	Staff Engineer	City of Wooster	jrice@woosteroh.com	City	26540	50
Alan Moran	Pavement Program Manager	City of Columbus	apmoran@columbus.gov	City	860000	10000
Ed Nutter		City of Newark, Division of Water & Wastewater	enutter@newarkohio.net	City	46000	225
Sean C. Sink	Street/Equipment Maint Supt	City of Fairborn	sean.sink@ci.fairborn.oh.us	City	37000	350/400
Denise Crews P.E.	Stormwater Manager	City of Lancaster	dcrews@ci.lancaster.oh.us	City	39000	100
Matt McCuistion	Engineering Technician IV	City of Springfield Engineering	mmccuistion@springfieldohio.gov	City	60000	300
Zachary Gerdeman	Roadway Technician	Allen County Engineer	zgerdeman@allencountyohio.com	County	105000	5
Wesley Wade	Street Supervisor	Miami Township	wwade@miamitownship.com	Township	50000	50
David Escobar	Senior Engineer I (Public Works)	City of Dayton	david.escobar@daytonohio.gov	City	140000	1000
Greg Butcher	Township Engineer	Violet Township	engineer@violet.oh.us	Township	40000	50
Jacolyn Thiel	Deputy Director Public Service â€“ City Engineer	City of Upper Arlington	jthiel@uaoh.net	City	35000	75
blake a vermilion	operations manager	City of Newark Street/Traffic	bvermilion@newarkohio.net	City	47500	150

Name	Job Title	Name of Agency	Email Address	Affiliation	Approximately what is the population of your municipality?	What is the approximate number of open utility cuts performed on your roads, on average, per year?
Steve Caddell	Project Coordinator	City of Mason	scaddell@masonoh.org	City	33000	25
Mark Papke	City Engineer	City of Lakewood	mark.papke@lakewoodoh.net	City	52000	50
Brian Thomas	Director of Public Service/Acting City Engineer	City of Findlay	bthomas@findlayohio.com	City	42000	75
Mike Darmos	Street Superintendent	City of Lorain	Mike_Darmos@cityoflorain.org	City	68000	250
Pat Yingling	Senior Civil Engineer	City of Hamilton	pat.yingling@hamilton-oh.gov	City	65000	200
Paul Fatica	Consulting Engineer	City of Cleveland	pfaitca@city.cleveland.oh.us	City	400000	4000
Cindi Fitzpatrick	Public Service Director	City of Grove City	cfitzpatrick@grovecityohio.gov	City	40000	50
John C. Sopko	Project Manager	Northwestern Water and Sewer District	jsopko@nwwsd.org	Water & Sewer District	30,000 +	15-25
Kenneth Seitz	Resident Engineer	Lake County Engineer	ken.seitz@lakecountyohio.gov	County	228600	We do not permit open cuts in pavement unless absolutely unavoidable. Road crossings or installations in pavement must be bored. This would only apply to repairs of existing lines under pavement.
Michael Dorn	Senior Engineer	Montgomery County Engineers Office	dornm@mcohio.org	County	550000	75
Dave Weinandy	Construction Bureau Chief - Civil Engineering	City of Dayton	dave.weinandy@daytonohio.gov	City	125000	5000
John Musselman	Service Director	Miami Township (Clermont)	John.Musselman@miamitwpoh.gov	Township	42000	30
Nicholas Smith	Assistant City Engineer	City of Beavercreek	smith@beavercreekohio.gov	City	47000	50
William J Forthofer	Engineering Admin. Support	City of Elyria	wforthofer@cityofelyria.org	City	54000	150

Name	Job Title	Name of Agency	Email Address	Affiliation	Approximately what is the population of your municipality?	What is the approximate number of open utility cuts performed on your roads, on average, per year?
Douglas Davis	County Engineer	Muskingum County	davis.mceo@rrohio.com	County	88000	
Roy Scott Sanders	Engineering Project Inspector	City of Dublin	ssanders@dublin.oh.us	City	45000	less than 3 per year
Jeremy Kalb	Project Manager	City of Findlay	jkalb@findlayohio.com	City	50000	75-100
Steve Buskirk	Buskirk	Franklin County Engineer	sbuskirk@franklincountyengineer.org	County	1.2 Million	50
Michael Teodecki	Design Division Manager	City of Akron	Mteodecki@akronohio.gov	City	200000	500
Denyse Click	Transportation Tech	ODOT	denyse.click@dot.ohio.gov	State	STATE	3

	Please provide the approximate distribution (as % of total) of open utility cuts by utility type:						
Name of Agency	Water and Sewer	Gas	Electric	Telecommunication	Cable	Other	Other (Type)
City of Barberton	75	0	0	0	0	25	Storm Sewer
City of Middletown	50	45	0	5	0	0	
Summit County Engineer	0	0	0	0	0	0	
city of Lakewood	75	5	0	20	0	0	
Geauga County Engineer's Office	1	1	1	1	1	95	Storm
City of Wooster	50	50	0	0	0	0	
City of Columbus	30	30	10	10	10	10	
City of Newark, Division of Water & Wastewater	75	25	0	0	0	0	
City of Fairborn	25	45	5	10	0	15	Road maintenance and repair
City of Lancaster	20	50	0	30	0	0	
City of Springfield Engineering	30	50	5	10	5	0	
Allen County Engineer	0	20	0	0	0	80	drainage
Miami Township	50	20	20	5	5	0	
City of Dayton	75	20	1	2	2	0	
Violet Township	75	25	0	0	0	0	
City of Upper Arlington	20	70	0	5	5	0	
City of Newark Street/Traffic	45	25	0	5	0	25	storm water
City of Mason	50	30	10	5	5	0	
City of Lakewood	50	40	5	2.5	2.5	0	
City of Findlay	75	25	0	0	0	0	
City of Lorain	100	0	0	0	0	0	
City of Hamilton	50	35	5	5	5	0	
Engineering & Construction	20	30	10	25	15	0	
City of Grove City	20	15	5	30	30	0	
Northwestern Water and Sewer District	100	0	0	0	0	0	
Lake County Engineer	20	65	5	5	5		
Montgomery County Engineers Office	35	35	5	20	1	4	
City of Dayton	20	65	5	5	5		
Miami Township (Clermont)	40	15	15	10	20	0	
City of Beavercreek	25	50	5	10	10	0	
City of Elyria	50	45	0	5	0	0	
Muskingum County	0	0	0	0	0	100	driveway and storm
City of Dublin	0	0	50	50	0	0	
City of Findlay	60	40	0	0	0	0	
Franklin County Engineer	60	10	10	10	10	0	
City of Akron	11	35	1	12	0	39	Right of Way Repairs
ODOT	50	50	0	0	0	0	

Name of Agency	Please provide the type of pavement in your jurisdiction by indicating the approximate amount of each pavement type as a percentage of total roadway network.									
	Asphalt	Concrete	Concrete composite (concrete with asphalt surface)	Brick	Brick composite (brick over granular base with asphalt surface)	Rigid brick composite (brick over concrete base with asphalt surface)	Chip Seal	Gravel	Other	Other (type)
City of Barberton	70	5	15	0	0	0	10	0	0	
City of Middletown	100	0	0	0	0	0	0	0	0	
Summit County Engineer	43	5	10	0	0	0	40	2	0	
city of Lakewood	15	5	50	0	30	0	0	0	0	
Geauga County Engineer's Office	95	1	0	0	0	0	4	0	0	
City of Wooster	65	20	8	2	0	0	5	0	0	
City of Columbus	23	3	70	1	0	3	0	0	0	
City of Newark, Division of Water & Wastewater	85	10	0	5	0	0	0	0	0	
City of Fairborn	65	10	25	0	0	0	0	0	0	
City of Lancaster	97.6	0.3	0	0.1	0	0	2	0	0	
City of Springfield Engineering	50	0	50	0	0	0	0	0	0	
Allen County Engineer	75	5	0	0	0	0	20	0	0	
Miami Township	98	2	0	0	0	0	0	0	0	
City of Dayton	85	9	2	2	1	1	0	0	0	
Violet Township	95	0	0	0	0	0	5	0	0	
City of Upper Arlington	90	0	5	5	0	0	0	0	0	
City of Newark Street/Traffic	70	15	0	5	0	0	5	5	0	
City of Mason	100	0	0	0	0	0	0	0	0	
City of Lakewood	5	10	40	2	3	40	0	0	0	
City of Findlay	90	0	0	0	10	0	0	0	0	
City of Lorain	35	65	0	0	0	0	0	0	0	
City of Hamilton	98	2	0	0	0	0	0	0	0	
City of Cleveland	0	0	90	0	10	0	0	0	0	
City of Grove City	45	5	50	0	0	0	0	0	0	
Northwestern Water and Sewer District	75	10	10	0	0	0	0	0	0	
Lake County Engineer	98	1					1			
Montgomery County Engineers Office	97.5	0.2	0.8				1.5			
City of Dayton	50	20	10	5	5	5	5			
Miami Township (Clermont)	50	0	50	0	0	0	0	0	0	
City of Beavercreek	84	1	15	0	0	0	0	0	0	
City of Elyria	35	20	40	0	0	5	0	0	0	

Name of Agency	Please provide the type of pavement in your jurisdiction by indicating the approximate amount of each pavement type as a percentage of total roadway network.									
	Asphalt	Concrete	Concrete composite (concrete with asphalt surface)	Brick	Brick composite (brick over granular base with asphalt surface)	Rigid brick composite (brick over concrete base with asphalt surface)	Chip Seal	Gravel	Other	Other (type)
Muskingum County	30	0	0	0	0	0	30	40	0	
City of Dublin	95	5	0	0	0	0	0	0	0	
City of Findlay	60	5	0	0	25	0	10	0	0	
Franklin County Engineer	95	0	5	0	0	0	0	0	0	
City of Akron	45	10	3	7	10	15	3	2	0	
ODOT	100	0	0	0	0	0	0	0	0	

Name of Agency	What is the predominant subgrade soil type in your jurisdiction?	Does your agency have a standard method of repair for utility cuts?	Please provide a web address where we may access your agency's specifications and/or standard drawings or please provide a description of the method here:
City of Barberton	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	
City of Middletown	Granular (soils that drain quickly such as gravel, sand, silty or clayey gravel, silty or clayey sand)	Yes	
Summit County Engineer	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	
city of Lakewood	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	
Geauga County Engineer's Office	Granular (soils that drain quickly such as gravel, sand, silty or clayey gravel, silty or clayey sand)	Yes	http://www.co.geauga.oh.us/Portals/0/resources/County%20Documents/county%20engineer/documents/highway_use_manual.pdf?ver=2012-03-24-103158-000
City of Wooster	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	https://www.woosteroh.com/your-government/engineering/construction-standards
City of Columbus	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	
City of Newark, Division of Water & Wastewater	Granular (soils that drain quickly such as gravel, sand, silty or clayey gravel, silty or clayey sand)	Yes	
City of Fairborn	Granular (soils that drain quickly such as gravel, sand, silty or clayey gravel, silty or clayey sand)	Yes	
City of Lancaster	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	www.ci.lancaster.oh.us/174/Standard-Drawings
City of Springfield Engineering	Granular (soils that drain quickly such as gravel, sand, silty or clayey gravel, silty or clayey sand)	Yes	
Allen County Engineer	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	http://www.allencountyohengineer.com/
Miami Township	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	
City of Dayton	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	http://www.daytonohio.gov/DocumentCenter/View/705
Violet Township	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	No	
City of Upper Arlington	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	We follow the City of Columbus Standards
City of Newark Street/Traffic	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	No	
City of Mason	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	

Name of Agency	What is the predominant subgrade soil type in your jurisdiction?	Does your agency have a standard method of repair for utility cuts?	Please provide a web address where we may access your agency's specifications and/or standard drawings or please provide a description of the method here:
City of Lakewood	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	
City of Findlay	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	
City of Lorain	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	
City of Hamilton	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	
City of Cleveland	Granular (soils that drain quickly such as gravel, sand, silty or clayey gravel, silty or clayey sand)	Yes	
City of Grove City	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	http://www.grovecityohio.gov/development/standard-drawings/
Northwestern Water and Sewer District	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	We typically follow the ODOT specification on pavement repair
Lake County Engineer	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	No utility cuts directly under pavements are permitted. These installations must be bored. Utility cuts outside pavement require compacted granular backfill under a 45degree line (the zone of influence) and general fill can be used above this line.
Montgomery County Engineers Office	Granular (soils that drain quickly such as gravel, sand, silty or clayey gravel, silty or clayey sand)		Sawcut all edges. Compacted granular backfill. Hot mix asphalt to match existing pavement thickness. Edges sealed with hot AC sealer
City of Dayton	Granular (soils that drain quickly such as gravel, sand, silty or clayey gravel, silty or clayey sand)	Yes	City of Dayton. Department of Public Works. Rules and Regulations for Making Openings in a Public Way dated January 1, 2016. http://www.daytonohio.gov/DocumentCenter/View/705
Miami Township (Clermont)	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	
City of Beavercreek	Granular (soils that drain quickly such as gravel, sand, silty or clayey gravel, silty or clayey sand)	Yes	
City of Elyria	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	
Muskingum County	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	county engineer website, under utility permits and driveway permits
City of Dublin	Granular (soils that drain quickly such as gravel, sand, silty or clayey gravel, silty or clayey sand)	Yes	
City of Findlay	Granular (soils that drain quickly such as gravel, sand, silty or clayey gravel, silty or clayey sand)	Yes	

Name of Agency	What is the predominant subgrade soil type in your jurisdiction?	Does your agency have a standard method of repair for utility cuts?	Please provide a web address where we may access your agency's specifications and/or standard drawings or please provide a description of the method here:
Franklin County Engineer	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	
City of Akron	Fine-grained (soils that drain slowly such as silt, clay, silty clay); Granular (solids that drain quickly such as gravel, sand, silty or clayey gravel, silty or clayey sand)	Yes	http://www.akronohio.gov/cms/engmaintained until ineering/operationssupport_admin_standarddwgs/index.html
ODOT	Fine-grained (soils that drain slowly such as silt, clay, silty clay)	Yes	

	Does your standard method provide satisfactory results? Please answer Yes, No, or N/A for each pavement type.							
Name of Agency	Asphalt	Concrete	Concrete composite (concrete with asphalt surface)	Brick	Brick composite (brick over granular base with asphalt surface)	Rigid brick composite (brick over concrete base with asphalt surface)	What type of backfill materials are allowed? Select all that apply.	What type of backfill materials are allowed? Other:
City of Barberton	Yes	Yes	Yes	N/A	N/A	N/A	Granular material	
City of Middletown	Yes						Granular material, Controlled low-strength mortar	
Summit County Engineer								
city of Lakewood	Yes	Yes	Yes	Yes	Yes	Yes	Controlled low-strength mortar	
Geauga County Engineer's Office	Yes	Yes	N/A	N/A	N/A	N/A	Granular material, Controlled low-strength mortar	
City of Wooster	Yes	Yes	Yes	Yes	Yes	N/A	Granular material, Controlled low-strength mortar	
City of Columbus	Yes	Yes	Yes	Yes	N/A	Yes	Granular material, Controlled low-strength mortar	
City of Newark, Division of Water & Wastewater								
City of Fairborn								
City of Lancaster	Yes	Yes	Yes	Yes	Yes	Yes	Granular material, Controlled low-strength mortar	
City of Springfield Engineering								
Allen County Engineer	Yes	Yes	N/A	N/A	N/A	N/A	Controlled low-strength mortar	
Miami Township	Yes	Yes					Granular material, Controlled low-strength mortar	
City of Dayton	No	Yes	Yes	Yes	Yes	Yes	Granular material, Controlled low-strength mortar	
Violet Township								
City of Upper Arlington	Yes	N/A	No	Yes	N/A	N/A	Granular material, Controlled low-strength mortar	
City of Newark Street/Traffic								
City of Mason	Yes	Yes	N/A	N/A	N/A	N/A	Native material, Granular material, Controlled low-strength mortar	
City of Lakewood	Yes	Yes	Yes	Yes	Yes	Yes	Controlled low-strength mortar	
City of Findlay	Yes	N/A	N/A	N/A	Yes	N/A	Granular material	
City of Lorain	Yes	Yes	N/A	N/A	N/A	N/A	Granular material	
City of Hamilton	Yes	N/A	N/A	N/A	N/A	N/A	Controlled low-strength mortar	

	Does your standard method provide satisfactory results? Please answer Yes, No, or N/A for each pavement type.							
Name of Agency	Asphalt	Concrete	Concrete composite (concrete with asphalt surface)	Brick	Brick composite (brick over granular base with asphalt surface)	Rigid brick composite (brick over concrete base with asphalt surface)	What type of backfill materials are allowed? Select all that apply.	What type of backfill materials are allowed? Other:
City of Cleveland	Yes	Yes	Yes	Yes	Yes	Yes	Granular material	
City of Grove City	Yes	Yes	Yes	N/A	N/A	N/A	Granular material, Controlled low-strength mortar	
Northwestern Water and Sewer District	Yes	Yes	Yes				Granular material, Controlled low-strength mortar	
Lake County Engineer	Yes	Yes	Yes	N/A	N/A	N/A	Granular material	
Montgomery County Engineers Office	Yes	Yes	Yes	N/A	N/A	N/A	Granular material, Controlled low-strength mortar	
City of Dayton	Yes	Yes	Yes	Yes	Yes	Yes	Granular material, Controlled low-strength mortar	
Miami Township (Clermont)								
City of Beavercreek	Yes	Yes	Yes	N/A	N/A	N/A	Granular material, Controlled low-strength mortar	
City of Elyria	Yes	Yes	Yes	Yes	Yes	Yes	Granular material, Controlled low-strength mortar	
Muskingum County	Yes	N/A	N/A	N/A	N/A	N/A	Controlled low-strength mortar	
City of Dublin								
City of Findlay								
Franklin County Engineer	Yes		Yes				Granular material, Controlled low-strength mortar	
City of Akron	Yes	Yes	Yes	N/A	Yes	Yes	Native material, Controlled low-strength mortar, Other	304 Mix
ODOT	Yes	N/A	Yes	N/A	N/A	N/A	Controlled low-strength mortar	

Name of Agency	What pavement material is used as a temporary pavement surface, and how long is the patch typically left in place?				
	No temporary pavement surface is allowed	Asphalt	Concrete	Brick	Other
City of Barberton		60-90 Days			
City of Middletown		3 months			
Summit County Engineer					
city of Lakewood			5 months		
Geauga County Engineer's Office	No temporary pavement surface is allowed				Road Plated till complete / or during planned construction
City of Wooster		No limit	No limit		Aggregate, maximum of 5 days
City of Columbus					Asphalt Cold Mix, until proper material is available
City of Newark, Division of Water & Wastewater					
City of Fairborn					
City of Lancaster		3 mo	3 mo		
City of Springfield Engineering					
Allen County Engineer	No temporary pavement surface is allowed				
Miami Township	Other, please specify type and duration:				Cold Patch- 3 to 4 months
City of Dayton	Asphalt:	30 days			
Violet Township					
City of Upper Arlington	No temporary pavement surface is allowed				
City of Newark Street/Traffic					
City of Mason		120	120		Cold Patch 120
City of Lakewood	No temporary pavement surface is allowed				
City of Findlay		Cold Patch - Over the winter until asphalt plants open			
City of Lorain		1-2 weeks	2-3 weeks		These estimated are based on weather
City of Hamilton		1 month typ	winter months		
City of Cleveland	No temporary pavement surface is allowed				
City of Grove City		3 months	3 months		
Northwestern Water and Sewer District		2-3 months	2-3 months		LSM with asphalt cap
Lake County Engineer	Asphalt:				

Name of Agency	What pavement material is used as a temporary pavement surface, and how long is the patch typically left in place?				
	No temporary pavement surface is allowed	Asphalt	Concrete	Brick	Other
Montgomery County Engineers Office					Cold mix no duration if maintaned until final
City of Dayton		Weather dependent	Weather dependent		Cold Patch
Miami Township (Clermont)					
City of Beavercreek		3 months			
City of Elyria		hot and cold			
Muskingum County	No temporary pavement surface is allowed				
City of Dublin					
City of Findlay					
Franklin County Engineer		4 Months	4 Months		
City of Akron			Maintained until permanent restoration		
ODOT	No temporary pavement surface is allowed				

Name of Agency	Please indicate the permanent pavement surface for repairs of each pavement type in your jurisdiction.					
	Asphalt Pavements	Concrete Pavements	Concrete Composite Pavements	Brick Pavements	Brick Composite Pavements	Rigid Brick Composite Pavements
City of Barberton	Asphalt	Concrete	Asphalt			
City of Middletown	Asphalt					
Summit County Engineer						
city of Lakewood	Asphalt	Concrete	Asphalt, Concrete	Asphalt, Concrete	Asphalt, Concrete	Asphalt, Concrete
Geauga County Engineer's Office	Asphalt	Concrete				
City of Wooster	Asphalt	Concrete	Concrete	Concrete	Concrete	Other
City of Columbus	Asphalt	Concrete	Asphalt	Brick		Asphalt
City of Newark, Division of Water & Wastewater						
City of Fairborn						
City of Lancaster	Asphalt	Concrete	Asphalt	Concrete, Brick, Stamped concrete	Asphalt	
City of Springfield Engineering						
Allen County Engineer	Asphalt	Asphalt	Asphalt	Asphalt	Asphalt	Asphalt
Miami Township	Asphalt	Asphalt, Concrete				
City of Dayton	Asphalt	Concrete	Other	Brick	Brick	Asphalt
Violet Township						
City of Upper Arlington	Asphalt		Asphalt	Brick		
City of Newark Street/Traffic						
City of Mason	Asphalt	Concrete	Asphalt	Asphalt	Asphalt	Asphalt
City of Lakewood	Asphalt, Concrete	Concrete	Asphalt, Concrete	Brick	Asphalt, Concrete, Brick	Concrete, Brick
City of Findlay	Asphalt				Asphalt	
City of Lorain	Asphalt	Concrete				
City of Hamilton	Asphalt, Concrete	Concrete				
City of Cleveland	Asphalt	Concrete	Other	Brick	Other	Other
City of Grove City	Asphalt	Concrete	Asphalt			
Northwestern Water and Sewer District	Asphalt	Concrete	Asphalt			
Lake County Engineer	Asphalt	Concrete	Asphalt			
Montgomery County Engineers Office	Asphalt	Asphalt	Asphalt			
City of Dayton	Asphalt	Concrete	Asphalt, Concrete	Brick	Asphalt, Concrete	Concrete, Brick

Name of Agency	Please indicate the permanent pavement surface for repairs of each pavement type in your jurisdiction.					
	Asphalt Pavements	Concrete Pavements	Concrete Composite Pavements	Brick Pavements	Brick Composite Pavements	Rigid Brick Composite Pavements
Miami Township (Clermont)						
City of Beavercreek	Asphalt	Asphalt	Asphalt			
City of Elyria	Asphalt	Concrete	Concrete	Concrete		
Muskingum County	Concrete	Concrete	Concrete	Concrete	Concrete	Concrete
City of Dublin						
City of Findlay						
Franklin County Engineer	Asphalt					
City of Akron	Asphalt	Concrete	Asphalt	Brick, Stamped Concrete	Asphalt	Asphalt
ODOT	Asphalt					

Name of Agency	Do you have a different specification for seasonal repairs or emergency repairs?	Please upload the specification, or provide a web address where we may access them or a description of the method here:	Is cold weather protection required for curing of concrete?	If you do not have a standard method, who decides the method to be used?	
				Please select all that apply.	Other, please specify:
City of Barberton	Yes		Yes	Agency (e.g. municipal engineer)	
City of Middletown	Yes		Yes		
Summit County Engineer					
city of Lakewood	No		Yes	Contractor	
Geauga County Engineer's Office	No		N/A	Agency (e.g. municipal engineer), Other	County Engineer
City of Wooster	Yes		Yes	Agency (e.g. municipal engineer)	
City of Columbus	No		Yes		
City of Newark, Division of Water & Wastewater					
City of Fairborn					
City of Lancaster	No		Yes		
City of Springfield Engineering					
Allen County Engineer	No		N/A		
Miami Township	Yes		Yes	Agency (e.g. municipal engineer)	
City of Dayton	No		Yes	Agency (e.g. municipal engineer)	
Violet Township				Agency (e.g. municipal engineer),Utility company	
City of Upper Arlington	Yes		Yes	Agency (e.g. municipal engineer)	
City of Newark Street/Traffic				Utility company, Contractor	
City of Mason	No		Yes	Agency (e.g. municipal engineer)	
City of Lakewood	Yes		Yes		
City of Findlay	No		N/A		
City of Lorain	Yes		Yes	Contractor	

Name of Agency	Do you have a different specification for seasonal repairs or emergency repairs?	Please upload the specification, or provide a web address where we may access them or a description of the method here:	Is cold weather protection required for curing of concrete?	If you do not have a standard method, who decides the method to be used?	
				Please select all that apply.	Other, please specify:
City of Hamilton	Yes		Yes	Agency (e.g. municipal engineer)	
City of Cleveland	No		Yes		
City of Grove City	No		Yes	Other	Often utilties and or contractors will apply their own method without coordinating with the agency and our standard
Northwestern Water and Sewer District	Yes	For emergency repairs we will allow granular material to be placed to grade.	Yes	Agency (e.g. municipal engineer)	
Lake County Engineer	No		Yes		
Montgomery County Engineers Office	No		Yes		
City of Dayton	Yes	Long term winter temporary repairs are to be completed with a flow fill with a 3 inch concrete cap. http://www.daytonohio.gov/DocumentCenter/View/705	Yes	Agency (e.g. municipal engineer)	
Miami Township (Clermont)					
City of Beavercreek	No		Yes	Agency (e.g. municipal engineer)	
City of Elyria	Yes		Yes	Agency (e.g. municipal engineer)	
Muskingum County	No		Yes	Other	i have an inspector for this
City of Dublin					
City of Findlay					
Franklin County Engineer	No		Yes		
City of Akron	No		Yes	Other	We use Akron Engineering Standards
ODOT	No		Yes	Agency (e.g. municipal engineer)	

Name of Agency	What time of the year do utility failures occur most often?	What is the expected service life, in years, of a utility cut repair for each pavement type in your jurisdiction?					
		Asphalt Pavements	Concrete Pavements	Concrete Composite Pavements	Brick Pavements	Brick Composite Pavements	Rigid Brick Composite Pavements
City of Barberton	Winter	4	15	4			
City of Middletown	Winter	15 years					
Summit County Engineer	Spring	5	10	5			
city of Lakewood	Winter	25	25	25	25	25	25
Geauga County Engineer's Office	Spring	5-7	N/A	N/A	N/A	N/A	N/A
City of Wooster	Winter	3	10	10	10	10	
City of Columbus	Winter	20	20	20	20		20
City of Newark, Division of Water & Wastewater							
City of Fairborn							
City of Lancaster	Winter	10 yr	20 yr	10 yr	20 yr	10 yr	
City of Springfield Engineering							
Allen County Engineer							
Miami Township							
City of Dayton							
Violet Township	Winter	10					
City of Upper Arlington	Spring	10					
City of Newark Street/Traffic	Winter	1-3	3-5		1-3		
City of Mason	Winter	20	20				
City of Lakewood	Winter	10	20	20	20	10	10
City of Findlay	Winter	20				20	
City of Lorain	Winter	5-7 years	10 years				
City of Hamilton	Winter	10	20	15	20		
City of Cleveland	Winter	10	10	10	10	10	10
City of Grove City							
Northwestern Water and Sewer District	Spring, Summer	25	25				
Lake County Engineer	Spring	No pavement utility cuts permitted	No pavement utility cuts permitted	No pavement utility cuts permitted	No pavement utility cuts permitted	No pavement utility cuts permitted	No pavement utility cuts permitted
Montgomery County Engineers Office	Spring	12	12				

Name of Agency	What time of the year do utility failures occur most often?	What is the expected service life, in years, of a utility cut repair for each pavement type in your jurisdiction?					
		Asphalt Pavements	Concrete Pavements	Concrete Composite Pavements	Brick Pavements	Brick Composite Pavements	Rigid Brick Composite Pavements
City of Dayton	Winter	Until resurfacing occurs on all types	Until resurfacing occurs on all types	Until resurfacing occurs on all types	Until resurfacing occurs on all types	Until resurfacing occurs on all types	Until resurfacing occurs on all types
Miami Township (Clermont)							
City of Beavercreek	Winter	5	5	5			
City of Elyria	Winter	5-10	20	5-10			
Muskingum County							
City of Dublin							
City of Findlay							
Franklin County Engineer	Winter	5 years					
City of Akron	Winter	7	10-15	7	10-15	7	7
ODOT	Winter						

Name of Agency	How would you define premature failure of a pavement restoration of an open utility cut?	Have you experienced premature failures?					
		Asphalt Pavements	Concrete Pavements	Concrete Composite Pavements	Brick Pavements	Brick Composite Pavements	Rigid Brick Composite Pavements
City of Barberton		Yes	No	No	No	No	No
City of Middletown	Any surface distress or settling of the repair	No					
Summit County Engineer	inadequate compaction of backfill	Yes	Yes				
city of Lakewood	large depression or pot hole that needs to be filled.	Yes	Yes	Yes	Yes	Yes	Yes
Geauga County Engineer's Office	Unexpected / Reoccurring pavement Settlement	Yes	N/A	N/A	N/A	N/A	N/A
City of Wooster	Typically it occurs with asphalt due to poor compaction, generally due to the small size of the repair.	Yes	Yes	Yes	Yes	Yes	Yes
City of Columbus	settlement, cracking at joints						
City of Newark, Division of Water & Wastewater							
City of Fairborn							
City of Lancaster		Yes	No	Yes	No	Yes	N/A
City of Springfield Engineering							
Allen County Engineer							
Miami Township							
City of Dayton							
Violet Township	excessive settlement	Yes	N/A	N/A	N/A	N/A	N/A
City of Upper Arlington	settlement and joint separation	Yes					
City of Newark Street/Traffic	sinking due to lack of compaction, granulation of asphalt, breaking apart of repair to the point of an open void.	Yes	Yes	N/A	Yes	N/A	No
City of Mason	Settlement, pavement raveling, cracking, potholes	Yes	Yes	N/A	N/A	N/A	N/A
City of Lakewood	Settlement in excess of one inch	Yes	No	No	No	Yes	Yes
City of Findlay	Same as the roadway	No	N/A	N/A	N/A	No	N/A
City of Lorain		No	No	N/A	N/A	N/A	N/A
City of Hamilton		Yes	No	No	No	No	No
City of Cleveland		No	Yes	Yes	N/A	N/A	N/A
City of Grove City							

Name of Agency	How would you define premature failure of a pavement restoration of an open utility cut?	Have you experienced premature failures?					
		Asphalt Pavements	Concrete Pavements	Concrete Composite Pavements	Brick Pavements	Brick Composite Pavements	Rigid Brick Composite Pavements
Northwestern Water and Sewer District	Significant settlement.	Yes					
Lake County Engineer	Settlement	No	No	No	No	No	No
Montgomery County Engineers Office	1) settlement; 2) opening of joints; 3) failure of surrounding pavements	Yes		Yes			
City of Dayton	Sinkhole or settling	Yes	No	Yes	No	Yes	No
Miami Township (Clermont)							
City of Beavercreek	debonding, rutting, excessive alligatoring, settlement	Yes	Yes	Yes	N/A	N/A	N/A
City of Elyria	poor compaction of backfill materials in return failure of surface wearing course. non perform shoulder cutting ..no reinforcement	Yes	No	Yes	No		
Muskingum County		No	No	N/A	N/A	N/A	N/A
City of Dublin							
City of Findlay							
Franklin County Engineer	Pavement failure - Pavement coming our of trench or crumbling.	Yes					
City of Akron	Pavement will crack and break apart or trench area will settle causing a pot hole	Yes	No	No	Yes	Yes	Yes
ODOT							

Name of Agency	At what age (in years) does premature failure typically occur?					
	Asphalt Pavements	Concrete Pavements	Concrete Composite Pavements	Brick Pavements	Brick Composite Pavements	Rigid Brick Composite Pavements
City of Barberton	1					
City of Middletown						
Summit County Engineer	5	7				
city of Lakewood						
Geauga County Engineer's Office	0.5					
City of Wooster						
City of Columbus						
City of Newark, Division of Water & Wastewater						
City of Fairborn						
City of Lancaster	2 yr		2 yr		2 yr	
City of Springfield Engineering						
Allen County Engineer						
Miami Township						
City of Dayton						
Violet Township	3					
City of Upper Arlington	2					
City of Newark Street/Traffic	1	1-2		1-2		
City of Mason	1	1				
City of Lakewood	5				5	5
City of Findlay						
City of Lorain						
City of Hamilton	<1					
City of Cleveland	5	10	10			
City of Grove City						
Northwestern Water and Sewer District	1-2 years					
Lake County Engineer						
Montgomery County Engineers Office	Settlement		Shoving			
City of Dayton	Few weeks		Few months		Few weeks	
Miami Township (Clermont)						
City of Beavercreek	2	2	2			
City of Elyria	2-3	5-10	2-3	20	50	50
Muskingum County						
City of Dublin						
City of Findlay						
Franklin County Engineer	1-2 years					

Name of Agency	At what age (in years) does premature failure typically occur?					
	Asphalt Pavements	Concrete Pavements	Concrete Composite Pavements	Brick Pavements	Brick Composite Pavements	Rigid Brick Composite Pavements
City of Akron	2-3			3-4	2-3	4-5
ODOT						

Name of Agency	For each existing pavement type, approximately what percentage of repairs have experienced pavement performance problems?						
	Asphalt Pavements	Concrete Pavements	Concrete Composite Pavements	Brick Pavements	Brick Composite Pavements	Rigid Brick Composite Pavements	Other
City of Barberton	20	0	0	0	0	0	0
City of Middletown	5	0	0	0	0	0	0
Summit County Engineer	50	50	0	0	0	0	0
city of Lakewood	10	10	10	10	10	10	0
Geauga County Engineer's Office	5	0	0	0	0	0	0
City of Wooster	0	0	0	0	0	0	0
City of Columbus	0	0	0	0	0	0	0
City of Newark, Division of Water & Wastewater							
City of Fairborn							
City of Lancaster	2	0	1	0	1	0	0
City of Springfield Engineering							
Allen County Engineer							
Miami Township							
City of Dayton							
Violet Township	100	0	0	0	0	0	0
City of Upper Arlington	10	0	0	0	0	0	0
City of Newark Street/Traffic	90	25	5	75	0	0	0
City of Mason	10	10	0	0	0	0	0
City of Lakewood	50	0	50	0	0	0	0
City of Findlay	0	0	0	0	0	0	0
City of Lorain	10	0	0	0	0	0	0
City of Hamilton	25	0	0	0	0	0	0
City of Cleveland	20	5	10	0	0	0	0
City of Grove City							
Northwestern Water and Sewer District	10						
Lake County Engineer							No open cuts permitted
Montgomery County Engineers Office	30		30				
City of Dayton	80		10		10		
Miami Township (Clermont)							

Name of Agency	For each existing pavement type, approximately what percentage of repairs have experienced pavement performance problems?						
	Asphalt Pavements	Concrete Pavements	Concrete Composite Pavements	Brick Pavements	Brick Composite Pavements	Rigid Brick Composite Pavements	Other
City of Beavercreek	25	30	30	0	0	0	0
City of Elyria	30	10	45	0	10	5	0
Muskingum County	0	0	0	0	0	0	0
City of Dublin							
City of Findlay							
Franklin County Engineer	5	0	0	0	0	0	0
City of Akron	5			30	10	10	
ODOT	0	0	0	0	0	0	0

Name of Agency	What, in your opinion, is causing the problem?	How is performance evaluated? Please select all that apply	What criteria do you use to judge performance? Check all that apply and of those selected, rank your top three based on importance					
			Profile of the restored surface (settlement/hump) / Rank	Crack width / Rank	Extent of cracking around cut/ Rank	Public complaints / Rank	Other, please specify/ Rank	None
City of Barberton	improper compaction and prep	Visual inspection	X/2	X/3		X/1		
City of Middletown	Inconsistent density of either the granular backfill or the asphalt patch.	Visual inspection	X/1	X/2				
Summit County Engineer	inadequate backfill compaction & materials	Visual inspection	X/1	X/1	X/2	X/1		
city of Lakewood	Most of the time it is related to bad compaction and backfill, not the pavement repair itself. Others are just bad workmanship practices.	Visual inspection	X/2			X/1		
Geauga County Engineer's Office	Poor Compaction when LSM can't be utilized due to cover, etc.	Visual inspection	X/1		X/2			
City of Wooster		Visual inspection	X/1			X/2		
City of Columbus		Visual inspection						
City of Newark, Division of Water & Wastewater								
City of Fairborn								
City of Lancaster	Utility backfill materials	Visual inspection	X/1		X/2	X/3		
City of Springfield Engineering								
Allen County Engineer								
Miami Township								
City of Dayton								
Violet Township	compaction of materials, thickness of materials	Visual inspection	X/1			X/2		
City of Upper Arlington	Contractors not calling for inspection during the restoration	Visual inspection	X/1	X	X/2	X/3		
City of Newark Street/Traffic	I believe a majority of our issue is lack of prep and compaction of	Visual inspection	X			X/1		X

Name of Agency	What, in your opinion, is causing the problem?	How is performance evaluated? Please select all that apply	What criteria do you use to judge performance? Check all that apply and of those selected, rank your top three based on importance					
			Profile of the restored surface (settlement/hump) / Rank	Crack width / Rank	Extent of cracking around cut/ Rank	Public complaints / Rank	Other, please specify/ Rank	None
	subgrade. Many times it is difficult to impossible to be able to properly judge the extent of damage at water/storm water breaks, to the subgrade and the materials under the repair, this along with improper replacement with lack of correct compaction leads to repetitive ongoing damage issues with other utilities.							
City of Mason	Temperature of the asphalt placed is too cold, not placed in an adequate lift, and not compacted properly.	Visual inspection	X/1	X	X/3	X/2		
City of Lakewood	Trench backfill.	Visual inspection	X/1	X/3		X/2		
City of Findlay		Visual inspection	X/1			X/2		
City of Lorain		Visual inspection	X/1		X/2	X/3		
City of Hamilton	Contractor did not perform the necessary over cut to minimize settling along the edge of the trench. Trench restoration was not performed per standard	Visual inspection	X/1		X/3		settled edges/2	
City of Cleveland		Visual inspection						X
City of Grove City								
Northwestern Water and Sewer District	Substandard compaction of sub-grade	Visual inspection	X/2		X/3	X/1		
Lake County Engineer	Any pavement repair problem is most likely caused by settlement or water infiltration into the joints of the repair.	Visual inspection	X/1		X/3	X/2		
Montgomery County Engineers Office	Improper compaction of backfill. Improper thickness of hot mix asphalt	Visual inspection	X/1			X/2	visual/3	

Name of Agency	What, in your opinion, is causing the problem?	How is performance evaluated? Please select all that apply	What criteria do you use to judge performance? Check all that apply and of those selected, rank your top three based on importance					
			Profile of the restored surface (settlement/hump) / Rank	Crack width / Rank	Extent of cracking around cut/ Rank	Public complaints / Rank	Other, please specify/ Rank	None
City of Dayton	Lack of compaction on subgrade backfill or use of frozen gravel, or saturated surrounding area due to water main break.	Visual inspection	X/2		X/3	X/1		
Miami Township (Clermont)								
City of Beavercreek	Poor construction of the repair by the contractor doing the work	Visual inspection	X/2	X	X/3	X/1		
City of Elyria	poor compaction....no reinforcement .....no crack sealant. .....poor materials	Visual inspection	1		3	2		
Muskingum County		Visual inspection	X					
City of Dublin								
City of Findlay								
Franklin County Engineer		Visual inspection	X/1	X/3	X/2			
City of Akron	Compaction of the trench fill is not adequate and causing the pavement to fail	Visual inspection	X/1	X/3		X/2		
ODOT								

Name of Agency	Have you noticed a difference in performance between utility cuts made in the wheel path and those made between or outside the wheel path?		Please indicate the percentage of total repairs completed by each of the following				
	Yes/No	Please describe the difference	Agency	Utility Company	Contractor	Other	Other, please list
City of Barberton	No		70	15	15	0	
City of Middletown	No		50	25	25	0	
Summit County Engineer	Yes	probably due to wheel loading	50	30	2	0	
city of Lakewood	Yes	The ones in the wheel path will deteriorate faster.	75	0	25	0	
Geauga County Engineer's Office	No		50	25	25	0	
City of Wooster	Yes	Asphalt repairs in the wheel path tend to experience a greater tendency for settlement and premature failure than those not inside the wheel path.	50	30	20	0	
City of Columbus	No		10	30	60	0	
City of Newark, Division of Water & Wastewater							
City of Fairborn							
City of Lancaster	Yes	Higher traffic areas fail more	0	70	30	0	
City of Springfield Engineering							
Allen County Engineer							
Miami Township							
City of Dayton							
Violet Township	No		50	50	0	0	
City of Upper Arlington	Yes	We see more settlement and rutting in the wheel path	20	70	10	0	
City of Newark Street/Traffic	No		0	0	0	100	public water handles water cuts, street handles storm water cuts, utilities handle theirs with self or contractor

City of Mason	Yes	Repairs in the wheel path tend to fail more often	0	80	20	0	
City of Lakewood	Yes	Wheel path loading is more likely to cause performance issues than non-wheel path.	50	50	0	0	
City of Findlay	No		50	25	25	0	
City of Lorain	No		70	0	30	0	
City of Hamilton	Yes	In wheel paths there is typically ruts after time	40	10	50	0	
City of Cleveland	No		10	75	15	0	
City of Grove City							
Northwestern Water and Sewer District	No		50		50		
Lake County Engineer	No			50	50		Would apply only to repair of an existing line. No open cut installations in pavement permitted.
Montgomery County Engineers Office	Yes	Those driven on will settle more. If long trench, you'll get variable settlement and thus a wave effect.	10	50	40		
City of Dayton	No		5	80	15		
Miami Township (Clermont)							
City of Beavercreek	No		10	85	5	0	
City of Elyria	Yes	The wheel path usually shows signs of wearing sooner than non wheel.	50	35	15	0	
Muskingum County	No		0	0	0	0	
City of Dublin							
City of Findlay							
Franklin County Engineer	No		20	20	60	0	
City of Akron	No			47	53		
ODOT	Yes	Repairs within the wheel path tend to fail sooner	0	0	0	0	

Name of Agency	Do you have quality control/quality assurance requirements for open utility cut restoration?	Please describe your quality control/quality assurance requirements below.	Are the requirements effective in assuring a quality repair?	What percentage of pavement restorations of utility cuts are inspected at the time of the restoration?	Is any testing of the materials done at the time of restoration?	What types of testing are done on materials during restoration of open utility cuts?
City of Barberton	Yes	Inspection; engineering restoration standards	No	0.5	No	
City of Middletown	No			5	No	
Summit County Engineer	No			all	No	
city of Lakewood	No			50	No	
Geauga County Engineer's Office	Yes	On-site inspection during repairs	Yes	75	No	
City of Wooster	No			75	No	
City of Columbus	Yes	Construction and Material Specifications Standard Drawings	Yes		Yes	compaction
City of Newark, Division of Water & Wastewater						
City of Fairborn						
City of Lancaster	No			60	No	
City of Springfield Engineering						
Allen County Engineer						
Miami Township						
City of Dayton						
Violet Township	No			25	No	
City of Upper Arlington	Yes		Yes	50	No	
City of Newark Street/Traffic	No			not known	No	
City of Mason	No			10	No	
City of Lakewood	Yes	We have an inspector on most right of way work observe the work for non-agency work.	Yes	50	No	
City of Findlay	No			25	No	
City of Lorain	Yes	Engineering Dept. will inspect the repair prior to the permanent repair material going in.	Yes	50		

Name of Agency	Do you have quality control/quality assurance requirements for open utility cut restoration?	Please describe your quality control/quality assurance requirements below.	Are the requirements effective in assuring a quality repair?	What percentage of pavement restorations of utility cuts are inspected at the time of the restoration?	Is any testing of the materials done at the time of restoration?	What types of testing are done on materials during restoration of open utility cuts?
City of Hamilton	Yes	City Inspectors and 1 yr warranty for City contracts	Yes	75	No	
City of Cleveland	Yes	Inspection	Yes	25	No	
City of Grove City						
Northwestern Water and Sewer District	Yes	Sub-grade compaction testing by geotechnical service	Yes	100	Yes	
Lake County Engineer	No			100	No	
Montgomery County Engineers Office	No			10	No	
City of Dayton	Yes	Lifetime warranty on permanent restoration and using RFID tags in asphalt restorations for identification purposes	Yes	75	Yes	
Miami Township (Clermont)						
City of Beavercreek	No			85	No	
City of Elyria	Yes		Yes	10	No	
Muskingum County	Yes		Yes	100	No	
City of Dublin						
City of Findlay						
Franklin County Engineer	No			95	Yes	Plant inspection, asphalt samples
City of Akron	Yes	There is a restoration inspection for right of way work	Yes	80% of surface restoration	No	
ODOT	No			25	No	

Name of Agency	What factors influence your decision on repair procedure/material? Select all that apply and of those selected, rank the top three factors						
	Traffic Volume/ Rank	Age of existing surface/ Rank	Time to next resurfacing/ Rank	Time of year/ Rank	Past performance of procedure/material/ Rank	Cost/ Rank	Other
City of Barberton	X/2			X/1		3	
City of Middletown							
Summit County Engineer	X	X		X	X		
city of Lakewood						X/2	Time and staffing/1
Geauga County Engineer's Office	X/1			X/2			
City of Wooster			X/3	X/2			Type and condition/1
City of Columbus							pavement surface type
City of Newark, Division of Water & Wastewater							
City of Fairborn							
City of Lancaster							existing street section
City of Springfield Engineering							
Allen County Engineer							
Miami Township							
City of Dayton							
Violet Township	X/1		X/3	X/2			
City of Upper Arlington							
City of Newark Street/Traffic				X/1		X/1	
City of Mason	X/1		X/2	X/3			
City of Lakewood			X/1	X/2	X/3		
City of Findlay	X/1	X	X/3	X/2	X	X	
City of Lorain	X/1		X/3	X/2			
City of Hamilton	X/2		X/3		X/1		
City of Cleveland	X/2	X/1			X/3		
City of Grove City							
Northwestern Water and Sewer District	X/3	X/4			X/1	X/2	
Lake County Engineer	X/2		X/3		X/1		
Montgomery County Engineers Office		X/2	X/3		X/1		
City of Dayton	X/1	X/3		X/2			
Miami Township (Clermont)							
City of Beavercreek	X	X/3	X	X/1	X/2		
City of Elyria							

Name of Agency	What factors influence your decision on repair procedure/material? Select all that apply and of those selected, rank the top three factors						
	Traffic Volume/ Rank	Age of existing surface/ Rank	Time to next resurfacing/ Rank	Time of year/ Rank	Past performance of procedure/material/ Rank	Cost/ Rank	Other
Muskingum County							
City of Dublin							
City of Findlay							
Franklin County Engineer	X/3	X/2		X/1			
City of Akron							Follow Engineering Standard Drawings
ODOT							All open cuts must conform to the ODOT spec

Name of Agency	How is backfill material compacted? Please select all that apply and indicate type.					Does the following equipment provide adequate compaction?			
	Vibrating plate	Tamper	Roller	Other	None	Vibrating plate	Tamper	Roller	Other
City of Barberton	X					Yes			
City of Middletown	X walk behind					Yes			
Summit County Engineer	X	X				No			
city of Lakewood	X	X	X			Yes	Yes	Yes	
Geauga County Engineer's Office	X	X	X			Yes	Yes	Yes	
City of Wooster	X	X							
City of Columbus				X see CMSC Item 912					
City of Newark, Division of Water & Wastewater									
City of Fairborn									
City of Lancaster	X	X	X			Yes	Yes	Yes	
City of Springfield Engineering									
Allen County Engineer									
Miami Township									
City of Dayton									
Violet Township	X		X			Yes		Yes	
City of Upper Arlington									
City of Newark Street/Traffic	X unknown	X unknown	X bomag roller,mauldin tag along roller					Yes	
City of Mason	X plate	X Hand	X Small			No	No	Yes	
City of Lakewood				X Use LSM					Yes
City of Findlay	X					Yes			
City of Lorain		X	X			N/A	Yes	Yes	
City of Hamilton	X	X	X			Yes Only when proper thicknesses are enforced	Yes Only when proper thicknesses are enforced	Yes	
City of Cleveland	X	X	X			Yes	Yes	Yes	

Name of Agency	How is backfill material compacted? Please select all that apply and indicate type.					Does the following equipment provide adequate compaction?			
	Vibrating plate	Tamper	Roller	Other	None	Vibrating plate	Tamper	Roller	Other
City of Grove City									
Northwestern Water and Sewer District	X	X	X			Yes	No	Yes	
Lake County Engineer	X If repair on any existing line under pavement were necessary	X Jumping Jack (If repair on any existing line under pavement were necessary)							
Montgomery County Engineers Office	X	X	X			No	Yes	Yes	
City of Dayton	X	X				Yes If used correctly (in lifts)	Yes If used correctly (in lifts)		
Miami Township (Clermont)									
City of Beavercreek	X	X	X			Yes	Yes	Yes	
City of Elyria	X	X	X			Yes	Yes	Yes	
Muskingum County									
City of Dublin									
City of Findlay									
Franklin County Engineer	X	X	X			Yes	Yes	Yes	
City of Akron	X	X Jumping Jack			X	Yes	Yes		
ODOT									

Name of Agency	Has any of the following techniques been used in your jurisdiction?	For the "T" repair technique, what is the typical distance beyond the initial trench width that the existing pavement material is removed?	For the cutback technique, what is the depth of subgrade removed?	For the cutback technique, what is the typical lateral distance from the edge of the trench that is removed?
City of Barberton				
City of Middletown	"T" repair, Cutback	12"	6" minimum	12"
Summit County Engineer	"T" repair, Cutback			
city of Lakewood	"T" repair,Cutback	6"	6"	1'
Geauga County Engineer's Office	"T" repair, Cutback	12" Minimum	12"	Depends on Subgrade
City of Wooster	"T" repair	1'		
City of Columbus				
City of Newark, Division of Water & Wastewater				
City of Fairborn				
City of Lancaster	"T" repair	12 "		
City of Springfield Engineering				
Allen County Engineer				
Miami Township				
City of Dayton				
Violet Township				
City of Upper Arlington				
City of Newark Street/Traffic	Tapered, Cutback		varying	depending on depth
City of Mason	"T" repair, Cutback	6-in	6-in	6-in
City of Lakewood	"T" repair	18"		
City of Findlay	"T" repair	12" Min		
City of Lorain	Cutback			2-3 feet
City of Hamilton	Tapered, "T" repair	1' typ		
City of Cleveland	"T" repair, Cutback	2 feet	as needed	1 foot
City of Grove City				
Northwestern Water and Sewer District	"T" repair	One foot		
Lake County Engineer	No open utility cuts permitted in roadway	1 FT.		
Montgomery County Engineers Office	"T" repair	1' or 10' if milling the area		
City of Dayton	"T" repair, Cutback, Keyhole	12"	Asphalt surface only usually	Minimum of 12"
Miami Township (Clermont)				
City of Beavercreek	Tapered, "T" repair, Cutback, Keyhole			
City of Elyria	"T" repair, Cutback, Keyhole	12 inch	24 inch	12 inch
Muskingum County				
City of Dublin				

Name of Agency	Has any of the following techniques been used in your jurisdiction?	For the "T" repair technique, what is the typical distance beyond the initial trench width that the existing pavement material is removed?	For the cutback technique, what is the depth of subgrade removed?	For the cutback technique, what is the typical lateral distance from the edge of the trench that is removed?
City of Findlay				
Franklin County Engineer	Tapered, "T" repair, Cutback, Keyhole	1 foot	1 foot	1 foot
City of Akron	"T" repair, Cutback	1 foot	12" for Arterial and collector streets, 10" for all other improved streets, meet existing for unimproved streets	Premium backfill - 12" from base cutback and LSM backfill - 12" from trench edge
ODOT	"T" repair, Cutback, Keyhole			

Name of Agency	For each pavement type in your jurisdiction, what is the typical restoration of open utility cuts? - Typical Technique (e.g. T-repair or cutback)					
	Asphalt Pavements	Concrete Pavements	Concrete Composite Pavements	Brick Pavements	Brick Composite Pavements	Rigid Brick Composite Pavements
City of Barberton						
City of Middletown	T repair					
Summit County Engineer						
city of Lakewood	all	all	all	all	all	all
Geauga County Engineer's Office	T-Repair					
City of Wooster						
City of Columbus						
City of Newark, Division of Water & Wastewater						
City of Fairborn						
City of Lancaster						
City of Springfield Engineering						
Allen County Engineer						
Miami Township						
City of Dayton						
Violet Township						
City of Upper Arlington						
City of Newark Street/Traffic	cut back	cut back	cut back	cut back	cut back	cut back
City of Mason	Asphalt	Conc				
City of Lakewood	T	T	T	T	T	T
City of Findlay	T repair					
City of Lorain						
City of Hamilton	T-repair					
City of Cleveland	T Repair	T Repair	T Repair	T Repair	T Repair	T Repair
City of Grove City						
Northwestern Water and Sewer District	T Repair	T Repair				
Lake County Engineer	No open cuts permitted					
Montgomery County Engineers Office	T		T			
City of Dayton	T or Cutback	T or Cutback	T or Cutback	Restore with same surface	Restore with same surface	Restore with same surface
Miami Township (Clermont)						
City of Beavercreek						
City of Elyria	T	T	T			
Muskingum County						
City of Dublin						
City of Findlay						

Name of Agency	For each pavement type in your jurisdiction, what is the typical restoration of open utility cuts? - Typical Technique (e.g. T-repair or cutback)					
	Asphalt Pavements	Concrete Pavements	Concrete Composite Pavements	Brick Pavements	Brick Composite Pavements	Rigid Brick Composite Pavements
Franklin County Engineer						
City of Akron	both - up to contractor	both - up to contractor	both - up to contractor	both - up to contractor	both - up to contractor	both - up to contractor
ODOT						

Name of Agency	For each pavement type in your jurisdiction, what is the typical restoration of open utility cuts? - Backfill material (e.g. native material, or controlled low-strength mortar)					
	Asphalt Pavements	Concrete Pavements	Concrete Composite Pavements	Brick Pavements	Brick Composite Pavements	Rigid Brick Composite Pavements
City of Barberton						
City of Middletown	LSM or Granular					
Summit County Engineer						
city of Lakewood	lsm	lsm	lsm	lsm	lsm	lsm
Geauga County Engineer's Office	LSM/Stone					
City of Wooster						
City of Columbus						
City of Newark, Division of Water & Wastewater						
City of Fairborn						
City of Lancaster						
City of Springfield Engineering						
Allen County Engineer						
Miami Township						
City of Dayton						
Violet Township	asphalt					
City of Upper Arlington						
City of Newark Street/Traffic	304/sand	304/sand	304/sand	304/sand	304/sand	304/sand
City of Mason	LSM	Agg				
City of Lakewood	LSM	LSM	LSM	LSM	LSM	LSM
City of Findlay	granular material					
City of Lorain						
City of Hamilton	LSM					
City of Cleveland						
City of Grove City						
Northwestern Water and Sewer District	ODOT 304 or LSM	ODOT 304 or LSM				
Lake County Engineer						
Montgomery County Engineers Office	granular		granular, or concrete			
City of Dayton	304 or 411 only	CDF	CDF	gravel/cdf/ concrete	gravel/cdf/ concrete	gravel/cdf/concrete
Miami Township (Clermont)						
City of Beavercreek						
City of Elyria	304 limestone	304 Limestone	304 Limestone			
Muskingum County						

Name of Agency	For each pavement type in your jurisdiction, what is the typical restoration of open utility cuts? - Backfill material (e.g. native material, or controlled low-strength mortar)					
	Asphalt Pavements	Concrete Pavements	Concrete Composite Pavements	Brick Pavements	Brick Composite Pavements	Rigid Brick Composite Pavements
City of Dublin						
City of Findlay						
Franklin County Engineer						
City of Akron	both - up to contractor	both - up to contractor	both - up to contractor	both - up to contractor	both - up to contractor	both - up to contractor
ODOT						

Name of Agency	For each pavement type in your jurisdiction, what is the typical restoration of open utility cuts? - Average life (years)					
	Asphalt Pavements	Concrete Pavements	Concrete Composite Pavements	Brick Pavements	Brick Composite Pavements	Rigid Brick Composite Pavements
City of Barberton						
City of Middletown	15					
Summit County Engineer						
city of Lakewood	20	20	20	20	20	20
Geauga County Engineer's Office	Not Tracked					
City of Wooster						
City of Columbus						
City of Newark, Division of Water & Wastewater						
City of Fairborn						
City of Lancaster						
City of Springfield Engineering						
Allen County Engineer						
Miami Township						
City of Dayton						
Violet Township						
City of Upper Arlington						
City of Newark Street/Traffic	1-3	1-3	1-3	1-3	1-3	1-3
City of Mason	5	10				
City of Lakewood	10	20	10	20	20	20
City of Findlay	20					
City of Lorain						
City of Hamilton	10					
City of Cleveland						
City of Grove City						
Northwestern Water and Sewer District	25	25				
Lake County Engineer						
Montgomery County Engineers Office						
City of Dayton	10+	10+	10+	10+	10+	10+
Miami Township (Clermont)						
City of Beavercreek						
City of Elyria	5-10	20	5-10			
Muskingum County						
City of Dublin						
City of Findlay						
Franklin County Engineer						
City of Akron						
ODOT						

Name of Agency	For each pavement type in your jurisdiction, what is the typical restoration of open utility cuts? - Average Cost ($/sq. yd.)						Has trenchless technology (e.g. boring, pipe bursting, etc.) been used in your jurisdiction to install utilities?
	Asphalt Pavements	Concrete Pavements	Concrete Composite Pavements	Brick Pavements	Brick Composite Pavements	Rigid Brick Composite Pavements	
City of Barberton							Yes
City of Middletown	unknown						Yes
Summit County Engineer							Yes
city of Lakewood							Yes
Geauga County Engineer's Office	Not tracked						Yes
City of Wooster							Yes
City of Columbus							
City of Newark, Division of Water & Wastewater							
City of Fairborn							
City of Lancaster							Yes
City of Springfield Engineering							
Allen County Engineer							
Miami Township							
City of Dayton							
Violet Township							Yes
City of Upper Arlington							Yes
City of Newark Street/Traffic	?						Yes
City of Mason	?	?					Yes
City of Lakewood	53	59	59				Yes
City of Findlay							Yes
City of Lorain							Yes
City of Hamilton	70						Yes
City of Cleveland							Yes
City of Grove City							
Northwestern Water and Sewer District							Yes
Lake County Engineer							Yes
Montgomery County Engineers Office	80						Yes
City of Dayton							Yes
Miami Township (Clermont)							
City of Beavercreek							
City of Elyria							Yes
Muskingum County							

Name of Agency	For each pavement type in your jurisdiction, what is the typical restoration of open utility cuts? - Average Cost ($/sq. yd.)						Has trenchless technology (e.g. boring, pipe bursting, etc.) been used in your jurisdiction to install utilities?
	Asphalt Pavements	Concrete Pavements	Concrete Composite Pavements	Brick Pavements	Brick Composite Pavements	Rigid Brick Composite Pavements	
City of Dublin							
City of Findlay							
Franklin County Engineer							Yes
City of Akron							Yes
ODOT							

Name of Agency	Please list the trenchless technology used in your jurisdiction and the utilities they were used to install:	Please describe the procedures/materials typically used during low temperatures (indicate if the method is temporary):	Please describe the procedures/materials typically used during wet conditions (indicate if the method is temporary):
City of Barberton	Gas and Sewer - boring	Hygrade Cold Asphalt Mix over compacted 304 base	Hygrade Cold Asphalt Mix
City of Middletown	Directional drilling for gas and fiber optic		
Summit County Engineer	directional boring	flowable fill for backfill	
city of Lakewood	Boring: gas company	?	?
Geauga County Engineer's Office	Mole, Directional Drill, Bore	Per Utility Owner requirements. May require casing pipes	Per Utility Owner , Storm Water & Sediment control always required
City of Wooster	Dominion Energy contractors typically install pipelines by directional drilling. Contractors installing or replacing water services typically install by moling.	Typically concrete is used in low temperatures, when asphalt plants are closed.	Typically try to avoid work in wet conditions.
City of Columbus			
City of Newark, Division of Water & Wastewater			
City of Fairborn			
City of Lancaster			
City of Springfield Engineering			
Allen County Engineer			
Miami Township			
City of Dayton			
Violet Township	cable/telephone/water line		
City of Upper Arlington			
City of Newark Street/Traffic	directional boring	over fill with 304 until temp allows for more suitable correction	same as above
City of Mason	jack & bore (sanitary, water), directional drill (all), pipe burst (sanitary), CIPP (sanitary	cold patch- temporary	cold patch- temporary
City of Lakewood	Gas - Bore	Permanent concrete cap blanketed in winter or temporary cold asphalt in winter	Concrete if protected
City of Findlay	Boring - Fiber optics, gas mains, waterlines and sewers	asphalt is replaced with cold mix. cold mix is maintained until the asphalt plants open and then it is removed and normal asphalt is installed. Type B on our standard details is typically used.	nothing different
City of Lorain			

Name of Agency	Please list the trenchless technology used in your jurisdiction and the utilities they were used to install:	Please describe the procedures/materials typically used during low temperatures (indicate if the method is temporary):	Please describe the procedures/materials typically used during wet conditions (indicate if the method is temporary):
City of Hamilton	jack and boring, directional boring, pipe bursting, lining,	temporary concrete restoration	plate the trench and restore at a later date, or gravel up to top and restore next day or two
City of Cleveland	Jack and Bore		
City of Grove City			
Northwestern Water and Sewer District	Pipe bursting for sanitary sewer. Jack and bore for water and sanitary sewer. Directional drilling for mainly water.	Cold patch asphalt is typically used in low temperature conditions as a temporary repair.	The District will not allow work in wet weather conditions.
Lake County Engineer	Directional Boring - Gas, Electric, Water	N/A	N/A
Montgomery County Engineers Office	gas, water, electric, cable telecomm	cold mix asphalt if the plants are closed, temporary until spring	Gravel or cold mix. Temporary until dry weather
City of Dayton	gas mains and services (boring); pipe bursting/lining fior sanitary mains	Fast set concrete and hot asphalt	Tamped gravel, cold patch (temporary) restore at later date
Miami Township (Clermont)			
City of Beavercreek			
City of Elyria	water main thru existing water main directional gas service line[new] directional water service lines [new]	cold patch in winter months	cold patch
Muskingum County			
City of Dublin			
City of Findlay			
Franklin County Engineer	Bore- Gas, Electric, Communications Water, Sanitary		
City of Akron	Boring - Gas Line and Telecommunications	When the temperature is going to be below freezing contractors are required to cover concrete with insulated blankets. Asphalt repairs are not allowed until temperatures are 42 degrees and rising. All asphalt locations are typically concrete capped for the winter and paved in the spring.	Pouring of concrete or laying of asphalt during rain events is not allowed.
ODOT			

Name of Agency	What fees are assessed on utility cuts?	Where can we find the fee schedule assessed in your municipality? Please provide a web address below, if available.
City of Barberton	Permitting fees	
City of Middletown	Permitting fees	Generally $130 for either sod cut or pavement cut
Summit County Engineer	Permitting fees	
city of Lakewood	Other: inspection fees	
Geauga County Engineer's Office	Other: Bond $ submitted based on extent of work.	Call Office
City of Wooster	Permitting fees	https://www.woosteroh.com/sites/default/files/Fee%20Schedule%20Revised%202.1.17.pdf
City of Columbus	Permitting fees	https://www.columbus.gov/publicservice/Design-and-Construction/Document-Library/
City of Newark, Division of Water & Wastewater		
City of Fairborn		
City of Lancaster		
City of Springfield Engineering		
Allen County Engineer		
Miami Township		
City of Dayton		
Violet Township	Permitting fees	www.violet.oh.us
City of Upper Arlington	Permitting fees	https://upperarlingtonoh.viewpointcloud.com/#/1072/6342
City of Newark Street/Traffic	No fees are assessed	N/A
City of Mason	Permitting fees	https://www.imaginemason.org/city-government/engineering-building-planning/building-documents/
City of Lakewood	Permitting fees	Lakewood Codified Ordinances
City of Findlay	Other: cash or performance bond ($500 min or $30 per foot) plus contractor must have $10,000 license and permit bond on file with engineering	
City of Lorain		
City of Hamilton	Permitting fees	$20/sy
City of Cleveland	Permitting fees	
City of Grove City		
Northwestern Water and Sewer District	No fees are assessed	www.nwwsd.org
Lake County Engineer	No fees are assessed	Any utility installation in county road right-of-way requires right-of-way permit by contractor. There is no fee for the permit but a bond is usually required for an amount determined per project. The permit can be found on the Lake Co. Eng. Website under "downloadable forms and permits"
Montgomery County Engineers Office	No fees are assessed	
City of Dayton	Permitting fees	Section 95.33 found at the following link: https://library.municode.com/oh/dayton/codes/code_of_ordinances?nodeId=TITIXGERE_CH95STSI_DIV2STPR

Name of Agency	What fees are assessed on utility cuts?	Where can we find the fee schedule assessed in your municipality? Please provide a web address below, if available.
Miami Township (Clermont)		
City of Beavercreek		
City of Elyria	No fees are assessed	
Muskingum County		
City of Dublin		
City of Findlay		
Franklin County Engineer	No fees are assessed	
City of Akron	Permitting fees	
ODOT		

Name of Agency	Are you satisfied with your methods for managing utility cuts?	Please describe what needs to be improved in your methods for managing utility cuts in your jurisdiction:	Does your agency place a moratorium on utility cuts following the construction or resurfacing or a pavement? If so, what is the duration of the moratorium?
City of Barberton	No	Better tracking of contractors and coordination of visual inspection	No
City of Middletown	Yes		Yes, duration: 5 years
Summit County Engineer	Yes		Yes, duration: generally we dont permit open cuts
city of Lakewood	No	Tracking, inspection, follow up, cost recovery	No
Geauga County Engineer's Office	Yes		Yes, duration: Perpetual
City of Wooster	Yes		No
City of Columbus	Yes		Yes, duration: 3 years
City of Newark, Division of Water & Wastewater			
City of Fairborn			
City of Lancaster			
City of Springfield Engineering			
Allen County Engineer			
Miami Township			
City of Dayton			
Violet Township	Yes		No
City of Upper Arlington	No	more staff for inspection	Yes, duration: 5 years
City of Newark Street/Traffic	No	A set procedure (in my opinion) should be in place with all utilities. Therefore utilities could be held responsible for inadequate work.	No
City of Mason	No	additional staff to be able to administer and oversee ROW permitting and restoration inspections	Yes, duration: 30-days
City of Lakewood	Yes		No
City of Findlay	Yes		Yes, duration: 3 Years unless emergency (gas leak, sink hole, etc.)
City of Lorain			
City of Hamilton	Yes		No
City of Cleveland	Yes		Yes, duration: 5 years
City of Grove City			
Northwestern Water and Sewer District	No	Currently there is no mathos for managing utility cuts	Yes, duration: one year
Lake County Engineer	Yes		Yes, duration: Continuous
Montgomery County Engineers Office	Yes		Yes, duration: Five Years
City of Dayton	Yes		Yes, duration: Lifetime or until resurfaced.
Miami Township (Clermont)			
City of Beavercreek			

Name of Agency	Are you satisfied with your methods for managing utility cuts?	Please describe what needs to be improved in your methods for managing utility cuts in your jurisdiction:	Does your agency place a moratorium on utility cuts following the construction or resurfacing or a pavement? If so, what is the duration of the moratorium?
City of Elyria	No		
Muskingum County			
City of Dublin			
City of Findlay			
Franklin County Engineer	Yes		Yes, duration: 3 years
City of Akron	Yes		Yes, duration: 5 years
ODOT			

10 Appendix C: Ohio Local Agency Phone Interview Summary

10.1 Ohio Local Agency Phone Interviews

A sample of large local urban agencies in Ohio were selected from the survey responses for a follow-up phone interview to gather additional information related to their standards and practices for restoring pavement in open utility cuts. Based on survey responses, agencies were selected for phone interviews. A variety of agencies were selected, with focus on agencies in Northern Ohio.

Table 21 Ohio Local Agencies Interviewed by Phone

Name of Agency	Agency Type	Area of state	Interviewees	Date of interview
City of Columbus	City	Central	Alan Moran, and Ric Rosseti	3/7/2018
City of Akron	City	Northeast	Jim Hall, Travis Capper, Mike Teodecki, and Brent Kelley	4/18/2018
City of Cleveland (Engineering & Construction)	City	Northeast	Frank Keehl, and Bob Chaplin	5/18/2018
City of Cleveland (Water Dept)	City	Northeast	Martin Reese	4/17/2018
City of Cleveland (Streets Department)	City	Northeast	Shelton Coleman, Cherita Anglen, John Campbell, and Eric Bohanon	5/23/2018
City of Lakewood (City Engineer) City of Lakewood (Public Works)	City	Northeast	Joe Beno and Mark Papke	3/22/2018
City of Wooster	City	Northeast	John Rice	3/27/2018
Lake County Engineer	County	Northeast	Ken Sietz	3/8/2018
City of Findlay	City	Northwest	Brian Thomas	3/30/2018
Northwestern Water and Sewer District	Water & Sewer	Northwest	John Sopko	3/21/2018
City of Dayton	City	Southwest	David Escobar and Dave Weinandy	3/19/2018

10.2 Phone Interview Summary

Key points from the phone interviews are summarized in Table 22. A more detailed summary is provided after the summary of key points.

Table 22 Summary of key points from phone interviews.

Agency	Region	Number of Cuts	Type of Cut		Primary Pavement Type as Percent of Network				Primary Backfill		Special
			Vertical	T-Repair	Asphalt	Concrete	Composite	Brick Composite (flexible or rigid)	LSM	Granular	
City of Akron	NE	500		X	**45%**	10%		25%	X	X	LMS required in AC
City of Cleveland	NE	5000-6000		X			30%	**70%**	X		Coordinate w/ utility companies; seal joints
City of Columbus	C	10000	X		23%		**70%**		X	X	Heat weld (optional), pave full lane width based on repair size
City of Dayton	SW	1000-5000		X	**85%**				X (TF)	X (res)	RFID tags, seal joints
City of Findlay	NW	75-100		X	**90%**					X	seal joints
City of Lakewood	NE	50-100		X			**40-50%**	**40%**	X		Coordinate w/ utility companies; seal joints for composite pavement repair
City of Wooster	NE	50		X	**60%**					X	Seal joints, LMS required in surface AC and Concrete
Lake County	NE		Not Permitted		**98%**						No open cuts permitted. Policies are in-place where open cuts cannot be avoided
Northwestern Sewer and Water District	NW	15-20		X	**75%**				X	X	Seal joints; follow ODOT requirements on state routes; must follow village/municipality requirements and standards

TF : Thoroughfares
Res: Residential

Summary of phone interviews:

Agency	Date	Interviewees	Responsibility	Population*	Cuts per yr*
City of Akron	4/18/2018	Jim Hall, Travis Capper, Mike Teodecki, Brent Kelley	Public Works; Inspection of ROW construction; Plan Review	200000	500
City of Cleveland (Engineering & Construction)	5/18/2018	Frank Keehl, Bob Chaplin	capital projects. Bob is an inspector; Frank is a consulting engineer	400000	4000 (survey) 5000 - 6000 (interview; includes water pollution but does not include water department or streets department)
City of Cleveland (Streets Dept)	5/23/2018	Shelton Coleman, Cherita Anglen, John Campbell, Eric Bohanon	Division of Streets is under Public Works, mostly potholes, street repairs. Will repair previous utility cut repairs (usually years after the fact)	See above	See above
City of Cleveland (Water Dept.)	4/17/2018	Martin Reese	Division of Water is under Public Utilities	See above	See above
City of Columbus	3/7/2018	Alan Moran, Ric Rosseti	Alan: Pavement Program Manager Ric Rosseti: Superintendent of permitting section	860000	10000
City of Dayton	3/19/2018	David Escobar, Dave Weinandy	Construction, Public Works	140000	1000-5000
City of Findlay	3/30/2018	Brian Thomas, Jeremy Kalb	Directory of Public Service, Acting City Engineer (Brian - design and review; Jeremy handles questions)	50000	75-100
City of Lakewood (City Engineer)/ (Public Works)	3/22/2018	Joe Beno, Mark Papke	Public Works Director, City Engineer	52000	50-100
City of Wooster	3/27/2018	John Rice	Staff Engineer	26540	50
Lake County Engineer	3/8/2018	Ken Sietz	County Engineer	228600	Cuts not permitted
Northwestern Water and Sewer District	3/21/2018	John Sopko	Project Manager. Only responsible for water and sewer	30000	15-20

*from survey response

Agency	Network					
	% Asphalt	% Concrete	% Composite	% Brick	% Brick composite (flexible)	% Brick composite (rigid)
City of Akron	45	10	3		10	15
City of Cleveland (Engineering & Construction)	0.5	2	30		50	20
City of Cleveland (Streets Dept)	See above	See above	See above		See above	See above
City of Cleveland (Water Dept.)	Percentages differed from above (1%)	Percentages differed from above (0%)	Percentages differed from above (90%)		Percentages differed from above (10%) mostly concrete base	Percentages differed from above (10%) mostly concrete base
City of Columbus	23%	3% (jointed, no dowel bars)	70%		0	3%
City of Dayton	85	9	2	2	1	1
City of Findlay	90	0	0	0	10	0
City of Lakewood (City Engineer)/ (Public Works)	5	5-10	40-50	0-2	0-40 unsure what is under brick	0-40 unsure what is under brick
City of Wooster	60	20	5	<5	10	<5
Lake County Engineer	98	1	0	0	0	0
Northwestern Water and Sewer District	75	10	10	0	0	0

Agency	Type of cut (T, cutback, Keyhole, etc.)	Type of cut (T, cutback, Keyhole, etc.) [details]	Primary backfill material used
City of Akron	T-repair	T-Repair (Standard shows second saw cut to top of backfill or to achieve min. thickness of concrete base)	contractors choice: 304, sand, bank run gravel or LSM
City of Cleveland (Engineering & Construction)	T-repair	T-repair (standard shows to undisturbed subgrade)	Cleveland LSM
City of Cleveland (Streets Dept)	T-repair	Follows eng & construction standard (T-repair - saw cut min of 2' wider than existing utility cut to get back to good mat)	Cleveland LSM if repair requires they go below pavement layer
City of Cleveland (Water Dept.)	T-repair	T-repair - follows Eng & Construction standards	304 has been used, but mostly Cleveland LSM; LSM since 2000
City of Columbus	Vertical	Vertical cut	Mostly CDF (LSM) is used although compacted granular is allowed
City of Dayton	T-repair	1' on either side, if within 3' of joint or edge or pavement remove to joint or edge of pavement; cut to subgrade	CDF of thoroughfares, 304 or 411 on all other streets
City of Findlay	T-repair	min 1' on either side, and will cut into subgrade to allow for min pavement thickness (shown in standard dwg)	Granular material (have had bad experiences with CLSM)
City of Lakewood (City Engineer)/ (Public Works)	T-repair	Cutback min of 6" either side for AC pavements, 18" for others	LSM
City of Wooster	T-repair	cutback 1' either side	Granular material (ODOT Item 411); CLSM allowed but contractors rarely use
Lake County Engineer	T-repair** (No utility cuts directly under pavements are permitted)	cutback 1' either side; if within 5' to nearest joint replace to nearest joint**	LSM**
Northwestern Water and Sewer District	T-repair	cutback 1' on either side	Granular material (ODOT 304 or 411); CDF where granular not permitted

**from "County of Lake Utilities Department Rules and Regulations," April 2018.

Agency	Pavement Matl: Asphalt	Pavement Matl: Asphalt [details]	Pavement Matl: Concrete	Pavement Matl: Concrete [details]
City of Akron	Concrete Base + Asphalt surface	8" concrete Class "C" base; AC virgin limestone mix installed in maximum of 2" lifts. If trench is wide enough for paver/roller, 8" concrete Class "C" base can be subbed with 8" of asphalt base (301) Thicknesses above depends on type of road	Concrete	Variable thickness (meet existing pavement thickness) Concrete Class "C" base. Any reinforcing encountered during removal is to be replaced in kind (including dowel bars)
City of Cleveland (Engineering & Construction)	N/A	N/A	Agg base + concrete	6" Item 304, min. 9" plain concrete (dowels per table)
City of Cleveland (Streets Dept)	N/A	N/A	Agg base + concrete	3 - 4" 304 and compact with plate tamper; 8-10" concrete to grade; Seal joints using Crafco rubberized seal
City of Cleveland (Water Dept.)	N/A	Follows Eng & Construction Standard (see above)	Agg base + concrete	Follows Eng & Construction Standard (see above)
City of Columbus	Asphalt (base and surface)	3 compacted lifts of 3" each AC (total 9" AC) as min., if greater than 9" match existing	Concrete	concrete
City of Dayton	Asphalt	2 1 1/2" lifts of ODOT Item 442 (Superpave) on top of compacted 304 or CDF (depending on street type)	Concrete	whole slab replacement required. Min. 9" MS concrete directly in top of backfill (CDF or compacted 304 depending on street type)
City of Findlay	Asphalt (base and surface)	Type B repair: compacted agg base; 8" ODOT 301 AC base; 2" ODOT 448 AC Type C (for residential streets): aggregate base; 2" ODOT 448 AC	N/A	N/A (no concrete roads)
City of Lakewood (City Engineer)/ (Public Works)	Asphalt (base and surface)	6" Item 301 AC base; 1 1/2" 402 AC Intermediate; 1 1/2" 402 AC Surface	Concrete base (w/dowels or hook bolts) or AC base (if no hook bolts); AC surface	Fiber reinforced concrete if hook bolts can be placed; if no hook bolts can be placed with put back 301 AC; intermediate AC; and surface AC
City of Wooster	Full depth: Asphalt base + surface	Full depth: 7" 301 AC base; 1 3/4" 441 type 2 intermediate AC; 1 1/4" 441 type 1 surface AC	concrete (dowels required based on size of repair)	8" ODOT 452 plain concrete (limestone agg only)

Agency	Pavement Matl: Asphalt	Pavement Matl: Asphalt [details]	Pavement Matl: Concrete	Pavement Matl: Concrete [details]
	AC on granular: agg base + asphalt surface	AC on gran base (vertical cut): 6" 411 agg base; prime coat; 1 1/4" 441 type 1 surface AC an alternative for full depth: 8" 301 AC base; 2"441 Type AC surface limestone req'd in surface AC mixes		
Lake County Engineer	Asphalt (base and surface)**	min. 6" Item 301 AC base; 2" Item 402 AC; 1 1/2" Item 404 AC**	Agg base + concrete**	min. 4" 304 limestone aggregate; 7" Item 451 concrete with reinforcing fabric (6 x 6 x 10 gage wire mesh); if thickness is greater than 6" 5/8" hook bolts at 20" center to center are required**
Northwestern Water and Sewer District	Asphalt (base and surface)	12" aggregate 304 base; 6-9" Item 301 AC base (match existing asphalt); 1 3/4" Item 448 Type 2 intermediate AC; 1 1/4" Item 448 Type 1 AC surface; longitudinal joint sealer	Concrete	Not shown in standards. Details not provided in interview

**from "County of Lake Utilities Department Rules and Regulations," April 2018.

Agency	Pavement Matl: Composite	Pavement Matl: Composite [details]	Pavement Matl: Brick composite flexible	Pavement Matl: Brick composite flexible [details]
City of Akron	Concrete base + asphalt surface	Concrete base (thickness depends on type of roadway) + 2” AC		
City of Cleveland (Engineering & Construction)	Agg base + concrete base + asphalt surface	6" Item 304; min. 9" plain concrete (dowels per table); 1 3/4" intermediate AC (type 2 - PG 64-22); 1 1/4" surface AC (type 1 - PG 64-22)	Agg base + concrete base + asphalt surface	6" Item 304; 9" plain concrete; 3" AC (1 3/4" Intermediate, 1 1/4" Surface)
City of Cleveland (Streets Dept)	Agg base + concrete base + asphalt surface	3 - 4" 304 and compact with plate tamper; 8-10" concrete and 2" AC (if existing is asphalt surface) using Type 1 441; Seal joints using Crafco rubberized seal	Agg base + concrete base + asphalt surface	3 - 4" 304 and compact with plate tamper; 8-10" concrete and 2" AC (if existing is asphalt surface) using Type 1 441; Seal joints using Crafco rubberized seal
City of Cleveland (Water Dept.)	Agg base + concrete base + asphalt surface	Follows Eng & Construction Standard (see above)	Agg base + concrete base + asphalt surface	Follows Eng & Construction Standard (see above)
City of Columbus	Either AC or PCC base* + asphalt surface *depends on size of repair	if width of repair is < 5' place asphalt; if > 5' place concrete base and asphalt surface	N/A	N/A
City of Dayton	Concrete base + asphalt surface	min. 9" FS concrete (no dowels) + 2 1 1/2" lifts of ODOT Item 442 AC	concrete base + asphalt surface	min. 9" FS concrete (no dowels) + 2 1 1/2" lifts of ODOT Item 442 AC
City of Findlay	N/A	N/A (no composite roads)	Agg base + asphalt base + asphalt surface	Type B repair: 411 compacted aggregate base; 8" ODOT 301 AC base; 2" ODOT 448 AC
City of Lakewood (City Engineer)/ (Public Works)	concrete base + asphalt surface	8" fiber reinforced concrete (hook bolts into existing); 1 3/4" AC intermediate; 1 1/4" AC surface; seal joints	concrete base + asphalt surface	8" fiber reinforced concrete (hook bolts into existing); 1 3/4" AC intermediate; 1 1/4" AC surface [not confirmed in interview]
City of Wooster	Concrete base + asphalt surface	6" 305 MS concrete; Tack coat; 1 3/4" 441 Type 2 medium intermediate AC; 1 1/4" 441 Type 1 medium surface AC	concrete base + asphalt surface	6" 305 concrete base; tack coat; 1 3/4" 441 type 2 intermediate AC; 1 1/4" 441 type 1 surface AC
Lake County Engineer	N/A	N/A (no composite roads)	N/A	N/A
Northwestern Water and Sewer District	Concrete base + asphalt surface	12" ODOT 304 aggregate base; min. 8" ODOT item 452 non-reinforced concrete (base thickness to match	Concrete base + asphalt surface	12" ODOT 304 aggregate base; min. 8" ODOT item 452 non-reinforced concrete (base thickness to match existing base thickness); 1

Agency	Pavement Matl: Composite	Pavement Matl: Composite [details]	Pavement Matl: Brick composite flexible	Pavement Matl: Brick composite flexible [details]
		existing base thickness); 1 3/4" Item 448 Type 2 intermediate AC; 1 1/4" Item 448 Type 1 AC surface		3/4" Item 448 Type 2 intermediate AC; 1 1/4" Item 448 Type 1 AC surface

Agency	Pavement Matl: Brick composite rigid	Pavement Matl: Brick composite rigid [details]	Backfill material used in winter/emergency repairs	Pavement material used in winter/emergency repairs
City of Akron	concrete base + AC surface	Concrete base (meet existing thickness of base + brick); AC virgin limestone mix installed in maximum of 2" lifts	contractors choice: 304, sand, bank run gravel or LSM	concrete base + visqueen and 2" concrete or no visqueen and 4" temporary or cold patch AC
City of Cleveland (Engineering & Construction)	Agg base + concrete base + asphalt surface	6" Item 304; min 9" plain concrete tie-in to existing with hook bolts or dowels (concrete from bottom of existing concrete to top of existing brick); 3" AC (1 3/4" Intermediate, 1 1/4" Surface)	Cleveland LSM	9" plain concrete (fast set); visqueen; 3" of temporary concrete or cold patch AC
City of Cleveland (Streets Dept)	Agg base + concrete base + asphalt surface	3 - 4" 304 and compact with plate tamper; 8-10" concrete and 2" AC (if existing is asphalt surface) using Type 1 441; Seal joints using Crafco rubberized seal	Emergency repairs of utilities is responsibility of utility (water dept or private utility company)	
City of Cleveland (Water Dept.)	Agg base + concrete base + asphalt surface	Follows Eng & Construction Standard (see above)	Not provided	Temporary repair uses cold patch or fast set concrete
City of Columbus	either asphalt or concrete base + asphalt surface	7" of either asphalt or concrete base + asphalt surface	CDF	cold mix used as temporary pavement (must be replaced by April 30) or for long trenches place concrete to surface and mill 1 1/2" later and pave lane width
City of Dayton	concrete base + asphalt surface	min. 9" FS concrete (no dowels) + 2 1 1/2" lifts of ODOT Item 442 AC	CDF	9" of class FS + plastic sheeting as bond breaker and 3" temporary concrete (FS). (Cold patch AC approved, but temp concrete is preferred, will replace 3" conc with asphalt in spring
City of Findlay	N/A	N/A (no rigid brick composite)	Compacted granular	either thinner layer of concrete with visqueen as bond breaker and temporary (5-6") layer of fast set concrete or place cold mix asphalt on top of compacted granular backfill and replace with asphalt in spring

Agency	Pavement Matl: Brick composite rigid	Pavement Matl: Brick composite rigid [details]	Backfill material used in winter/emergency repairs	Pavement material used in winter/emergency repairs
City of Lakewood (City Engineer)/ (Public Works)	concrete base + asphalt surface	8" fiber reinforced concrete (hook bolts into existing); 1 3/4" AC intermediate; 1 1/4" AC surface [not confirmed in interview]	LSM	If asphalt not available will place concrete cap (24 hr mix) as temporary surface until asphalt can be placed
City of Wooster	No standard (very little % of network)	No standard (very little % of network)	Compacted granular	either 8" of concrete or temporary cold patch AC
Lake County Engineer	N/A	N/A (no rigid brick composite)	LSM or compacted 304**	temporary repair uses 3 1/2" concrete cap**
Northwestern Water and Sewer District	Concrete base + asphalt surface	12" ODOT 304 aggregate base; min. 8" ODOT item 452 non-reinforced concrete (base thickness to match existing base thickness); 1 3/4" Item 448 Type 2 intermediate AC; 1 1/4" Item 448 Type 1 AC surface	LSM	Temporary repair with concrete cap

Agency	Size of repair/ boundary	Inspectors	Trenchless Tech
City of Akron	whole slab is replaced (required to saw cut). If repair is 12' or more in length or multiple holes in 100' required to replace surface course of AC at full lane width	Yes - 2 full time inspectors	Open cuts required, trenchless must be approved
City of Cleveland (Engineering & Construction)	entire slab is restored; street opening regulations shows entire lane is to be restored, was not confirmed in interview	4 full time inspectors	Against the law to bore or directional drill in the city (too many utilities in the way); water lines may be installed by moling
City of Cleveland (Streets Dept)			
City of Cleveland (Water Dept.)	min lane width for non-moratorium streets (full slab replacement; lane width paved), moratorium is curb to curb	Y - 1 full time inspector. water department oversees installation and restoration of water lines	Structural lining and jack and bore
City of Columbus	repair areas wider than 5' or longer than 100' place 3" AC on either 7" AC base or concrete base. Mill 1 1/2" one lane width, pave with paver	Y	No, some private utilities may have used outside or roadway
City of Dayton	if within 3' of curb they require the repair is taken all the way to the curb or entire slab is replaced. Joint to joint paving required for moratorium streets	Y - one full time	Up to contractors discretion. Technology used has mostly been boring in residential areas
City of Findlay	area depends on pavement thickness and need to cutback to prevent settling.	Y	Boring has been done by gas, and electric companies
City of Lakewood (City Engineer)/ (Public Works)	If large area (100 sq ft or bigger) may contract for a paver	Y. Non agency repairs are almost 100% inspected. Will have more inspectors on job if large project	Gas company has used boring and pipe bursting has been used for sewer work/
City of Wooster	Min. 1' cutback on either side of trench. For concrete pavements: saw cut transverse joints at 2x replacement width.	Yes, 75% of repairs are inspected.	Gas company will bore; water company will mole for 1" service lines and bore for water main. Generally trenchless tech not used in roadway.
Lake County Engineer	Min. 1' cutback on either side of trench. For concrete pavements, if less than 5' to nearest joint remove and replace same to the nearest joint**	Yes, 100% of open cuts are inspected. Not all directional boring repairs are inspected	5% of repairs done by trenching 95% done be directional boring
Northwestern Water and Sewer District (NWSD)	Must follow standards of city/village.	Yes. 100% inspected either by NWSD or 3rd party	Jack and bore under major roads or railroads (some municipalities prohibit open

Agency	Size of repair/ boundary	Inspectors	Trenchless Tech
		lab/engineering firm. 3rd party for large projects. 5 full time inspectors for NWSD	cuts). Pipe bursting and jack and bore has been used for sanitary sewer; directional drilling is mainly used for water lines

Agency	Policy - Moratorium	Fees
City of Akron	Y - 4 yrs from paving and/or resurfacing	Yes, deposit and fees for permit, inspection fees
City of Cleveland (Engineering & Construction)	Y - 5 yrs construction or reconstruction and 7 yrs from rehabilitation, improvement, reconstruction or resurfaced	Yes
City of Cleveland (Streets Dept)		N/A
City of Cleveland (Water Dept.)	Y - 5 years for new pavement; 7 years for rehabilitated pavement	Yes; water dept. pays contractor the fees to the city. Must set allowances for fees on bid documents.
City of Columbus	Y - 3 year moratorium	Yes, inspection fee
City of Dayton	Y - lifetime or until resurfaced. Permit fees for repairs on pavements less than 5 yrs old	Yes, permitting fees
City of Findlay	Yes, 3 years	Street opening permit; performance bond based on dimensions
City of Lakewood (City Engineer)/ (Public Works)	No	Yes, transitioning fees from permit fee based on area of repair to fee based on time spent (reviewing plans, inspecting repair, etc.)
City of Wooster	No	Yes. Permitting fees + restoration deposit. Requires 2-year maintenance and guarantee bond on larger projects
Lake County Engineer		No permit fees, but bond required
Northwestern Water and Sewer District	No - follows city/village requirements	No fees, paving is part of the project so residents are assessed for the project

Agency	Special Activities	Performance Issues
City of Akron	Limestone required in asphalt. Permitting policy requires contractor to contact City at critical points in repair (backfill) in order for inspector to be present; Non-compliance clause (warranty) - 5yrs	Settlement is most common failure; issues with compaction for restorations for water line repairs
City of Cleveland (Engineering & Construction)	try to coordinate road work with utility projects. They will ask the utility companies if they have work in that area. And will try to replace catch basins and laterals as part of the work. Aggressive crack sealing program (2 year cycle) Seal joint at surface at 6" wide	If repair was inspected and concrete was tied in with dowel bars or hook bolts tends to not be any problems. AC patch on concrete typically last less than 10 years. Settlement (even with LSM) tends to occur where existing pavement is brick composite or rigid brick composite and unable to anchor new concrete to existing pavement. Overall, not many repairs settle. The edges of concrete repair will deteriorate (spalling under AC) and then the AC crumbles. To correct this issues they may mill 3" into concrete at 1' wide slot at the trench joint and put AC back. If water department did repair it may deteriorate quicker (within a few years)
City of Cleveland (Streets Dept)	5% of their work is spent repairing previous utility cut repairs. The vast majority repaired has settlement issue.	
City of Cleveland (Water Dept.)		Settlement has been an issue in the past; settlement due to using improper backfill; training and inspectors have helped resolve issue, but they need more inspectors
City of Columbus	Heat weld joints (optional); paving full lane width if larger area repaired	Failures seen have been cracking at the joints (even with heat weld); settlement in the repair
City of Dayton	RFID tags placed in temporary and permanent repairs for city to be able to determine who was responsible for repair in event of failure. Contractors must call inspector before beginning work. Requires sealing of joints	settlement issues in winter mostly on water main breaks; CDF has helped to reduce settlement on thoroughfares
City of Findlay	requires sealing of saw cut (joints), although not shown in standard drawing	repairs completed in colder months where cold morning and warms up in day tend to not perform as well. Failures tend to be raveling/deterioration of joints, settlement
City of Lakewood (City Engineer)/ (Public Works)	switched to LSM 8 years ago (incorporated into spec 5 yrs ago). seal joints for composite pavement repair. Coordinates with utility companies by informing them of resurfacing plans a head of time; gas company has provided city 20 year capital improvement program plans.	some settlement on all pavement types, especially on long tie-in projects. Usually occurs within 1 yr of repair (after subjected to 1 freeze/thaw cycle)

Agency	Special Activities	Performance Issues
	Identified issues: being able to track location of temporary utility repairs.	
City of Wooster	Seal all joints with Crafco Roadsaver 515. Limestone aggregate in surface course of asphalt and concrete.	Very satisfied with concrete (it is more forgiving and contractors are more familiar with it). Issues related to asphalt repairs include washboard effect in long longitudinal repairs and areas where paver used perform better (possibly not getting good compaction in small repairs). Irregular sized concrete repairs will crack at corners/edges; where control joint is not sawed will also have cracking
Lake County Engineer	No utility cuts directly under pavement are permitted has been in place for approximately 10 years due to inability to inspect 100% of open cuts and settlement issues related to open cuts	Benefit of boring: no settlement or ill effects on pavement
Northwestern Water and Sewer District	joint sealer (item 409) required at trench edges. Standard not uniform, and must follow ODOT where cut on state owned routes	settlement and large cracks between new asphalt and existing

10.3 Ohio Local Agency Phone Interview Questions

Phone Interview Questions

Name:
Affiliation:
Title:
Contact Info:

General

1. Please provide the type of pavement in your jurisdiction by indicating the approximate amount of each pavement type as a percentage of total roadway network:
    a. Asphalt
    b. Concrete
    c. Concrete composite
    d. Brick (exposed)
    e. Brick composite (overlaid with asphalt)
    f. Rigid Brick composite (brick on a concrete base, overlaid with asphalt)
    g. Chip Seal
    h. Aggregate

Standard Method of Repair

1. Do you have a standard method of repair?
    a. How long have you been using this standard?

2. Did you adopt this standard from another entity? If so, who?

3. What are the standard methods of repair of open utility cuts used by each department, utility company, and/or contractor within your jurisdiction (including method, materials, and equipment)?
    a. For each existing pavement type?
        i. Asphalt
            1. Department/Utility Company/Contractor:
                a. Method:
                b. Backfill material(s):
                c. Pavement repair material(s):
                d. Equipment:
        ii. Concrete
            1. Department/Utility Company/Contractor:
                a. Method:
                b. Backfill material(s):
                c. Pavement repair material(s):
                d. Equipment:
        iii. Concrete composite
            1. Department/Utility Company/Contractor:
                a. Method:

            b. Backfill material(s):
            c. Pavement repair material(s):
            d. Equipment:
    iv. Brick
        1. Department/Utility Company/Contractor:
            a. Method:
            b. Backfill material(s):
            c. Pavement repair material(s):
            d. Equipment:
    v. Brick composite
        1. Department/Utility Company/Contractor:
            a. Method:
            b. Backfill material(s):
            c. Pavement repair material(s):
            d. Equipment:
    vi. Rigid Brick composite
        1. Department/Utility Company/Contractor:
            a. Method:
            b. Backfill material(s):
            c. Pavement repair material(s):
            d. Equipment:

4. Do the standard methods of repair of open utility cuts differ by utility type? If so, how?
    a. Water
    b. Sewer
    c. Storm water drainage
    d. Gas
    e. Electric
    f. Telecommunication
    g. Cable
    h. Other:

5. What issues have you encountered with your standard repair details?

6. Do you match existing pavement thickness?
    a. If no, how is the thickness of the pavement repair material determined?

7. Do you match existing pavement type?
    a. If no, how is the pavement repair material(s) determined?

8. Have you tried other techniques (T-repair, cutback, tapered, keyhole)? What has been your experience in terms of performance and cost?

9. If you have tried the keyhole technique,
    a. For what existing pavement types was the technique used?
    b. For what utilities was the technique used?
    c. Was it used as a routine method of repair or for exploratory purposes?

10. Do your restoration practices differ by season?
    a. If so, how?

11. Do you have any plans to change your standards?
    a. Is cost preventing changes to the standards?
    b. Do you have any plans to incorporate trenchless technology in your standards?

Materials

1. What, if any, are the requirements for the following:
    a. Unbound backfill material
        i. Gradation requirements
        ii. Aggregate type
    b. Controlled Low Strength Material (CLSM)
        i. Strength requirement
    c. Fabric
    d. Concrete
        i. Strength requirement
    e. Asphalt
    f. Other

2. Could you please provide details on the CLSM materials you use:
    a. Do you have a mix design and who is responsible for developing the mix design?
    b. What is the commercial name of the CLSM material you typically use, if proprietary?
    c. Have you tried others and do you notice a difference?
    d. Have you had any issues with removing CLSM and how have you addressed it?

3. Have you used geosynthetic products?
    a. Name and type:
    b. What are the specifications or standards associated with the product(s)?
    c. How does it perform relative to other repairs that do not use such products?

4. What materials are typically used during,
    a. Wet weather
    b. Cold weather
    c. Emergency repairs
    d. How did the above perform?

5. Has the quality of repairs been affected by the availability of materials?

Construction

1. Do you have specifications for the following:
    a. Compaction of backfill
        i. Density
    b. Asphalt
        i. Density

c. Concrete
    i. Strength
    ii. Opening to traffic
d. CLSM
    i. Strength
e. Granular material
    i. Density
f. Other

2. Who is responsible for construction of pavement restoration of open utility cuts? And what is the percentage of the total repairs they are responsible for?
    a. Agency:
        i. Departments:
    b. Utility Company:
    c. Contractor:
        i. For whom?

3. Do you have any requirements for contractors performing work within your jurisdiction?
    a. Do you have any prequalification requirements for contractors performing repairs of open utility cuts?
    b. Have you seen any differences in repair performance associated with prequalification requirements?

4. What equipment is typically employed for the following operations?
    a. Excavation
    b. Backfill
    c. Compaction
    d. Pavement repair material
    e. Other (e.g. fabric, LSM)

5. Has the quality of repairs been affected by the availability of the equipment? Please explain.

6. Do you have a different method of repair for large repair areas?
    a. What defines a large area?
    b. Have you noticed a difference in performance for large areas relative to smaller areas?

7. Do you have QA/QC procedures?
    a. If yes, please provide a copy
    b. If printed procedures are not available, please describe:

8. Do the QA/QC procedures differ by utility type?

9. How does your construction procedure differ during
    a. Wet weather
    b. Cold weather
    c. Emergency repairs

Performance

1. Are you satisfied with the short- and long-term performance of the restorations of open utility cuts on each pavement type? (Y/N)
    a. Asphalt
    b. Concrete
    c. Concrete composite
    d. Brick
    e. Brick composite
    f. Rigid Brick composite

2. If no, what is being done (or what needs to be done) to improve performance?
    a. Asphalt
    b. Concrete
    c. Concrete composite
    d. Brick
    e. Brick composite
    f. Rigid Brick composite

3. What types of failures do you typically see and when do they occur, on average?
    a. What do you attribute these failures to?

4. Do you notice a difference in performance based on the entity (agency/department, contractor, utility company) responsible for the pavement restoration?
    a. If so, how?

5. Do your notice a difference in performance based on the season in which the restoration was completed?
    a. If so, how?

6. Do you notice a difference in performance based on the backfill material used?
    a. If so, please describe:

7. Do you notice a difference in performance based on the pavement material used for the repair? If so, please describe:

8. What are the biggest challenges in achieving good performing pavement restorations of open utility cuts?

Policy/Coordination

1. Do you now or have you
    a. Assessed fees
    b. Imposed a moratorium

2. If you assess fees,
    a. How are the fees established?
    b. What are the fee amounts based on?
    c. Where do the fees that are collected go?

3. What, if any, obstacles did you encounter in implementing them?
    a. How did you overcome these obstacles?

New and emerging technology

1. What has been your experience with trenchless technology (boring, pipe bursting, etc.)?
    a. Do you have any plans to incorporate such technology in standard practice?

2. Are there any other practices (methods, materials, or equipment) you would like to try in the future?

Miscellaneous

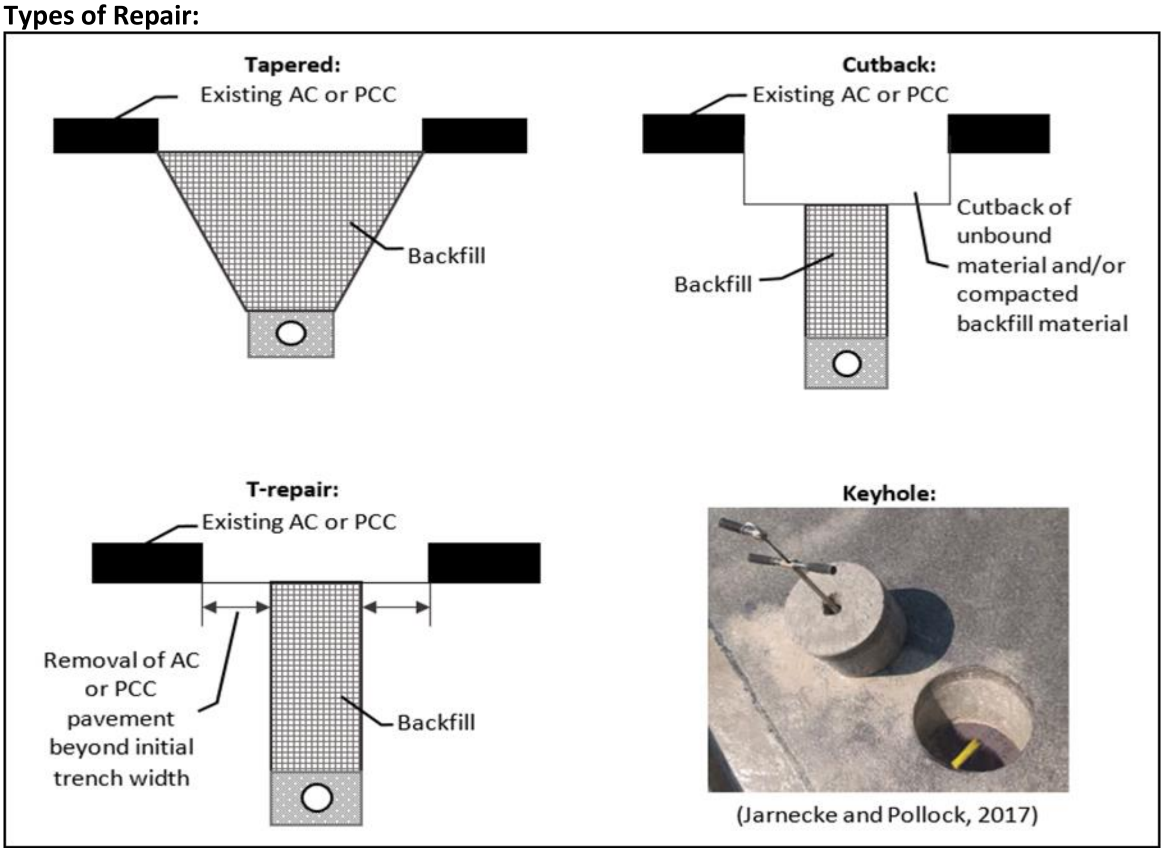
1. If money were not a concern, what would you change in your standard repair to achieve the maximum performance?

2. Are there any items you would like to discuss further?

Definitions:

Concrete composite: concrete with asphalt surface
Brick composite: brick over granular base with asphalt surface
Rigid brick composite pavements: brick over a concrete base with an asphalt surface
CLSM: controlled low-strength mortar

Types of Repair:



(Jarnecke and Pollock, 2017)

11 Appendix D: Local Agency In-Person Interviews and Site Visit Observations

11.1 Local Agency In-person Interviews

Based on the phone interviews, three agencies were selected for a follow-up in-person interview and field site visits. These agencies were also selected for field and laboratory evaluation of existing repairs of open utility cuts. The three agencies were selected based on the predominant pavement types in their jurisdiction, number of open utility cuts performed each year, the type of repair (vertical cut, or T-repair) specified in their standard, and the backfill material allowed. The three agencies selected for in-person interviews, field site visits, and field evaluation were City of Cleveland, City of Columbus, and City of Dayton.

In-person interviews were conducted to further clarify previous information collected through the survey and phone interviews, to identify possible best practices, to identify possible reasons the identified repairs may be performing well or poorly, and to coordinate field evaluations. As part of the in-person interview, the research team also inquired as to what characteristics defined poor and good performance.

As shown in the Table 23, a total of four interviews were conducted with representatives from three agencies: City of Cleveland, City of Columbus, and City of Dayton. Representatives from two different offices within the City of Columbus were interviewed. When water lines are repaired or replaced the City of Columbus's Water Distribution Engineering is responsible for restoring the open utility cut, therefore a representative from that office was interviewed. Additionally, an inspector, who, as part of their job, is responsible for inspecting open utility cut repairs to ensure compliance with their specifications, was also interviewed.

Table 23 In-person interviews conducted.

Agency	Interviewees	Date of Interview
City of Cleveland	Dave Weglicki, Section Chief of Permits and Sidewalks Bob Chaplain, Inspector, Bureau of Sidewalks	10/10/2018
City of Columbus	Dwayne Byrum, Construction Inspector	1/11/2019
City of Columbus	Tim Huffman, Manager, Water Distribution Engineering	1/11/2019
City of Dayton	David Escobar, Senior Engineer, Division of Civil Engineering Dave Weinandy, Chief Engineer, Construction Bureau	9/27/2018

11.2 Local Agency In-person Interview Questions

The questions used during the in-person interviews were tailored to each agency based on previous survey responses and phone interview responses. Questions for each agency are listed in the subsections below. When possible, questions were provided to the interviewees prior to the in-person interviews. The questions were used to help guide the conversation with the interviewees.

11.2.1 City of Cleveland

"Best Practices for Pavement Restoration of Open Cut Utility Installations/Repairs on Local Roadways in Northern Ohio"

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City of Cleveland

1. Have any changes been made to your specifications, policy, or procedures since our last communication (May 2018)?
    a. If so, why and please describe the changes
2. For each of the repairs identified, what is the existing pavement type (e.g. asphalt on brick over sand, asphalt on brick over concrete, asphalt on concrete, concrete, brick on sand, etc)?
3. For each of the repairs identified what materials were used in the repair (e.g. LSM + 304 + concrete + asphalt)?
4. Of the repairs identified, which were completed by the water department?
5. Of the repairs identified which, if any, were due to water main breaks?
6. Of the poor performing repairs identified, why were they identified as such?
7. What are the ages of the identified repairs?
8. Of the repairs identified, which are on truck routes?
9. If known, what time of year were the identified (permanent) repairs completed?
    a. Were any of the identified repairs initially constructed as temporary repairs?

11.2.2 City of Columbus

"Best Practices for Pavement Restoration of Open Cut Utility Installations/Repairs on Local Roadways in Northern Ohio"

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City of Columbus – Permit/Inspecting Section

1. Have any changes been made to your specifications, policy, or procedures related to repair of open utility cuts since our last communication (March 2018)?
    a. If so, why and please describe the changes
        i. Material specifications:
        ii. Regulations or procedures for repair:
2. Can you identify 3 or 4 repairs in composite and brick composite pavement suitable for testing which have performed exceptionally?
3. Can you identify 3 or 4 repairs in composite and brick composite pavement suitable for testing which have performed poorly?
    a. Were specifications followed?
4. Of the poor performing repairs identified, why were they identified as such?
5. What are the ages of the identified repairs?
6. Of the repairs identified, which are on truck routes?
7. If known, what time of year were the identified (permanent) repairs completed?
    a. Were any of the identified repairs initially constructed as temporary repairs?
8. What is the percentage of open utility cuts inspected?
9. How many inspectors are employed?
10. How many repairs are inspected per day?
11. What are you looking for during an inspection?
    a. Compaction test
    b. Tickets for materials taken
    c. Following procedure
12. Is work completed by any city department/forces inspected? If so, which department?
    a. Are these repairs required to have a permit?

    b. If yes, does that inspection of repairs by city forces differ from private utility/contractor work?

13. Is work completed for any city department/forces by a contractor inspected? If so, which department?
    a. Are these repairs required to have a permit?
    b. If yes, does that inspection of repairs for city forces differ from private utility/contractor work?
14. Which type of FCDF is used for repairs (Type 1, 2, 3 or 4)?
15. Is the heat weld in lieu of sealing the edges of the cut?

"Best Practices for Pavement Restoration of Open Cut Utility Installations/Repairs on Local Roadways in Northern Ohio"

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City of Columbus – Water Distribution Engineering

1. What is the general procedure for restoring the pavement after repairing or installing water lines/mains/connections?
2. Is the existing pavement cutback beyond the original width of the trench? If so, how far?
3. What backfill material is used?
    a. Are there any circumstances in which FCDF would be used instead of granular material, and vice versa?
4. How is the pavement material used for the restoration determined (i.e. selected to match existing pavement type)?
5. What acceptance tests, if any, are conducted on
    a. Asphalt concrete
    b. Portland cement concrete
    c. Granular backfill
    d. FCDF backfill
6. How does the pavement restorations for waterline installation/upgrades for capital improvement plans differ from restorations for small area trenches (as in watermain breaks, repairs or residential connections)?
7. Can you identify 3 or 4 repairs in composite and brick composite pavement suitable for testing which have performed exceptionally?
8. Can you identify 3 or 4 repairs in composite and brick composite pavement suitable for testing which have performed poorly?
    a. Were specifications followed?
9. Of the poor performing repairs identified, why were they identified as such?
10. Were any of the identified repairs for water main breaks?
11. What are the ages of the identified repairs?
12. Of the repairs identified, which are on truck routes?
13. If known, what time of year were the identified (permanent) repairs completed?
    a. Were any of the identified repairs initially constructed as temporary repairs?
14. How does a temporary repair differ from a permanent repair in terms of the pavement material?

11.2.3 City of Dayton

"Best Practices for Pavement Restoration of Open Cut Utility Installations/Repairs on Local Roadways in Northern Ohio"

Sponsored by Ohio Research Initiative for Locals

City of Dayton

1. Have any changes been made to your specifications, policy, or procedures since our last communication (March 2018)?
    a. If so, why and please describe the changes
2. How much do RFID tags cost? Are RFID tags cost-effective?
3. What have been the benefits of using RFID tags (i.e. have the RFID tag ever helped to enforce spec or bring a contractor back to correct work, etc.)?
4. For each of the repairs identified, what is the existing pavement type (e.g. asphalt with granular base, asphalt on subgrade, asphalt on brick, brick on concrete, etc)?
5. Of the repairs identified which, if any, were due to water main breaks?
6. Of the poor performing repairs identified, why were they identified as such?
7. What are the ages of the identified repairs?
8. Of the repairs identified, which are on truck routes?
9. If known, what time of year were the identified (permanent) repairs completed?
    a. Were any of the identified repairs initially constructed as temporary repairs?

11.3 Summary of Local Agency In-person Interview Responses

11.3.1 City of Cleveland

- Regarding current policy, the permitting process has been improved recently. Changes made were related to how permit are distributed within the agency for review and approval.
- For the repairs identified:
    - The existing pavement is not known or would be difficult to determine based on current records.
    - The age is not known since widespread inspection was started the previous year.
    - It is not known which repairs were performed by the water department, although if sounding holes or water valves are present that is indication it was a water line repair.
    - Unless recently repaired and observed by an inspector, materials used in the repair are not known, however they should be following the City's standards (6 inches of LSM, 6 inches of Item 304 aggregate base, nine inches of concrete, and three inches for asphalt for all pavements, with the exception that pavements with underlying concrete require dowels or hook bolts).
- Characteristics of poor performing repairs are:
    - Standard and/or specifications were not followed
    - Repairs on moratorium streets are not full lane width as specified in the standard
    - Failures have mostly been due to poor or lack of joint sealant and joints not being cut straight
- Inspection program is relatively new; it has been implemented for one full year.

    - Prior to inspection program, there was only one inspector which was not sufficient to inspect all of the repairs.
    - As part of the current program, the City employs 5 inspectors, 4 of which are assigned to street opening repairs
- When inspecting a street opening repair, the things they look for to ensure compliance with the standard may include:
    - The use of LSM as backfill
    - Completing the overcut as part of the T repair
    - Using hook bolts or dowel bars where appropriate
    - Material tickets for asphalt
- The City tries to coordinate planned resurfacing work with planned utility repairs by sharing capital projects list with utility companies.

11.3.2 City of Columbus

Interview with inspector:

- Regarding the amount of repairs that are inspected:
    - There are currently 10 inspectors employed. Previously there had only been two. This allows for approximately 150 cuts to be inspected per month per inspector.
    - Currently work completed by city forces is not inspected, however, they are required to have a permit.
- When inspecting a street opening repair, the things they look for to ensure compliance with the standard may include:
    - Ensuring the inspector was contacted prior to work
    - Checking that OUPS had been called and marked utilities in the area
    - Looking at the base and/or subgrade material on either side of the cut to see if the material is saturated
    - Layer thickness follows the standard (three 3-inch lifts of asphalt)
    - Check that all edges were sawcut to achieve clean, straight edges
    - Work is on schedule for completion of heat weld
- Selection of backfill material
    - Item 304 requires a compaction test either by a 3rd party or city forces, most contractors would rather use flowable controlled density fill (FCDF)
- Regarding winter repairs:
    - Cold patch is not allowed, only hot mix asphalt.
        - One contractor keeps a plant open all year around
    - Concrete can be placed to the surface if they are required to come back and mill it and pave the full lane width, as required when the repair is 100 feet or longer in length.

Interview with representative from Water Distribution Engineering:

- Regarding backfill material used
    - In street opening repairs, FCDF is used most often, however it is more expensive than granular material

        - FCDF is used mainly in repairs of water main breaks
        - FCDF is a little quicker and easier to place
    - The standard allows for the use FCDF type 3, also referred to as “flash fill”
- Regarding repairs completed for capital improvement programs
    - Where cast iron pipe (CIP) is replaced granular material is often used for backfill material and concrete is placed to the surface. It is later milled at 1.5 inches deep and overlaid with asphalt
    - Repairs for CIP replacement are completed by a contractor

11.3.3 City of Dayton

- Regarding changes made to specification, policy, or procedures since March 2018
    - No changes have been made
- Regarding the use of RFID tags
    - They cost $1.40 per tag.
    - They are cost effective and the cost can easily be lumped into permit fees, although that is currently not being done.
    - They do not work well in concrete.
    - The benefit far outweighs the cost
- Benefits of using RFID tag:
    - The City receives a lot of calls related to potholes in temporary repairs and locations in need of repair. The RFID tags help the maintenance crew identify the utility company responsible for the temporary repair.
        - This alleviates the crew from having to perform the repair themselves, reduces time trying to identify the responsible party, and requires less city resources.
    - The RFID tags provide accountability for permanent repairs because it enables the City to easily and quickly identify the responsible party if the repair fails. This helps to enforce the lifetime warranty placed on all repairs.
- Regarding the permitting process
    - Previously permits had to be sent in via mail. They can now be submitted via e-mail.
    - They would like to move to an online system with the capability of paying online as well.
        - This would reduce resources spent on paperwork and entering information into the computer.
- Regarding permanent repairs
    - All repairs are required to be performed initially as temporary repairs.
    - When completing the permanent repairs, edges are saw cut to perform T repair and provide straight edges; joints are sealed.
    - RFID tags are placed in both temporary and permanent repairs.

11.4 Site visits

In-person interviews were conducted in conjunction with a visit to each of the three cities for field site visits. Site visits were conducted to look at existing repairs of open utility cuts with a range of ages and performance. Therefore, prior to conducting the interview and site visit, the research team requested a list of at least six repairs performing poorly and six repairs performing well for the pavement type of interest, and at least three repairs on other pavement types. The sites on the city's list of poor and well performing repairs were visited before or after the in-person interviews. Three well performing and three poor performing sites were chosen in each city for field and laboratory evaluation.

Additionally, as feasible, the research team observed repairs being conducted. Repairs of open utility cuts, depending on the size of the cut and the agencies standards, may span several days. Therefore, only portions of repairs could be observed. In the City of Cleveland, observations were made during the repair of a large open utility cut on a concrete pavement for the repair of a sanitary sewer line. The research team observed placement of the backfill material and sampled low-strength mortar being placed. In the City of Dayton, their standards dictate all initial repairs are performed as temporary repairs, and the utility or contractor return to complete the permanent repair. While visiting City of Dayton, the research team observed the placement of the permanent pavement surface for an open utility cut for a gas service line on an existing asphalt pavement.

The following subsections provided a summary of observations made during visits to view active repairs being performed.

11.4.1 City of Cleveland

A large open utility cut repair on a concrete pavement for the repair of a sanitary sewer line in City of Cleveland was being restored when the research team visited. It was observed that the first load of LSM delivered to the site appeared dry, whereas the second load appeared wet, as shown in Figure 23. Samples of both materials were collected and allowed sufficient time for the material to set. The sample of "wet" LSM, shown on the left in Figure 24, set, whereas the "dry" sample of LSM remained granular. As shown, the "dry" sample did not set, and therefore will not provide the level of performance anticipated with LSM. This highlights the importance in adherence to the specification for backfill material.

Figure 23 Observed open cut utility repair in progress, City of Cleveland.

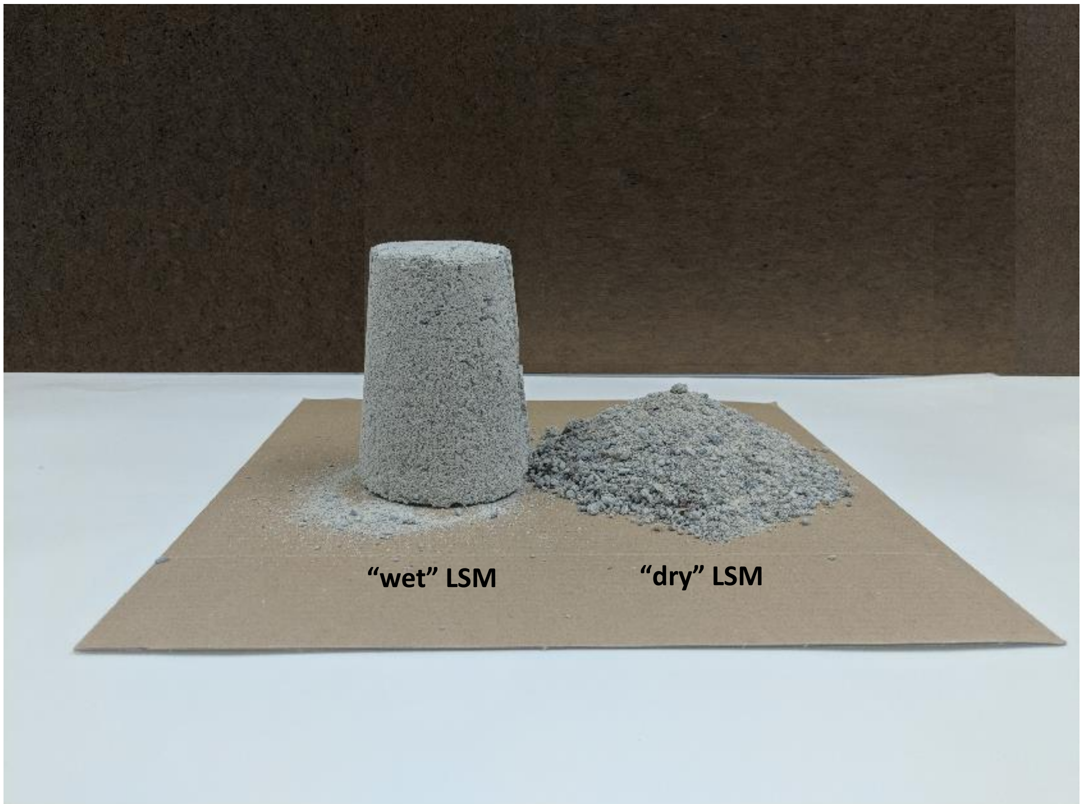


Figure 24 LSM samples from observed repair after allowed to set, City of Cleveland.

11.4.2 City of Dayton

The research team observed the permanent repair of a gas service line on an asphalt pavement. It was revealed during the in-person interview that all repairs are initially performed as temporary repairs. Numerous repairs were being repaired or had been recently completed by the same contractor on the same street as the repair in-progress. Therefore, the research team had an opportunity to observe the repairs at different stages of the process. An example of the surface of temporary repair is provided in Figure 25. In Figure 26, the repair has been saw cut to provide the overcut and straight edges, and granular base is being compacted as part of the permanent repair. An example of the permanent repair surface is shown in Figure 27.

Figure 25 Example of temporary repair prior, City of Dayton.

Figure 26 Example of granular base compaction during repair of open utility cut, City of Dayton.

Figure 27 Example of completed permanent repair, City of Dayton.

12 Appendix E: Site Selection for Field Evaluation

Based on the preliminary literature search, the research team identified three primary factors to consider for the performance of open cut utility repairs for each pavement type (asphalt, concrete, and composite): the open cut method used, the material used for the surface of the pavement repair, and the backfill material. Four primary methods used for the open cut have been identified in the literature including vertical cut, cutback, T-section, and other (e.g. keyhole). It was anticipated three backfill material types may be used which include granular material, controlled low-strength mortar, and native soil. Lastly, the pavement repair may be completed using either asphalt or concrete as the pavement surface. This would result in 21 different combinations for repair of each pavement type which are laid out in Table 24. Considering three pavement types and 21 combinations for each, the total repair types that would be possible is 63.

Table 24 Preliminary Matrix of Repair Factors for Open Cut Utility Installation

Open Cut Method	Backfill	Repair Surface
Vertical Cut	G	AC
		PCC
	CLSM	AC
		PCC
	NS	AC
		PCC
Cutback	G	AC
		PCC
	CLSM	AC
		PCC
	NS	AC
		PCC
T-section	G	AC
		PCC
	CLSM	AC
		PCC
	NS	AC
		PCC
Other (e.g. Keyhole)	G	Replace Core
	CLSM	Replace Core
	NS	Replace Core

G: Granular material

CLSM: controlled low-strength mortar

NS: native soil

To evaluate an open cut utility repair, at least two performance categories should be considered to discern the properties of a well performing open cut utility repair from a poorly performing repair. Although it is unlikely that all of the above combinations of factors exist or an adequate number of sites are present for each combination in Ohio, Table 25 helps to illustrate a minimum number of sites necessary to evaluate all of the combination of factors shown in Table 24 for each pavement type. As noted, testing would be done for at least two performance categories (poor or good) and as a minimum, three poor repairs and three good repairs should be tested for each combination. As shown Table 25, this would amount to 126 sites (21 combinations × 2 performance categories × 3 sites/performance category = 126 sites) for each pavement type, and a total of 378 sites necessary for all three pavement types.

Table 25 Number of Sites for All Combinations of Open Cut Utility Repair Factors

Open Cut Method	Performance	Backfill	Repair Surface	No. of Sites
Vertical Cut	Poor	G	AC	3
Vertical Cut	Poor	G	PCC	3
Vertical Cut	Poor	CLSM	AC	3
Vertical Cut	Poor	CLSM	PCC	3
Vertical Cut	Poor	NS	AC	3
Vertical Cut	Poor	NS	PCC	3
Vertical Cut	Good	G	AC	3
Vertical Cut	Good	G	PCC	3
Vertical Cut	Good	CLSM	AC	3
Vertical Cut	Good	CLSM	PCC	3
Vertical Cut	Good	NS	AC	3
Vertical Cut	Good	NS	PCC	3
Cutback	Poor	G	AC	3
Cutback	Poor	G	PCC	3
Cutback	Poor	CLSM	AC	3
Cutback	Poor	CLSM	PCC	3
Cutback	Poor	NS	AC	3
Cutback	Poor	NS	PCC	3
Cutback	Good	G	AC	3
Cutback	Good	G	PCC	3
Cutback	Good	CLSM	AC	3
Cutback	Good	CLSM	PCC	3
Cutback	Good	NS	AC	3
Cutback	Good	NS	PCC	3
T-section	Poor	G	AC	3
T-section	Poor	G	PCC	3
T-section	Poor	CLSM	AC	3
T-section	Poor	CLSM	PCC	3
T-section	Poor	NS	AC	3
T-section	Poor	NS	PCC	3
T-section	Good	G	AC	3
T-section	Good	G	PCC	3
T-section	Good	CLSM	AC	3
T-section	Good	CLSM	PCC	3
T-section	Good	NS	AC	3
T-section	Good	NS	PCC	3
Other (e.g. Keyhole)	Poor	G	Replace Core	3
Other (e.g. Keyhole)	Poor	CLSM	Replace Core	3
Other (e.g. Keyhole)	Poor	NS	Replace Core	3
Other (e.g. Keyhole)	Good	G	Replace Core	3
Other (e.g. Keyhole)	Good	CLSM	Replace Core	3
Other (e.g. Keyhole)	Good	NS	Replace Core	3
Total sites for repair of flexible pavements:				126
Total sites for repair of rigid pavements:				126
Total sites for repair of composite pavements:				126
Grand Total				378

G: Granular material

CLSM: controlled low-strength mortar

NS: native soil

Based on the minimum number of sites necessary, it was not feasible to evaluate all combinations of repairs of open cut utility installation. It was anticipated each municipality had arrived at the most effective repair technique(s) for their jurisdiction through trial and error. Therefore, it was proposed that for each of the three pavement types, three sites which represent well performing pavement repairs and three which represent poorly performing pavement repairs be tested, for a total of 18 sites. This would allow for the evaluation of the single most common combination of variables for each pavement type.

The information collected from the phone interviews and in-person interviews identified the vertical cut and T section as the most used open-cut repair method in Ohio. Flexible, concrete composite, and brick/rigid brick composite pavements were the most common pavement types. Exposed brick and exposed concrete pavements were encountered to a lesser extent. Granular material or controlled density backfill were almost exclusively used as backfill for repairs. The cities of Cleveland, Columbus, and Dayton were selected for the field test sites based on the quantity of repairs performed in a year and their predominant pavement type was brick composite, concrete composite, and asphalt, respectively.

Originally it was planned to select three repairs with good performance and three repairs with poor performance for each pavement type, such that one pavement type would be tested in each city. However, through discussions with City of Cleveland, it was found it would be difficult to know the build-up of the pavement at each site prior to testing. Although it was intended to test repairs on brick composite pavements in Cleveland, there was a possibility the research team would encounter other pavement types. Therefore, the testing plan was altered to account for these unknowns and submitted and approved by the Technical Advisory Committee. The testing plan was as follows:

- Three poor and three good performing restorations will be tested in the City of Cleveland, despite the lack of historical records indicating the existing pavement type. Rather, the existing pavement type will be determined by coring the pavement during field testing.
- Based on the pavement types identified in City of Cleveland during field testing, the research team will adjust selections in City of Columbus and City of Dayton, to the extent possible to obtain a mix of original pavement type and restoration performance.
- If the research team encounters an unexpected pavement type during field testing, the mix of pavement type and performance (three good performing and three poor performing restorations of each of the three presumed pavement types) may change based on budget and time constraints.

The research team worked with each agency to develop an initial list of repairs to consider for field evaluations. During site visits to conduct interviews with city representatives, the research team also visited the list of repairs provided by the agency. At that time the research team made notes regarding performance and utilities that may be associated with the repair. In some cases, numerous visits were made to a city before the lists of sites to be evaluated could be finalized. The research team also requested from each agency, the utility repaired, age of the repair, and the pavement type at each site, if known. In selecting sites for testing, the research team considered the condition of the repair, age of repair (if known), type of utility, proximity to intersections and the type of maintenance of traffic needed.

Representatives from City of Cleveland's Engineering and Construction office provided the research team with a long list of repairs that had been identified by one of their inspectors, and a long list of repairs on moratorium streets. The research team visited over 30 locations, half of which were accompanied by the inspector. This was invaluable in understanding Cleveland's standards and enforcement, as well as expectations relative to performance. The type of utility repaired and the age of the repair were requested. However, City of Cleveland representatives were unable to identify that information for many of the repairs, as many were repaired prior to the implementation of more wide spread inspection, and tracking of repairs. Based on this site visit and discussions with City of Cleveland representatives, locations were selected for field testing.

The research team worked with representatives from City of Dayton's Construction Bureau to identify repairs on asphalt pavements. Representatives for the city were able to provide age of the repair as well as the type of repair and pavement type for most of the sites. The research team made multiple visits to finalize the list of sites for testing. The City of Dayton was able to identify a list of repairs through an existing database of repairs.

The research team worked with City of Columbus to identify repairs that would provide a mix of the desired pavement types. In the City of Columbus, the research team initially worked with a representative from the Division of Planning and Operations. However, it was believed it would be best to focus on one utility type initially. Therefore, the research team worked with a representative from the Water Distribution Engineering office. This representative provided an initial list of waterline repairs. The research team then requested information related to the build-up of the pavement at each site from the representative with the Division of Planning and Operations. Many of the repairs initially provided were recent and performing well or had been overlaid in the time since the repair, therefore other repairs would need to be identified. The research team then worked with the inspector that had been interviewed to identify other potential repairs. The research team made several visits to observe identified repairs and worked with these representatives to identify the existing pavement type. Due to time, difficulty identifying the existing pavement type, and difficulty identifying repairs suitable for testing (sites off major thoroughfares were desired) some repairs were selected that did not meet the mix of pavement types needed based on the results of testing in Cleveland.

The final lists of sites selected in each city are listed in the following subsections.

12.1 City of Cleveland

Six test locations were selected such that three locations represented poor performance and three locations which represented good performance. When these sites were selected, the existing pavement type was not known, although City of Cleveland has predominantly brick composite and concrete composites pavements on their network. The following six sites were selected for testing:

1. "Good" repairs
    a. Pepper Ave.
    b. 16214 Sanford Ave.
    c. 3504 Woodbridge Ave.
2. "Poor" repairs
    a. 1412 E. 45th St.
    b. 13009 Terminal Ave.
    c. 16713 Valleyview Av.

Table 26 Selected sites for testing in City of Cleveland

Location	Performance	Utility Repaired	Year of Repair
16214 Sanford Ave.	Good	Water	Unknown
Pepper Ave.	Good	Water	2017
3504 Woodbridge Ave.	Good	Water	Unknown
1412 E. 45th St.	Poor	Sewer	Unknown
13009 Terminal Ave.	Poor	Sewer	Unknown
16713 Valleyview Ave.	Poor	Sewer or water	Unknown

12.1.1 "Good" Repairs

Figure 28 Repair on Pepper Ave.

Figure 29 Repair on Sanford Ave.

Figure 30 Repair on Woodbridge Ave.

12.1.2 “Poor” Repairs

Figure 31 Repair on E. 45 Street Location (Courtesy of City of Cleveland).

Figure 32 Repair on Terminal Ave.

Figure 33 Repair on Valleyview Ave.

12.2 City of Columbus

Six test locations were selected such that three locations represented poor performance and three locations which represented good performance. Sites were selected to provide a mix of concrete composite and brick composite pavements. Information related to the pavement type was identified through original plans and was not available for all locations. Where unavailable, assumptions were made based on the pavement type in surrounding areas within the same subdivision. Therefore, the pavement type listed below was unable to be confirmed prior to testing and is presented here only to provide insight into why these sites were selected. The following six sites were selected for testing:

1. “Good” repairs
    a. 62 E. Barthman Ave.
        i. Assumed pavement type: brick composite
    b. 50 E. Jeffrey Place
        i. Assumed pavement type: concrete composite or asphalt depending on proximity to widening limits
    c. 1576 Old Leonard Ave.
        i. Assumed pavement type: concrete composite
2. “Poor” repairs
    a. 61 W. 3rd Ave.
        i. Assumed pavement type: asphalt
    b. 85 W. 3rd Ave.
        i. Assumed pavement type: asphalt
    c. 1734 Old Leonard Ave.
        i. Assumed pavement type: concrete composite

Table 27 Selected sites for testing in City of Columbus

Location	Performance	Utility Repaired	Year of Repair
62 E. Barthman Ave.	Good	Water	Unknown
50 E. Jeffrey Place	Good	Water	Unknown
1576 Old Leonard Ave.	Good	Storm Sewer*	Unknown*
61 W. 3rd Ave.	Poor	Gas	2011 or 2012
85 W. 3rd Ave.	Poor	Gas	2011 or 2012
1734 Old Leonard Ave.	Poor	Water	2016

*City of Columbus believed it was a water repair completed in 2013, however, no water lines in the area. OUPS markings revealed only storm sewer lines in the repair tied to the manhole in the repair.

12.2.1 “Good” Repairs

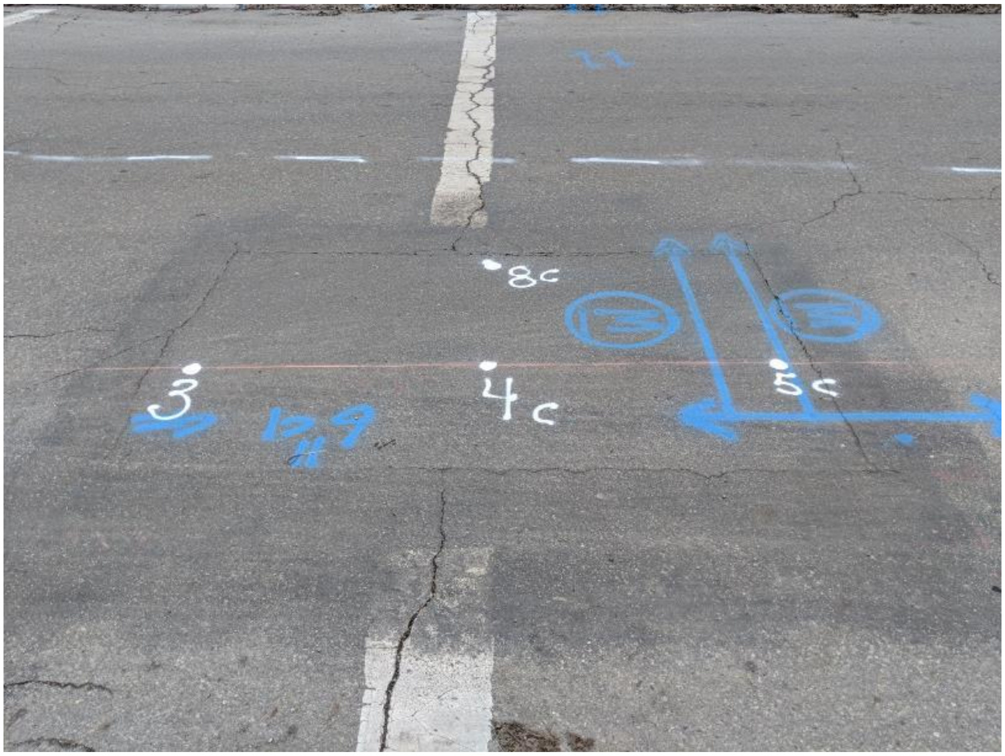


Figure 34 Repair at 62 E. Barthman Ave.

Figure 35 Repair at 50 E. Jeffrey Place.

Figure 36 Repair at 1576 Old Leonard Ave.

12.2.2 "Poor" Repairs

Figure 37 Repair at 61 W. 3rd Ave.

Figure 38 Repair at 85 W. 3rd Ave. (maps.google.com)

Figure 39 Repair at 1734 Old Leonard Ave.

12.3 City of Dayton

Six test locations were selected such that three locations represented poor performance and three locations which represented good performance. Based on information provided by the City of Dayton, all sites selected were believed be asphalt pavements. The following six sites were selected for testing:

1. "Good" repairs
    a. 66 S. Sperling Ave.
    b. 74 S. Sperling Ave.
    c. N. Torrence at Springfield.
2. "Poor" repairs
    a. 85 Paw Paw St.
    b. 316 Urbana Ave.
    c. 60 S. Wright Ave.

Table 28 Selected sites for testing in City of Dayton

Location	Performance	Utility Repaired	Year of Repair
66 S. Sperling Ave.	Good	Water	unknown
74 S. Sperling Ave.	Good	Gas	2014
N. Torrence at Springfield	Good	Gas	2014
85 Paw Paw St.	Poor	Water	2014
316 Urbana Ave.	Poor	Water	2017
60 S. Wright Ave.	Poor	Water	unknown

12.3.1 "Good" Repairs

Figure 40 Repair on 66 S. Sperling Ave.

Figure 41 Repair on 74 S. Sperling Ave.

Figure 42 Repair on N. Torrence at Springfield.

12.3.2 "Poor" Repairs

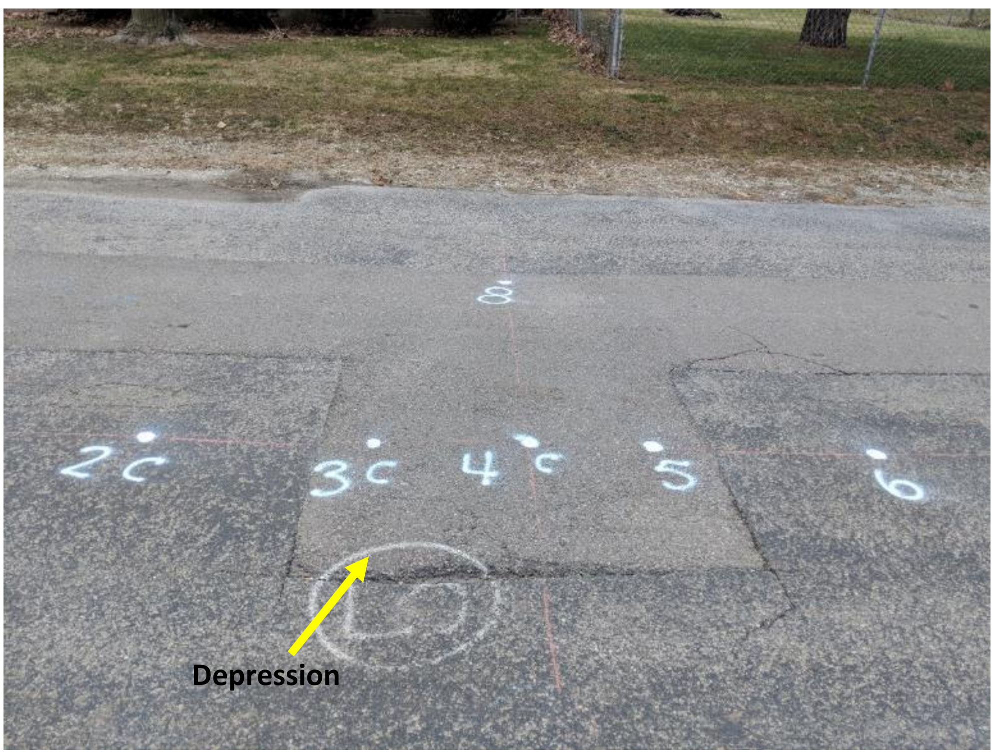


Figure 43 Repair on 85 Paw Paw St.

Figure 44 Repair on 316 Urbana Ave.

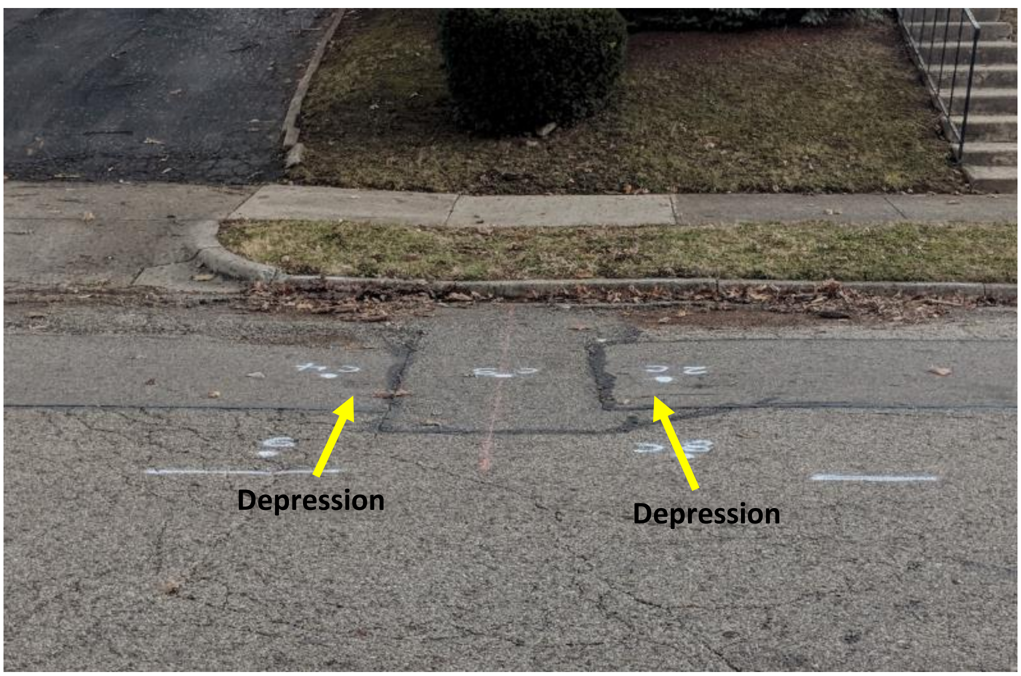


Figure 45 Repair on 60 S. Wright Ave.

13 Appendix F: Results of Field and Laboratory Testing

13.1 Field and Laboratory Testing

Field evaluations were conducted to identify possible mechanisms of failure for the poorly performing repairs and possible reasons for success on the well performing repairs. Falling weight deflectometer

(FWD) testing was conducted to evaluate the quality of the pavement restoration and to determine if the restoration created a weakening of the soil near the repair boundary (zone of influence as identified by Schaefer et al., (2005)). Pavement cores were extracted for observation and laboratory testing to verify quality of construction, and profile measurements of the repair will be measured in the field to evaluate ride quality.

Tasks performed during the field evaluation included:

1. Measure patch and pavement dimensions
2. Photograph site to document condition of pavement and repair
3. Measure longitudinal profile of the pavement and repair through the centerline of the repair and transverse profile through the center of the repair to evaluate ride quality of the repaired area
4. Measure pavement stiffness/response with the falling weight deflectometer
5. Core pavement and repair to determine pavement layer thickness and collect samples for laboratory testing.

The cities of Cleveland and Columbus required a permit to work on city right-of-way. Both granted the research team a blanket permit. A permit was not required in the City of Dayton.

The week prior to the planned field evaluation, the Ohio Utility Protection Service (OUPS) was contacted. Ohio law required OUPS be contacted no less than 48 hours before, and no more than 10 days when excavation or drilling is planned near a utility. OUPS is a one call service which notifies underground utilities located in the area of work. These utilities mark the location of their respective utility on the pavement prior to the planned work.

Maintenance of traffic (MOT) was coordinated with the city. MOT typically consisted of signs and cones. Flag people, with paddle stop/slow signs, were used as necessary.

After MOT was in place, the dimensions of the repair were measured. A line for FWD and dipstick measurements was marked on the pavement using a chalk line and locations for FWD tests and cores, as shown in Figure 46, were marked on the pavement using paint. Photographs of the repair and markings were taken to document test locations and condition of the repair and pavement. Valves and manhole covers, utility markings on the pavement in response to the OUPS notice, etc. were noted in order to identify the utility repaired.

Figure 46 Example of chalk line and core layout.

Profile of the pavement was collected along the centerline of the lane using a FACE Dipstick 2200 profiler, as shown in Figure 47. The centerline, rather than a wheel path, was chosen because this was assumed to be the “as constructed” profile, unaffected by traffic, and would show any changes in road profile due to settlement or heaving. Dipstick measurements were typically began 25 feet from the edge of the repair and continued to approximately 25 feet on the opposite side of the repair. The dipstick measurements were then continued back to the original starting point along the same chalk line. The transverse profile of the centerline of the repair was also measured with the dipstick.


Figure 47 FACE Dipstick profiler used to collect profile along center of the lane.

Upon completion of the dipstick measurements, FWD tests were conducted. Schaefer et al. (2005) were able to capture the effect of the zone of influence in measured FWD deflections by conducting tests strategically spaced within the repair and outside of the repair and at varying load levels. An example of the FWD test spacing used by Schaefer et al. (2005) for one site is shown in Figure 48. The distances between FWD tests Schaefer et al. (2005) used were varied based on the dimensions of the patch and if applicable, the cutback region. Deflections measured away from the boundary of the repair help to determine how much of the adjacent area is affected by the open cut. While deflections measured within the cutback region and just outside the boundary captured the effect of the zone of influence. Schaefer et al. (2005) found deflections far away from the boundary of the repair (19 ft (5.8 m) in the example shown) were generally low, indicating the area was relatively undisturbed by the open cut. Tests within the cutback region (the area outside the limits of the excavation but within the pavement patch) were assumed to be in the zone of influence. Furthermore, they found measured deflections in the cutback region tended to be the highest, indicating a reduction in stiffness of the material in the zone, while tests in the middle of the repair tended to be the lowest (Schaefer et al., 2005).

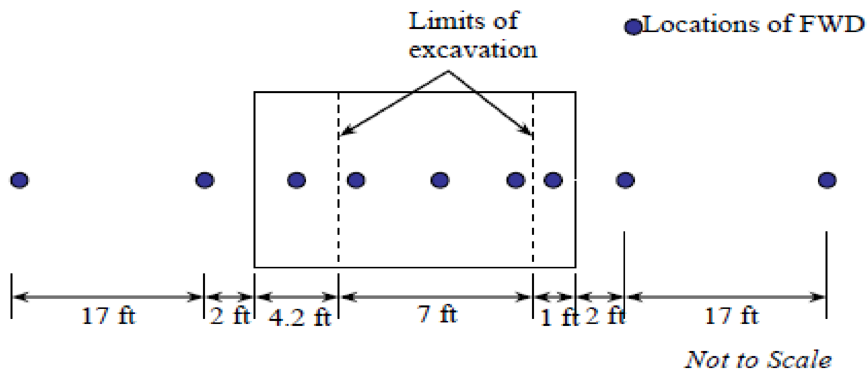


Figure 48 FWD Layout (Schaefer et al., 2005)

An approach similar to the one used by Schaefer et al. (2005) was used to capture the FWD deflections in and adjacent to the repair. To do so, FWD tests at four drop heights corresponding to target loads of 6000 lbs (26.7 kN), 9000 lbs (40.0 kN), 12,000 lbs (53.4 kN), and 15,000 lbs (66.7 kN) were conducted at three locations within the pavement repair and two each on either side of the repair, as shown in Figure 49. Testing was conducted with a JILS FWD, shown in Figure 50. Locations within the pavement repair were near the middle of the repair, and just inside the edge of the repair on each side. Testing outside of the repair was conducted near the boundary, at approximately two to three feet from the edge and at a distance far enough away the material would be undisturbed by the open cut. Measurements were collected in both directions to permit determination of base resilient modulus, as explained in section 13.1.2, on both sides of the repair. The sensor arrangement shown in Figure 51 was used for all testing. Distances between tests were determined on a site-by-site basis.

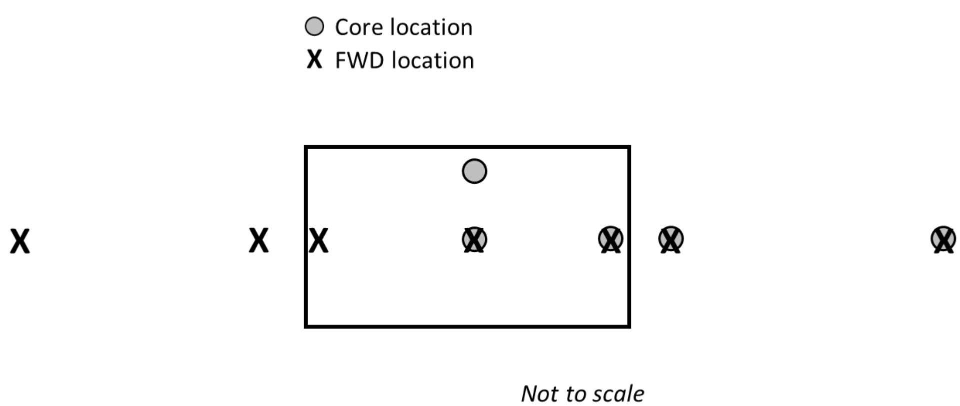


Figure 49 Schematic of test layout.

Figure 50 JILS FWD.

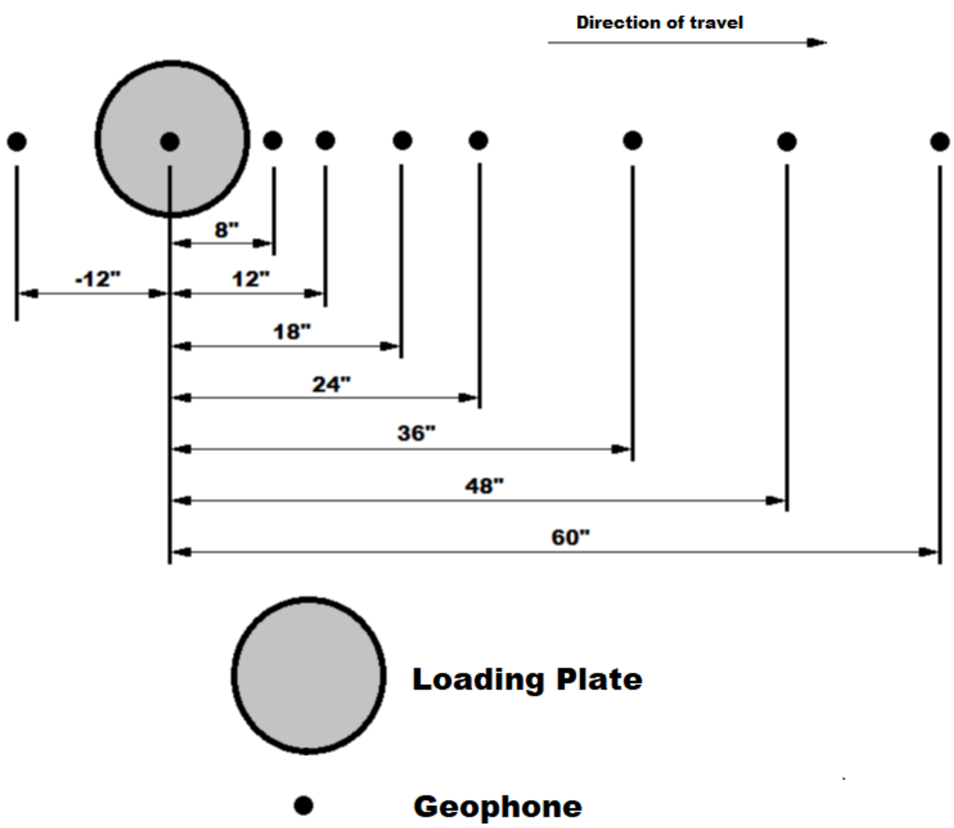


Figure 51 Layout of sensors (geophones).

Coring, as shown in Figure 52, was conducted at five locations at each site to observe the cross-sections of the existing pavement restoration and existing pavement. Typically, three pavement cores were collected within the boundary of the repair, and two outside, as shown in the testing schematic. Observations of each core were used to help characterize the performance of each site. Thicknesses of each core were measured. Samples of the granular or stabilized base were collected using a core bit or hammer driven soil core sampler, as shown in Figure 53. Base material sampled was sealed in tubes or bags and transported to the laboratory for determination of moisture content and visual determination of color and grain size. Upon completion of the sampling, holes were repaired in accordance with the requirements of the respective city.

Figure 52 Coring of existing pavement.

Figure 53 Sampling of base or backfill material.

A plot of each repair along with FWD and core locations are provided for each location in Figures 54 through 71.

Laboratory testing was conducted on the collected cores to evaluate quality of construction. The laboratory testing is described in later subsections.

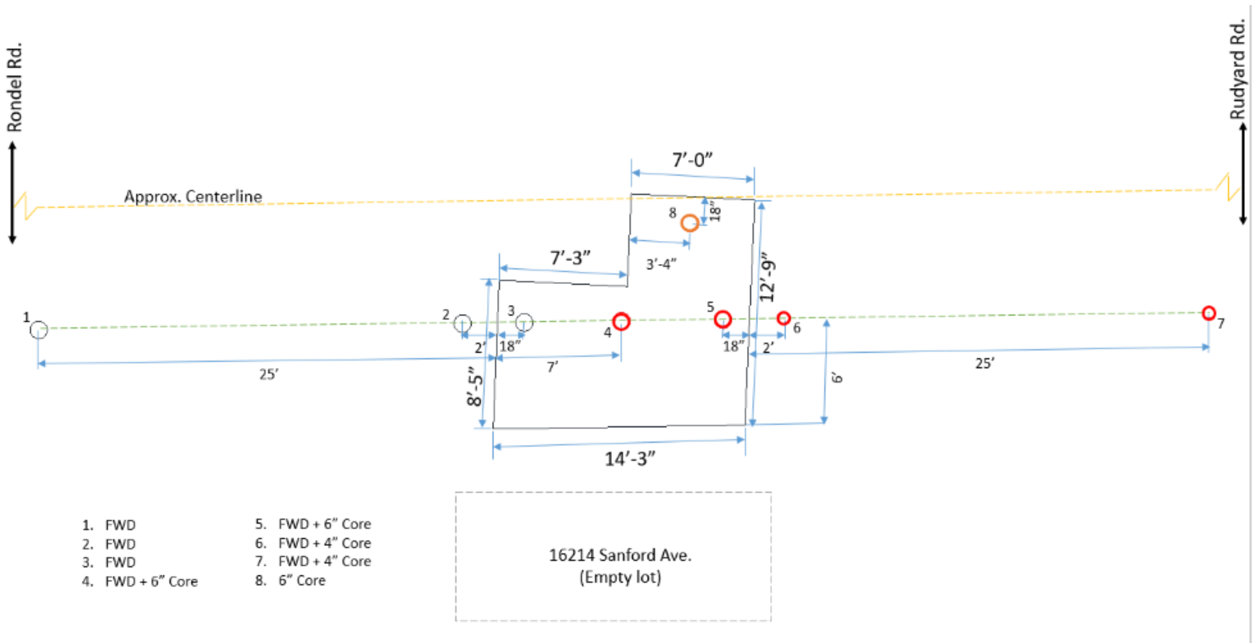


Figure 54 Repair dimensions and testing layout, 16214 Sanford Ave. (1 ft = 0.3048 m; 1 in = 2.54 cm)

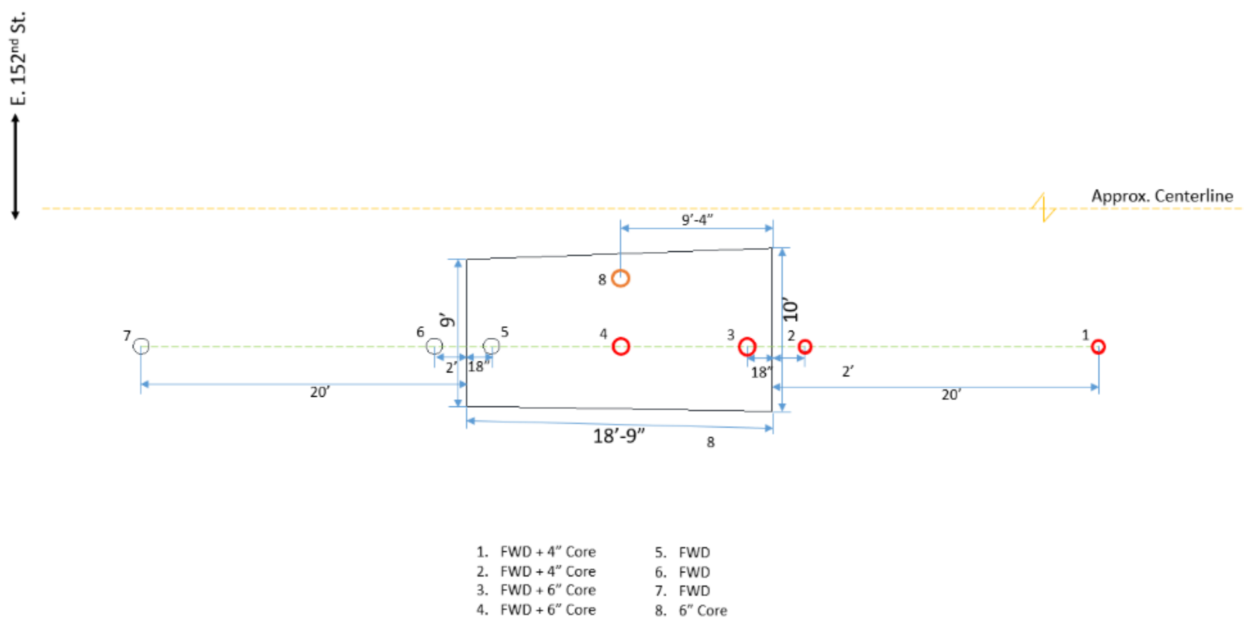


Figure 55 Repair dimensions and testing layout, Pepper Ave. (1 ft = 0.3048 m; 1 in = 2.54 cm)

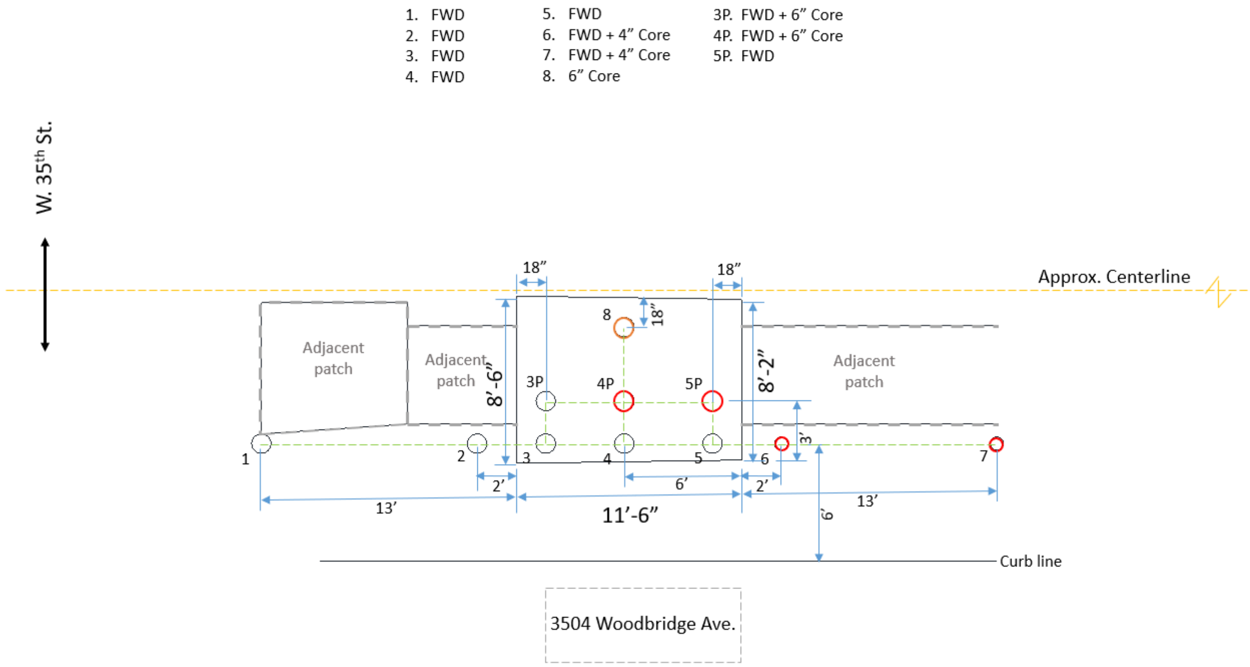


Figure 56 Repair dimensions and testing layout, 3504 Woodbridge Ave. (1 ft = 0.3048 m; 1 in = 2.54 cm)

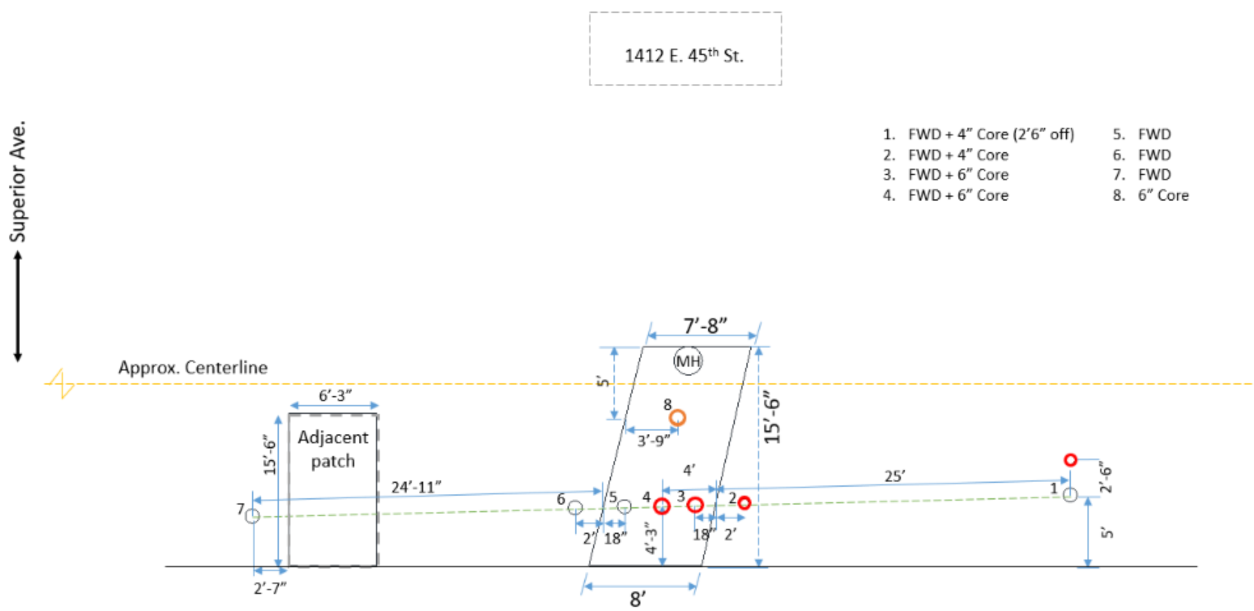


Figure 57 Repair dimensions and testing layout, 1412 E. 45th St. (1 ft = 0.3048 m; 1 in = 2.54 cm)

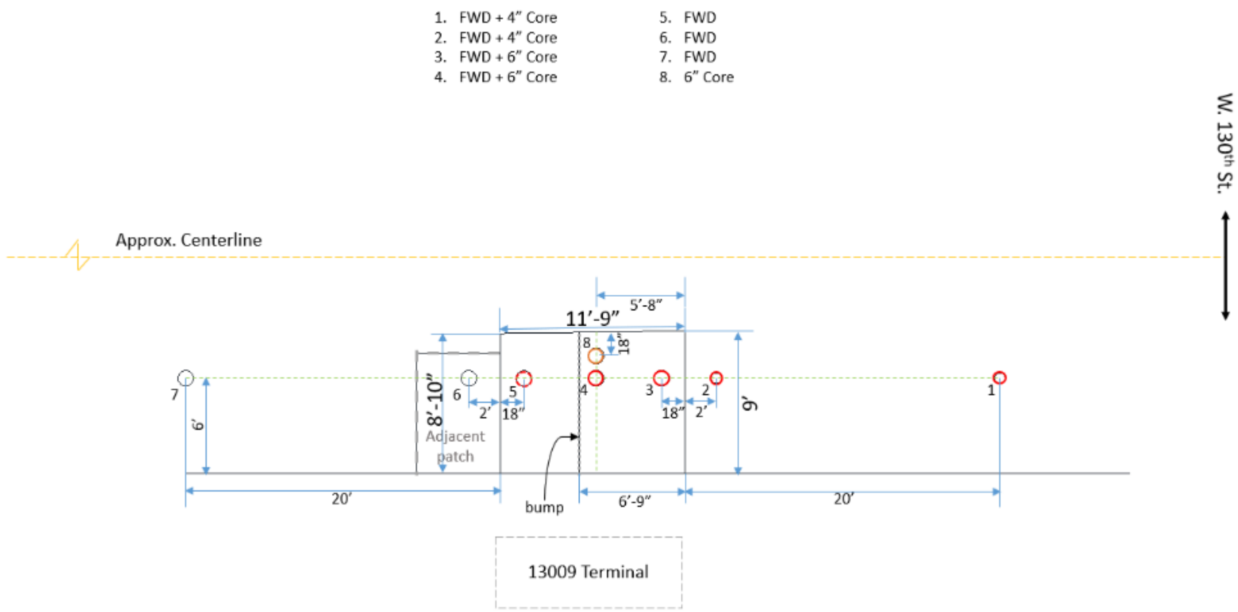


Figure 58 Repair dimensions and testing layout, 13009 Terminal Ave. (1 ft = 0.3048 m; 1 in = 2.54 cm)

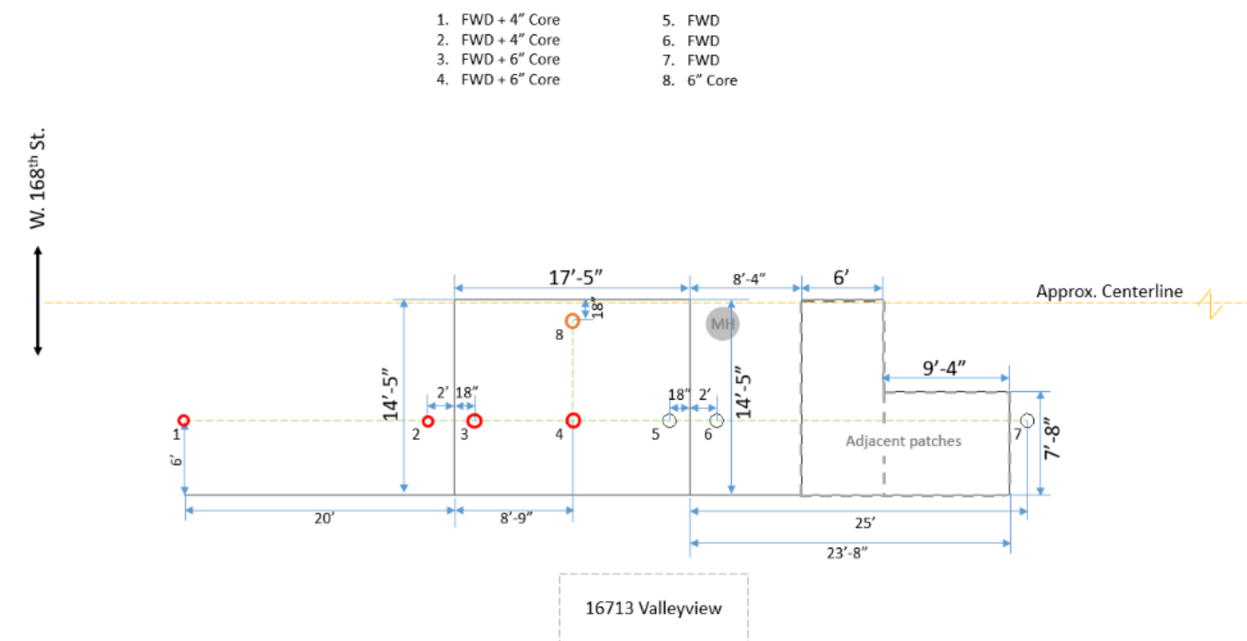


Figure 59 Repair dimensions and testing layout, 16713 Valleyview Ave. (1 ft = 0.3048 m; 1 in = 2.54 cm)

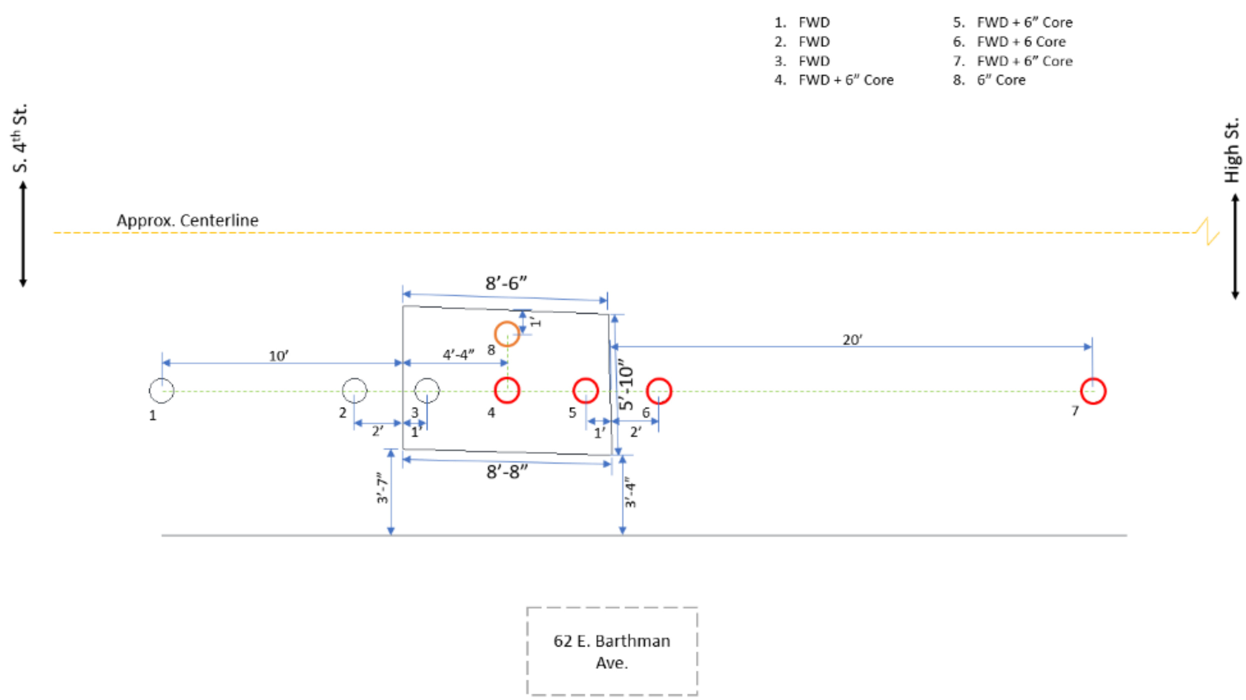


Figure 60 Repair dimensions and testing layout, 62 E. Barthman Ave. (1 ft = 0.3048 m; 1 in = 2.54 cm)

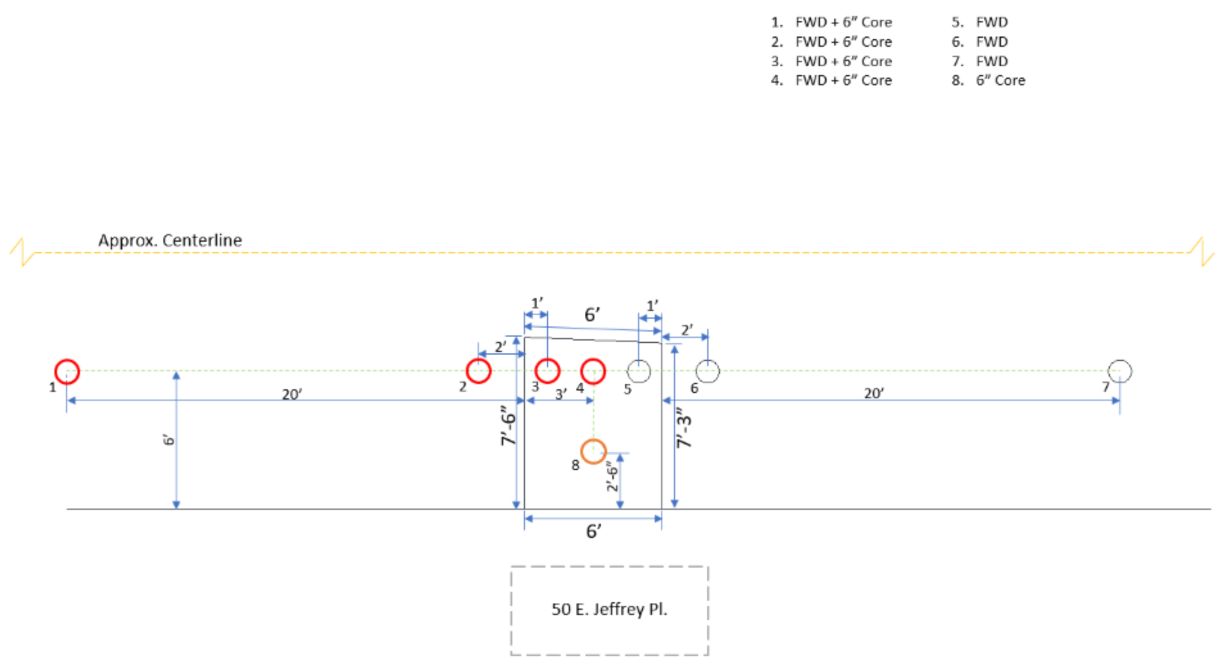


Figure 61 Repair dimensions and testing layout, 50 E. Jeffrey Pl. (1 ft = 0.3048 m; 1 in = 2.54 cm)

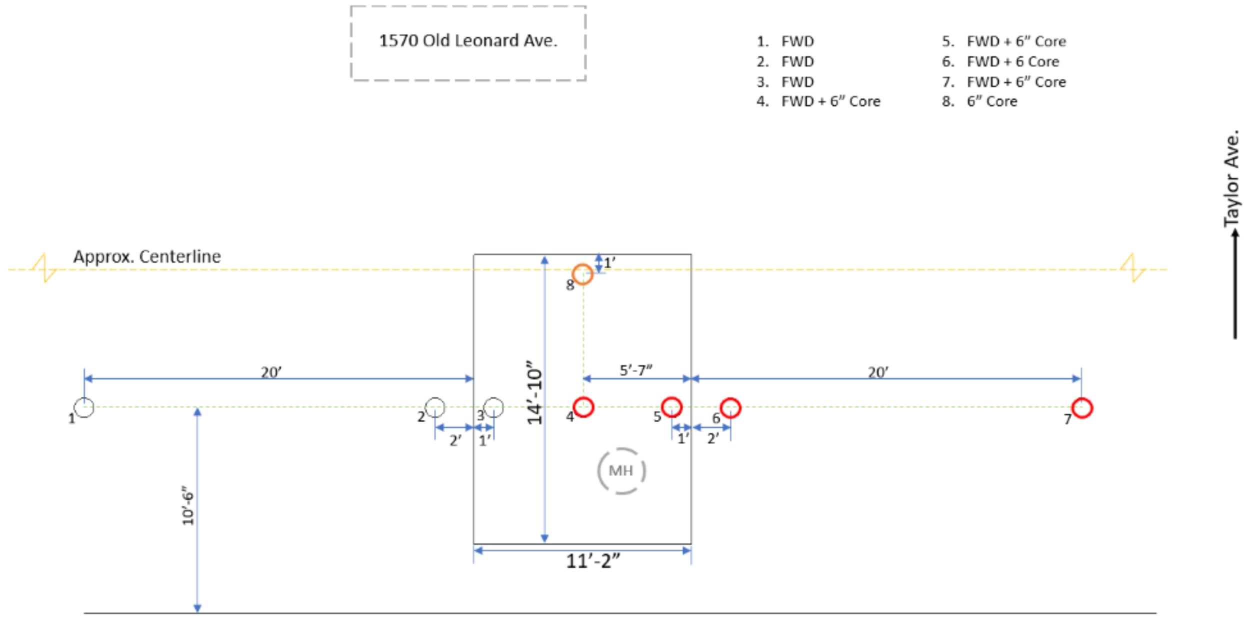


Figure 62 Repair dimensions and testing layout, 1576 Old Leonard Ave. (1 ft = 0.3048 m; 1 in = 2.54 cm)

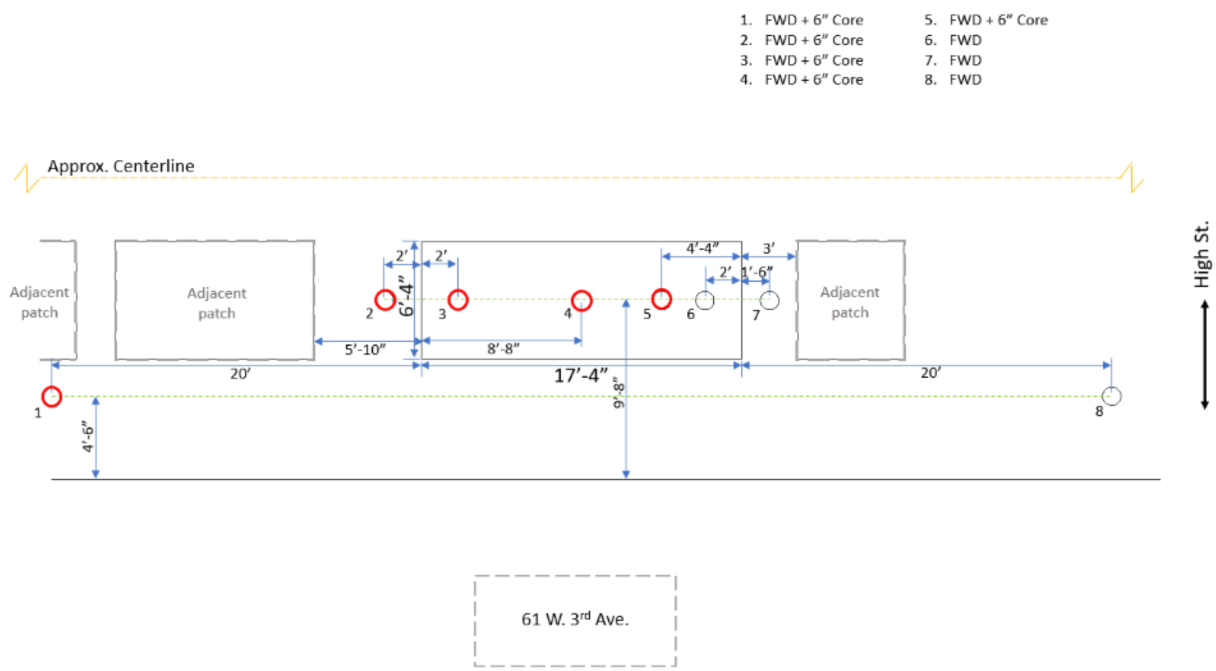


Figure 63 Repair dimensions and testing layout, 61 W. 3rd Ave. (1 ft = 0.3048 m; 1 in = 2.54 cm)

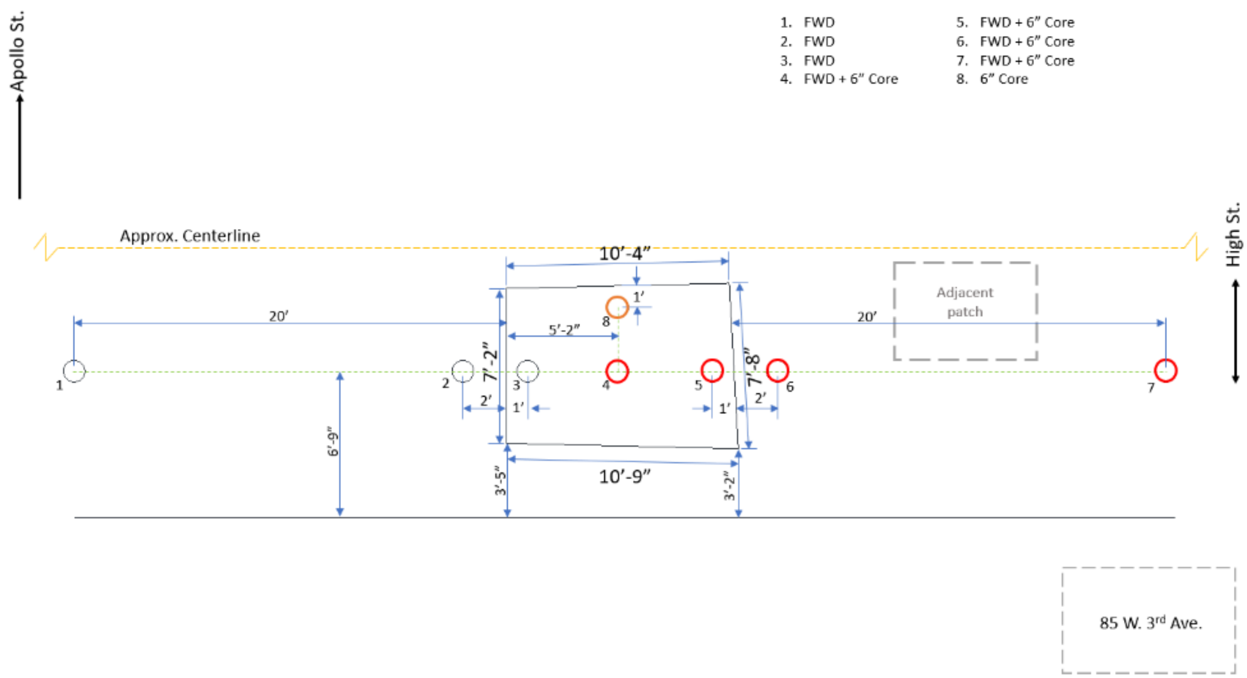


Figure 64 Repair dimensions and testing layout, 85 W. 3rd Ave. (1 ft = 0.3048 m; 1 in = 2.54 cm)

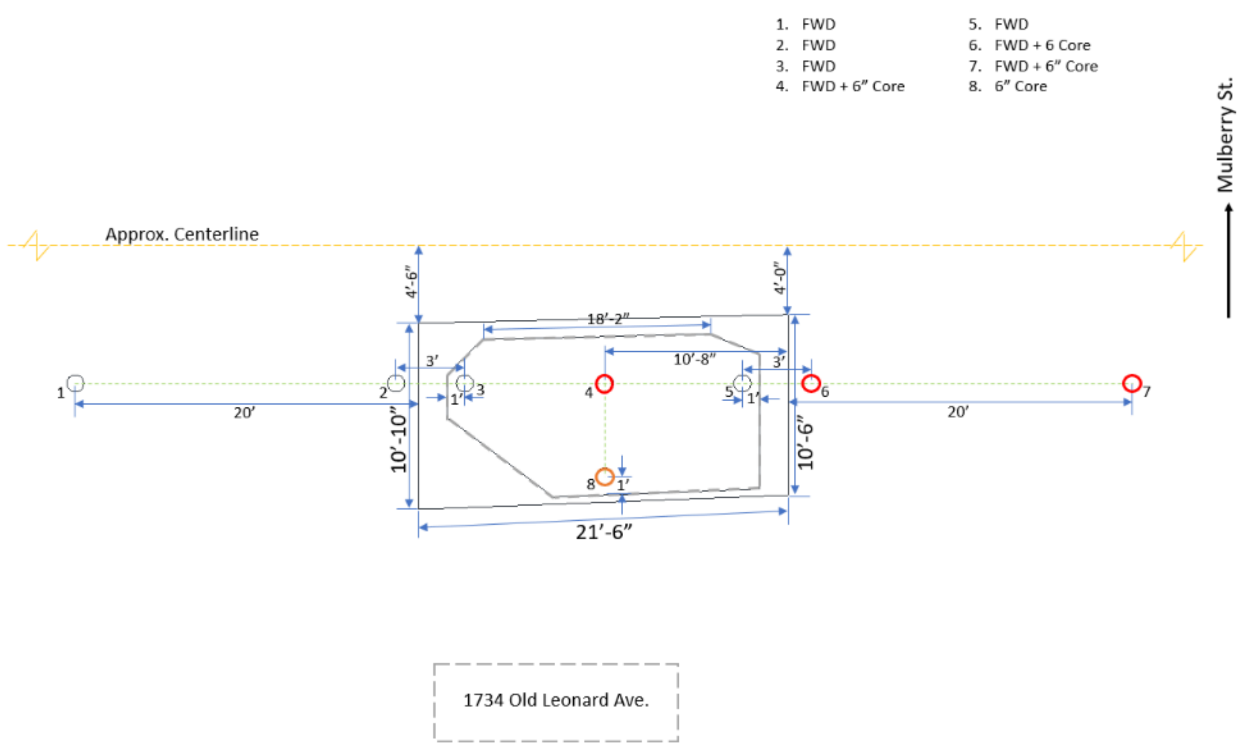


Figure 65 Repair dimensions and testing layout, 1734 Old Leonard Ave. (1 ft = 0.3048 m; 1 in = 2.54 cm)

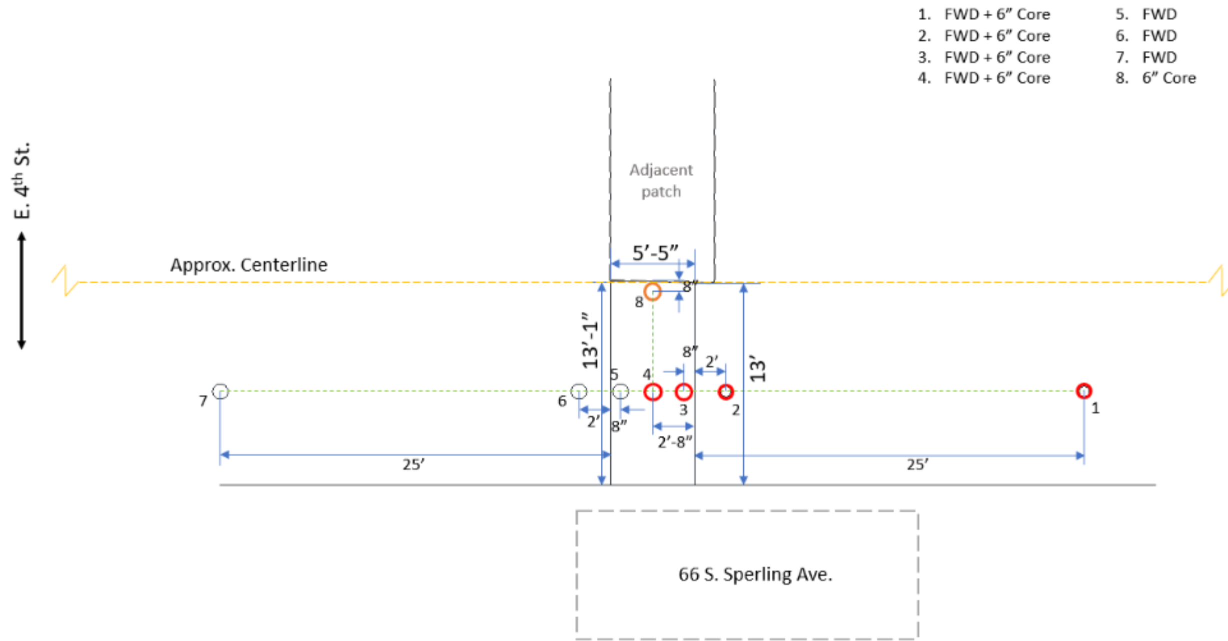


Figure 66 Repair dimensions and testing layout, 66 S. Sperling Ave. (1 ft = 0.3048 m; 1 in = 2.54 cm)

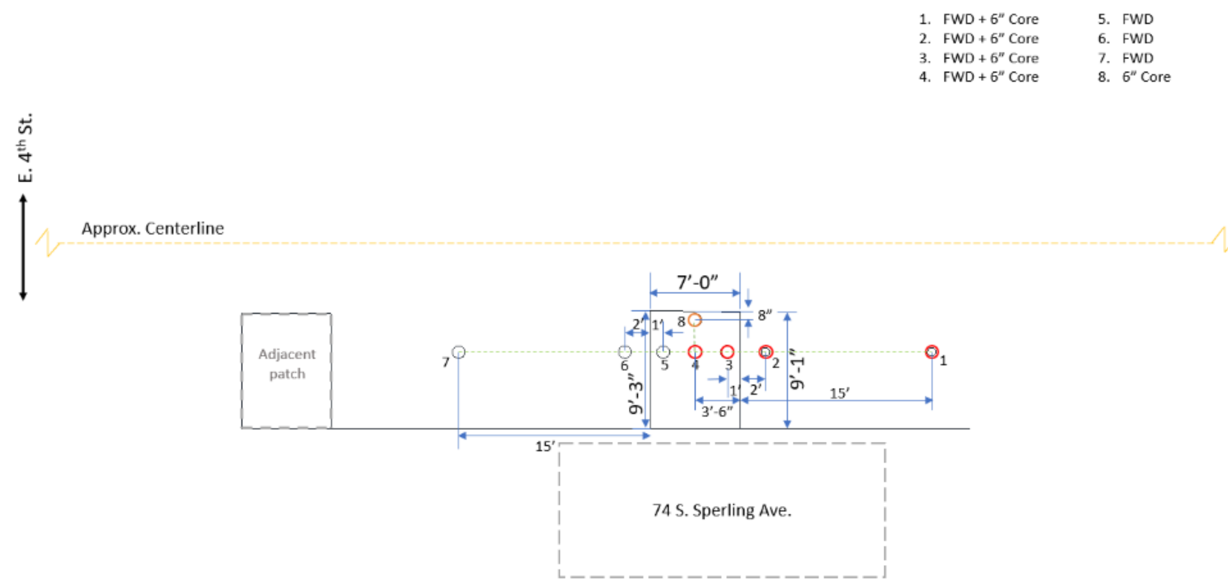


Figure 67 Repair dimensions and testing layout, 74 S. Sperling Ave. (1 ft = 0.3048 m; 1 in = 2.54 cm)

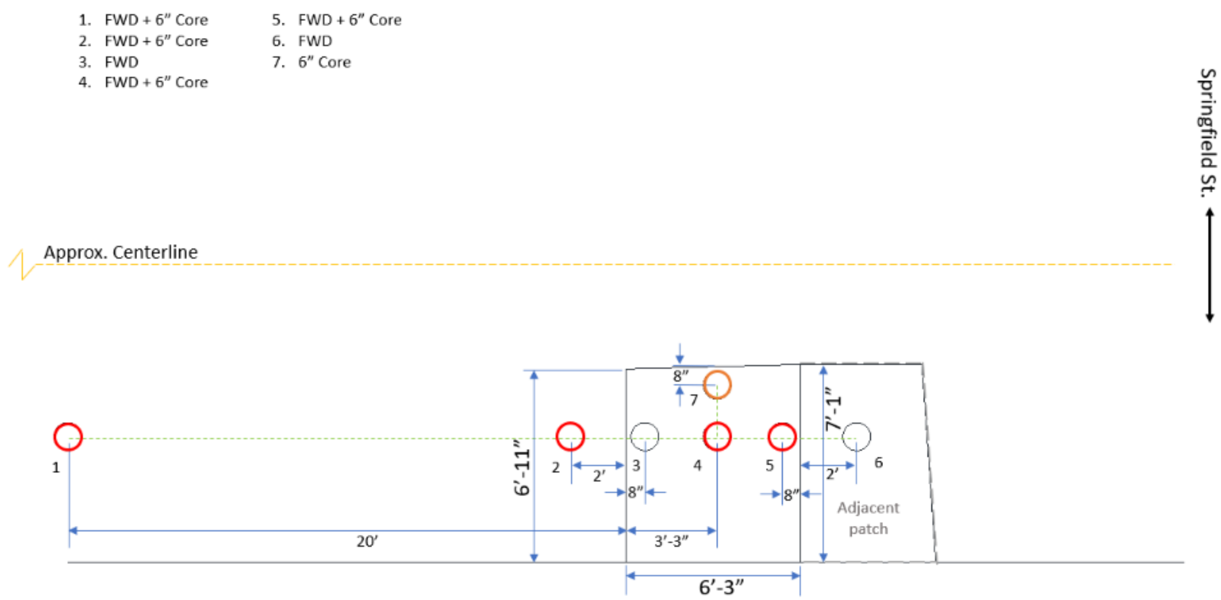


Figure 68 Repair dimensions and testing layout, N. Torrence and Springfield St. (1 ft = 0.3048 m; 1 in = 2.54 cm)

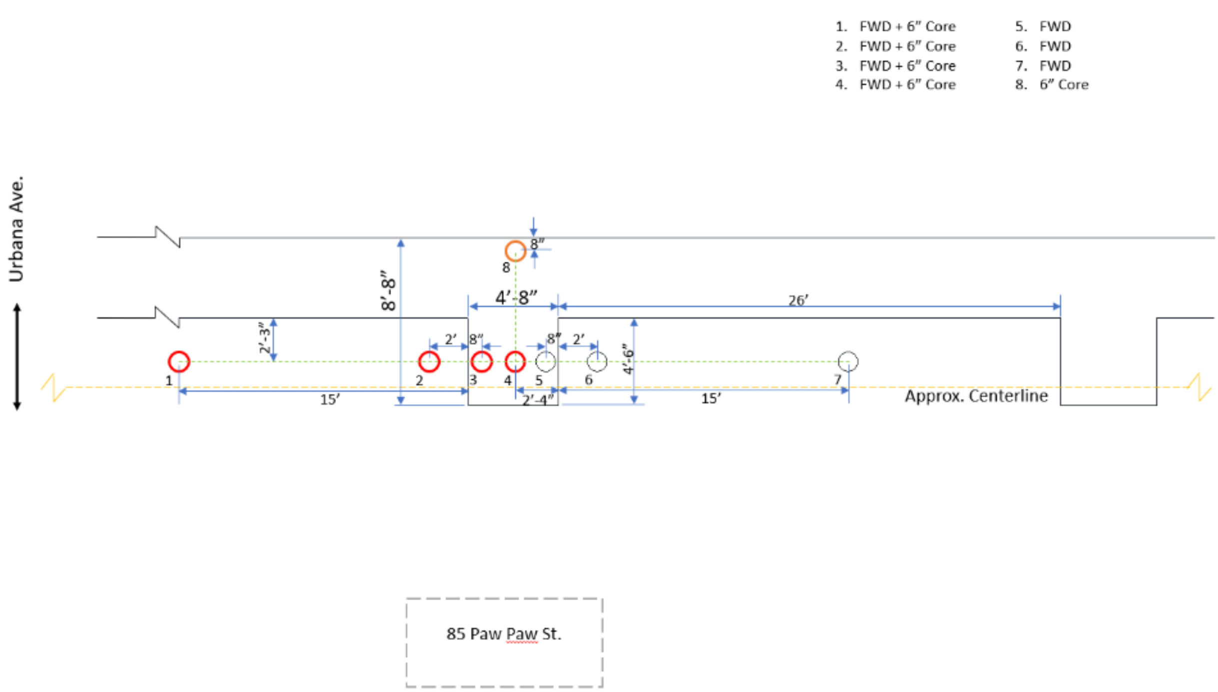


Figure 69 Repair dimensions and testing layout, 85 Paw Paw St. (1 ft = 0.3048 m; 1 in = 2.54 cm)

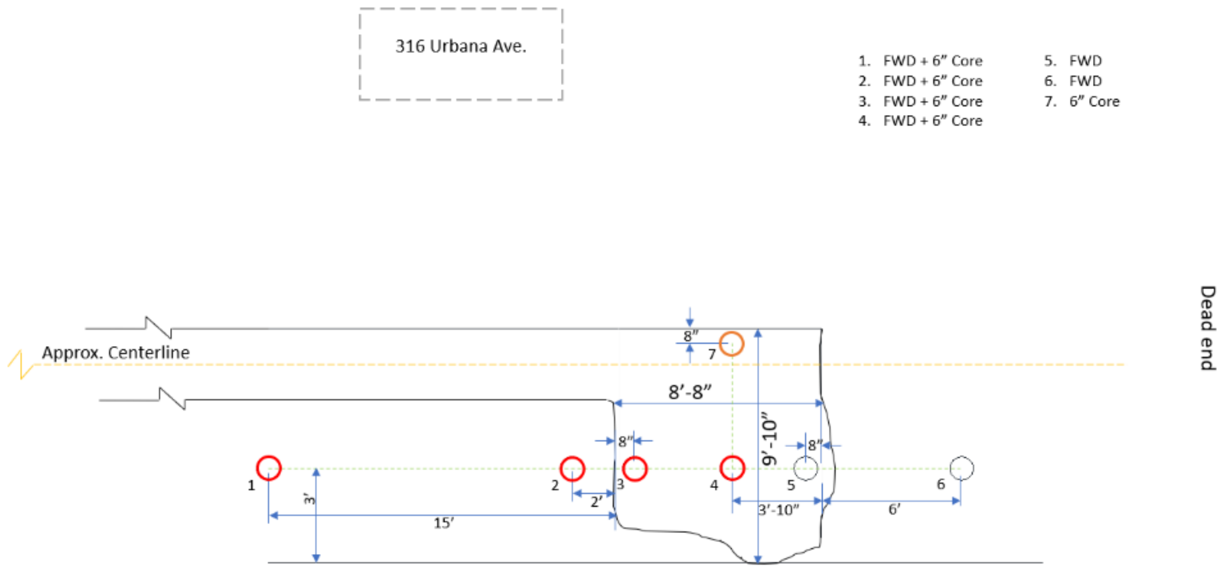


Figure 70 Repair dimensions and testing layout, 316 Urbana Ave. (1 ft = 0.3048 m; 1 in = 2.54 cm)

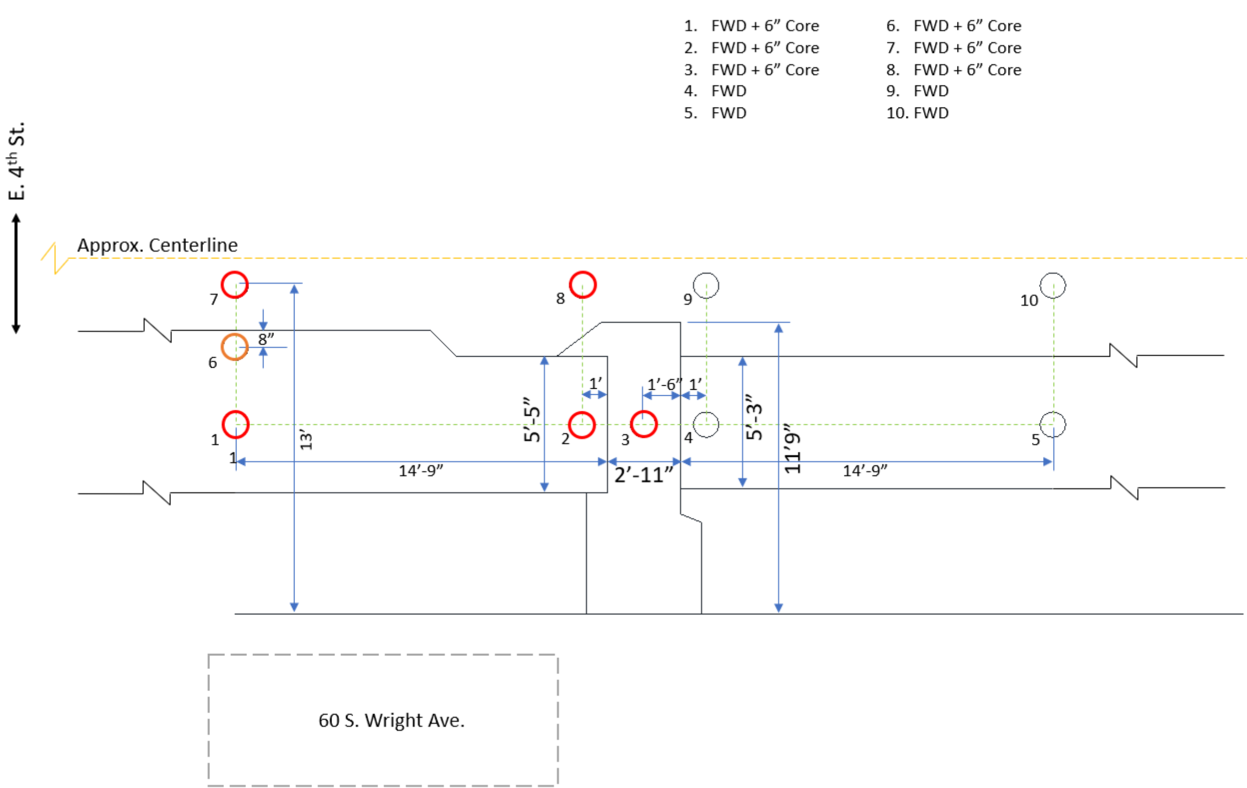


Figure 71 Repair dimensions and testing layout, 60 S. Wright Ave. (1 ft = 0.3048 m; 1 in = 2.54 cm)

13.1.1 Dipstick Testing

Profile elevations were collected with a FACE Dipstick model 2200 on the dates indicated in Table 29. Per manufacturer's instructions, the dipstick was turned on and allowed to warm up 5 minutes before testing. Dipstick measurement were taken beginning at FWD/core location 1 for longitudinal profile or the edge of pavement/curb for transverse profiles. The first measurement point of each profile was used to calibrate the dipstick per manufacturer's recommendations. The dipstick was placed on the chalk line and the location of the feet marked with a lumber crayon. The calibration mode was initiated and the first calibration measurement taken. The dipstick was lifted, rotated 180 degrees, the feet placed on the marks, and the last calibration measurement taken. Despite the care taken during this step, there was small error in the calibration as evident by the drift in the data. Once calibrated, dipstick measurements were taken longitudinally up station and down station, and transversely from edge of pavement to centerline of the road and back, through the estimated center of the repair.

Table 29 Dipstick Profile Collection Date

City	Location	Dipstick Test Date
Cleveland	13009 Terminal Avenue	11/30/2018
Cleveland	16713 Valleyview Avenue	11/29/2018
Cleveland	3504 Woodbridge Avenue	11/29/2018
Cleveland	1412 East 45th Street	11/29/2018
Cleveland	Pepper Avenue at East 152nd Street	11/28/2018
Cleveland	16214 Sanford Avenue	11/28/2018
Dayton	74 S. Sperling Avenue	1/9/2019
Dayton	66 S. Sperling Avenue	1/9/2019
Dayton	60 S. Wright Avenue	1/9/2019
Dayton	N. Torrence at Springfield	1/9/2019
Dayton	316 Urbana Avenue	1/9/2019
Dayton	85 Paw Paw Street	1/9/2019
Columbus	1734 Old Leonard Avenue	3/12/2019
Columbus	1576 Old Leonard Avenue	3/12/2019
Columbus	62 East Barthman Avenue	3/12/2019
Columbus	50 East Jeffrey Place	3/11/2019
Columbus	85 West 3rd Avenue	3/11/2019
Columbus	61 West 3rd Avenue	3/11/2019

13.1.2 FWD Testing

A properly repaired open utility cut would be expected to have a service life equal to or greater than the surrounding pavement. In addition, the repair should be sufficiently long enough to encompass all subgrade material weakened by the utility break or by excavation to repair the utility. Deflection data collected by the falling weight deflectometer (FWD) can be utilized to analyze the pavement structure and subgrade.

FWD measurements were collected with a JILS falling weight deflectometer (FWD). The JILS model used was a trailer mounted, self-powered model. FWD measurements were collected at seven test locations shown in Figure 49. At some sites, additional test locations were tested due to the configuration of the repair. The FWD measurements were taken in both directions in order to collect a full deflection bowl in the repair at the boundaries. The JILS FWD was equipped with nine sensors as shown in Figure 51.

Typically, layer modulus values are backcalculated from the data however, the results obtained from this process can be highly variable, especially when the layers being analyzed vary in terms of material type and thickness. The closely spaced sensors near the loading plate were chosen to improve backcalculation estimates of layer moduli when evaluating thin pavement layers. The sensors spaced at 12 inches (30.48 cm) allow for the commonly used AREA analysis method (Pavement Interactive, 2019).

However, the parameters of interest on this project, the stiffness of the repair compared to the surrounding pavement, and the modulus of the base used in the repair, do not require the use of sophisticated backcalculation techniques. An analysis of pavement stiffness, i.e. the load divided by deflection, can achieve the goal of comparing the structure capacity of the repair to the surrounding pavement. If the stiffness values are normalized relative to the repair stiffness, comparisons within and between sections can be made.

FWD data were normalized using the following procedure:

- Stiffness is determined by dividing the measured load at test location by the deflection data collected at the sensor located at the center of the load plate
- Stiffness is normalized relative to the repair for a location by dividing the stiffness at an FWD test location by the stiffness at the center of the repair (typically FWD location 4).

As a result of the calculation, the value for normalized stiffness at the center of the repair will be 1.00. Values higher than 1.00 indicate the pavement structure at that location is more stiff than the repair. A value lower than 1.00 indicate the pavement structure at that location less stiff than the repair.

FWD measurements were also used to determine the modulus of the material used for the base under the repair. Equation 1, from section 5.4.5 of the 1993 AASHTO Guide for Design of Pavement Structures (AASHTO, 1993) was used to directly estimate base resilient modulus.

$$M_R = \frac{0.24P}{d_r r} \quad \text{Equation 1}$$

where,

M_R = backcalculated subgrade resilient modulus, psi
P = applied load, pounds
d_r = deflection at distance r from the center of the load, inches
r = distance from center of load, inches

The stress from the FWD load applied to the pavement is distributed at an angle of approximately 34 degrees from the surface (Irwin et al., 2010). The deflection at a location is only affected by the layers below the stress bulb at the distance of the sensor from the load. For example, the deflection at location 2 in Figure 72 is only influenced by the modulus that would be measured at the top of layer 2. Likewise, the deflection at location 5 is only influenced by the modulus measured at the top of layer 3. The modulus values determined for this project using equation 1 were determined using the sensor distance which would most closely match the intersection of the stress bulb, assuming an angle of 34 degree, and the base layer. Testing in both directions was necessary to place the outlying sensors in the repair area, rather than across the repair boundary, for the test.

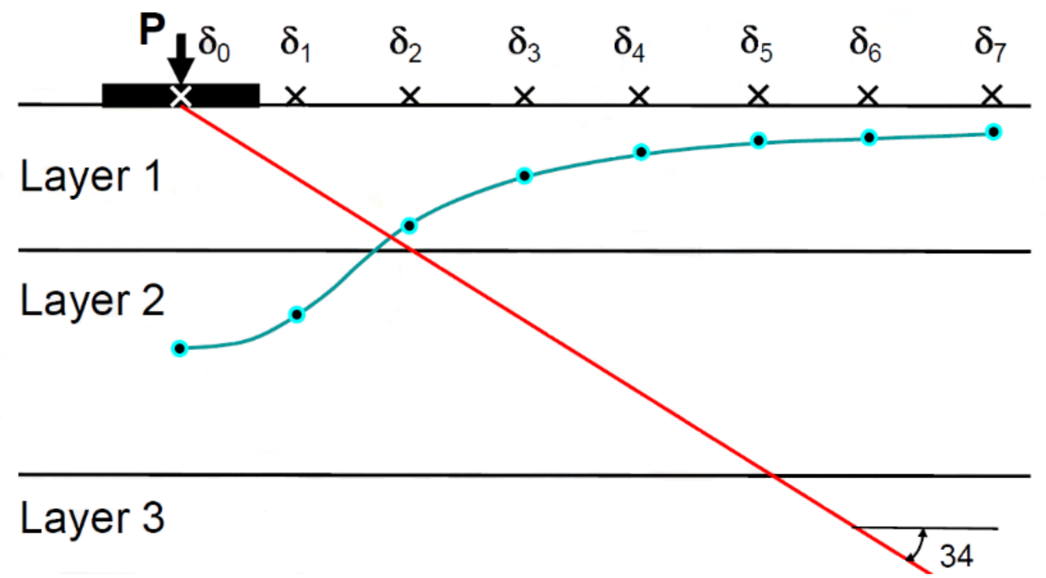


Figure 72 Stress distribution under FWD loading (Irwin et al., 2010).

13.1.3 Coring

Coring was performed on the dates indicated in Table 30. Cores were taken after profile measurement and FWD testing were completed. This was because core holes would affect the profile and deflection measurements. Cores were obtained with an electric core drill mounted on a core rig anchor stand. For concrete pavements, coring was conducted in accordance with ASTM C42. Four-inch diameter cores were obtained outside the repair area. Cores within the repair area were drilled to the depth of the asphalt with a six-inch diameter core bit to ensure sufficient quantity of asphalt would be available for determining bulk specific gravity and maximum theoretical specific gravity. In some cases, the six-inch diameter core bit was used outside of the repair in order to facilitate the measurement of the granular base depth. In addition to determining BSG and MSG on asphalt samples, the cored material was used to determine layer thicknesses, compressive strength of the cemented material, and to obtain samples of the repair base material.

Table 30 Core Sampling Date

City	Location	Date
Cleveland	16214 Sanford Ave.	11/28/2018
Cleveland	Pepper Ave.	11/28/2018
Cleveland	3504 Woodbridge Ave.	11/29/2018
Cleveland	1412 E. 45th St.	11/29/2018
Cleveland	13009 Terminal Ave.	11/30/2018
Cleveland	16713 Valleyview Ave.	11/30/2018
Columbus	62 E. Barthman Ave.	3/12/2019
Columbus	50 E. Jeffrey Place	3/11/2019
Columbus	1576 Old Leonard Ave.	3/12/2019
Columbus	61 W. 3rd Ave.	3/11/2019
Columbus	85 W. 3rd Ave.	3/11/2019
Columbus	1734 Old Leonard Ave.	3/12/2019
Dayton	66 S. Sperling Ave.	1/29/2019
Dayton	74 S. Sperling Ave.	1/29/2019
Dayton	N. Torrence at Springfield	2/27/2019
Dayton	85 Paw Paw St.	2/27/2019
Dayton	316 Urbana Ave.	2/27/2019
Dayton	60 S. Wright Ave.	2/27/2019

13.1.4 Asphalt Density Determination in the Repair

After the research team acquired the pavement cores and returned them to the laboratory, the research team examined the cores to describe the various pavement layer types (asphalt or concrete), the thickness of the various pavement layers, and the condition of the asphalt and concrete materials along the vertical profile. The research team also photographed the pavement cores during the examination to create a core log to accurately describe each core's condition, as shown in Appendix G.

The asphalt laboratory testing program consisted of performing bulk specific gravity and maximum theoretical specific gravity testing on the asphalt surface material. The research team trimmed the cores specimens and performed bulk specific gravity (BSG) in general accordance with ASTM D2726-19 *Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Asphalt Mixtures* on the asphalt surface material. The BSG value is used to determine the bulk specific gravity and density of the existing compacted asphalt mixture, in this case, the asphalt surface mixture. After completing the bulk specific gravity testing, the asphalt surface cores were heated to 140°F to where the asphalt material became plastic. The research team then removed the cut aggregate pieces from each core and combined the asphalt surface material for each sample location into a composite sample. Each composite sample was tested for maximum theoretical specific gravity (MSG) in general accordance with ASTM D2041-11 *Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures*. The MSG value is used to determine the percent compaction and percent air voids of the asphalt cores in general accordance with ASTM D3203 *Percent Air Voids in Compacted Asphalt Mixtures*. The percent compaction for each core was determined by dividing the core BSG by the composite MSG value at each sample location per the following equation:

$$\%\ Compaction = \frac{BSG_{Core}}{MSG_{Composite}}\ x\ 100\%$$

The percent air voids was determined using the following equation from ASTM D3203:

$$\%\ Air\ Voids = 100(1 - \left(\frac{BSG_{Core}}{MSG_{Composite}}\right))$$

13.1.5 Compressive Strength Test

Concrete pavement was recovered from the repair area at all six sites in Cleveland and the site at 1576 Old Leonard Avenue in Columbus. When cores were of sufficient height and the concrete was sound, they were trimmed to a length of two times the diameter. Compressive strength was then determined in accordance with AASHTO T 22.

13.1.6 Analysis of Backfill Material

Moisture content of base and subgrade sampled was determined in accordance with AASHTO T 265. The color and grain size of the material was visually observed. A 6-inch depth of base was collected using a hammer driven soil core sampler. If the sample consisted of CDF or similar cemented material, the sample was sealed in the tube with lids and electrical tape. If the sample consisted of granular material, the sample was sealed in a plastic bag. The moisture content of the sample was determined in accordance with AASHTO T 265, Standard Method of Test for Laboratory Determination of Moisture Content of Soils. CDF samples were examined with a Leica Zoom 2000 microscope to confirm particles were cemented. The color and grain size were visually determined.

13.2 Field Testing Results

13.2.1 Dipstick Results

Profiles were plotted on drawings of the repair to allow for better interpretation. Figures 73 through 75 are profile plots for good performing sections in the cities of Cleveland, Columbus, and Dayton, respectively, whereas Figures 76 through 78 are profile plots for poor performing sections in the cities of Cleveland, Columbus, and Dayton respectively.

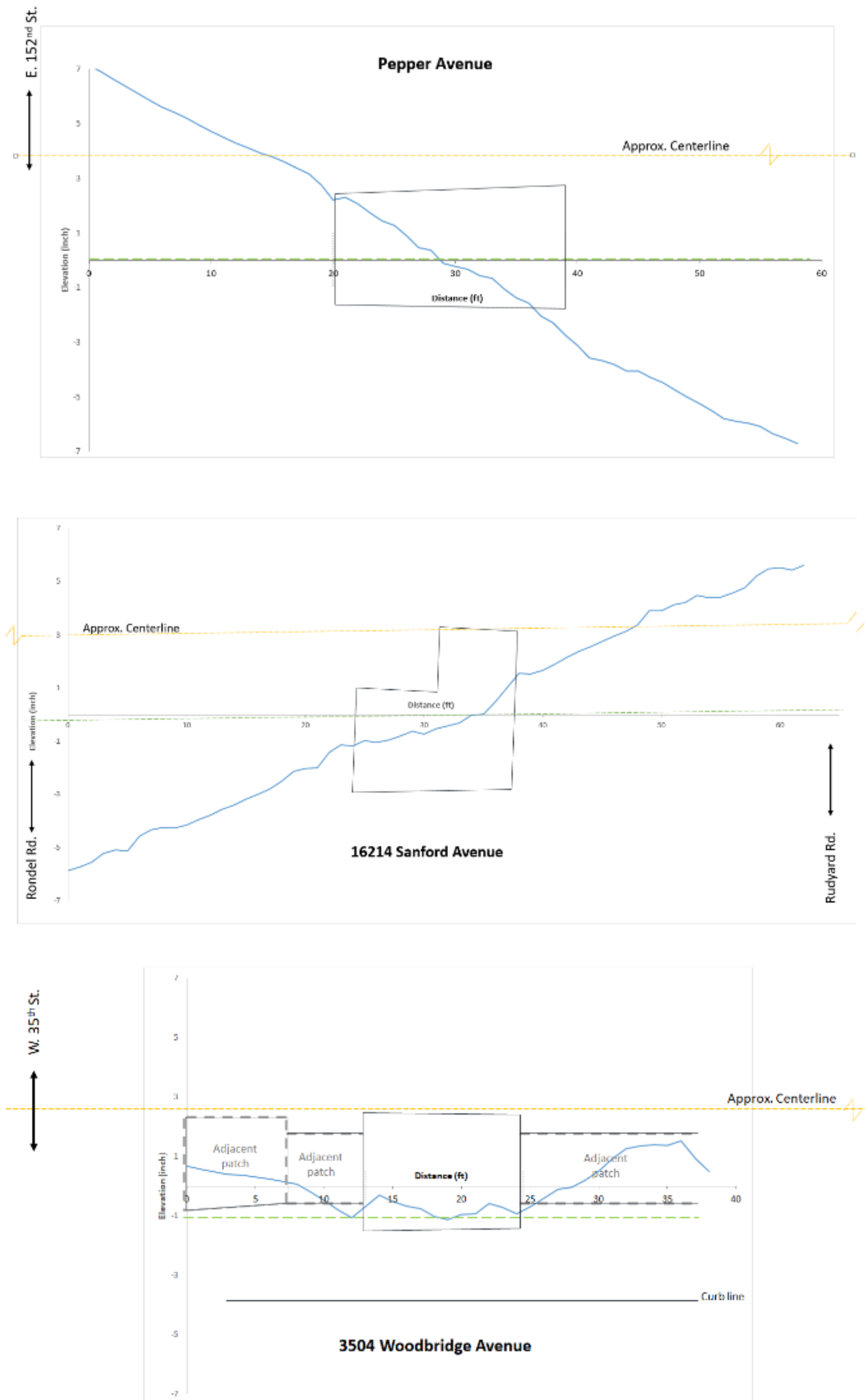


Figure 73 Longitudinal Profiles of Good Performing Sections, Cleveland (1 in = 2.54 cm)

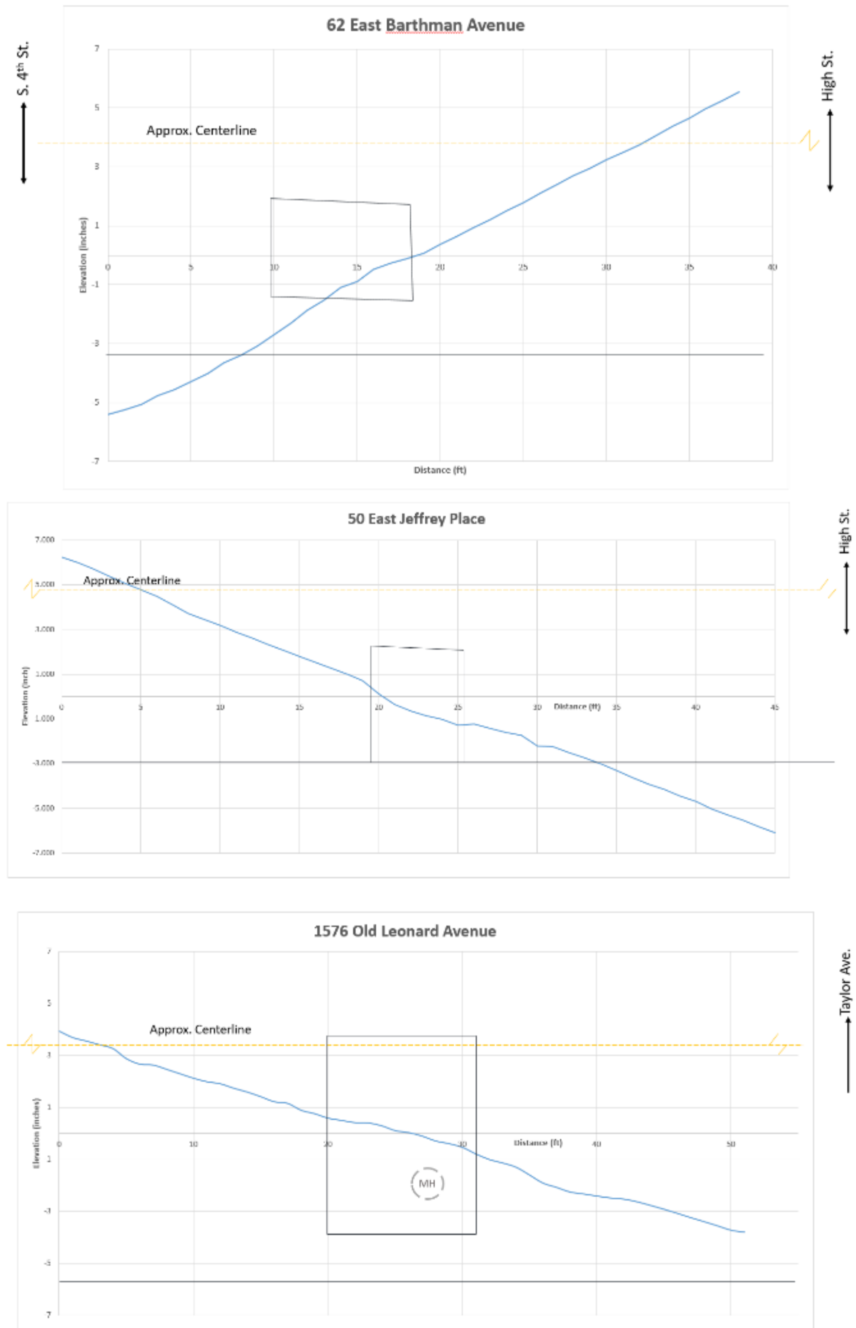


Figure 74 Longitudinal Profiles of Good Performing Sections, Columbus (1 in = 2.54 cm)

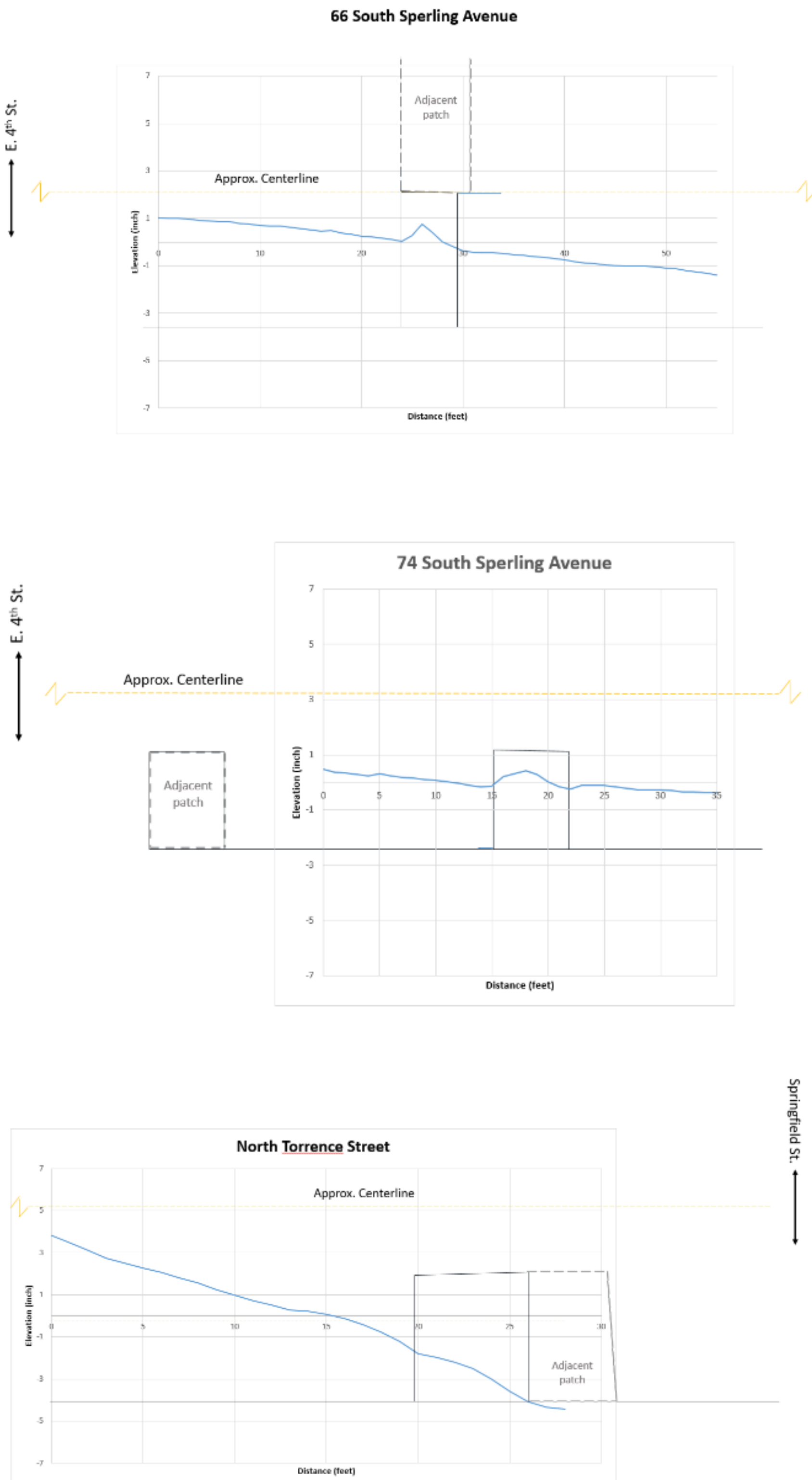


Figure 75 Longitudinal Profiles of Good Performing Sections, Dayton (1 in = 2.54 cm)

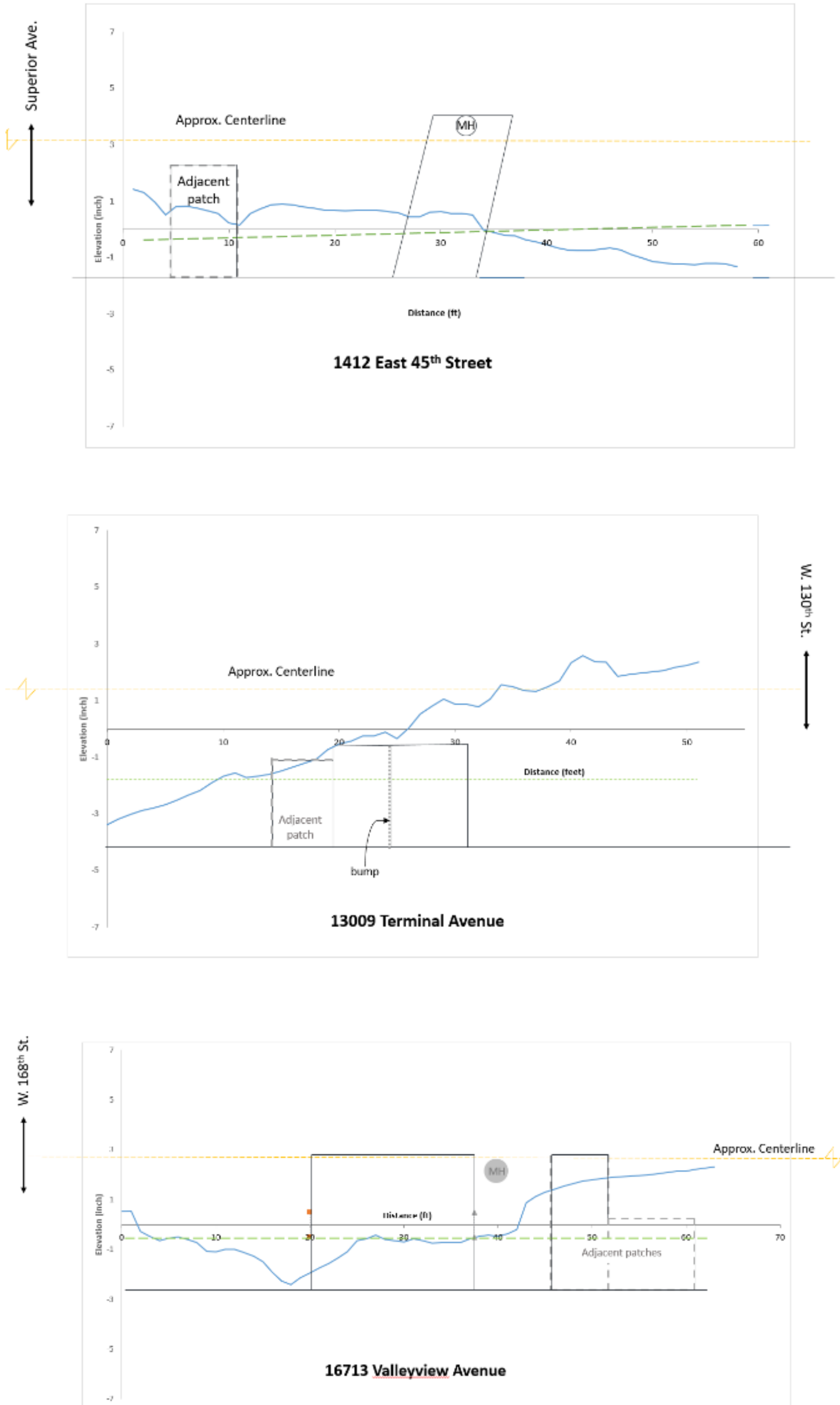


Figure 76 Longitudinal Profiles of Poor Performing Sections, Cleveland (1 in = 2.54 cm)

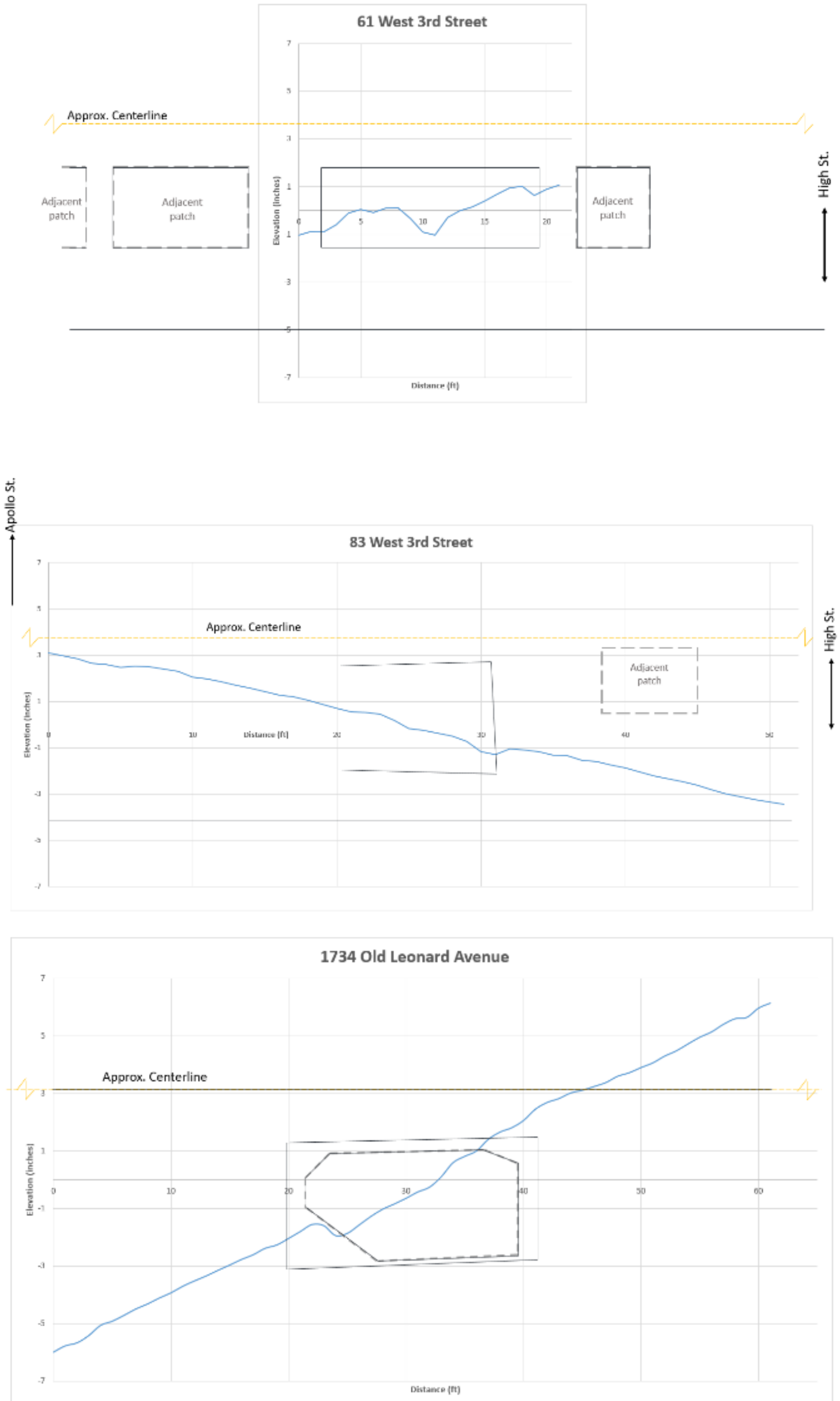


Figure 77 Longitudinal Profiles of Poor Performing Sections, Columbus (1 in = 2.54 cm)

Figure 78 Longitudinal Profiles of Poor Performing Sections, Dayton (1 in = 2.54 cm)

To quantify the amount of dip or heave in a repair, the deviations of the profile from a straight line drawn from one boundary of the repair to the other were determined. The maximum hump and dip, as well as the maximum elevation deviation within the repair (maximum hump plus maximum dip) are shown in Table 31. Sections are shown in order of increasing total elevation deviation. A majority of the good performing sections had total elevation deviation 0.80 inch or less whereas a majority of the poor performing sections had a total elevation deviation of 0.80 inch or more, which indicates the ride quality of the repair most likely influenced the perception of the patch performance.

Table 31 Repair Elevation Deviations (1 in = 2.54 cm)

City	Location	Condition	Maximum Dip (inches)	Maximum hump (inches)	total deviation (inches)
Columbus	1576 Old Leonard Avenue	Good	0.00	0.21	0.21
Cleveland	1412 East 45th Street	Poor	0.16	0.08	0.24
Columbus	50 East Jeffrey Place	Good	0.31	0.00	0.31
Columbus	85 West 3rd Avenue	Poor	0.06	0.26	0.32
Columbus	62 East Barthman Avenue	Good	0.00	0.37	0.37
Dayton	N. Torrence at Springfield	Good	0.00	0.44	0.44
Cleveland	Pepper Avenue at East 152nd Street	Good	0.00	0.52	0.52
Dayton	74 S. Sperling Avenue	Good	0.00	0.60	0.60
Dayton	66 S. Sperling Avenue	Good	0.09	0.60	0.69
Cleveland	3504 Woodbridge Avenue	Good	0.40	0.40	0.80
Cleveland	13009 Terminal Avenue	Poor	0.36	0.59	0.95
Columbus	1734 Old Leonard Avenue	Poor	0.89	0.06	0.95
Dayton	316 Urbana Avenue	Poor	0.33	0.62	0.95
Dayton	85 Paw Paw Street	Poor	0.48	0.48	0.96
Cleveland	16214 Sanford Avenue	Good	0.80	0.20	1.00
Cleveland	16713 Valleyview Avenue	Poor	0.09	0.95	1.04
Dayton	60 S. Wright Avenue	Poor	1.13	0.00	1.13
Columbus	61 West 3rd Avenue	Poor	1.24	0.59	1.83

The total deviation, maximum dip and maximum hump were further explored by plotting the average for each value relative to the type of repair (vertical or T-repair) and backfill material (granular or LSM), as shown in Figure 79. Repair type was assumed based on the type required by each agency's specifications. The backfill material for the repair on Sanford Avenue in Cleveland was unknown as part of the repair had granular material and the other part, which appeared to be a second repair within the repair had LSM. As shown in the figure, the most frequent type of repair evaluated in this study was T-repair with granular backfill. The average total deviation for T-repairs with granular material were comparable to T-repairs backfilled with LSM, with the average among the 8 repairs using granular backfill at approximately 0.80 inches (2.0 cm) and the average among the three backfilled with LSM at approximately 0.70 inches (1.8 cm). Similarly, the averages of the maximum hump and maximum deviation for T-repairs using granular backfill were comparable to values for T-repairs with LSM backfill. Differences are noted in averages of the total deviation and maximum dip between the vertical repairs using granular or LSM backfill. For the three vertical repairs backfilled with granular material, the average total deviation and average maximum dip were greater than the average total deviation and average maximum dip for all other combinations of repair and backfill material. While this may indicate there is a tendency towards settlement for vertical repairs backfilled with granular material, there are too few repairs of each combination to truly draw conclusions on this topic.

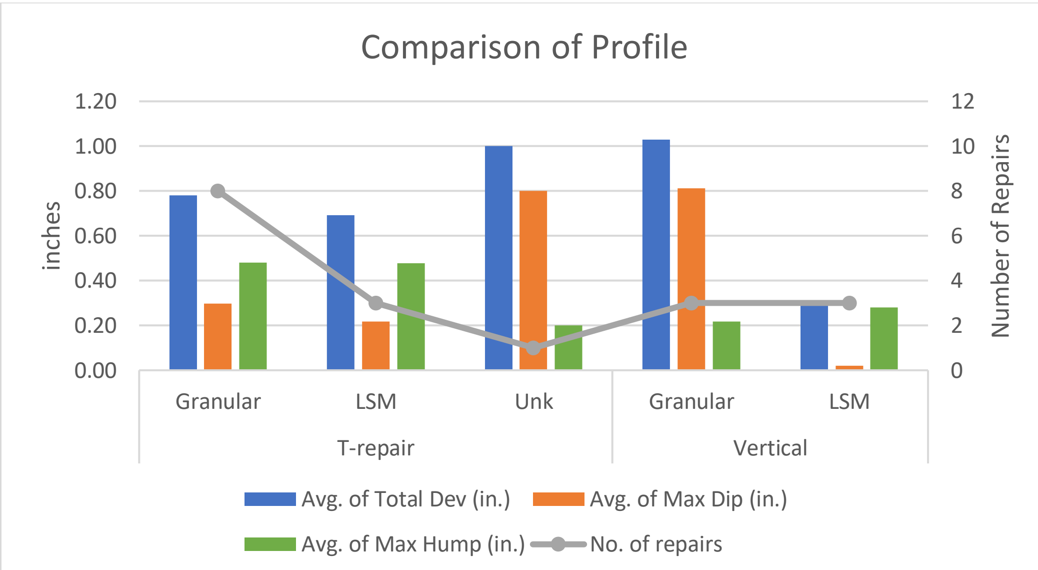


Figure 79 Comparison of average profile characteristics by repair type and backfill material used (1 in = 2.54 cm).

13.2.2 Determination of Existing Pavement Structure

Once cores were removed from the pavement, initial measurements were taken and layers identified by examining the core and core hole. The samples were then bound with duct tape and taken to the lab where the cores were photographed, layers identified, and detailed measurements made. A summary of the cores obtained outside the repair are shown in Tables 32 through 37.

Table 32 Summary of Existing Pavement Type, City of Cleveland (1 in = 2.54 cm)

Location	Pavement Type	Pavement Cross-section	Notes
1412 E. 45th St.	Rigid brick composite	2 – 3” Asphalt 4 ¾” Brick Paver	
13009 Terminal Ave.	Concrete composite	4 – 4 ¼” Asphalt 8 ½ - 10 ½” Concrete	Soft subgrade LSM found beneath concrete
16713 Valleyview Ave.	Concrete composite	4 ½ - 6” Asphalt 7 – 9” Concrete	
16214 Sanford Ave.	Concrete composite	2 ½ - 3” Asphalt 5 ½ - 6 ½” Concrete	LSM found beneath concrete at core location 6
Pepper Ave.	Rigid brick composite	2 ½” Asphalt 4” Brick Paver 5 ½” Concrete	Very soft subgrade
3504 Woodbridge Ave.	Brick composite	2 ½” Asphalt 4 ¾” Brick Paver	

Table 33 Results for cores taken outside repair, City of Cleveland. (1 ft = 0.3048 m; 1 in = 2.54 cm)

Site	Core No.	Distance from edge of repair	Asphalt Thickness	Brick Thickness	Concrete Thickness	Aggregate Base Thickness
1412 E. 45th Ave.	1	25 ft.	3 in.	4.75 in.	0	Unk
1412 E. 45th Ave.	2	2 ft.	2 in.	4.75 in.*	0	Unk
13009 Terminal Ave.	1	20 ft.	4.25 in.	0	10.5 in.	LSM (Unk thickness)
13009 Terminal Ave.	2	2 ft.	4 in.	0	8.5 in.	3.25 in. LSM
16713 Valleyview Ave.	1	20 ft.	4.5 in.	0	9 in.	Unk
16713 Valleyview Ave.	2	2 ft.	6 in.	0	7 in.	Unk
16214 Sanford Ave.	6	2 ft.	2.5 in.	0	6.5 in.	Unk
16214 Sanford Ave.	7	20 ft.	3 in.	0	5.5 in.	Unk
Pepper Ave.	1	20 ft.	2.5 in.	4 in.	5.5 in.	Unk
Pepper Ave.	2	2 ft.	2.5 in.	4 in.*	5.5 in.*	Unk
3504 Woodbridge Ave.	6	2 ft.	2.5 in.	4.75 in.*	0	Unk
3504 Woodbridge Ave.	7	13 ft.	2.5 in.	4.75 in.	0	Unk

*assumed thickness, brick layer verified but not extracted

Table 34 Summary of Existing Pavement Type, City of Columbus (1 in = 2.54 cm)

Location	Pavement Type	Pavement Cross-section	Notes
62 E. Barthman Ave.	Rigid brick composite	2.5 in. Asphalt 4 in. Brick 5 in. Concrete	
50 E. Jeffrey Place	Asphalt	5 in. Asphalt 4.5 in. Bituminous macadam base	On aggregate base
1576 Old Leonard Ave.	Concrete composite	5 – 7 in. Asphalt 6 – 7.5 in. Concrete	On subgrade; underlying concrete severely D-cracked
61 W. 3rd Ave.	Asphalt or concrete composite	7 in. Asphalt	Unable to distinguish base material, either crushed concrete or severely deteriorated concrete base
85 W. 3rd Ave.	Asphalt	6.75 – 7.25 in. Asphalt	On aggregate base
1734 Old Leonard Ave.	Asphalt	7 in. Asphalt	On aggregate base

Table 35 Results for cores taken outside repair, City of Columbus. (1 ft = 0.3048 m; 1 in = 2.54 cm)

Site	Core No.	Distance from edge of repair	Asphalt Thickness	Brick Thickness	Concrete Thickness	Aggregate Base Thickness
62 E. Barthman Ave.	6	2 ft.	2.5 in.	4 in.	5 in.	unknown
62 E. Barthman Ave.	7	20 ft.	2.5 in.	4 in.*	5 in.*	unknown
50 E. Jeffrey Place	1	20 ft.	5 in. asphalt + 4.5 in. bituminous macadam base	0	0	
50 E. Jeffrey Place	2	2 ft.	5 in. asphalt + 4.5 in. bituminous macadam base	0	0	4 in.
1576 Old Leonard Ave.	6	2 ft.	7 in.	0	6 in.	N/A
1576 Old Leonard Ave.	7	20 ft.	5 in.	0	7.5 in.	N/A
61 W. 3rd Ave.	1	20 ft.	7 in.	0	0	unknown
61 W. 3rd Ave.	2	2 ft.	7 in.	0	0	7 in.**
85 W. 3rd Ave.	6	2 ft.	7.25 in.	0	0	unknown
85 W. 3rd Ave.	7	20 ft.	6.75 in.	0	0	unknown
1734 Old Leonard Ave.	6	1 ft.	7 in.	0	0	unknown
1734 Old Leonard Ave.	7	22 ft.	7 in.	0	0	> 6 in.

*assumed thickness, did not extract brick

**either LSM with large aggregate, or severely deteriorated concrete

Table 36 Summary of Existing Pavement Type, City of Dayton (1 in = 2.54 cm)

Location	Pavement Type	Pavement Cross-section	Notes
66 S. Sperling Ave.	Asphalt	2 ¾ - 3 ¼ in. Asphalt 4 in. Granular base	
74 S. Sperling Ave.	Asphalt	3 ½ in Asphalt 1 ½ in. Granular base	
N. Torrence at Springfield	Asphalt	4 – 4 ½ in. Asphalt 5 – 6 ½ in. Granular base	
85 Paw Paw St.	Asphalt	4 ½ - 5 ½ in. Asphalt 3 ¾ in. Granular base	
316 Urbana Ave.	Asphalt	3 ¾ - 5 in. Asphalt 12 ¾ - 13 ¼ in. Granular base	
60 S. Wright Ave.	Asphalt	2 ½ - 4 ½ in. Asphalt 8 ½ - 9 ½ in. Granular base	

Table 37 Results for cores taken outside repair, City of Dayton. (1 ft = 0.3048 m; 1 in = 2.54 cm)

Site	Core No.	Distance from edge of repair	Asphalt Thickness	Brick Thickness	Concrete Thickness	Aggregate Base Thickness
66 S. Sperling Ave.	1	25 ft.	2.75 in.	0	0	4 in.
66 S. Sperling Ave.	2	2 ft.	3.25 in.	0	0	Unknown
74 S. Sperling Ave.	1	15 ft.	3.5 in.	0	0	unknown
74 S. Sperling Ave.	2	2 ft.	3.5 in.	0	0	1.5 in.
N. Torrence at Springfield	1	20 ft.	4 in.	0	0	5 in.
N. Torrence at Springfield	2	2 ft.	4.5 in.	0	0	6.5 in.
85 Paw Paw St.	1	15 ft.	4.5 in.	0	0	3.75 in.
85 Paw Paw St.	2	2 ft.	5.5 in.	0	0	Unknown
316 Urbana Ave.	1	15 ft.	5 in.	0	0	13.25 in
316 Urbana Ave.	2	2 ft.	3.75 in.	0	0	12.75 in.
60 S. Wright Ave.	7	13 ft.	4.5 in.	0	0	8.5 in.
60 S. Wright Ave.	8	2 ft.	2.5 in.	0	0	9.5 in.

*assumed thickness, existence of brick layer verified but not extracted

13.2.3 Determination of Material used in Repair

A summary of the cores obtained inside the repair are shown in Tables 38 through 40.

Table 38 Results for cores taken inside repair, City of Cleveland (1 ft = 0.3048 m; 1 in = 2.54 cm)

Site	Core No.	Distance from edge of repair	Asphalt Thickness	Concrete Thickness	Backfill Material
1412 E. 45th Ave.	3	1.5 ft.	1.5 in.	8 in.	uncemented soil grains.
1412 E. 45th Ave.	4	4 ft.	1.5 in.	9.5 in.	cemented granular soil grains (i.e. LSM).
1412 E. 45th Ave.	8	3.75 ft.	2 in.	10 in.	uncemented soil grains.
13009 Terminal Ave.	3	1.5 ft.	1.25 in.	7.25 in.	
13009 Terminal Ave.	4	5.67 ft.	1 in.	15.5 in.	uncemented soil grains.
13009 Terminal Ave.	5	1.5 ft.	1 in.	17 in.	uncemented soil grains.
13009 Terminal Ave.	8	1.5 ft.	1 in.	18 in.	
16713 Valleyview Ave.	3	1.5 ft.	1.25 in.	6.25 in.	uncemented soil grains.
16713 Valleyview Ave.	4	8.75 ft.	1.75 in.	7.25 in.	cemented soil grains (i.e. LSM); 4 in. core of LSM
16713 Valleyview Ave.	8	1.5 ft.	1.5 in.	8.75 in.	
16214 Sanford Ave.	4	7 ft.	1.25 in.	7.75 in.	
16214 Sanford Ave.	5	1.5 ft.	2 in.	12 in.	uncemented soil grains.
16214 Sanford Ave.	8	1.5 ft.	1 in.	6.5 in	cemented soil grains (i.e. LSM)
Pepper Ave.	3	1.5 ft.	1.25 in.	0.5 in. On top of brick	
Pepper Ave.	4	9.25 ft.	1 in.	12 in.	uncemented soil grains.
Pepper Ave.	8	1.5 ft.	1.75 in.	11.5 in.	uncemented soil grains.
3504 Woodbridge Ave.	4P	6 ft.	2 in.	8.25 in.	broken pieces of concrete.
3504 Woodbridge Ave.	5P	1.5 ft.	2.25 in.	9.75 in.	cemented granular soil grains (i.e. LSM).
3504 Woodbridge Ave.	8	1.5 ft.	2.25 in.	8.5 in.	cemented granular soil grains (i.e. LSM).

Table 39 Results for cores taken inside repair, City of Columbus. (1 ft = 0.3048 m; 1 in = 2.54 cm)

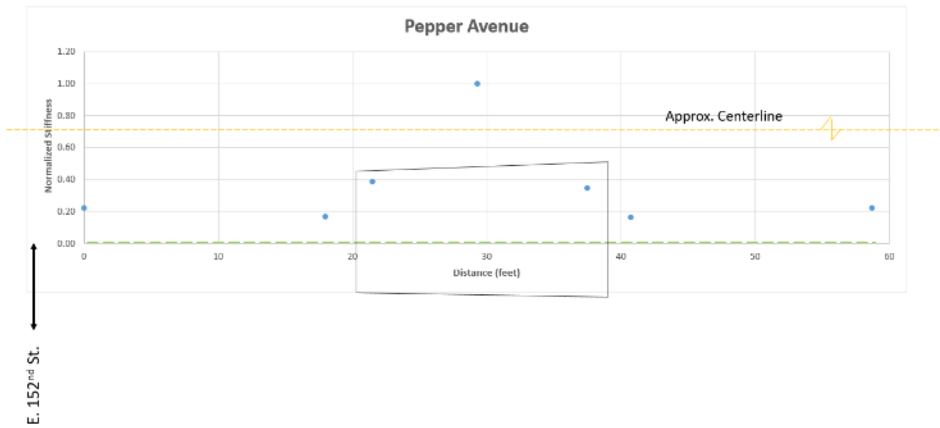
Site	Core No.	Distance from edge of repair	Asphalt Thickness	Concrete Thickness	Backfill Material
62 E. Barthman Ave.	4	4.33 ft.	9.75 in.	0	cemented soil grains (i.e. LSM).
62 E. Barthman Ave.	5	1 ft.	10.75 in.	0	uncemented soil grains.
62 E. Barthman Ave.	8	1 ft.	10.5 in.	0	cemented granular soil grains (i.e. LSM).
50 E. Jeffrey Place	3	1 ft.	9.5 in.	0	uncemented soil grains.
50 E. Jeffrey Place	4	3 ft.	9.5 in.	0	N/A
50 E. Jeffrey Place	8	2.5 ft.	8 in.	0	uncemented soil grains.
1576 Old Leonard Ave.	4	5.58 ft.	4 in.	11 in.	uncemented soil grains.
1576 Old Leonard Ave.	5	1 ft.	8.25 in.	3 in.	N/A
1576 Old Leonard Ave.	8	1 ft.	7 in.	6 in.	cemented soil grains (i.e. LSM).
61 W. 3rd Ave.	3	2 ft.	9 in.	0	uncemented soil grains.
61 W. 3rd Ave.	4	8.67 ft.	6 in.	0	6 in. of granular material
61 W. 3rd Ave.	5	4.33 ft.	10.75 in.	0	uncemented soil grains.
85 W. 3rd Ave.	4	5.17 ft.	7 in.	0	uncemented soil grains.
85 W. 3rd Ave.	5	1 ft.	8 in.	0	cemented soil grains (i.e. LSM).
85 W. 3rd Ave.	8	1 ft.	7.25 in.	0	uncemented soil grains.
1734 Old Leonard Ave.	4	10.67 ft.	14.5 in.	0	N/A
1734 Old Leonard Ave.	8	1 ft.	7 in.	0	uncemented soil grains.

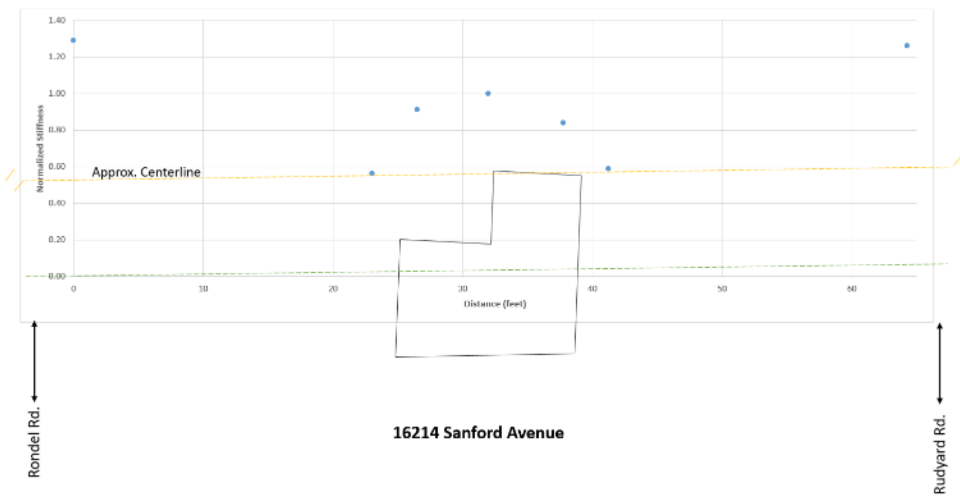
Table 40 Results for cores taken inside repair, City of Dayton. (1 ft = 0.3048 m; 1 in = 2.54 cm)

Site	Core No.	Distance from edge of repair	Asphalt Thickness	Concrete Thickness	Backfill Material
66 S. Sperling Ave.	3	0.67 ft.	6 in.	0	Uncemented soil grains (i.e granular material)
66 S. Sperling Ave.	4	2.67 ft.	6.25 in.	0	Uncemented soil grains (i.e granular material)
66 S. Sperling Ave.	8	0.67 ft.	5.5 in.	0	Uncemented soil grains (i.e granular material)
74 S. Sperling Ave.	3	1 ft.	4.5 in.	0	Uncemented soil grains (i.e granular material)
74 S. Sperling Ave.	4	3.5 ft.	6 in.	0	Uncemented soil grains (i.e granular material)
74 S. Sperling Ave.	8	0.67 ft.	6.25 in.	0	Uncemented soil grains (i.e granular material)
N. Torrence at Springfield	4	3.25 ft.	5.25 in.	0	Uncemented soil grains (i.e granular material)
N. Torrence at Springfield	5	0.67 ft.	5.25 in.	0	Uncemented soil grains (i.e granular material)
N. Torrence at Springfield	7	0.67 ft.	5.25 in.	0	Uncemented soil grains (i.e granular material)
85 Paw Paw St.	3	0.67 ft.	4.25 in.	0	Uncemented soil grains (i.e granular material)
85 Paw Paw St.	4	2.33 ft.	5.25 in.	0	Uncemented soil grains (i.e granular material)
85 Paw Paw St.	8	0.67 ft.	4.25 in.	0	Uncemented soil grains (i.e granular material)
316 Urbana Ave.	3	0.67 ft.	4.25 in.	0	Uncemented soil grains (i.e granular material)
316 Urbana Ave.	4	3.83 ft.	6.5 in.	0	Uncemented soil grains (i.e granular material)
316 Urbana Ave.	7	0.67 ft.	4.5 in.	0	Granular material
60 S. Wright Ave.	1	14.75 ft. from middle patch	6 in.	0	Granular material
60 S. Wright Ave.	2	1 ft. from middle patch	6.5 in.	0	Granular material
60 S. Wright Ave.	3	1.5 ft.	4.75 in.	0	Granular material
60 S. Wright Ave.	6	0.67 ft.	6.25 in.	0	Granular material

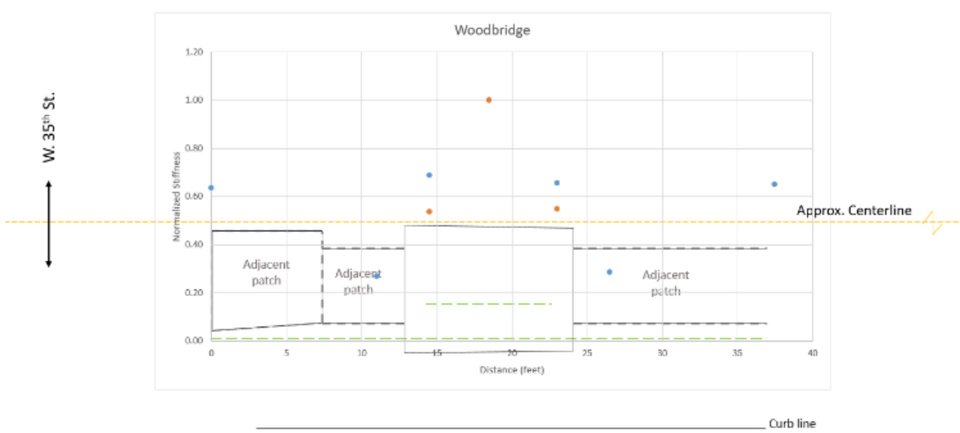
13.2.4 FWD Results

The relative stiffness was plotted on drawings of the repair to allow for better interpretation. Figures 80 through 82 are profile plots for good performing sections in the cities of Cleveland, Columbus, and Dayton respectively whereas Figures 83 through 85 are profile plots for poor performing sections in the cities of Cleveland, Columbus, and Dayton respectively. With the exception of three sections, the stiffness of the repair was greater than or equal to the existing pavement, indicating the repairs should have a service equal to the expected remaining life of the existing pavement. Of the three sections with a stiffness less than the existing pavement, two were rated as good performing, indicating the repairs were stiff sufficiently stiff enough to provide good performance to date but would not be expected to provide a service life equal to the surrounding pavement. The poor performing repair with stiffness less than the existing pavement is located on Valleyview Avenue in Cleveland. This repair is located in an area with multiple repairs and has a surface which has been patched multiple times.



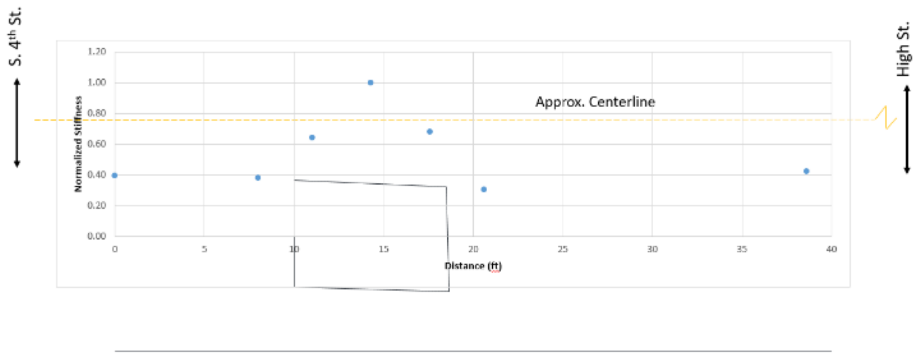


16214 Sanford Avenue

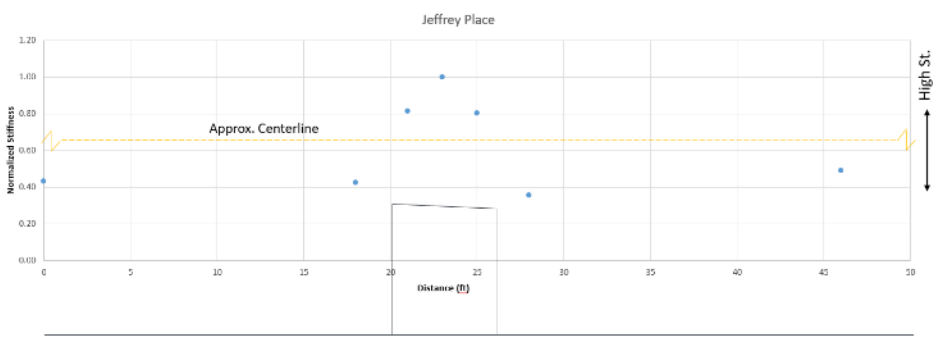


3504 Woodbridge Avenue

Figure 80 FWD Relative Stiffness for Good Performing Sections, Cleveland



62 East Barthman Avenue



50 East Jeffrey Place

1570 Old Leonard Avenue

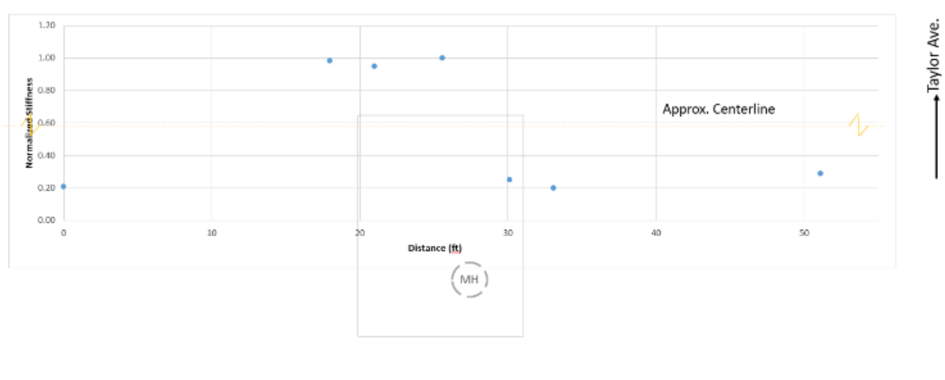
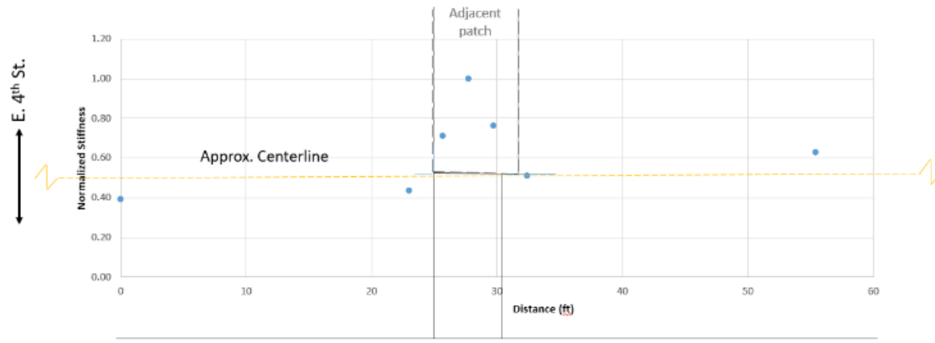
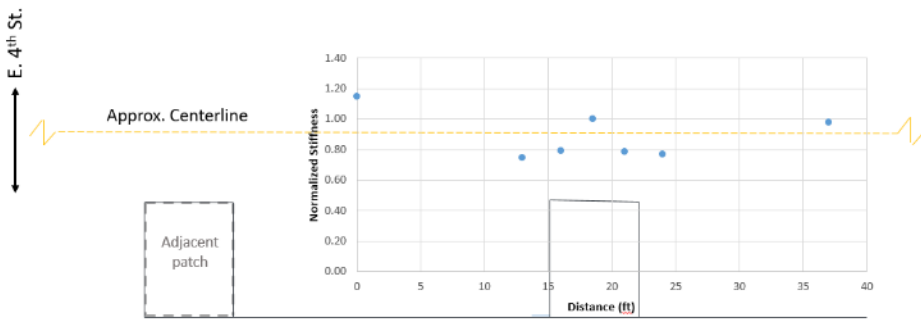


Figure 81 FWD Relative Stiffness for Good Performing Sections, Columbus



66 South Sperling Avenue



74 South Sperling Avenue

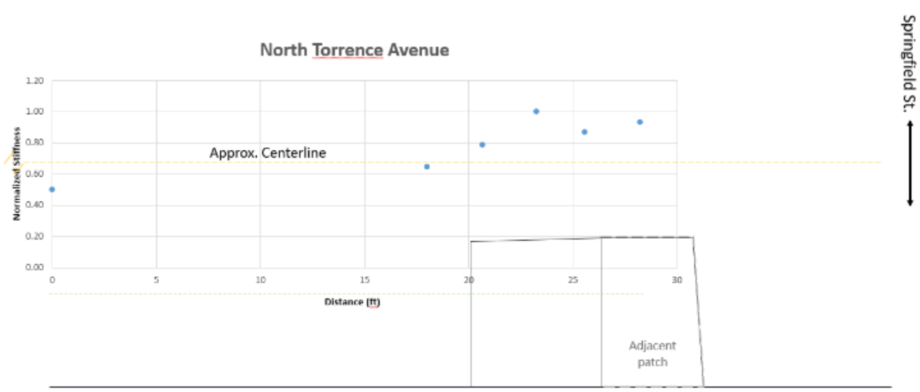
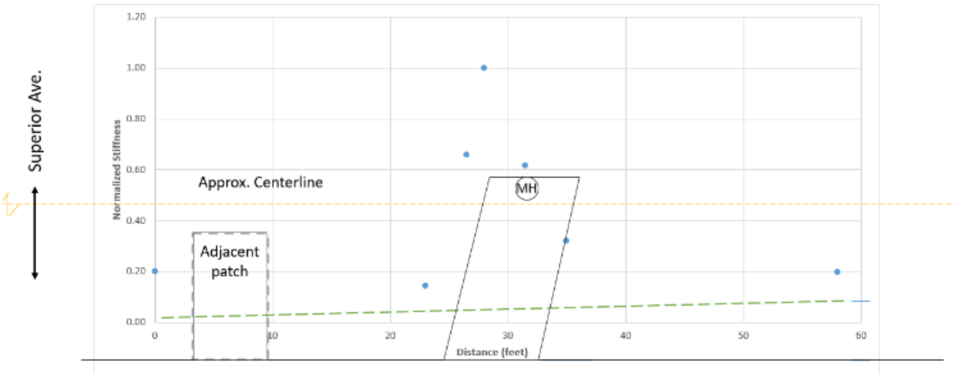
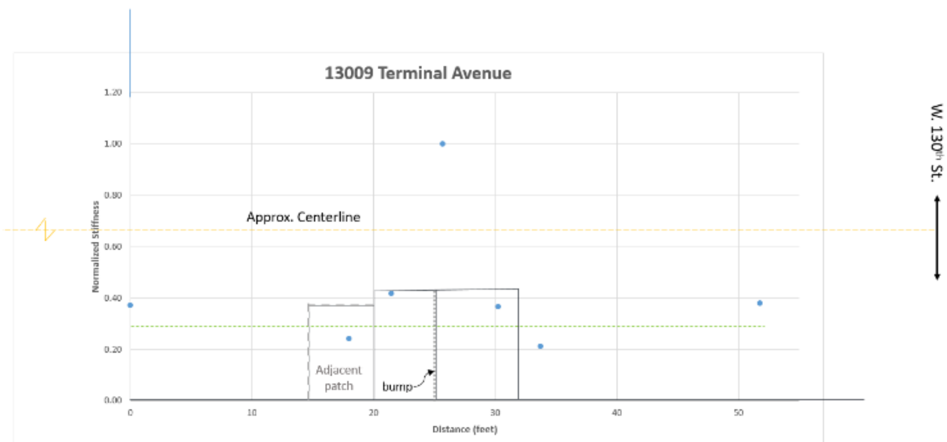
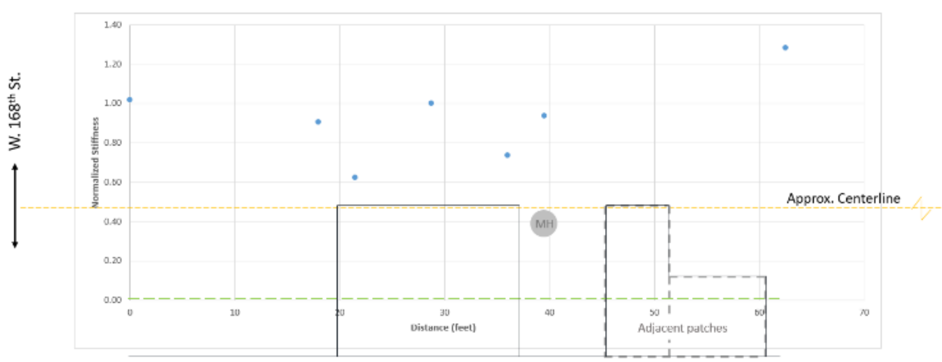


Figure 82 FWD Relative Stiffness for Good Performing Sections, Dayton



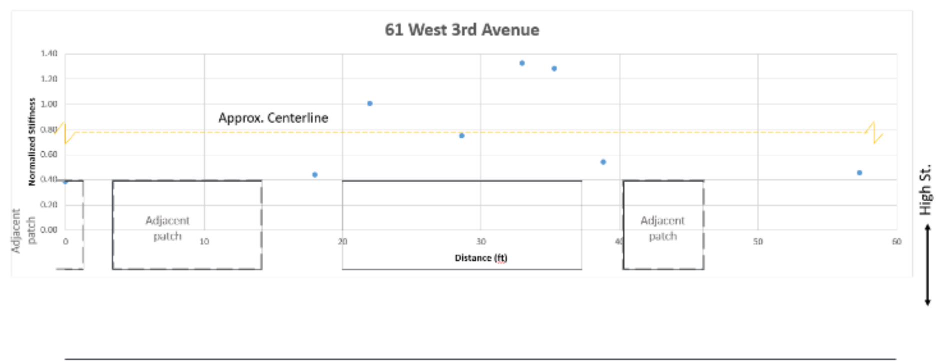
1412 East 45th Street

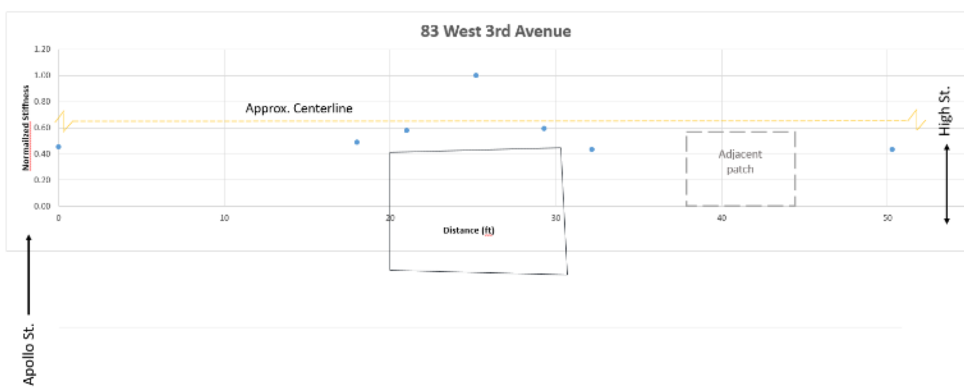


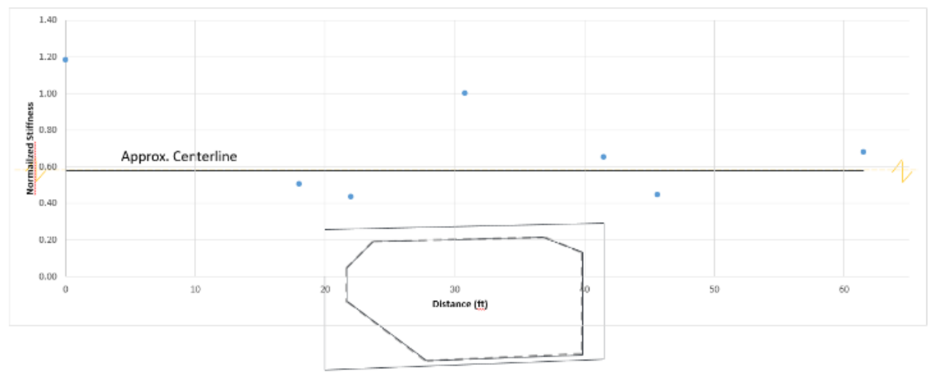


16713 Valleyview Avenue

Figure 83 FWD Relative Stiffness for Poor Performing Sections, Cleveland







1734 Old Leonard Avenue

Figure 84 FWD Relative Stiffness for Poor Performing Sections, Columbus

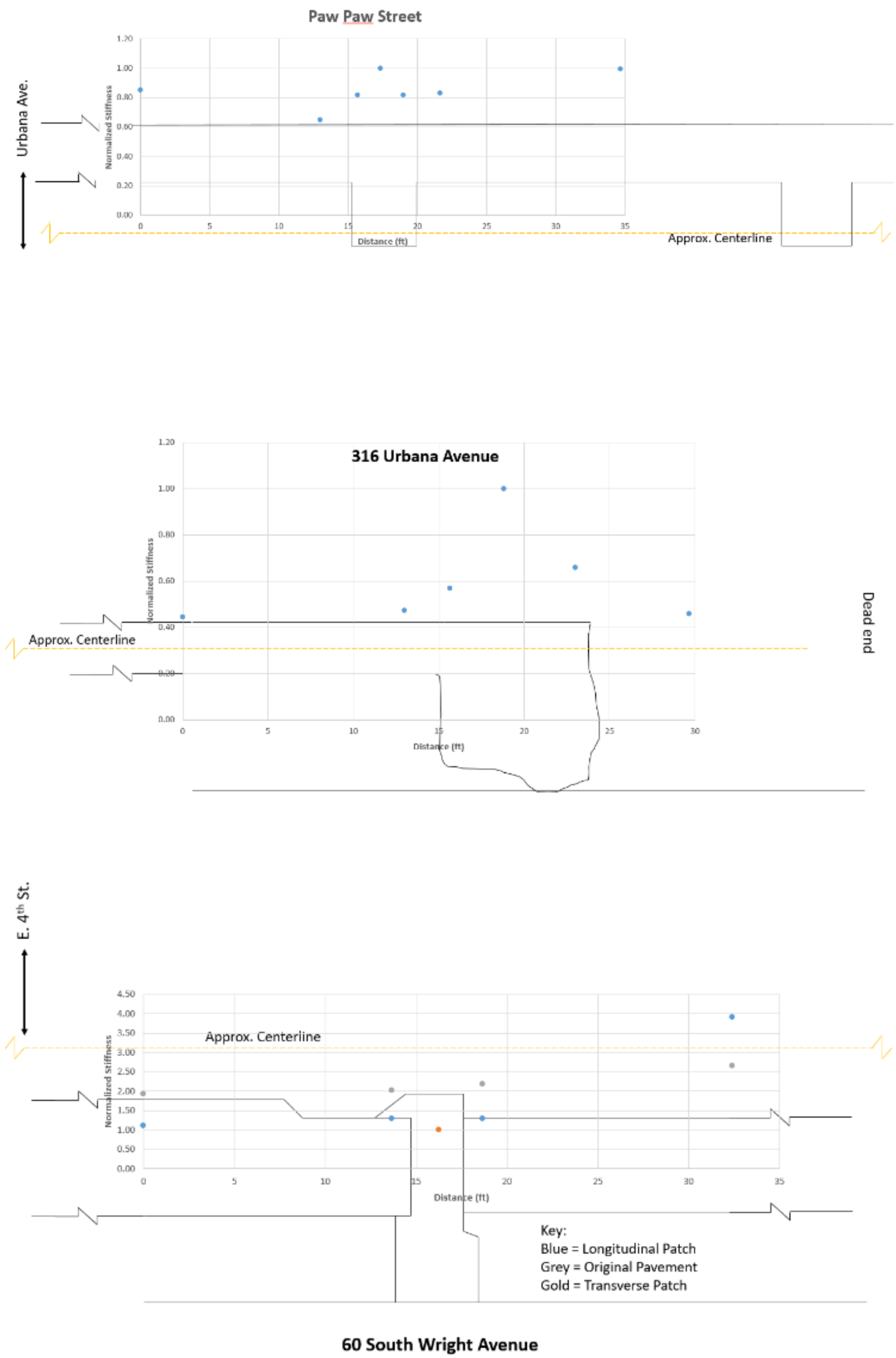


Figure 85 FWD Relative Stiffness for Poor Performing Sections, Dayton

The FWD data was further analyzed using box plots (Figures 86 through 87). Box plots are useful for determining the spread and skew of the data. The plots can be used to identify outliers for removal from data analysis. The bottom and top of the box represents the 1st and 3rd quartiles, respectively. The line inside the box represents the median value and the dot inside the box represents the mean value. The two lines extending from the box represents values outside the 1st and 3rd quartile and the horizontal bars on the end of the vertical lines represent the minimum and maximum values. When comparing data, if the boxes do not overlap, there is a difference in the two variables. If the boxes overlap, but do not include both medians, there is likely a difference in the two variables. If the boxes overlap and include both medians, both variables are considered to have the same values.

Figure 86 is a box plot comparing the base modulus for repairs with good and poor performance. Base modulus values were determined using Equation 1. The box plot indicates the base modulus for poor performing sections is more variable but statistically, the values are considered the same for good and poor performing sections.

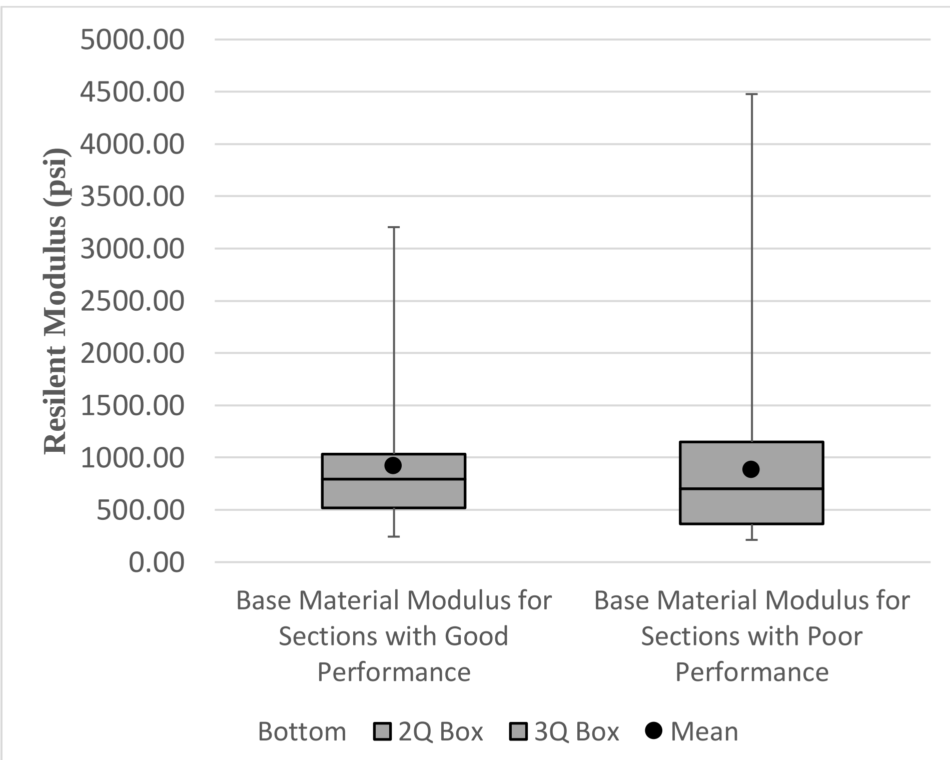


Figure 86 Repair Base Material Resilient Modulus (1 psi = 6.895 kPa)

Figure 87 is a box plot comparing stiffness determined at the center of the load plate for FWD testing on the repair. The plot compares stiffness for repairs with good and poor performance. The box plot indicates the repair stiffness for poor performing sections is slightly more variable but statistically, the values are considered the same for good and poor performing sections.

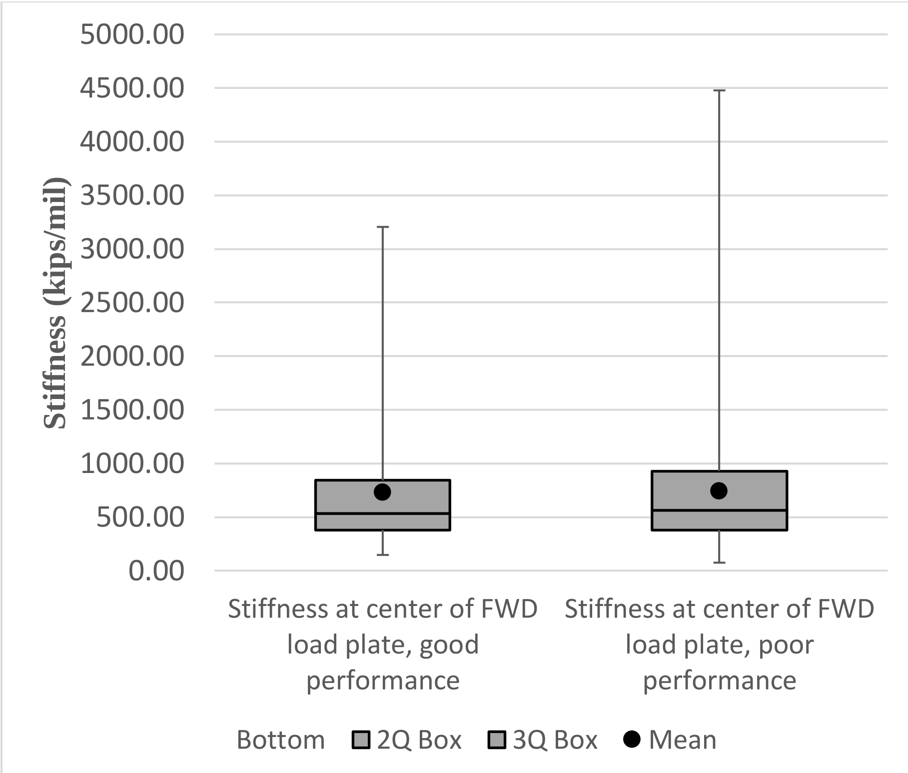


Figure 87 Box Plot for Repair Pavement Stiffness (1kip/mil = 0.15 kN/mm)

Figure 88 is a box plot of the stiffness of the pavement measured with the FWD just outside of the repair boundary (typically two feet). This location was chosen to evaluate the zone of influence. Two cases are considered in the figure. The first is a comparison of the stiffness at this location for good versus poor performing repairs. The box plot shows the stiffness at this location is more variable for the poor performing sections and is likely statistically different than the good performing sections although the means are approximately the same.

Figure 88 also includes a comparison of the stiffness of the pavement just beyond the boundary for Columbus, which uses the vertical cut repair method, with the stiffness of the pavement at the same test location for repairs in Cleveland and Dayton, which use the T repairs. The results are more conclusive with the vertical cut method having a less variable and higher stiffness.

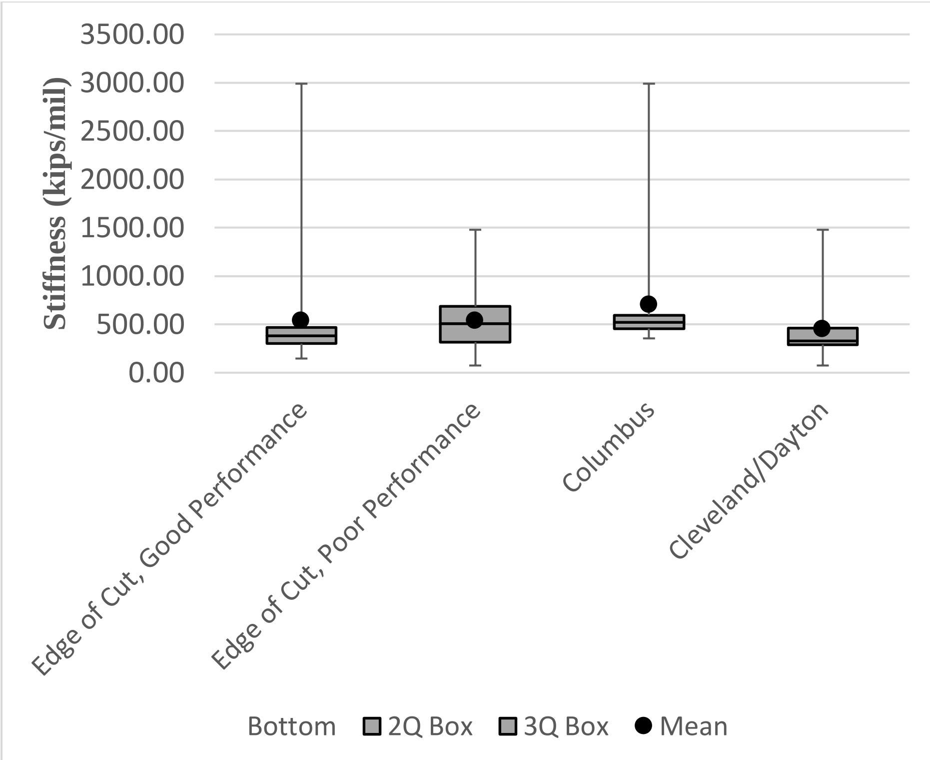


Figure 88 Box plot of pavement stiffness outside repair boundary. (1kip/mil = 0.15 kN/mm)

13.2.5 Asphalt Density Determination in the Repair

The asphalt density was determined in the laboratory for each extracted asphalt core within the repair. Percent air voids (100 – asphalt density) have been compiled for each core, listed in Tables 42 through 44. Additionally, the average air voids and average thickness among the extracted asphalt cores in each repair have been summarized in Table 41.

For reference, a value of 7% air voids is typically targeted during paving of an asphalt mat, as the anticipation traffic will further consolidate the mat, thereby reducing the air voids. Brown (1990) indicated initial in-place air voids should be a maximum of 8% and a minimum of 3%. Poor compaction, or high air voids can lead to durability issues. Linden et al. (1989) reported for each 1% increase in air voids beyond 7% approximately 10% loss in pavement life results. However, density can be difficult to achieve in repairs of open utility cuts due to the small size of the area and therefore inability to use standard compaction equipment. As shown in the summary table, average air voids ranged from 3.9% to 13.4% for repairs performing well, and from 7.4% to 18.1% for those performing poorly.

Table 41 Summary of average asphalt density and thickness at each location, within the repair. (1 in = 2.54 cm)

City	Location	Performance category	Average Air Voids	Average thickness
Cleveland	16214 Sanford Ave.	Good	10.8%	1.42 in.
Cleveland	Pepper Ave.	Good	6.2%	1.33 in.
Cleveland	3504 Woodbridge Ave.	Good	3.9%	2.17 in.
Cleveland	1412 E. 45th St.	Poor	8.5%	1.67 in.
Cleveland	13009 Terminal Ave.	Poor	18.1%	1.06 in.
Cleveland	16713 Valleyview Ave.	Poor	9.6%	1.5 in.
Columbus	62 E. Barthman Ave.	Good	13.4%	10.33 in.
Columbus	50 E. Jeffrey Place	Good	11.3%	9.00 in.
Columbus	1576 Old Leonard Ave.	Good	7.5%	6.42 in.
Columbus	61 W. 3rd Ave.	Poor	9.1%	8.58 in.
Columbus	85 W. 3rd Ave.	Poor	9.1%	7.42 in.
Columbus	1734 Old Leonard Ave.	Poor	8.3%	10.75 in.
Dayton	66 S. Sperling Ave.	Good	8.5%	5.92 in.
Dayton	74 S. Sperling Ave.	Good	9.5%	5.58 in.
Dayton	N. Torrence at Springfield	Good	13.2%	5.25 in.
Dayton	85 Paw Paw St.	Poor	9.8%	4.58 in.
Dayton	316 Urbana Ave.	Poor	10.5%	5.08 in.
Dayton	60 S. Wright Ave.	Poor	7.4%	5.83 in.

In looking at the extracted asphalt cores, most appeared to have been placed in one lift, as there was no discernable layer interface visible. This is evident in the pictures of the cores shown in the core logs (Appendix G) for each city. In some cases in Columbus, the asphalt layer was placed greater than 10 inches (25.4 cm) thick. This may make it difficult to achieve reasonable air voids in the repair. For ease of testing, the asphalt cores with large thicknesses were cut in half during testing. Therefore, there are many cases where there are two results for each core listed as “A” and “B” for each core number in tables for Dayton and Columbus.

In comparing the average thicknesses of the asphalt layer in the repair to each agency’s standards, many locations do not meet the minimum thickness requirement. According to the standard for City of Cleveland for brick composite, rigid brick composite, and concrete composite pavements a total of three inches of asphalt should be placed in two lifts (1.75 inches (4.45 cm) of intermediate and 1.25 inches (3.18 cm) of surface). However, the greatest average thickness in the repair was found to be only 2.17 inches (5.51 cm). In the City of Columbus, clarification of their standard provided in the phone interview indicate the minimum thickness of asphalt in a repair on asphalt pavements should be 9 inches (22.86 cm), placed in three 3-inch (7.62 cm) lifts. Of the four repairs on asphalt pavements, 50 E. Jeffrey Pl. and 61 W. 3rd Ave., 85 W. 3rd Ave., and 1734 Old Leonard Ave. two locations met or exceeded the standard with an average thickness of 9 inches. However, in looking at the extracted cores, they do not appear to have been placed in three lifts. The average thickness at 85 W. 3rd Ave. was closer to the thickness of asphalt in the surrounding pavement, whereas the thickness at 61 W. 3rd Ave. was shy of the standard by 0.5 inches (1.27 cm), on average. In Dayton, all locations exceeded the total thickness of 3 inches (7.62 cm) specified in their standard, however they do not appear to have been placed in two lifts as specified.

Table 42 Asphalt density at each core location inside repair, City of Cleveland.

Site	Core No.	Air voids	Notes
1412 E. 45th Ave.	3	8.4%	
1412 E. 45th Ave.	4	9.8%	
1412 E. 45th Ave.	8	7.3%	
13009 Terminal Ave.	3	18.0%	Appeared to be cold patch asphalt
13009 Terminal Ave.	4	N/A	Broke during extraction; appeared to be cold patch asphalt
13009 Terminal Ave.	5	N/A	Could not separate from concrete without damaging; appeared to be cold patch asphalt
13009 Terminal Ave.	8	18.2%	Appeared to be cold patch asphalt
16713 Valleyview Ave.	3	8.8%	
16713 Valleyview Ave.	4	9.6%	
16713 Valleyview Ave.	8	10.3%	
16214 Sanford Ave.	4	11.4%	
16214 Sanford Ave.	5	9.0%	
16214 Sanford Ave.	8	11.9%	
Pepper Ave.	3	6.4%	
Pepper Ave.	4	6.2%	
Pepper Ave.	8	6.1%	
3504 Woodbridge Ave.	4	5.2%	
3504 Woodbridge Ave.	5	2.7%	
3504 Woodbridge Ave.	8	3.9%	

Table 43 Asphalt density at each core location inside repair, City of Columbus. (1 in = 2.54 cm)

Site	Core No.	Air voids	Notes
62 E. Barthman Ave.	4-A	12.8%	Height = 4.30 in.
62 E. Barthman Ave.	4-B	14.1%	Height = 4.95 in.
62 E. Barthman Ave.	5-A	12.5%	Height = 4.55 in.
62 E. Barthman Ave.	5-B	15.4%	Height = 5.10 in.
62 E. Barthman Ave.	8-A	11.2%	Height = 4.65 in.
62 E. Barthman Ave.	8-B	14.2%	Height = 5.20 in.
50 E. Jeffrey Place	3-A	9.2%	Height = 4.35 in.
50 E. Jeffrey Place	3-B	12.7%	Height = 4.95 in.
50 E. Jeffrey Place	4-A	10.0%	Height = 4.05 in.
50 E. Jeffrey Place	4-B	12.5%	Height = 4.00 in.
50 E. Jeffrey Place	8-A	11.3%	Height = 3.20 in.
50 E. Jeffrey Place	8-B	11.9%	Height = 3.30 in
1576 Old Leonard Ave.	4-A	8.3%	Height = 2.15 in.
1576 Old Leonard Ave.	4-B	4.6%	Height = 1.75 in.
1576 Old Leonard Ave.	5-A	7.2%	Height = 2.95 in.
1576 Old Leonard Ave.	5-B	5.0%	Height = 2.85 in.
1576 Old Leonard Ave.	8	12.4%	Height = 2.65 in.
61 W. 3rd Ave.	3A	6.1%	Height = 3.95 in.
61 W. 3rd Ave.	3B	7.2%	Height = 4.30 in.
61 W. 3rd Ave.	4A	9.6%	Height = 3.60 in.
61 W. 3rd Ave.	4B	12.5%	Height = 1.50 in.
61 W. 3rd Ave.	5A	8.4%	Height = 3.85 in.
61 W. 3rd Ave.	5B	9.8%	Height = 4.50 in.
85 W. 3rd Ave.	4A	5.3%	Height = 3.50 in.
85 W. 3rd Ave.	4B	8.8%	Height = 3.40 in.
85 W. 3rd Ave.	5A	5.7%	Height = 3.80 in.
85 W. 3rd Ave.	5B	9.0%	Height = 3.65 in.
85 W. 3rd Ave.	8	9.2%	Height = 6.80 in.
1734 Old Leonard Ave.	4A	5.9%	Height = 6.35 in.
1734 Old Leonard Ave.	4B	10.4%	Height = 6.55 in.
1734 Old Leonard Ave.	8A	7.8%	Height = 3.95 in.
1734 Old Leonard Ave.	8B	9.0%	Height = 3.95 in.

Table 44 Asphalt density at each core location inside repair, City of Dayton. (1 in = 2.54 cm)

Site	Core No.	Air voids	Notes
66 S. Sperling Ave.	3A	7.7%	Height = 2.55 in.
66 S. Sperling Ave.	3B	8.1%	Height = 2.65 in.
66 S. Sperling Ave.	4A	8.8%	Height = 2.85 in.
66 S. Sperling Ave.	4B	9.6%	Height = 2.80 in.
66 S. Sperling Ave.	8A	9.3%	Height = 2.85 in.
66 S. Sperling Ave.	8B	7.8%	Height = 2.65 in.
74 S. Sperling Ave.	3A	9.1%	Height = 2.35 in.
74 S. Sperling Ave.	3B	8.1%	Height = 1.95 in.
74 S. Sperling Ave.	4A	11.3%	Height = 2.80 in.
74 S. Sperling Ave.	4B	9.6%	Height = 3.05 in.
74 S. Sperling Ave.	8A	9.9%	Height = 3.30 in.
74 S. Sperling Ave.	8B	9.1%	Height = 3.00 in.
N. Torrence at Springfield	4A	12.3%	Height = 2.40 in.
N. Torrence at Springfield	4B	13.0%	Height = 2.45 in.
N. Torrence at Springfield	5A	13.8%	Height = 2.80 in.
N. Torrence at Springfield	5B	12.0%	Height = 2.40 in.
N. Torrence at Springfield	7A	13.6%	Height = 2.55 in.
N. Torrence at Springfield	7B	14.4%	Height = 2.75 in.
85 Paw Paw St.	3A	9.9%	Height = 2.10 in.
85 Paw Paw St.	3B	11.5%	Height = 2.65 in.
85 Paw Paw St.	4	12.3%	Height = 5.35 in.
85 Paw Paw St.	8	5.6%	Height = 4.10 in.
316 Urbana Ave.	3A	12.4%	Height = 2.05 in.
316 Urbana Ave.	3B	13.0%	Height = 1.70 in.
316 Urbana Ave.	4A	9.2%	Height = 3.10 in.
316 Urbana Ave.	4B	8.3%	Height = 2.65 in.
316 Urbana Ave.	7A	9.9%	Height = 1.80 in.
316 Urbana Ave.	7B	10.0%	Height = 1.85 in.
60 S. Wright Ave.	1A	5.4%	Height = 2.10 in.
60 S. Wright Ave.	1B	7.3%	Height = 2.75 in.
60 S. Wright Ave.	2A	5.5%	Height = 2.75 in.
60 S. Wright Ave.	2B	10.3%	Height = 2.50 in.
60 S. Wright Ave.	3	N/A	Not tested
60 S. Wright Ave.	6A	6.4%	Height = 2.25 in.
60 S. Wright Ave.	6B	9.6%	Height = 2.45 in.

13.2.6 Compressive Strength of Concrete

Results for compressive strength of concrete cores extracted from the selected sites are tabulated in the tables below.

Table 45 Results of compressive strength of concrete in repair, City of Cleveland. (1 psi = 6.895 kPa)

Site	Core No.	Compressive Strength (psi)	Notes
1412 E. 45th Ave.	3	N/A	Non-uniform core, unable to test
1412 E. 45th Ave.	4	7777	
1412 E. 45th Ave.	8	8021	
13009 Terminal Ave.	3	6696	
13009 Terminal Ave.	4	7225	
13009 Terminal Ave.	5	5618	Appears to be two difference sources of concrete. Top 6 inches was fractured. Bottom 11 inches had slag aggregate and appeared blue on removal, as did concrete in existing pavement. Only bottom portion was tested
13009 Terminal Ave.	8	5125	
16713 Valleyview Ave.	3	N/A	Concrete was fractured
16713 Valleyview Ave.	4	5683	
16713 Valleyview Ave.	8	6073	
16214 Sanford Ave.	4	N/A	Concrete fractured and broken. Appeared to have two sources of concrete.
16214 Sanford Ave.	5	4836	
16214 Sanford Ave.	8	6622	
Pepper Ave.	3	N/A	Concrete on top of existing pavement; too thin for testing
Pepper Ave.	4	4959	
Pepper Ave.	8	4717	
3504 Woodbridge Ave.	4	7277	
3504 Woodbridge Ave.	5	5048	
3504 Woodbridge Ave.	8	5352	

Table 46 Results of compressive strength of concrete in repair, City of Columbus. (1 psi = 6.895 kPa)

Site	Core No.	Compressive strength (psi)	Notes
1576 Old Leonard Ave.	4	3939	
1576 Old Leonard Ave.	5	N/A	Unable to extract intact core due to deterioration of concrete
1576 Old Leonard Ave.	8	N/A	Concrete was broken and fractured; unable to test

The American Concrete Institute (ACI) recommends a minimum 28 day compressive strength of 4500 psi for exterior concrete (ACI Committee, 2011). While the ODOT Construction and Materials Specifications specifies a 28 day compressive strength of 4500 psi for Class S concrete, the requirement for Class C, which is typically used for concrete pavement and repairs, is a 28 day strength of 4000 psi (ODOT, 2016). All specimens tested, with the exception of the specimen from Old Leonard Avenue, exceeded 4000 psi.

13.2.7 Analysis of Backfill Material

The moisture content, grain size and color analysis for base material and soils collected at each site are shown in Tables 47 through 49 for material collected inside the repair area for the cities of Cleveland, Columbus, and Dayton, respectively.

Cleveland specifications require the use of LSM under all utility cut repairs. The results of the lab test are mixed, with most locations showing cemented and uncemented granular soil in the base.

Table 47 Backfill material analysis, inside repair, City of Cleveland. (1 ft = 0.3048 m)

Site	Core No.	Distance from edge of repair	Moisture Content	Backfill Material	Grain Size and Color
1412 E. 45th Ave.	3	1.5 ft.	4.4% (damp)	appears to be a collection of uncemented soil grains.	Color = grey; Grain Size = silt to small gravel (sub-round grains)
1412 E. 45th Ave.	4	4 ft.	5.7% (damp)	appears to be a sample of cemented granular soil grains (i.e. LSM)	Color = grey; Grain Size = silt to small gravel (sub-round grains)
1412 E. 45th Ave.	8	3.75 ft.	6.5% (damp)	appears to be a collection of uncemented soil grains.	Color = grey; Grain Size = silt to gravel (sub-round & angular grains)
13009 Terminal Ave.	3	1.5 ft.	Not sampled		
13009 Terminal Ave.	4	5.67 ft.	11.1% (moist)	appears to be a collection of uncemented soil grains.	Color = dark brown; Grain Size = silt to small gravel (round grains)
13009 Terminal Ave.	5	1.5 ft.	5.3.% (damp)	appears to be a collection of uncemented soil grains.	Color = mostly light grey; Grain Size = silt to gravel (round grains)
13009 Terminal Ave.	8	1.5 ft.	Similar to material from core number 4		
16713 Valleyview Ave.	3	1.5 ft.	15.2% (moist)	appears to be a collection of uncemented soil grains.	Color = mostly dark brown; Grain Size = silt to gravel (round grains)
16713 Valleyview Ave.	4	8.75 ft.	1-2% (dry)	each core appears to be a piece of **cemented** soil grains (= **LSM**). Two sections of the core definitely do not look like concrete or asphalt samples.	Color = dark grey-brown; Core Size = about 3.5" in diameter
16713 Valleyview Ave.	8	1.5 ft.	Not sampled		
16214 Sanford Ave.	4	7 ft.	Not sampled		
16214 Sanford Ave.	5	1.5 ft.	1-2% (dry)	appears to be a collection of uncemented soil grains.	Color = mostly light grey; Grain Size = silt to gravel (round grains)
16214 Sanford Ave.	8	1.5 ft.	1-2% (dry)	appears to be broken pieces of **cemented** granular soil (= **LSM**), the largest piece is many gravel-size particles cemented together, impossible to break it into smaller pieces by hand (very hard).	Color = mostly grey; Grain Size = silt to very large gravel (many angular grains)

Site	Core No.	Distance from edge of repair	Moisture Content	Backfill Material	Grain Size and Color
Pepper Ave.	3	1.5 ft.	Not sampled		
Pepper Ave.	4	9.25 ft.	16.0% (moist)	appears to be a collection of uncemented soil grains.	Color = light grey; Grain Size = silt to gravel (round grains)
Pepper Ave.	8	1.5 ft.	16.7% (moist)	appears to be a collection of uncemented soil grains.	Color = light grey; Grain Size = silt to gravel (round grains)
3504 Woodbridge Ave.	4P	6 ft.	1-2% (dry)	appears to be a collection of broken pieces of concrete.	Color = mostly light grey; Grain Size = silt to gravel (round grains)
3504 Woodbridge Ave.	5P	1.5 ft.	1-2% (dry)	appears to be a collection of **cemented** soil grains (= **LSM**).	Color = light grey; Grain Size = silt to gravel (sub-round grains)
3504 Woodbridge Ave.	8	1.5 ft.	1-2% (dry)	appears to be a collection of broken pieces of **cemented** soil grains (= **LSM**).	Color = light grey; Grain Size = silt to large gravel (sub-round & angular grains)

Table 48 Backfill material analysis, inside repair, City of Columbus. (1 ft = 0.3048 m)

Site	Core No.	Distance from edge of repair	Moisture Content	Backfill Material	Grain Size and Color
62 E. Barthman Ave.	4	4.33 ft.	4.7% (dry)	Consists of a large piece of cemented soil grains (= LSM).	Color = light grey; Grain Size = silt to gravel (round grains)
62 E. Barthman Ave.	5	1 ft.	17.0% (moist)	Appears to be a collection of uncemented soil grains.	Color = mostly light brown; Grain Size = silt & sand (round grains)
62 E. Barthman Ave.	8	1 ft.	18.9% (moist)	Appears to consist of broken pieces of cemented soil grains (= LSM).	Color = mostly light grey; Grain Size = silt & sand (round grains)
50 E. Jeffrey Place	3	1 ft.	14.9% (moist)	Appears to be a collection of uncemented soil grains.	Color = mostly brown; Grain Size = silt & sand (round grains)
50 E. Jeffrey Place	4	3 ft.	Not sampled		
50 E. Jeffrey Place	8	2.5 ft.	15.6% (moist)	Appears to consist of uncemented soil grains.	Color = brown; Grain Size = silt & sand (round grains)
1576 Old Leonard Ave.	4	5.58 ft.	5.8% (dry)	Appears to consist of uncemented soil grains or a granular base material.	Color = mostly brown; Grain Size = sand & gravel (round grains)
1576 Old Leonard Ave.	5	1 ft.	Not sampled		
1576 Old Leonard Ave.	8	1 ft.	3.6% (dry)	Appears to consist of large broken pieces of cemented soil grains (= LSM).	Color = mostly light grey; Grain Size = silt to gravel (round grains)
61 W. 3rd Ave.	3	2 ft.	13.9% (moist)	Appears to consist of uncemented soil grains.	Color = brown; Grain Size = silt & sand (round grains)
61 W. 3rd Ave.	4	8.67 ft.	Not sampled		
61 W. 3rd Ave.	5	4.33 ft.	31.6% (moist)	Appears to be a collection of uncemented soil grains.	Color = dark grey brown; Grain Size = mostly silt (round grains)
85 W. 3rd Ave.	4	5.17 ft.	15.4% (moist)	Appears to consist of uncemented soil grains.	Color = brown; Grain Size = silt & sand (round grains)
85 W. 3rd Ave.	5	1 ft.	11.0% (damp)	Appears to consist of cemented soil grains (= LSM).	Color = light grey; Grain Size = silt & sand (round grains)
85 W. 3rd Ave.	8	1 ft.	15.1% (moist)	Appears to consist of uncemented soil grains.	Color = brown; Grain Size = silt & sand (round grains)
1734 Old Leonard Ave.	4	10.67 ft.	Not sampled		
1734 Old Leonard Ave.	8	1 ft.	14.5% (moist)	Appears to be a collection of uncemented soil grains.	Color = mostly light brown; Grain Size = silt & sand (round grains)

Table 49 Backfill material analysis, inside repair, City of Dayton. (1 ft = 0.3048 m)

Site	Core No.	Distance from edge of repair	Moisture Content	Backfill Material	Grain Size and Color
66 S. Sperling Ave.	3	0.67 ft.	6.82%	Uncemented soil grains (i.e granular material)	Grain size = sand Color = dark grey
66 S. Sperling Ave.	4	2.67 ft.	7.77%	Uncemented soil grains (i.e granular material)	Grain size = silt to gravel Color = brown
66 S. Sperling Ave.	8	0.67 ft.	8.20%	Uncemented soil grains (i.e granular material)	Grain size = sand to gravel Color = brown
74 S. Sperling Ave.	3	1 ft.	8.95%	Uncemented soil grains (i.e granular material)	Grain size = silt to gravel Color = dark brown
74 S. Sperling Ave.	4	3.5 ft.	6.45%	Uncemented soil grains (i.e granular material)	Grain size = silt to gravel Color = brown
74 S. Sperling Ave.	8	0.67 ft.	5.94%	Uncemented soil grains (i.e granular material)	Grain size = silt to gravel Color = grey
N. Torrence at Springfield	4	3.25 ft.	5.46%	Uncemented soil grains (i.e granular material)	Grain size = sand with some gravel Color = brown
N. Torrence at Springfield	5	0.67 ft.	7.27%	Uncemented soil grains (i.e granular material)	Grain size = silt to gravel and RAP Color = brown
N. Torrence at Springfield	7	0.67 ft.	10.97%	Uncemented soil grains (i.e granular material)	Grain size = silty sand with gravel and RAP Color = brown
85 Paw Paw St.	3	0.67 ft.	5.01%	Uncemented soil grains (i.e granular material)	Grain size = sand to gravel Color = dark grey
85 Paw Paw St.	4	2.33 ft.	5.18%	Uncemented soil grains (i.e granular material)	Grain size = sand to gravel Color = dark grey
85 Paw Paw St.	8	0.67 ft.	4.99%	Uncemented soil grains (i.e granular material)	Grain size = sand to gravel Color = grey
316 Urbana Ave.	3	0.67 ft.	5.89%	Uncemented soil grains (i.e granular material)	Grain size = sand to gravel Color = brown
316 Urbana Ave.	4	3.83 ft.	5.30%	Uncemented soil grains (i.e granular material)	Grain size = silt to gravel Color = brown
316 Urbana Ave.	7	0.67 ft.	5.74%	Uncemented soil grains (i.e granular material)	Grain size = sand to gravel Color = brown

Site	Core No.	Distance from edge of repair	Moisture Content	Backfill Material	Grain Size and Color
60 S. Wright Ave.	1	14.75 ft. from middle patch	5.87%	Uncemented soil grains (i.e granular material)	Grain size = silt to gravel Color = dark brown
60 S. Wright Ave.	2	1 ft. from middle patch	13.69%	Uncemented soil grains (i.e granular material)	Grain size = silty sand with gravel Color = dark brown
60 S. Wright Ave.	3	1.5 ft.	10.95%	Uncemented soil grains (i.e granular material)	Grain size = sand Color = grey
60 S. Wright Ave.	6	0.67 ft.	4.81%	Uncemented soil grains (i.e granular material)	Grain size = silt to gravel Color = brown

Figure 89 is a box plot comparing the base moisture content for repairs with good performance to repairs with poor performance. The plot shows the moisture contents are statistically the same although the section with poor performance have a wider range of moisture contents and the mean is slightly higher than the moisture content of good performing repairs.

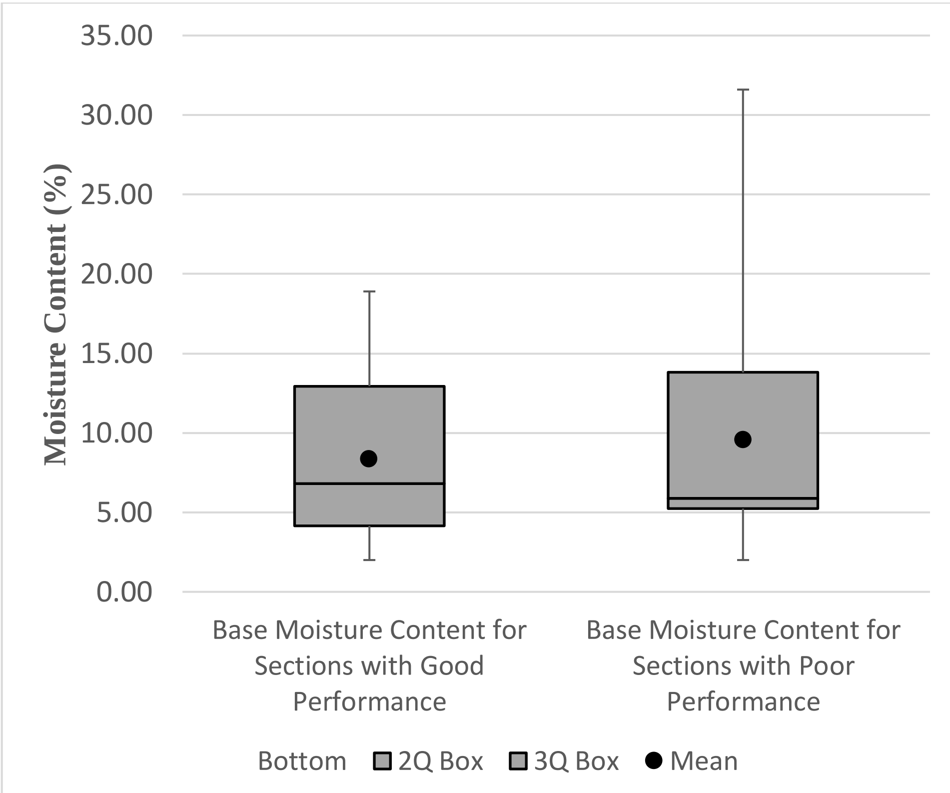


Figure 89 Box Plot for Base Moisture Content

The moisture content of base material, as a function of distance from the boundary of the repair, is shown in Figure 90. The data is divided by location (city) and performance. As shown in the figure, the moisture content of the base was higher for the City of Columbus, regardless of performance. It was found that 79% of the 14 base samples tested from Columbus had a moisture content of 10% or higher. However, only 23% of the 13 samples tested from Cleveland and 16% of the samples tested from Dayton had a moisture content 10% or higher.

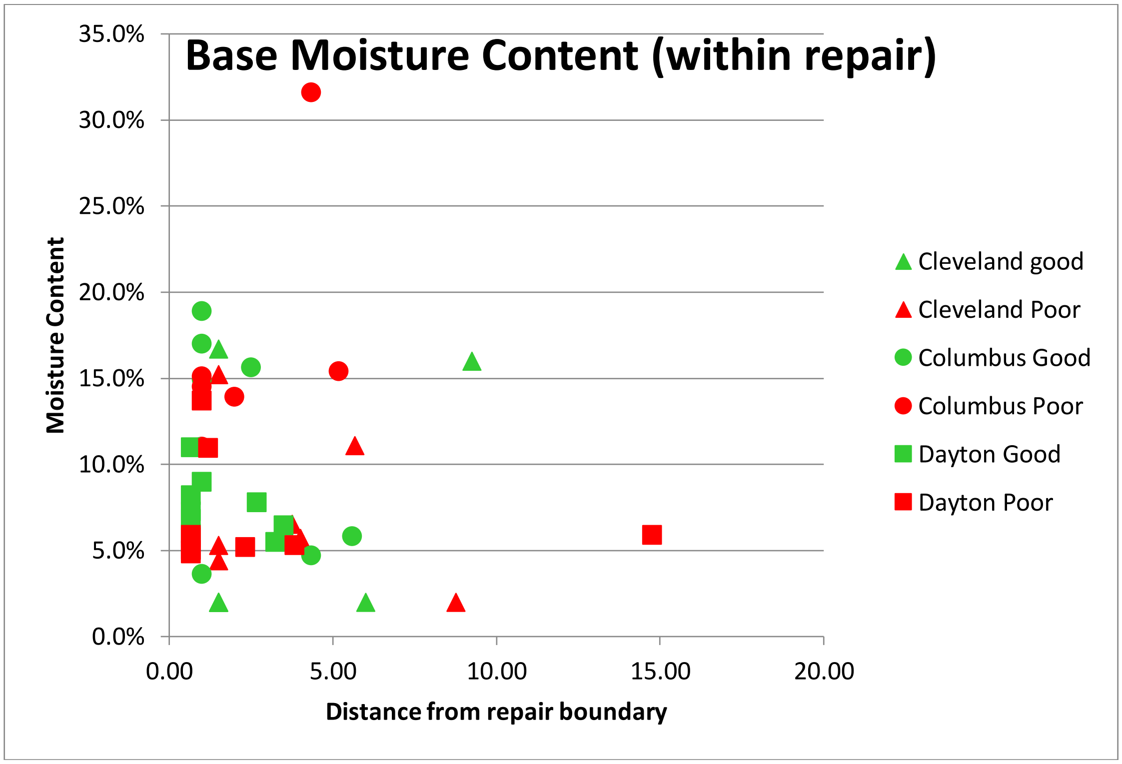


Figure 90 Comparison of base moisture contents within repair (1 ft = 0.3048 m)

14 Appendix G Pavement Core Logs

14.1 City of Columbus

6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB	61 W. 3RD Ave.
No.	W-18-151
BORING/CORE No. DATE	1-1
CORE OBTAINED CORE	3/11/2019
OBTAINED BY	Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
1-1	1.25	X								
	1.25		X							
	4.50			X						
	7.00					X				

Comments/Remarks

- Asphalt layers contain trace voids
- Asphalt intermediate and base layers are separated
- Lift thickness of aggregate base was not determined in the field

Total Pavement Thickness = 7.00 in. Total Asphalt Thickness = 7.00 in. Total Concrete Thickness = 0.00 in. Total Base Thickness = 7.00 in.

6350 Presidential Gateway Columbus, Ohio 43231 Telephone: (614) 823-4949 Fax Number: (614) 823-4990	**Pavement Core Data Summary**

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB	61 W. 3RD Ave.
No.	W-18-151
BORING/CORE No. DATE	1-2
CORE OBTAINED CORE	3/11/2019
OBTAINED BY	Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
1-2	1.00	X								
	1.50		X							
	1.25		X							
	3.25			X						
	7.00				X					

Comments/Remarks

- Voids observed in first lift of intermediate asphalt
- Concrete is highly fractured and in pieces

Total Pavement Thickness = 7.00 in.	Total Asphalt Thickness = 7.00 in.	Total Concrete Thickness = 0.00 in.	Total Base Thickness = 7.00 in.

6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

Pavement Core Data Summary

PROJECT: Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB: 61 W. 3RD Ave.
No.: W-18-151

BORING/CORE No. DATE: 1-3
CORE OBTAINED CORE: 3/11/2019
OBTAINED BY: Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
1-3	9.00	X								
	Unknown						X			

Comments/Remarks

- Voids throughout asphalt layer
- Lift thickness of CDF was not determined in the field

Total Pavement Thickness = 9.00 in.   Total Asphalt Thickness = 9.00 in.   Total Concrete Thickness = 0.00 in.   Total Base Thickness = 0.00 in.

	Pavement Core Data Summary
6350 Presidential Gateway Columbus, Ohio 43231 Telephone: (614) 823-4949 Fax Number: (614) 823-4990	PROJECT: Practices for Pavement Rest. of Open Cut Utility LOCATION JOB: 61 W. 3RD Ave. No.: W-18-151 BORING/CORE No. DATE: 1-4 CORE OBTAINED CORE: 3/11/2019 OBTAINED BY: Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
1-4	1.50	X								
	1.50		X							
	1.50			X						
	1.50			X						
	6.00					X				

Comments/Remarks

- Trace voids observed in asphalt base

Total Pavement Thickness =	6.00	in.	Total Asphalt Thickness =	6.00	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00 in.

6350 Presidential Gateway Columbus, Ohio 43231 Telephone: (614) 823-4949 Fax Number: (614) 823-4990	**Pavement Core Data Summary** PROJECT: Practices for Pavement Rest. of Open Cut Utility LOCATION JOB: 61 W. 3RD Ave. No.: W-18-151 BORING/CORE No. DATE: 1-5 CORE OBTAINED CORE: 3/11/2019 OBTAINED BY: Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
1-5	1.00	X								
	9.75			X						
	Unknown						X			

Comments/Remarks

- Trace voids observed in asphalt base
- Lift thickness of CDF was not determined in the field

Total Pavement Thickness = 10.75 in.	Total Asphalt Thickness = 10.75 in.	Total Concrete Thickness = 0.00 in.	Total Base Thickness = 0.00 in.

6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

Pavement Core Data Summary

PROJECT: Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB: 85 W. 3RD Ave.
No.: W-18-151

BORING/CORE No. DATE: 2-4
CORE OBTAINED CORE: 3/11/2019
OBTAINED BY: Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
2-4	2.00	X								
	5.00			X						
	Unknown						X			

Comments/Remarks

- Trace voids observed in asphalt base

Lift thickness of aggregate base was not determined in the field

Total Pavement Thickness = 7.00 in. Total Asphalt Thickness = 7.00 in. Total Concrete Thickness = 0.00 in. Total Base Thickness = 0.00 in.

6350 Presidential Gateway Columbus, Ohio 43231 Telephone: (614) 823-4949 Fax Number: (614) 823-4990	**Pavement Core Data Summary** PROJECT: Practices for Pavement Rest. of Open Cut Utility LOCATION JOB: 85 W. 3RD Ave. No.: W-18-151 BORING/CORE No. DATE: 2-5 CORE OBTAINED CORE: 3/11/2019 OBTAINED BY: Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
2-5	8.00	X								
	Unknown						X			

Comments/Remarks

- Trace voids observed in asphalt

Total Pavement Thickness = 8.00 in.	Total Asphalt Thickness = 8.00 in.	Total Concrete Thickness = 0.00 in.	Total Base Thickness = 0.00 in.

6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB	85 W. 3RD Ave.
No.	W-18-151
BORING/CORE No. DATE	2-6
CORE OBTAINED CORE	3/11/2019
OBTAINED BY	Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt					Other			
		Surface	Intermediate	Base	Concrete	Aggregate/Granular Base	CDF			
2-6	1.00	X								
	1.50		X							
	4.75			X						
	Unknown					X				

Comments/Remarks

- Trace voids observed in intermediate asphalt
- Lift thickness of aggregate base was not determined in the field

Total Pavement Thickness =	7.25	in.	Total Asphalt Thickness =	7.25	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00 in.

6350 Presidential Gateway Columbus, Ohio 43231 Telephone: (614) 823-4949 Fax Number: (614) 823-4990	**Pavement Core Data Summary** PROJECT: Practices for Pavement Rest. of Open Cut Utility LOCATION JOB: 85 W. 3RD Ave. No.: W-18-151 BORING/CORE No. DATE: 2-7 CORE OBTAINED CORE: 3/11/2019 OBTAINED BY: Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
2-7	0.75	X								
	1.75		X							
	4.25			X						
	Unknown					X				

Comments/Remarks

- Trace voids observed in intermediate asphalt
- Lift thickness of aggregate base was not determined in the field

Total Pavement Thickness =	6.75 in.	Total Asphalt Thickness =	6.75 in.	Total Concrete Thickness =	0.00 in.	Total Base Thickness =	0.00 in.

6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB	85 W. 3RD Ave.
No.	W-18-151
BORING/CORE No. DATE	2-8
CORE OBTAINED CORE	3/11/2019
OBTAINED BY	Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
2-8	6.50	X								
	Unknown						X			

Comments/Remarks

- Asphalt surface layer is separated in three pieces
- Lift thickness of CDF was not determined in the field

Total Pavement Thickness =	6.50	in.	Total Asphalt Thickness =	6.50	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00 in.

Pavement Core Data Summary

6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB	50 E. Jefferey Place
No.	W-18-151
BORING/CORE No. DATE	3-1
CORE OBTAINED CORE	3/11/2019
OBTAINED BY	Tom Harper, CET

Core Composition

		Asphalt					Other			
Core Number	Lift Thickness (in.)	Surface	Intermediate	Base	Concrete	Aggregate/Granular Base	CDF			
3-1	1.25	X								
	1.75		X							
	2.00		X							
	4.50			X						
	unknown					X				

Comments/Remarks

- Trace voids in surface and intermediate asphalt layers
- Separation of asphalt intermediate and base layers
- Lift thickness of aggregate base was not determined in the field

Total Pavement Thickness = 9.50 in. Total Asphalt Thickness = 9.50 in. Total Concrete Thickness = 0.00 in. Total Base Thickness = 0.00 in.

6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB	50 E. Jefferey Place
No.	W-18-151
BORING/CORE No. DATE	3-2
CORE OBTAINED CORE	3/11/2019
OBTAINED BY	Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
3-2	1.00	X								
	1.50		X							
	2.50		X							
	4.50			X						
	unknown					X				

Comments/Remarks

- Trace voids observed in upper intermediate asphalt
- Asphalt base layer separated from intermediate asphalt layer
- Lift thickness of aggregate base was not determined in the field

Total Pavement Thickness = 9.50 in.	Total Asphalt Thickness = 9.50 in.	Total Concrete Thickness = 0.00 in.	Total Base Thickness = 0.00 in.

6350 Presidential Gateway Columbus, Ohio 43231 Telephone: (614) 823-4949 Fax Number: (614) 823-4990	**Pavement Core Data Summary** PROJECT: Practices for Pavement Rest. of Open Cut Utility LOCATION JOB: 50 E. Jefferey Place No.: W-18-151 BORING/CORE No. DATE: 3-3 CORE OBTAINED CORE: 3/11/2019 OBTAINED BY: Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
3-3	2.25	X								
	3.75		X							
	4.00			X						
	unknown						X			

Comments/Remarks

- Trace voids observed in intermediate and base asphalt
- Lift thickness of aggregate base was not determined in the field

Total Pavement Thickness = 9.50 in. Total Asphalt Thickness = 9.50 in. Total Concrete Thickness = 0.00 in. Total Base Thickness = 0.00 in.

Pavement Core Data Summary

6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB	50 E. Jefferey Place
No.	W-18-151
BORING/CORE No. DATE	3-4
CORE OBTAINED CORE	3/11/2019
OBTAINED BY	Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
3-4	2.25	X								
	3.75		X							
	4.00			X						
	unknown						X			

Comments/Remarks

- Trace voids observed in intermediate and base asphalt
- Lift thickness of CDF was not determined in the field

Total Pavement Thickness =	9.50	in.	Total Asphalt Thickness =	9.50	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00 in.

Pavement Core Data Summary

6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB	50 E. Jefferey Place
No.	W-18-151
BORING/CORE No. DATE	3-8
CORE OBTAINED CORE	3/11/2019
OBTAINED BY	Tom Harper, CET

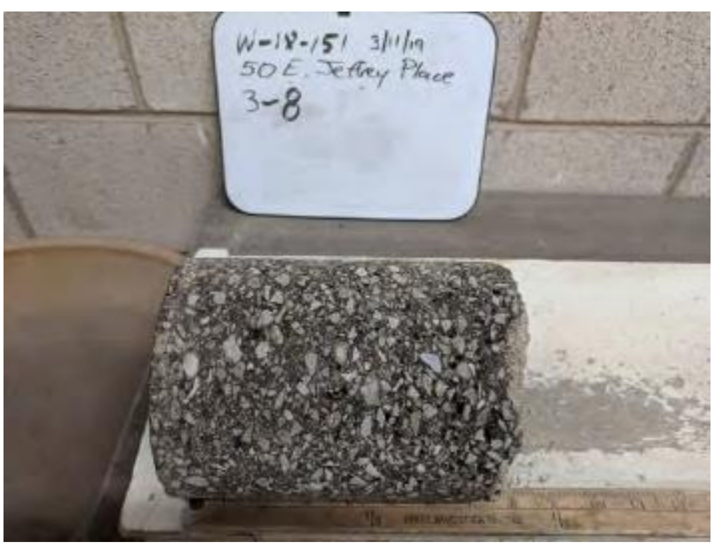
Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
3-8	1.50	X								
	2.00		X							
	4.50			X						
	unknown						X			

Comments/Remarks

- Trace voids observed in intermediate and base asphalt
- Lift thickness of CDF was not determined in the field

Total Pavement Thickness = 8.00 in.	Total Asphalt Thickness = 8.00 in.	Total Concrete Thickness = 0.00 in.	Total Base Thickness = 0.00 in.



	Pavement Core Data Summary	
6350 Presidential Gateway Columbus, Ohio 43231 Telephone: (614) 823-4949 Fax Number: (614) 823-4990	PROJECT	Practices for Pavement Rest. of Open Cut Utility
	LOCATION JOB	62 E Bartman Ave
	No.	W-18-151
	BORING/CORE No. DATE	4-4
	CORE OBTAINED CORE	3/12/2019
	OBTAINED BY	Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
4-4	9.75	X								
	unknown						X			

Comments/Remarks

- Voids throughout asphalt layer
- Lift thickness of CDF was not determined in the field

Total Pavement Thickness =	9.75	in.	Total Asphalt Thickness =	9.75	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB	62 E Bartman Ave
No.	W-18-151
BORING/CORE No. DATE	4-5
CORE OBTAINED CORE	3/12/2019
OBTAINED BY	Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
4-5	10.75	X								
	unknown						X			

Comments/Remarks

- Trace voids observed throughout asphalt
- Lift thickness of CDF was not determined in the field

Total Pavement Thickness = 10.75 in.	Total Asphalt Thickness = 10.75 in.	Total Concrete Thickness = 0.00 in.	Total Base Thickness = 0.00 in.

6350 Presidential Gateway Columbus, Ohio 43231 Telephone: (614) 823-4949 Fax Number: (614) 823-4990	**Pavement Core Data Summary** PROJECT: Practices for Pavement Rest. of Open Cut Utility LOCATION JOB: 62 E Bartman Ave No.: W-18-151 BORING/CORE No. DATE: 4-6 CORE OBTAINED CORE: 3/12/2019 OBTAINED BY: Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Brick	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
4-6	2.50	X								
	4.00		X							
	5.00				X					
	unknown					X				

Comments/Remarks

- Core samples contained brick beneath asphalt surface
- Concrete is intact with little to no voids.
- Lift thickness of aggregate base was not determined in the field

Total Pavement Thickness = 11.50 in. Total Asphalt Thickness = 2.50 in. Total Concrete Thickness = 5.00 in. Total Base Thickness = 0.00 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB	62 E Bartman Ave
No.	W-18-151
BORING/CORE No. DATE	4-7
CORE OBTAINED CORE	3/12/2019
OBTAINED BY	Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Brick	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
4-7	3.00	X								
	4.00		X							
	5.00				X					
	unknown					X				

Comments/Remarks

- Asphalt surface has trace voids
- Concrete layer was measured in the core hole
- Lift thickness of aggregate base was not determined in the field

Total Pavement Thickness = 11.50 in. Total Asphalt Thickness = 2.50 in. Total Concrete Thickness = 5.00 in. Total Base Thickness = 0.00 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB	62 E Bartman Ave
No.	W-18-151
BORING/CORE No. DATE	4-8
CORE OBTAINED CORE	3/12/2019
OBTAINED BY	Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
4-8	10.50	X								
	unknown						X			

Comments/Remarks

- Voids observed throughout asphalt layer
- Lift thickness of CDF was not determined in the field

Total Pavement Thickness = 10.50 in. Total Asphalt Thickness = 10.50 in. Total Concrete Thickness = 0.00 in. Total Base Thickness = 0.00 in.

Pavement Core Data Summary

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PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB	1586 Old Leonard Ave
No.	W-18-151
BORING/CORE No. DATE	5-4
CORE OBTAINED CORE	3/12/2019
OBTAINED BY	Tom Harper, CET

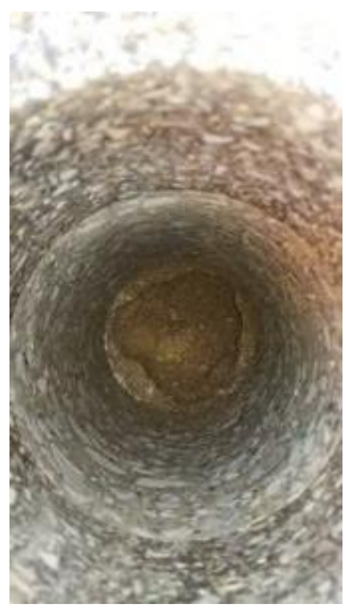
Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
5-4	1.50	X								
	2.50		X							
	11.00				X					
	unknown					X				

Comments/Remarks

- Trace voids observed at surface/intermediate asphalt
- Concrete layer is intact
- Lift thickness of aggregate base was not determined in the field

Total Pavement Thickness =	15.00	in.	Total Asphalt Thickness =	4.00	in.	Total Concrete Thickness =	11.00	in.	Total Base Thickness =	0.00 in.



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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB	1586 Old Leonard Ave
No.	W-18-151
BORING/CORE No. DATE	5-5
CORE OBTAINED CORE	3/12/2019
OBTAINED BY	Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
5-5	1.50	X								
	1.50		X							
	1.25		X							
	1.25		X							
	2.75			X						
	3.00				X					

Comments/Remarks

- Trace voids observed at top layer of intermediate asphalt
- Concrete layer was measured in the core hole

Total Pavement Thickness = 11.25 in.	Total Asphalt Thickness = 8.25 in.	Total Concrete Thickness = 3.00 in.	Total Base Thickness = 0.00 in.

Pavement Core Data Summary

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PROJECT: Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB: 1586 Old Leonard Ave
No.: W-18-151

BORING/CORE No. DATE: 5-6
CORE OBTAINED CORE: 3/12/2019
OBTAINED BY: Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
5-6	1.25	X								
	1.25		X							
	1.25		X							
	1.50		X							
	6.00				X					

Comments/Remarks

- Asphalt layers contain little voids
- Concrete layer is fractured and in pieces

Total Pavement Thickness = 13.00 in. Total Asphalt Thickness = 7.00 in. Total Concrete Thickness = 6.00 in. Total Base Thickness = 0.00 in.

Pavement Core Data Summary

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PROJECT Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB 1586 Old Leonard Ave
No. W-18-151

BORING/CORE No. DATE 5-7
CORE OBTAINED CORE 3/12/2019
OBTAINED BY Tom Harper, CET

Core Composition

		Asphalt					Other			
Core Number	Lift Thickness (in.)	Surface	Intermediate	Base	Concrete	Aggregate/Granular Base	CDF			
5-7	1.00	X								
	2.50		X							
	1.50			X						
	7.50				X					

Comments/Remarks

- Asphalt layers contain little voids
- Concrete layer is fractured and in pieces

Total Pavement Thickness = 12.50 in. Total Asphalt Thickness = 5.00 in. Total Concrete Thickness = 7.50 in. Total Base Thickness = 0.00 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB	1586 Old Leonard Ave
No.	W-18-151
BORING/CORE No. DATE	5-8
CORE OBTAINED CORE	3/12/2019
OBTAINED BY	Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
5-8	1.75	X								
	1.25		X							
	10.00				X					

Comments/Remarks

- Asphalt layers contain many voids
- Concrete base is highly fractured and in pieces

Total Pavement Thickness = 13.00 in.	Total Asphalt Thickness = 3.00 in.	Total Concrete Thickness = 10.00 in.	Total Base Thickness = 0.00 in.

Pavement Core Data Summary

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PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB	1734 Old Leonard Ave
No.	W-18-151
BORING/CORE No. DATE	6-4
CORE OBTAINED CORE	3/12/2019
OBTAINED BY	Tom Harper, CET

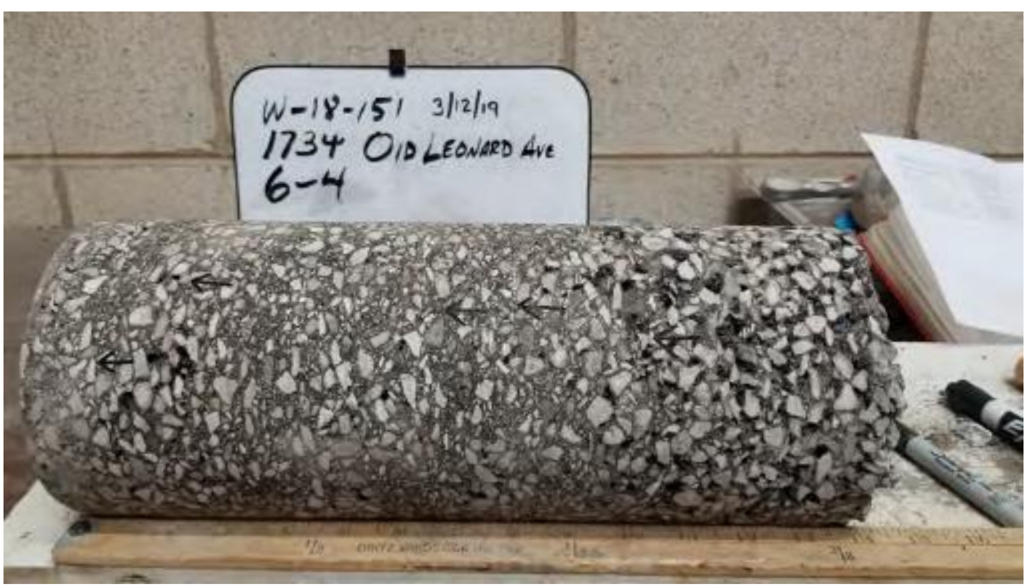
Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
6-4	1.00	X								
	1.25		X							
	4.25		X							
	1.25		X							
	2.25		X							
	4.50			X						
	unknown					X				

Comments/Remarks

- Asphalt surface and intermediate layers have trace voids
- Asphalt base layer contains many voids
- Lift thickness of aggregate base was not determined in the field

Total Pavement Thickness = 14.50 in. Total Asphalt Thickness = 14.50 in. Total Concrete Thickness = 0.00 in. Total Base Thickness = 0.00 in.



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PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB	1734 Old Leonard Ave
No.	W-18-151
BORING/CORE No. DATE	6-6
CORE OBTAINED CORE	3/12/2019
OBTAINED BY	Tom Harper, CET

Core Composition

		Asphalt					Other			
Core Number	Lift Thickness (in.)	Surface	Intermediate	Base	Concrete	Aggregate/Granular Base	CDF			
6-6	1.25	X								
	1.50		X							
	4.25			X						
	unknown					X				

Comments/Remarks

- Asphalt layers contain trace voids
- Lift thickness of aggregate base was not determined in the field

Total Pavement Thickness =	7.00	in.	Total Asphalt Thickness =	7.00	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION JOB	1734 Old Leonard Ave
No.	W-18-151
BORING/CORE No. DATE	6-7
CORE OBTAINED CORE	3/12/2019
OBTAINED BY	Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
6-7	1.25	X								
	1.75		X							
	4.00			X						
	unknown					X				

Comments/Remarks

- Asphalt surface layer contains some voids
- Lift thickness of aggregate base was not determined in the field

Total Pavement Thickness = 7.00 in.	Total Asphalt Thickness = 7.00 in.	Total Concrete Thickness = 0.00 in.	Total Base Thickness = 0.00 in.

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Pavement Core Data Summary

PROJECT: Practices for Pavement Rest. of Open Cut Utility
LOCATION: 1734 Old Leonard Ave
JOB No.: W-18-151
BORING/CORE No.: 6-8
DATE CORE OBTAINED: 3/12/2019
CORE OBTAINED BY: Tom Harper, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: CDF	Other	Other	Other
6-8	3.00	X								
	5.50			X						
	unknown						X			

Comments/Remarks

- Little to no voids in both asphalt layers
- Lift thickness of CDF was not determined in the field

Total Pavement Thickness = 8.50 in. Total Asphalt Thickness = 8.50 in. Total Concrete Thickness = 0.00 in. Total Base Thickness = 0.00 in.

14.2 City of Cleveland

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	16212 Sanford Ave.
JOB No.	W-18-151
BORING/CORE No.	1-4
DATE CORE OBTAINED	11/28/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other			
1-4	1.25	✓								
	7.75				✓					

Comments/Remarks

- Voids observed throughout asphalt
- Concrete fractured and broken

Total Pavement Thickness =	9.00	in.	Total Asphalt Thickness =	1.25	in.	Total Concrete Thickness =	7.75	in.	Total Base Thickness =	0.00	in.

Pavement Core Data Summary

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PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	16212 Sanford Ave.
JOB No.	W-18-151
BORING/CORE No.	1-5
DATE CORE OBTAINED	11/28/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other			
1-5	2.00	✓								
	12.00				✓					
	Unknown					✓				

Comments/Remarks

- Small voids throughout asphalt
- Lift thickness of granular base could not be determined.

Total Pavement Thickness =	14.00	in.	Total Asphalt Thickness =	2.00	in.	Total Concrete Thickness =	12.00	in.	Total Base Thickness =	0.00	in.


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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	16212 Sanford Ave.
JOB No.	W-18-151
BORING/CORE No.	1-6
DATE CORE OBTAINED	11/28/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other			
1-6	1.00	✓								
	1.50		✓							
	6.50				✓					
	Unknown					✓				

Comments/Remarks

- Trace voids scattered throughout asphalt
- Lift thickness of granular base could not be determined.

Total Pavement Thickness = 9.00 in.	Total Asphalt Thickness = 2.50 in.	Total Concrete Thickness = 6.50 in.	Total Base Thickness = 0.00 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	16212 Sanford Ave.
JOB No.	W-18-151
BORING/CORE No.	1-7
DATE CORE OBTAINED	11/28/2018
CORE OBTAINED BY	11/28/2018
	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other			
1-7	3.00	✓								
	5.50				✓					

Comments/Remarks

- Trace voids in surface asphalt
- Small voids throughout bottom asphalt layer

Total Pavement Thickness =	8.50	in.	Total Asphalt Thickness =	3.00	in.	Total Concrete Thickness =	5.50	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	16212 Sanford Ave.
JOB No.	W-18-151
BORING/CORE No.	1-8
DATE CORE OBTAINED	11/28/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: 404	Asphalt: 402	Asphalt: 301	Concrete	Aggregate/Granular Base	Other: Pulverized Asphalt	Other	Other	Other
1-8	1.00	✓								
	6.50				✓					
	1.50						✓			

Comments/Remarks

- Voids throughout asphalt layer

Total Pavement Thickness = 7.50 in.	Total Asphalt Thickness = 1.00 in.	Total Concrete Thickness = 6.50 in.	Total Base Thickness = 0.00 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	Pepper Ave. & E. 152nd St.
JOB No.	W-18-151
BORING/CORE No.	2-1
DATE CORE OBTAINED	11/28/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other: Red Brick Paver	Other	Other	Other
2-1	2.50	✓								
	4.00						✓			
	5.50				✓					

Comments/Remarks

- Voids throughout asphalt surface layer

Total Pavement Thickness =	12.00	in.	Total Asphalt Thickness =	2.50	in.	Total Concrete Thickness =	5.50	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	Pepper Ave. & E. 152nd St.
JOB No.	W-18-151
BORING/CORE No.	2-2
DATE CORE OBTAINED	11/28/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other			
2-2	0.88	✓								
	1.63		✓							

Comments/Remarks

- Voids throughout asphaltlayers

Total Pavement Thickness =	2.50	in.	Total Asphalt Thickness =	2.50	in.	Total Concrete Thickness =	).00	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT: Practices for Pavement Rest. of Open Cut Utility
LOCATION: Pepper Ave. & E. 152nd St.
JOB No.: W-18-151

BORING/CORE No.: 2-3
DATE CORE OBTAINED: 11/28/2018
CORE OBTAINED BY: Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other			
2-3	1.25	✓								
	0.50				✓					

Comments/Remarks

- Trace voids and cracking at asphalt and concrete interface

Total Pavement Thickness = 1.75 in. | Total Asphalt Thickness = 1.25 in. | Total Concrete Thickness =).50 in. | Total Base Thickness = 0.00 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	Pepper Ave. & E. 152nd St.
JOB No.	W-18-151
BORING/CORE No.	2-4
DATE CORE OBTAINED	11/28/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other			
2-4	1.00	✓								
	12.00				✓					
	Unknown					✓				

Comments/Remarks

- Trace voids along bottom of asphalt surface layer
- Lift thickness of granular base could not be determined.

Total Pavement Thickness =	13.00	in.	Total Asphalt Thickness =	1.00	in.	Total Concrete Thickness =	12.00	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	Pepper Ave. & E. 152nd St.
JOB No.	W-18-151
BORING/CORE No.	2-8
DATE CORE OBTAINED	11/28/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other			
2-8	1.75	✓								
	11.50				✓					

Comments/Remarks

- Trace small voids throughout asphalt

Total Pavement Thickness =	13.25	in.	Total Asphalt Thickness =	1.75	in.	Total Concrete Thickness =	11.50	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	1412 E. 45th St.
JOB No.	W-18-151
BORING/CORE No.	3-1
DATE CORE OBTAINED	11/29/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other: Red Brick Paver	Other	Other	Other
3-1	1.125	✓								
	1.875		✓							
	4.75						✓			
	Unknown					✓				

Comments/Remarks

- Small, trace voids scattered throughout asphalt base layer

Total Pavement Thickness =	7.75	in.	Total Asphalt Thickness =	3.00	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	1412 E. 45th St.
JOB No.	W-18-151
BORING/CORE No.	3-2
DATE CORE OBTAINED	11/29/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other			
3-2	0.75	✓								
	1.25			✓						

Comments/Remarks

Total Pavement Thickness = 2.00 in. Total Asphalt Thickness = 2.00 in. Total Concrete Thickness = 0.00 in. Total Base Thickness = 0.00 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	1412 E. 45th St.
JOB No.	W-18-151
BORING/CORE No.	3-3
DATE CORE OBTAINED	11/29/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other			
3-3	1.50	✓								
	8.00				✓					
	Unknown					✓				

Comments/Remarks

- Voids throughout asphalt
- Lift thickness of granular base could not be determined.

Total Pavement Thickness = 9.50 in.	Total Asphalt Thickness = 1.50 in.	Total Concrete Thickness = 8.00 in.	Total Base Thickness = 0.00 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	1412 E. 45th St.
JOB No.	W-18-151
BORING/CORE No.	3-4
DATE CORE OBTAINED	11/29/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other			
3-4	1.50	✓								
	9.50				✓					
	Unknown					✓				

Comments/Remarks

- Voids throughout asphalt layer
- Lift thickness of granular base could not be determined.

Total Pavement Thickness = 11.00 in.	Total Asphalt Thickness = 1.50 in.	Total Concrete Thickness = 9.50 in.	Total Base Thickness = 0.00 in.

Pavement Core Data Summary

Resource International (Rii)
6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

PROJECT: Practices for Pavement Rest. of Open Cut Utility
LOCATION: 1412 E. 45th St.
JOB No.: W-18-151

BORING/CORE No.: 3-8
DATE CORE OBTAINED: 11/29/2018
CORE OBTAINED BY: Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other			
3-8	2.00	✓								
	10.00				✓					
	Unknown					✓				

Comments/Remarks

- Voids throughout asphalt layer
- Lift thickness of granular base could not be determined.

Total Pavement Thickness =	12.00	in.	Total Asphalt Thickness =	2.00	in.	Total Concrete Thickness =	10.00	in.	Total Base Thickness =	0.00	in.

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Telephone: (614) 823-4949
Fax Number: (614) 823-4990

Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	3504 Woodbridge Ave.
JOB No.	W-18-151
BORING/CORE No.	4-4
DATE CORE OBTAINED	11/29/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt					Other			
		404	402	301	Concrete	Aggregate/Granular Base	Pulverized Asphalt	Pulverized Concrete		
	2.00	✓								
	8.25				✓					
	Unknown						✓			
	Unknown							✓		
4-4										

Comments/Remarks

- Lift thickness of pulverized asphalt and concrete could not be determined.
- Voids throughout asphalt layer

Total Pavement Thickness =	10.25	in.	Total Asphalt Thickness =	2.00	in.	Total Concrete Thickness =	8.25	in.	Total Base Thickness =	0.00	in.

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Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	3504 Woodbridge Ave.
JOB No.	W-18-151
BORING/CORE No.	4-5
DATE CORE OBTAINED	11/29/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: 404	Asphalt: 402	Asphalt: 301	Concrete	Aggregate/Granular Base	Other			
4-5	2.25	✓								
	9.75				✓					
	Unknown					✓				
	Unknown					✓				

Comments/Remarks

- Lift thickness of granular base could not be determined.
- Trace small voids scattered throughout asphalt

Total Pavement Thickness =	12.00	in.	Total Asphalt Thickness =	2.25	in.	Total Concrete Thickness =	9.75	in.	Total Base Thickness =	0.00	in.

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Fax Number: (614) 823-4990

Pavement Core Data Summary

PROJECT: Practices for Pavement Rest. of Open Cut Utility
LOCATION: 3504 Woodbridge Ave.
JOB No.: W-18-151

BORING/CORE No.: 4-6
DATE CORE OBTAINED: 11/29/2018
CORE OBTAINED BY: Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other			
4-6	1.25	✓								
	1.25			✓						

Comments/Remarks

- Small voids scattered throughout asphalt

Total Pavement Thickness =	2.50	in.	Total Asphalt Thickness =	2.50	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00	in.

6350 Presidential Gateway Columbus, Ohio 43231 Telephone: (614) 823-4949 Fax Number: (614) 823-4990	**Pavement Core Data Summary**

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	3504 Woodbridge Ave.
JOB No.	W-18-151
BORING/CORE No.	4-7
DATE CORE OBTAINED	11/29/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other: Brown Brick Paver	Other	Other	Other
4-7	1.25	✓								
	1.25			✓						
	4.75						✓			
	Unknown					✓				

Comments/Remarks

- Lift thickness of granular base could not be determined.
- Trace voids throughout asphalt

Total Pavement Thickness =	7.25	in.	Total Asphalt Thickness =	2.50	in.	Total Concrete Thickness =	).00	in.	Total Base Thickness =	0.00	in.

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Fax Number: (614) 823-4990

Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	3504 Woodbridge Ave.
JOB No.	W-18-151
BORING/CORE No.	4-8
DATE CORE OBTAINED	11/29/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other			
4-8	2.25	✓								
	8.50				✓					
	Unknown					✓				
	Unknown					✓				

Comments/Remarks

- Lift thickness of granular base could not be determined.
- Voids present in asphalt surface

Total Pavement Thickness = 10.75 in.	Total Asphalt Thickness = 2.25 in.	Total Concrete Thickness = 8.50 in.	Total Base Thickness = 0.00 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	16714 Valleyview Ave.
JOB No.	W-18-151
BORING/CORE No.	5-1
DATE CORE OBTAINED	11/30/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt			Concrete	Aggregate/Granular Base	Other			
		404	402	301						
5-1	2.00	✓								
	2.50			✓						
	9.00				✓					

Comments/Remarks

- Voids present in asphalt base layer

Total Pavement Thickness =	13.50	in.	Total Asphalt Thickness =	4.50	in.	Total Concrete Thickness =	9.00	in.	Total Base Thickness =	0.00	in.

Pavement Core Data Summary

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Fax Number: (614) 823-4990

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	16714 Valleyview Ave.
JOB No.	W-18-151
BORING/CORE No.	5-2
DATE CORE OBTAINED	11/30/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other			
5-2	2.00	✓								
	4.00			✓						
	7.00				✓					

Comments/Remarks

- Trace voids in asphalt surface layer
- Voids present in asphalt base layer

Total Pavement Thickness = 13.00 in.	Total Asphalt Thickness = 6.00 in.	Total Concrete Thickness = 7.00 in.	Total Base Thickness = 0.00 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	16714 Valleyview Ave.
JOB No.	W-18-151
BORING/CORE No.	5-3
DATE CORE OBTAINED	11/30/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other			
5-3	1.25	✓								
	6.25				✓					
	unknown					✓				

Comments/Remarks

- Lift thickness of granular base could not be determined.
- Trace small voids throughout asphalt surface layer

Total Pavement Thickness =	7.50	in.	Total Asphalt Thickness =	1.25	in.	Total Concrete Thickness =	6.25	in.	Total Base Thickness =	0.00	in.

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Fax Number: (614) 823-4990

Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	16714 Valleyview Ave.
JOB No.	W-18-151
BORING/CORE No.	5-4
DATE CORE OBTAINED	11/30/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other: Pulverized Asphalt	Other	Other	Other
5-4	1.75	✓								
	7.25				✓					
	4.00						✓			

Comments/Remarks

- Small and medium voids throughout asphalt surface layer

Total Pavement Thickness = 9.00 in.	Total Asphalt Thickness = 1.75 in.	Total Concrete Thickness = 7.25 in.	Total Base Thickness = 0.00 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	16714 Valleyview Ave.
JOB No.	W-18-151
BORING/CORE No.	5-8
DATE CORE OBTAINED	11/30/2018
CORE OBTAINED BY	Beth Bricker, CET

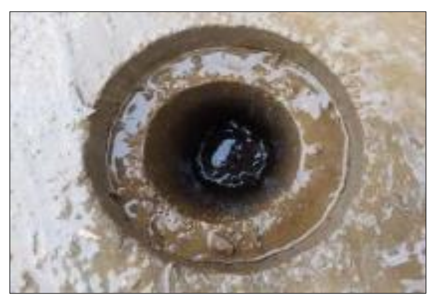
Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other: Pulverized Asphalt	Other	Other	Other
5-8	1.50	✓								
	8.75				✓					

Comments/Remarks

- Voids throughout asphalt surface layer

Total Pavement Thickness =	10.25 in.	Total Asphalt Thickness =	1.50 in.	Total Concrete Thickness =	8.75 in.	Total Base Thickness =	0.00 in.



Pavement Core Data Summary

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Telephone: (614) 823-4949
Fax Number: (614) 823-4990

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	13009 Terminal Ave.
JOB No.	W-18-151
BORING/CORE No.	6-1
DATE CORE OBTAINED	11/30/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other: Pulverized Asphalt	Other	Other	Other
6-1	2.00	✓								
	2.25			✓						
	10.50				✓					
	unknown						✓			

Comments/Remarks

- Lift thickness of pulverized asphalt could not be determined.
- Asphalt layers separated
- Voids present is asphalt surface layer

Total Pavement Thickness =	14.75	in.	Total Asphalt Thickness =	4.25	in.	Total Concrete Thickness =	10.50	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	13009 Terminal Ave.
JOB No.	W-18-151
BORING/CORE No.	6-2
DATE CORE OBTAINED	11/30/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt			Concrete	Aggregate/Granular Base	Other			
		404	402	301			Slag			
6-2	2.00	✓								
	2.00			✓						
	8.50				✓					
	3.25						✓			

Comments/Remarks

- Asphalt layers separated
- Trace voids present is both asphalt layers
- Asphalt base layer in pieces

Total Pavement Thickness =	12.50	in.	Total Asphalt Thickness =	4.00	in.	Total Concrete Thickness =	8.50	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	13009 Terminal Ave.
JOB No.	W-18-151
BORING/CORE No.	6-3
DATE CORE OBTAINED	11/30/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition										
		Asphalt					Other			
Core Number	Lift Thickness (in.)	404	402	301	Concrete	Aggregate/Granular Base				
6-3	1.25	✓								
	7.25				✓					

Comments/Remarks

- Voids throughout asphalt surface layer
- Heavy tack coat on bottom of asphalt surface layer

Total Pavement Thickness =	8.50	in.	Total Asphalt Thickness =	1.25	in.	Total Concrete Thickness =	7.25	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	13009 Terminal Ave.
JOB No.	W-18-151
BORING/CORE No.	6-4
DATE CORE OBTAINED	11/30/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other			
6-4	1.00	✓								
	15.50				✓					
	Unknown					✓				

Comments/Remarks

- Lift thickness of granular base could not be determined.
- Asphalt surface layer in pieces
- Voids present throughout asphalt surface layer
- Heavy tack coat on bottom of asphalt surface layer

Total Pavement Thickness =	16.50	in.	Total Asphalt Thickness =	1.00	in.	Total Concrete Thickness =	15.50	in.	Total Base Thickness =	0.00	in.

Pavement Core Data Summary

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PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	13009 Terminal Ave.
JOB No.	W-18-151
BORING/CORE No.	6-5
DATE CORE OBTAINED	11/30/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other			
6-5	1.00	✓								
	17.00				✓					
	unknown					✓				

Comments/Remarks

- Lift thickness of granular base could not be determined.
- Asphalt layer bonded to concrete base

Total Pavement Thickness = 18.00 in. Total Asphalt Thickness = 1.00 in. Total Concrete Thickness = 17.00 in. Total Base Thickness = 0.00 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	13009 Terminal Ave.
JOB No.	W-18-151
BORING/CORE No.	6-8
DATE CORE OBTAINED	11/30/2018
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt 404	Asphalt 402	Asphalt 301	Concrete	Aggregate/Granular Base	Other	Other	Other	Other
6-8	1.00	✓								
	18.00				✓					
	Unknown					✓				

Comments/Remarks

- Lift thickness of granular base could not be determined.
- Voids throughout asphalt surface layer
- Heavy tack coat on bottom of asphalt surface layer

Total Pavement Thickness =	19.00	in.	Total Asphalt Thickness =	1.00	in.	Total Concrete Thickness =	18.00	in.	Total Base Thickness =	0.00	in.

14.3 City of Dayton

Pavement Core Data Summary

6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	74 S. Sperling Ave.
JOB No.	W-18-151
BORING/CORE No.	1-1
DATE CORE OBTAINED	1/29/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

		Asphalt					Other			
Core Number	Lift Thickness (in.)	Surface	Intermediate	Base	Concrete	Aggregate/Granular Base	Pulverized Asphalt			
1-1	2.00	✓								
	1.50		✓							
	1.00						✓			

Comments/Remarks

- Trace voids observed throughout asphalt

Total Pavement Thickness =	3.50	in.	Total Asphalt Thickness =	3.50	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00	in.

6350 Presidential Gateway Columbus, Ohio 43231 Telephone: (614) 823-4949 Fax Number: (614) 823-4990	**Pavement Core Data Summary** PROJECT: Practices for Pavement Rest. of Open Cut Utility LOCATION: 74 S. Sperling Ave. JOB No.: W-18-151 BORING/CORE No.: 1-2 DATE CORE OBTAINED: 1/29/2019 CORE OBTAINED BY: Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other: Pulverized Asphalt	Other	Other	Other
1-2	2.00	✓								
	1.50		✓							
	1.00						✓			

Comments/Remarks

- Trace voids observed throughout asphalt

Total Pavement Thickness =	3.50	in.	Total Asphalt Thickness =	3.50	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	74 S. Sperling Ave.
JOB No.	W-18-151
BORING/CORE No.	1-3
DATE CORE OBTAINED	1/29/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
1-3	4.50	✓								
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Trace voids observed throughout asphalt

Total Pavement Thickness =	4.50	in.	Total Asphalt Thickness =	4.50	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	74 S. Sperling Ave.
JOB No.	W-18-151
BORING/CORE No.	1-4
DATE CORE OBTAINED	1/29/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
1-4	6.00	✓								
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Trace voids observed throughout asphalt

Total Pavement Thickness = 6.00 in.	Total Asphalt Thickness = 6.00 in.	Total Concrete Thickness = 0.00 in.	Total Base Thickness = 0.00 in.

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PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	74 S. Sperling Ave.
JOB No.	W-18-151
BORING/CORE No.	1-8
DATE CORE OBTAINED	1/29/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt					Other			
		Surface	Intermediate	Base	Concrete	Aggregate/Granular Base				
1-8	6.25	✓								
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Trace voids observed throughout asphalt

Total Pavement Thickness =	6.25	in.	Total Asphalt Thickness =	6.25	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	66 S. Sperling Ave.
JOB No.	W-18-151
BORING/CORE No.	2-1
DATE CORE OBTAINED	1/29/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other	Other	Other	Other
	2.00	✓								
	0.75		✓							
	4.00					✓				
2-1										

Comments/Remarks

- Trace voids observed throughout asphalt

Total Pavement Thickness = 2.75 in.	Total Asphalt Thickness = 2.75 in.	Total Concrete Thickness = 0.00 in.	Total Base Thickness = 4.00 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	66 S. Sperling Ave.
JOB No.	W-18-151
BORING/CORE No.	2-2
DATE CORE OBTAINED	1/29/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
2-2	1.75	✓								
	1.50		✓							
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Trace voids observed throughout asphalt

Total Pavement Thickness = 3.25 in.	Total Asphalt Thickness = 3.25 in.	Total Concrete Thickness =).00 in.	Total Base Thickness = 0.00 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	66 S. Sperling Ave.
JOB No.	W-18-151
BORING/CORE No.	2-3
DATE CORE OBTAINED	1/29/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
2-3	6.00	✓								
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Trace voids observed throughout asphalt

Total Pavement Thickness =	6.00	in.	Total Asphalt Thickness =	6.00	in.	Total Concrete Thickness =	).00	in.	Total Base Thickness =	0.00	in.

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Fax Number: (614) 823-4990

Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	66 S. Sperling Ave.
JOB No.	W-18-151
BORING/CORE No.	2-4
DATE CORE OBTAINED	1/29/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
2-4	6.25	✓								
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Trace voids observed throughout asphalt

Total Pavement Thickness =	6.25	in.	Total Asphalt Thickness =	6.25	in.	Total Concrete Thickness =	).00	in.	Total Base Thickness =	0.00	in.

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Fax Number: (614) 823-4990

Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	66 S. Sperling Ave.
JOB No.	W-18-151
BORING/CORE No.	2-8
DATE CORE OBTAINED	1/29/2019
CORE OBTAINED BY	Beth Bricker, CET

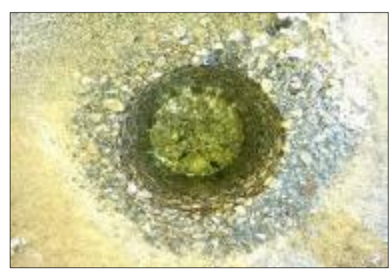
Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other	Other	Other	Other
2-8	5.50	✓								
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Trace voids observed throughout asphalt

Total Pavement Thickness =	5.50	in.	Total Asphalt Thickness =	5.50	in.	Total Concrete Thickness =	).00	in.	Total Base Thickness =	0.00	in.



6350 Presidential Gateway Columbus, Ohio 43231 Telephone: (614) 823-4949 Fax Number: (614) 823-4990	**Pavement Core Data Summary**

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	60 S. Wright Ave.
JOB No.	W-18-151
BORING/CORE No.	3-1
DATE CORE OBTAINED	2/27/2019
CORE OBTAINED BY	Beth Bricker, CET

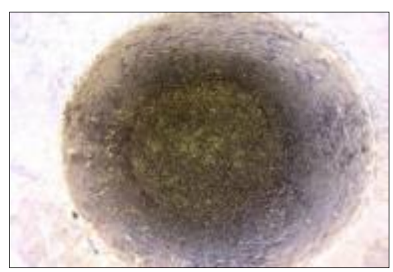
Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
3-1	2.25	✓								
	3.75		✓							
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Trace voids observed throughout asphalt

Total Pavement Thickness =	6.00	in.	Total Asphalt Thickness =	6.00	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00	in.



6350 Presidential Gateway Columbus, Ohio 43231 Telephone: (614) 823-4949 Fax Number: (614) 823-4990	**Pavement Core Data Summary** PROJECT: Practices for Pavement Rest. of Open Cut Utility LOCATION: 60 S. Wright Ave. JOB No.: W-18-151 BORING/CORE No.: 3-2 DATE CORE OBTAINED: 2/27/2019 CORE OBTAINED BY: Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
3-2	3.00	✓								
	3.50		✓							
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Trace voids observed throughout asphalt

Total Pavement Thickness =	6.50	in.	Total Asphalt Thickness =	6.50	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	60 S. Wright Ave.
JOB No.	W-18-151
BORING/CORE No.	3-3
DATE CORE OBTAINED	2/27/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
3-3	4.75	✓								
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field

Total Pavement Thickness =	4.75	in.	Total Asphalt Thickness =	4.75	in.	Total Concrete Thickness =	).00	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	60 S. Wright Ave.
JOB No.	W-18-151
BORING/CORE No.	3-6
DATE CORE OBTAINED	2/27/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other	Other	Other	Other
3-6	2.50	✓								
	3.75		✓							
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Trace voids observed throughout asphalt

Total Pavement Thickness = 6.25 in.	Total Asphalt Thickness = 6.25 in.	Total Concrete Thickness = 0.00 in.	Total Base Thickness = 0.00 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	60 S. Wright Ave.
JOB No.	W-18-151
BORING/CORE No.	3-7
DATE CORE OBTAINED	2/27/2019
CORE OBTAINED BY	Beth Bricker, CET

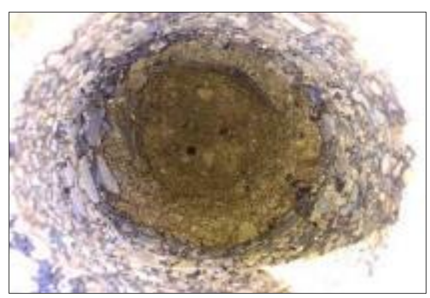
Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other	Other	Other	Other
	2.00	✓								
	2.50			✓						
	8.50					✓				
3-7										

Comments/Remarks

- Large voids seen separating the asphalt courses
- Voids observed throughout asphalt

Total Pavement Thickness =	4.50	in.	Total Asphalt Thickness =	4.50	in.	Total Concrete Thickness =	).00	in.	Total Base Thickness =	8.50	in.



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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	60 S. Wright Ave.
JOB No.	W-18-151
BORING/CORE No.	3-8
DATE CORE OBTAINED	2/27/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
3-8	2.50	✓								
	9.50					✓				

Comments/Remarks

- Small voids observed throughout asphalt

Total Pavement Thickness = 2.50 in.	Total Asphalt Thickness = 2.50 in.	Total Concrete Thickness =).00 in.	Total Base Thickness = 9.50 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	N. Torrence Ave. at Springfield
JOB No.	W-18-151
BORING/CORE No.	4-1
DATE CORE OBTAINED	2/27/2019
CORE OBTAINED BY	Beth Bricker, CET

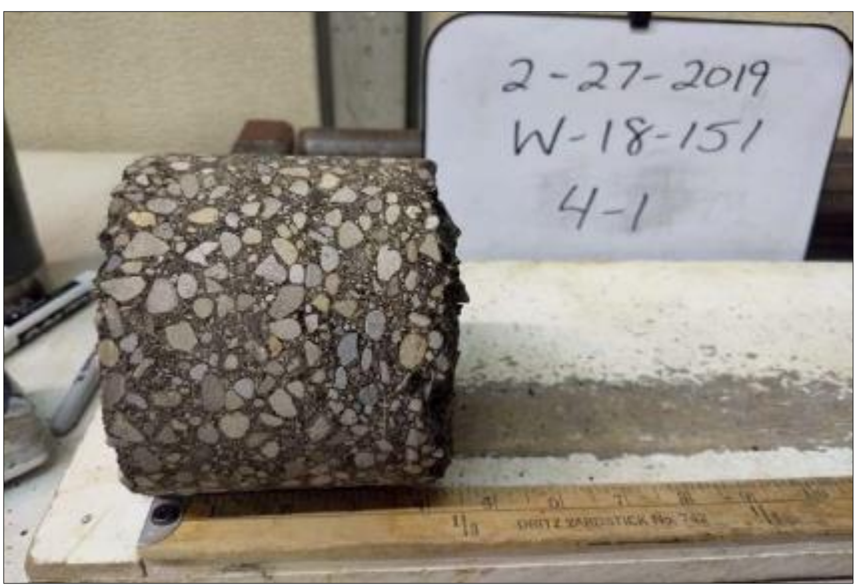
Core Composition

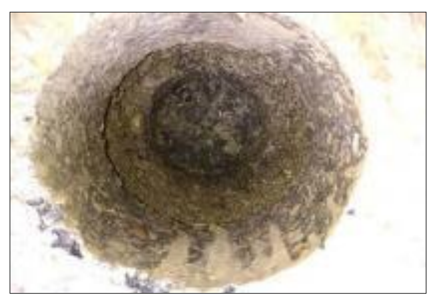
Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
4-1	2.50	✓								
	1.50		✓							
	5.00					✓				

Comments/Remarks

- Trace voids observed throughout asphalt

Total Pavement Thickness =	4.00	in.	Total Asphalt Thickness =	4.00	in.	Total Concrete Thickness =	).00	in.	Total Base Thickness =	5.00	in.





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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	N. Torrence Ave. at Springfield
JOB No.	W-18-151
BORING/CORE No.	4-2
DATE CORE OBTAINED	2/27/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
4-2	2.00	✓								
	2.50		✓							
	6.50					✓				

Comments/Remarks

- Trace voids observed throughout asphalt

Total Pavement Thickness = 4.50 in. | Total Asphalt Thickness = 4.50 in. | Total Concrete Thickness = 0.00 in. | Total Base Thickness = 6.50 in.

6350 Presidential Gateway Columbus, Ohio 43231 Telephone: (614) 823-4949 Fax Number: (614) 823-4990	**Pavement Core Data Summary** PROJECT: Practices for Pavement Rest. of Open Cut Utility LOCATION: N. Torrence Ave. at Springfield JOB No.: W-18-151 BORING/CORE No.: 4-4 DATE CORE OBTAINED: 2/27/2019 CORE OBTAINED BY: Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
4-4	5.25	✓								
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Trace voids observed throughout asphalt

Total Pavement Thickness =	5.25	in.	Total Asphalt Thickness =	5.25	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	N. Torrence Ave. at Springfield
JOB No.	W-18-151
BORING/CORE No.	4-5
DATE CORE OBTAINED	2/27/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
4-5	5.25	✓								
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Trace voids observed throughout asphalt

Total Pavement Thickness =	5.25	in.	Total Asphalt Thickness =	5.25	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00	in.

Pavement Core Data Summary

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PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	N. Torrence Ave. at Springfield
JOB No.	W-18-151
BORING/CORE No.	4-7
DATE CORE OBTAINED	2/27/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
4-7	5.25	✓								
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Trace voids observed throughout asphalt

Total Pavement Thickness =	5.25	in.	Total Asphalt Thickness =	5.25	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	86 Paw Paw St.
JOB No.	W-18-151
BORING/CORE No.	5-1
DATE CORE OBTAINED	2/27/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
5-1	2.00	✓								
	1.00		✓							
	1.50			✓						
	3.75					✓				

Comments/Remarks

- Trace voids observed throughout asphalt

Total Pavement Thickness = 4.50 in.	Total Asphalt Thickness = 4.50 in.	Total Concrete Thickness = 0.00 in.	Total Base Thickness = 3.75 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	86 Paw Paw St.
JOB No.	W-18-151
BORING/CORE No.	5-2
DATE CORE OBTAINED	2/27/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
5-2	2.00	✓								
	3.50		✓							
	unknown					✓				

Comments/Remarks

- Encountered cohesive subgrade immediately under asphalt on north side of core
- Lift thickness of aggregate base was not determined in the field
- 2 large chips observed on lateral surface of intermediate course
- Trace voids observed throughout asphalt

Total Pavement Thickness = 5.50 in.	Total Asphalt Thickness = 5.50 in.	Total Concrete Thickness = 0.00 in.	Total Base Thickness = 0.00 in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	86 Paw Paw St.
JOB No.	W-18-151
BORING/CORE No.	5-3
DATE CORE OBTAINED	2/27/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other	Other	Other	Other
5-3	2.00	✓								
	2.25		✓							
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Asphalt courses separated
- Small voids observed throughout asphalt

Total Pavement Thickness =	4.25	in.	Total Asphalt Thickness =	4.25	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	86 Paw Paw St.
JOB No.	W-18-151
BORING/CORE No.	5-4
DATE CORE OBTAINED	2/27/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
5-4	2.00	✓								
	3.25		✓							
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Small voids observed throughout asphalt

Total Pavement Thickness =	5.25	in.	Total Asphalt Thickness =	5.25	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	86 Paw Paw St.
JOB No.	W-18-151
BORING/CORE No.	5-8
DATE CORE OBTAINED	2/27/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
5-8	4.25	✓								
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Trace voids observed throughout asphalt

Total Pavement Thickness =	4.25	in.	Total Asphalt Thickness =	4.25	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	316 Urbana
JOB No.	W-18-151
BORING/CORE No.	6-1
DATE CORE OBTAINED	2/27/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
6-1	2.50	✓								
	2.50		✓							
	13.25					✓				

Comments/Remarks

- Asphalt courses separated

Total Pavement Thickness =	5.00	in.	Total Asphalt Thickness =	5.00	in.	Total Concrete Thickness =	).00	in.	Total Base Thickness =	13.25	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	316 Urbana
JOB No.	W-18-151
BORING/CORE No.	6-2
DATE CORE OBTAINED	2/27/2019
CORE OBTAINED BY	Beth Bricker, CET

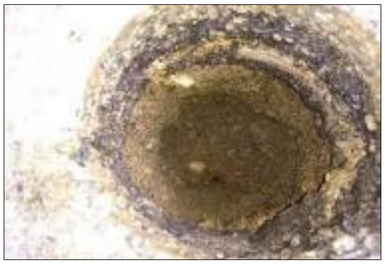
Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
6-2	1.50	✓								
	2.25		✓							
	12.75					✓				

Comments/Remarks

- Surface course has a single fracture that penetrates the entire depth of the course
- Intermediate course is in several pieces
- Asphalt courses separated
- Trace voids observed throughout surface course of asphalt

Total Pavement Thickness = 3.75 in. Total Asphalt Thickness = 3.75 in. Total Concrete Thickness = 0.00 in. Total Base Thickness = 12.75 in.



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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	316 Urbana
JOB No.	W-18-151
BORING/CORE No.	6-3
DATE CORE OBTAINED	2/27/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
6-3	4.25	✓								
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Trace voids observed throughout asphalt

Total Pavement Thickness =	4.25	in.	Total Asphalt Thickness =	4.25	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT: Practices for Pavement Rest. of Open Cut Utility
LOCATION: 316 Urbana
JOB No.: W-18-151

BORING/CORE No.: 6-4
DATE CORE OBTAINED: 2/27/2019
CORE OBTAINED BY: Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other	Other	Other	Other
6-4	6.50	✓								
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Trace voids observed throughout asphalt

Total Pavement Thickness =	6.50	in.	Total Asphalt Thickness =	6.50	in.	Total Concrete Thickness =	0.00	in.	Total Base Thickness =	0.00	in.

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Pavement Core Data Summary

PROJECT	Practices for Pavement Rest. of Open Cut Utility
LOCATION	316 Urbana
JOB No.	W-18-151
BORING/CORE No.	6-7
DATE CORE OBTAINED	2/27/2019
CORE OBTAINED BY	Beth Bricker, CET

Core Composition

Core Number	Lift Thickness (in.)	Asphalt: Surface	Asphalt: Intermediate	Asphalt: Base	Concrete	Aggregate/Granular Base	Other			
6-7	4.50	✓								
	unknown					✓				

Comments/Remarks

- Lift thickness of aggregate base was not determined in the field
- Trace voids observed throughout asphalt

Total Pavement Thickness = 4.50 in.	Total Asphalt Thickness = 4.50 in.	Total Concrete Thickness = 0.00 in.	Total Base Thickness = 0.00 in.

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