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CUY-Brookpark Road Bridge 0283
Cuyahoga County, OH

CUY-17-02.83 Brookpark Road Over Rocky River

Structure File Number: 1802046

RAILING FEASIBILITY STUDY

Prepared for:

Ohio Department of Transportation District 12
5500 Transportation Boulevard
Garfield Heights, Ohio 44306

April 2016

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APPENDICES

SCOPE

ODOT District 12 has contracted E.L. Robinson Engineering of Ohio (ELR) to perform a Feasibility Study for either repairing or replacing the existing railings of the Brookpark Road Bridge over the Rocky River (Bridge No. CUY-17-0283). If the railing is to be replaced, the new railing shall meet the TL-3 crashworthiness as per NCHRP Report 350 or the AASHTO "Manual for Assessing Safety Hardware" (MASH). The study includes 4 alternatives, discussion of the pros and cons, cost estimates, and the final recommendation. The Feasibility Study is under Part 1 of the overall scope of services.

BACKGROUND

Bridge Description:

The Brookpark Road Bridge over the Rocky River (Bridge No. CUY-17-0283) is an 8 span open spandrel, reinforced concrete arch bridge with two approach spans and cellular abutment spans. The total bridge length is approximately 1,920'±. The deck is 52'-0"± face to face curbs and carries four lanes of traffic and two 5 foot wide sidewalks. The structure was originally built in 1933, with minor retrofits and repair projects, and one major rehabilitation in 1989. The 1989 rehabilitation consisted of structural patching of concrete surfaces, widening of the structure, replacement of the sidewalks, and replacement of the combined traffic / pedestrian railing. The bridge is over the Rocky River Reservation, the Valley Parkway, two Park Trails and the Rocky River. *Figure 1* shows the typical sections of the widened bridge. Widened sections are hatched.

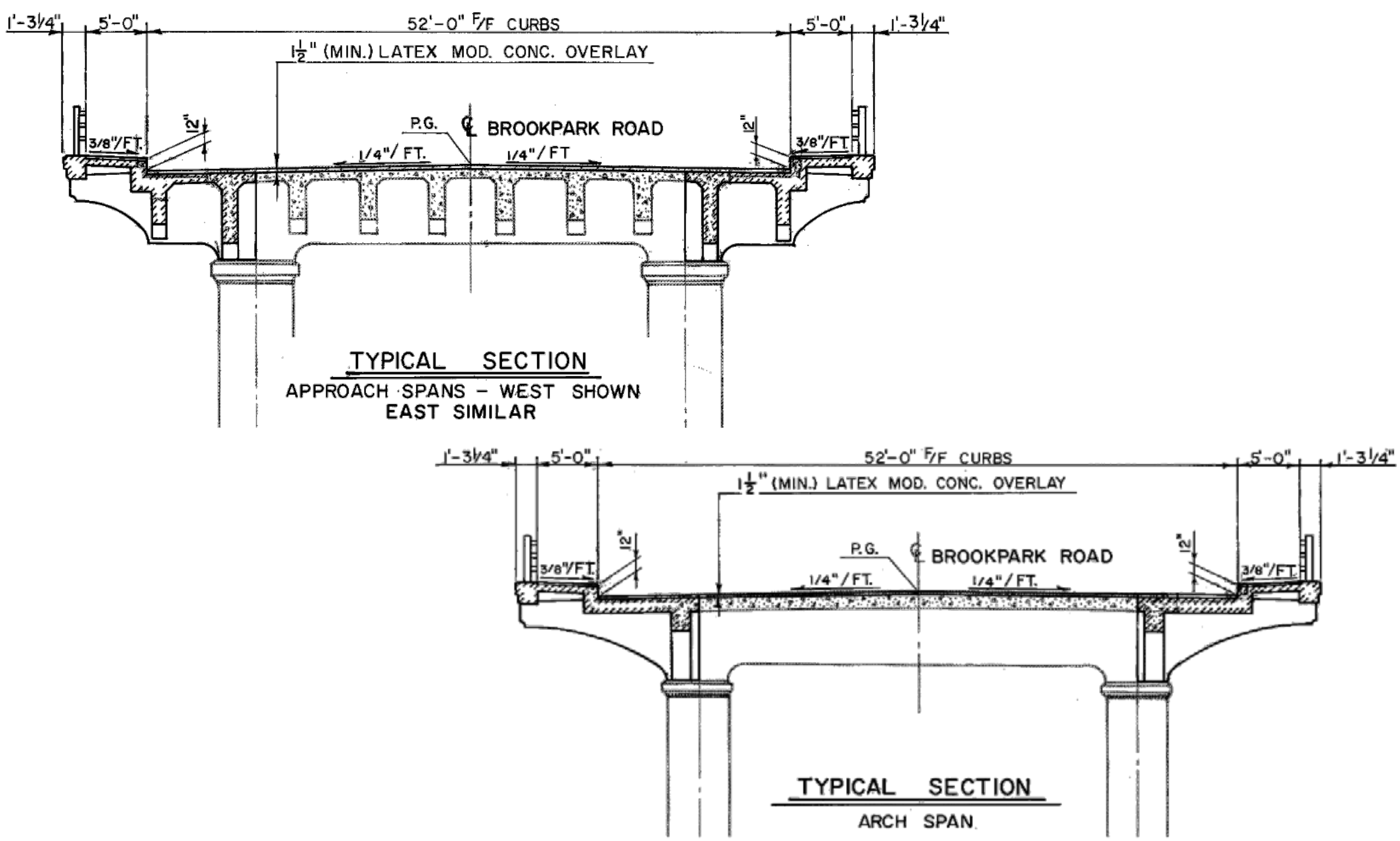


Figure 1 – Typical Approach and Arch sections of the 1989 rehabilitation.

Railing Requirements:

Due to the advanced section losses to the horizontal steel rails and advanced deterioration of the decorative panels, this Study will analyze feasible alternatives to replace the existing horizontal rails and panels in-kind, or to replace the entire railing with a TL-3 crashworthy railing. Preferably, the new railing should not exceed the existing railing's weight. A heavier proposed railing may require an analysis of the structure for the additional loads.

The existing railing is a combined traffic and pedestrian railing and is at the outside of a 5 foot clear sidewalk with a 12" curb. The existing railing is a steel tubular rail with a decorative, steel panel. The average weight of the existing railing is approximately 86 pounds per foot.

Existing Geometry:

The bridge has a combination traffic and pedestrian railing, a 5 foot wide sidewalk and a 12" tall curb (see *Figure 2*). The railing and sidewalks are supported by a sidewalk fascia beam and a curb edge beam, and will be referred to as the "fascia beam" and "curb beam" for clarity throughout this study. *Figure 2* shows the sidewalk section that spans between the floor beams. These floor beams are typically spaced at 16'-8" throughout. Because the existing fascia beam does not have the torsional capacity to withstand a vehicular impact transferred through the railing, any alternatives that place a crashworthy barrier at the fascia beam must increase the torsional capacity by bracing the fascia beam or by replacing this beam.

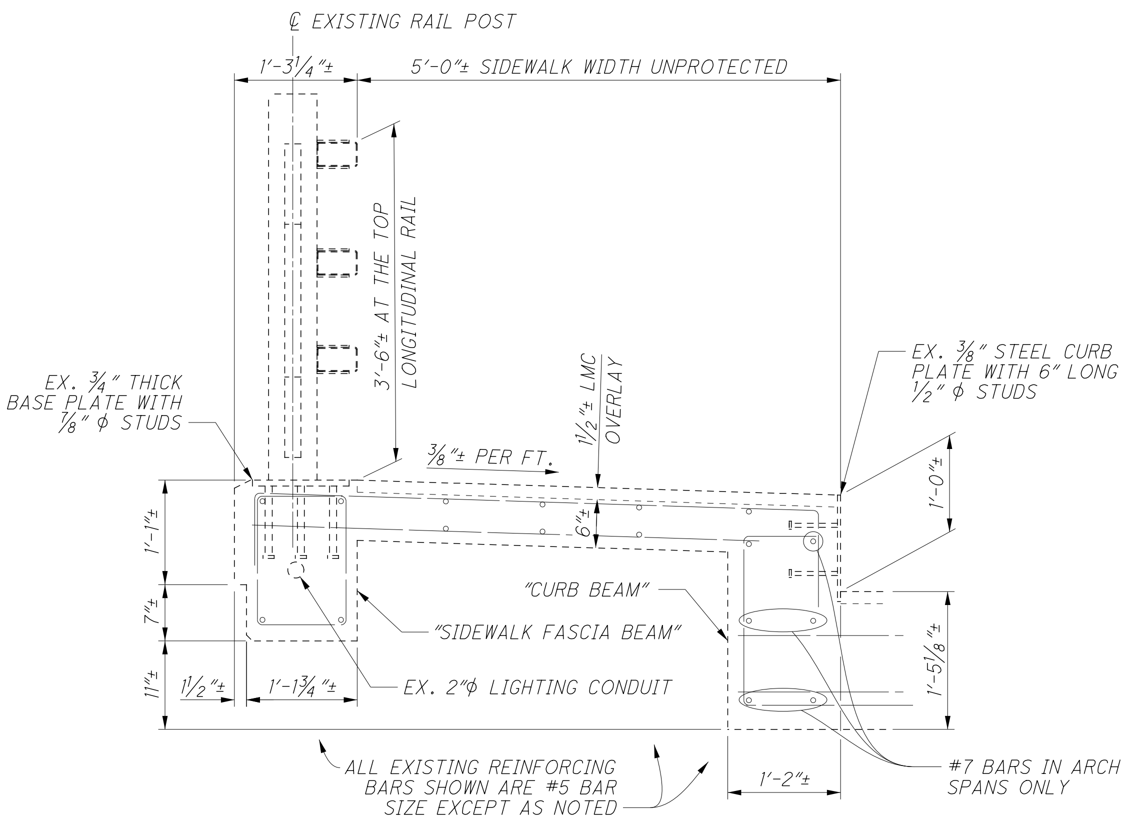


Figure 2 – Existing sidewalk configuration between floor beams, typical both sides.

The fascia, curb beam and sidewalk consist of concrete reinforced with number 5 bars. Figure 2 indicates there is a 2" diameter lighting conduit, nearly centered within the beam (according to the plans). This conduit exists at each sidewalk fascia. The steel curb plate has alternating top and bottom 6" long, 1/2" studs into the curb beam. In addition, the railing post base plates have 9" long, 7/8" studs that anchor the railing to the fascia beam.

SUMMARY OF INSPECTION AND CORE TESTING

EXISTING CONDITION OF THE SIDEWALK

An inspection of the sidewalk framing was performed February 15 and 16, 2016. The fascia beams are in Fair Condition overall with typical surface spalls adjacent to every railing post (see *Photo 1*), and up to 1/16" open, longitudinal cracks running along the bottom vertical faces (see *Photo 2*) and along the undersides (see *Photo 3*). These longitudinal cracks typically have minor surface delamination beginning, rust staining from rebar chairs and occasional corner spalling (see *Photo 4*). Isolated locations have exposed reinforcing.

Photo 1 – Top Corner spall exposing approximately ¼" of bottom of post base plate. Fourth post of Arch B, South Sidewalk shown.

Photo 2 – Typical longitudinal cracks along the vertical face of the sidewalk fascia beam. North Sidewalk, Arch H Bay 4 Shown.

Photo 3 – Typical corner delamination with side and bottom cracks pointed out. North Sidewalk, Arch E Bay 5 shown.

Photo 4 – Typical corner spalling along the fascia beam bottom. 2"x2"x9" spall and 3" diameter spall shown at North Sidewalk, Arch D Bay 2.

The curb beams are in Good Condition overall with minor hairline cracks and localized spalling with exposed reinforcing at the deck joints only (see *Photo 5*). In addition, the arch deck underside adjacent to the scuppers are beginning to delaminate (see *Photo 6*).

Photo 5 – Curb beam and deck soffit delaminated and spalled to bottom mat at the West Pylon joint. South Sidewalk shown.

Photo 6 – Large delaminated area beginning approximately 9" from the back of the curb beam, approximately 12" by 4 feet. North Sidewalk, Arch D Bay 1 shown.

Photo 7 – Typical good condition of the bottom of the sidewalk slab. West Approach, South sidewalk shown.

The sidewalk slab underside is in Good Condition overall (see *Photo 7*) with minor, hairline transverse cracks approximately every 2 feet, occasionally with efflorescence. The top of the sidewalk slab is in Good Condition overall with isolated locations of large delaminations and spalls adjacent to the curb plate at the North Sidewalk in the Arch A and Arch B Spans (see *Photos 8 and 9*). The delaminations/spalls are 6″ to 12″ wide, and at one location is 25 feet long. In addition, the North Sidewalk is also spalled full length at the east approach slab. The steel curb plate is in Fair Condition with scrape marks, surface rust and impacted rust up to ¼″ thick at the top.

Photo 8 – Portion of an 11 foot long, 1 foot wide delamination of the Arch B North sidewalk. Water and rust is buckling the delaminated layer of concrete up.

Photo 9 – Another Arch B North sidewalk location showing asphalt fill in a spalled portion of the sidewalk.

SIDEWALK CONCRETE TESTING

A total of 12 sidewalk cores (six in each sidewalk) were taken throughout the structure by PSI, and compression strength and acid soluble chloride ion tests were taken (see Appendix C for PSI's full report). All the compressive strengths are over 4500 psi, ranging from 5750 psi to 8990 psi. According to the BDM Section 412.1, if there is more than 2 pounds of acid soluble chlorides per cubic yard, then active corrosion is considered present in the concrete. The tests indicate that four samples are above the 2 pound indicator, the largest having 4.9 lbs/cy (see *Table 1*). These four samples (two curb and two fascia cores) are located at the east end of the bridge and are identified in *Figure 3*.

CORE	CHLORIDES (LB/CF)	COMPRESSIVE STRENGTH (psi)
C-4	2.208	5750
C-5	2.132	8070
C-6	4.911	6480
C-7	2.893	5930

Table 1 – Concrete Core Test Summary of cores with more than 2 lbs pf chlorides per cubic foot.

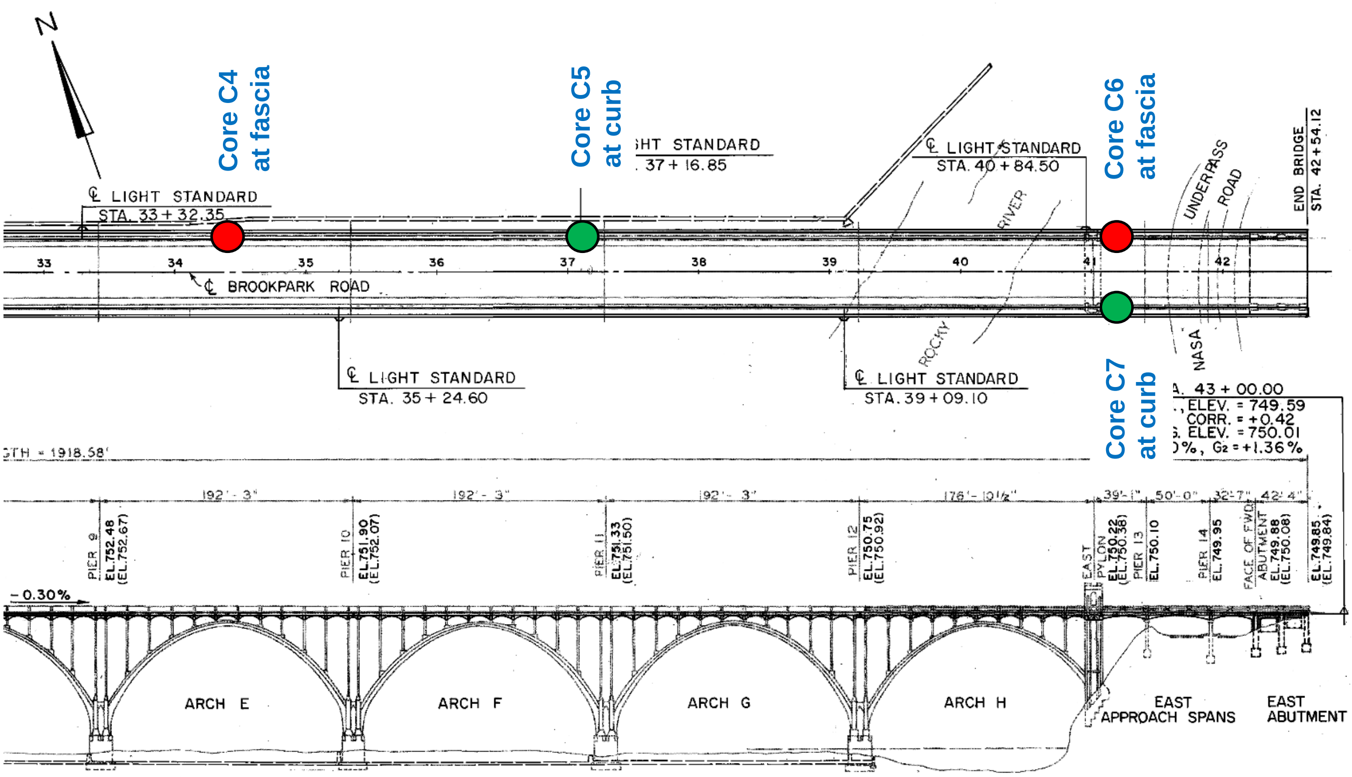


Figure 3 – Existing sidewalk configuration, typical both sides. The red dots are cores taken adjacent to the railings, and the green dots were taken at the curbs.

Due to the existing condition of the sidewalks and the results of the sidewalk core testing, ELR believes it is feasible to re-use the existing fascia or curb beam with minor concrete patching depending on the analysis of impact loads to the proposed railing's anchorage. Any modifications to the sidewalk fascia beam and the railing anchorage are discussed in the Railing Alternatives section below.

RAILING ALTERNATIVES

The following railing alternatives were taken from a larger preliminary list of railing concepts, whose number has been reduced by structural connection feasibility and ODOT preferences in a meeting held Thursday, March 31st, 2016. The following is a discussion of the remaining alternatives after the decisions of that meeting. For information regarding the entire list of preliminary railing concepts, see Appendix B.

ALTERNATIVE 1 – REPAIR THE EXISTING STEEL RAILING

This alternative (see *Figure 4*) consists of removing the existing horizontal tube rails and the decorative panels and replacing them. The replacement rails will utilize the same steel tube sections (5x3x1/8 top rail and 5x3x1/4 center and bottom rails) with the exception that the ends of the new tubes will be capped. The existing rails have open ends allowing water infiltration that is deteriorating the rail connections and perforating the bottom of the tubes.

The decorative panels consist of cut, steel tube sections welded together to form alternating triangular shapes. Since this would require extensive fabrication and welding, consideration will be given to utilizing a 3/8" plate (stiffened at the top and bottom) with the triangular shapes cut out. Another option is to use fiberglass for the decorative panels in order to reduce weight if necessary; however, the cost of building the molds and fabricating the special panel shape is costly and the reduction of weight at the ends of the cantilevered floor beams would increase the positive dead load moment, thereby decreasing the controlling rating at the center of the floor beams. Consequently, this option was not considered further.

Vandal Protection Fence can be placed if required, utilizing the ODOT Standard Drawing base plate type 2 between the existing posts.

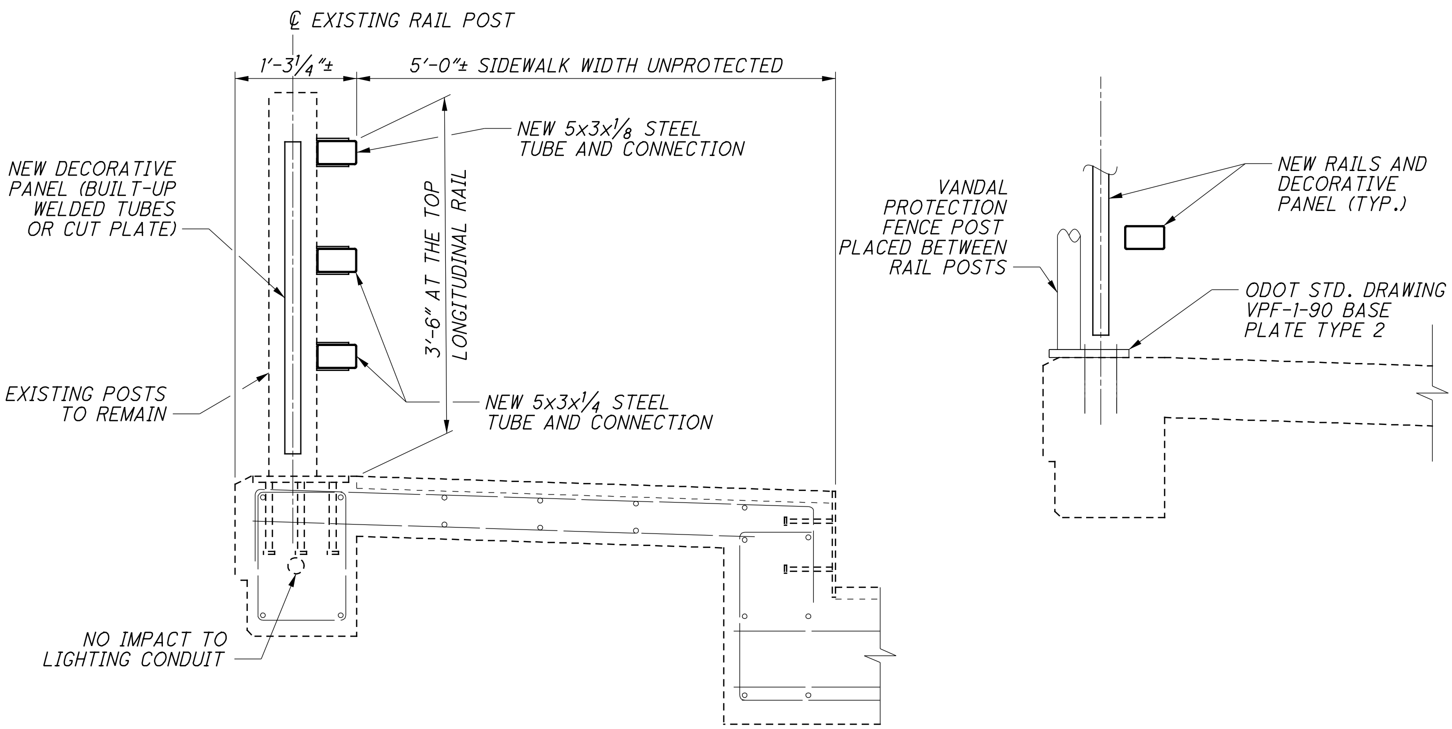


Figure 4 – Alternative 1 will repair the existing railing by replacing the horizontal rails and the decorative panels. Optional vandal protection fence detail shown separately for clarity.

Since the nature of the project is temporary (7 to 10 years due to the remaining useful life of the deck), the minimum amount of work required for this alternative reduces the amount of new structure that will be discarded at the end of the deck's life. Because this alternative proposes to repair the existing railing, leaving the existing posts and connections as is, the TL-3 crash worthy requirement is not warranted.

Pros:

- Limited removal
- Re-use of the posts
- Weight does not materially change
- Lower construction cost of $0.9 million (without Vandal Protection Fence)
- No invasive anchorage into existing structure
- No framing modification
- No Bridge Rating required
- No lighting Impact
- Maintains the decorative panel's aesthetic design
- Minimum construction time

Cons:

- Not TL-3 crashworthy
- No pedestrian protection from traffic

See the Alternative Matrix at the end of this section for a side by side comparison with the other alternatives.

ALTERNATIVE 2 – SIDE MOUNTED TST-1-99 ON NEW FASCIA BEAM

This alternative (see *Figures 5 and 6*) consists of removing the existing railings, fascia beams and sidewalks, and placing new sidewalks, new fascia beams with the torsional capacity to withstand AASHTO Standard Specification vehicular load, and cast-in-place TST railings. If a vandal protection fence is required, the TST railing will be as per the ODOT standard drawing. If it is not required, the TST railing must be modified for the pedestrian railing height and would also require an extra tube near the base to prevent a child from slipping through.

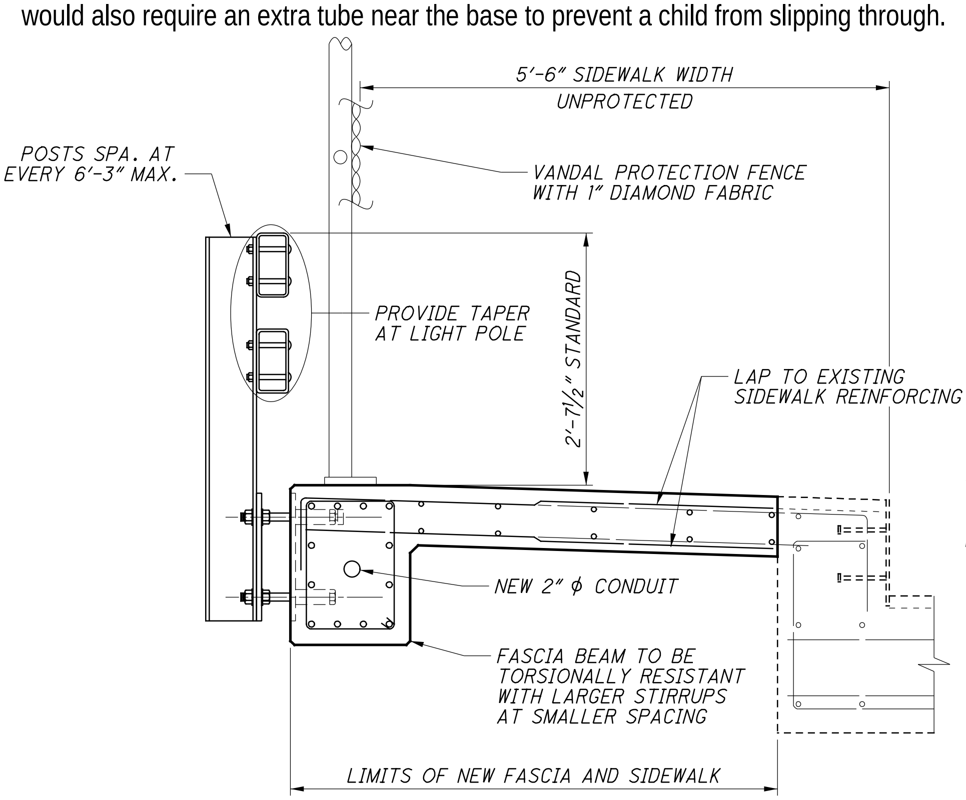


Figure 5 – Alternative 2 with new sidewalk and fascia beam with side mounted TST railing and vandal protection fence.

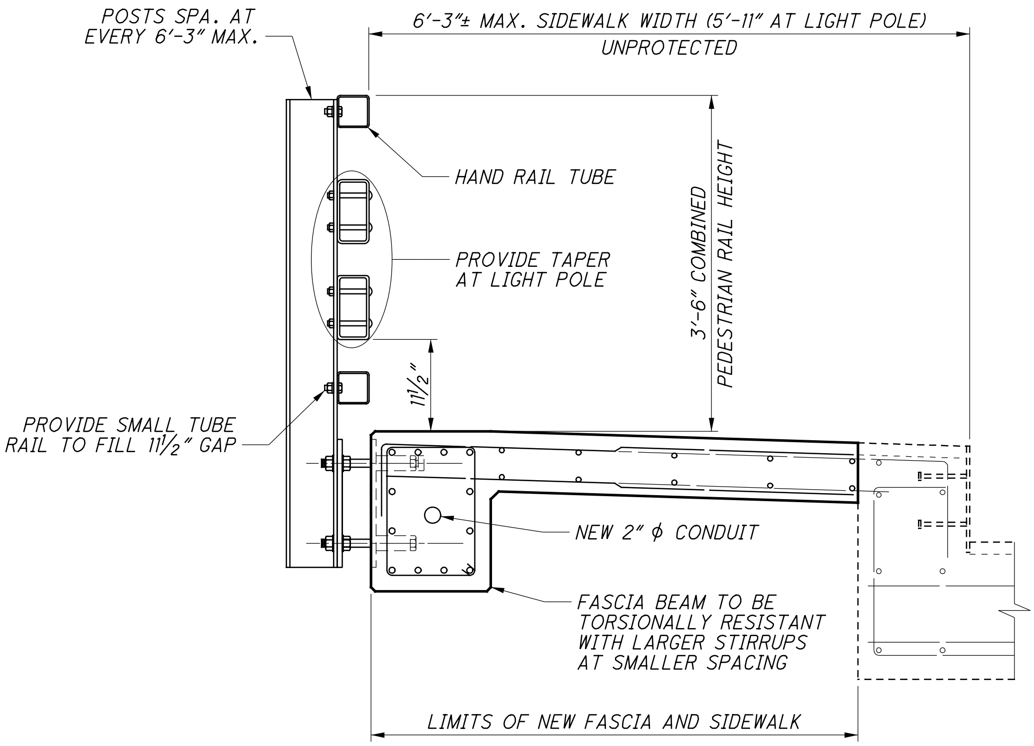


Figure 6 – Alternative 2 without the vandal protection fence requires added height to the TST rail post and additional horizontal tubes but allows the railing to have a see-through aesthetic.

This alternative requires extensive removal and construction of new material, and a longer construction time. The figures show the entire sidewalk slab to be replaced to the edge of the curb edge beam with enough of the transverse sidewalk reinforcing to remain for the new bars to lap onto. Although larger portions of the sidewalk slab may remain, ELR believes a cold joint at the new fascia, lapping at the new fascia or doweling into the center of the existing sidewalk slab are undesirable.

Pros:

- New Railing is TL-4 crash tested
- Weight increase is nominal, and location of added load helps increase the controlling positive moment rating at the center of the floor beams

Cons:

- Removal of all existing railing, fascia beams and sidewalks
- Longer Construction Time
- Lighting Impact (to be removed and replaced in-kind)
- Higher Construction Cost of $2.5 million (without Vandal Protection Fence)
- No Pedestrian protection from traffic
- The horizontal rails will need to taper out at the light pole locations. As an alternative, placing an additional steel tube section as a spacer between the rail and the post will clear the pole and still maintain greater than the minimum 5'-0" sidewalk.

ALTERNATIVE 3 – TOP MOUNTED TST-1-99 ON NEW FASCIA BEAM

This alternative (see ***Figure 7***) consists of removing the existing railings, fascia beams and sidewalks, and placing new sidewalks, new fascia beams with the torsional capacity to withstand AASHTO Standard Specification vehicular load, and cast-in-place, top mounted TST railings. If a vandal protection fence is required, the base plate for the TST rail may be modified to include the fence post connection. If the fence is not required, the TST railing post must increase to the pedestrian railing height and additional horizontal tubes must be added similar to ***Figure 6*** on the preceding page.

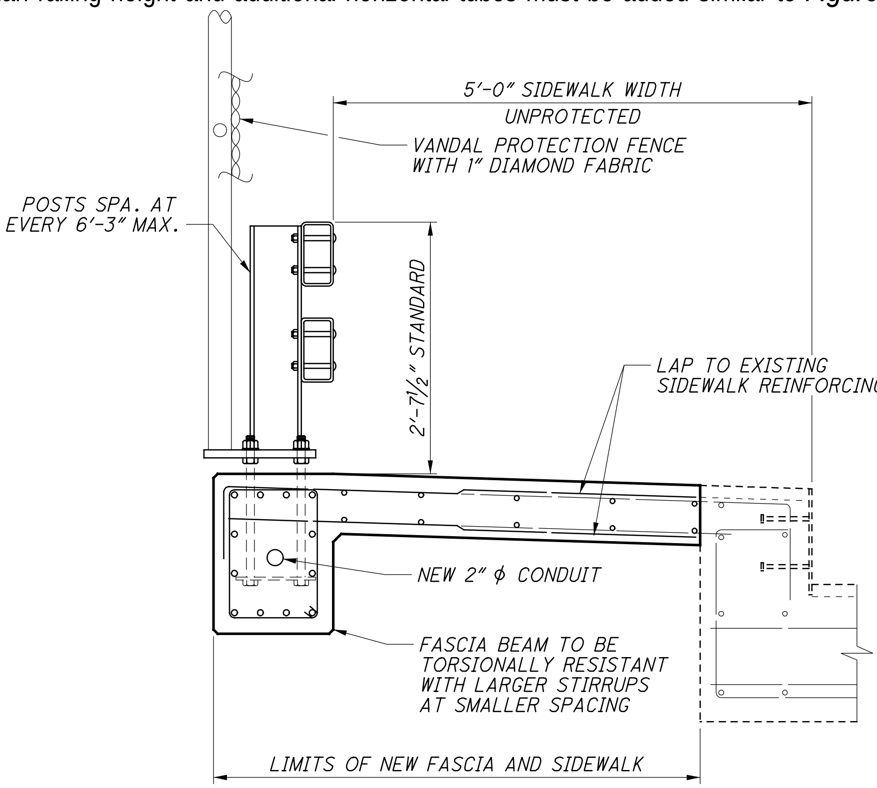


Figure 7 – Alternative 3 with a new sidewalk, fascia beam, TST railing and vandal protection fence.

This alternative is very similar to alternative 2 regarding the pros and cons with a construction cost of $2.5 million without Vandal Protection Fence.

Pros:

- New Railing is TL-4 crash tested
- Weight increase is nominal, and location of added load helps increase the controlling positive moment rating at the center of the floor beams

Cons:

- Removal of all existing railing, fascia beams and sidewalks
- Longer Construction Time
- Lighting Impact (to be removed and replaced in-kind)
- Higher Construction Cost of $2.5 million (without Vandal Protection Fence)
- No Pedestrian protection from traffic

Modifying this alternative to re-use the existing fascia and sidewalk is not possible. Steel brackets must be added at each post location between the fascia and curb beam to brace the fascia under the 10 kip vehicular impact load and the anchors would need to be through-bolts with a steel base plate at the bottom. The through-bolts and the dowels of the steel brackets would impact the existing reinforcement such that this option is not feasible. The reason post installed adhesive anchors cannot be used is the small edge distance from each anchor to the sides of the fascia severely reduces the concrete breakout strength and bond strength, and the anchors fail under impact. It was suggested that more anchors be placed on the tension side of the connection. Due to the wide failure cone (35° from horizontal), the anchors need to be spaced far apart enough that their respective failure cones do not overlap to the point of negating the benefit of an additional anchor as shown in the ACI figure below. At a 7" embedment (6.717" effective), the horizontal projection of the failure cone of one anchor is 10". The failure plane of the adjacent anchor needs to be outside this zone for full capacity giving a spacing of 20". This option is also not feasible.

Figure from ACI Section D5.2.4 for a group of CIP anchors placed in a narrow beam. In the existing beam, further reduction factors are applied for post-installed conditions.

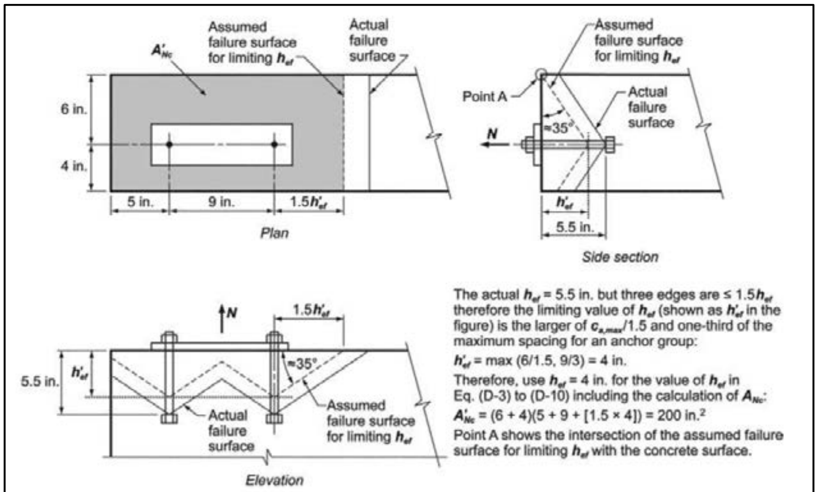


Fig. RD.5.2.3—Example of tension where anchors are located in narrow members.

Incidentally, if the top mounted TST railing is placed on the curb beam, the same edge distance breakout strengths affect the anchors. The curb edge beam is also not wide enough.

ALTERNATIVE 4 – BR-2-15 CONCRETE BARRIER ON EXISTING CURB EDGE BEAM

This alternative (see ***Figure 8***) consists of removing the existing railings, placing the BR-2-15 concrete barrier on top of the curb and side mounting vandal protection fence at the fascia beam. Placing the steel tube pedestrian railing on the concrete barrier as detailed in the standard drawing is not required here and has been left out.

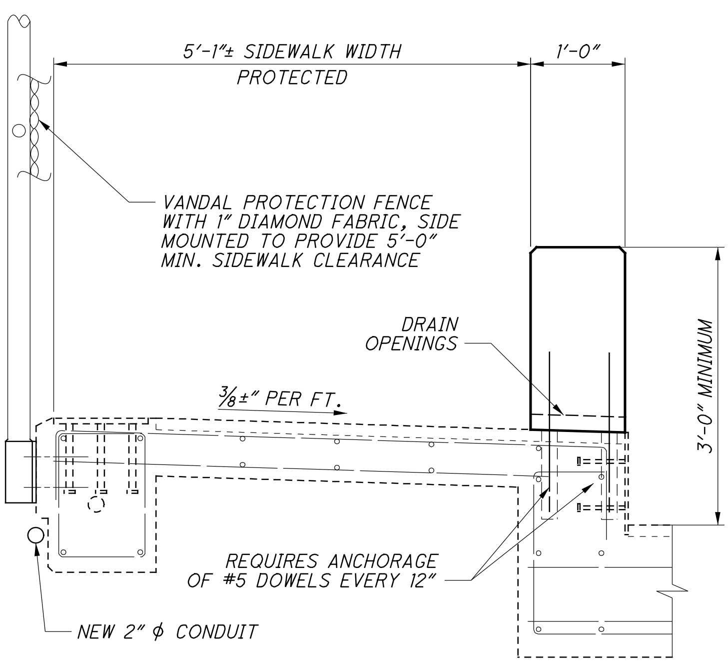


Figure 8 – Alternative 4 with a concrete barrier on the existing curb and a vandal protection fence side mounted on the existing fascia beam.

This alternative requires doweling two No. 5 reinforcing bars every 12". The impact to the existing reinforcing can only be minimally mitigated by locating the existing reinforcing and placing the new reinforcing dowel to avoid a conflict where possible. The amount of movement is limited to approximately 1½" towards the center, because moving the dowels towards the center of the barrier to avoid the existing reinforcement reduces the effective depth of the dowels and therefore reduces the moment capacity of the barrier. However, impact to reinforcing is limited to the area within the top of the curb beam and not the deck reinforcing. Because this rail is 12" wide, the vandal protection fence must be mounted outside to provide a minimum 5'-0" sidewalk clearance. This fence connection may impact the existing lighting conduit so the figure shows a new conduit.

Increasing the dead load on the floor beam cantilever reduces the positive moment of the floor beam where the critical rating occurs. This increases the rating at this location. However, the added weight is significant enough to change the critical rating location to another area of the structure. An updated bridge rating would need to be performed to determine the exact effect.

Since the sidewalk drains towards the curb, the new barrier needs intermittent drainage ports at the bottom to allow water to run through the barrier and be collected in the roadway gutter.

Pros:

- New Railing is TL-4 crash tested
- The existing sidewalk and fascia beam is re-used
- The pedestrians are separated and protected from traffic
- Lower construction cost of $1.1 million

Cons:

- Continuous concrete barrier requires extensive doweling
- Invasive connection in the existing top of curb beam
- Reduction of the moment capacity of the railing in comparison to the standard
- Considerably heavier than the existing railing, and the added weight may affect rating
- Probable lighting impact with the fence placement
- Requires bridge terminal guardrail assemblies at ends of bridge

All four alternatives are presented together in the alternative matrix shown in Table 1.

CONCLUSIONS AND RECOMMENDATIONS

Due to the condition of the existing deck, which may require replacement within the next seven to ten years, spending significant amounts of money on repairs that may only be in place for a short time would not be prudent. The total funds available for this project are limited. Therefore, cost is a significant factor in selecting a recommended alternative for the repair of the railings. As can be seen in Table 1, Alternatives 2 and 3 would cost over twice as much as Alternatives 1 and 4. Consequently, Alternatives 2 and 3 are not recommended.

Alternatives 1 and 4 are relatively close in cost, but if vandal protection fence is not installed, Alternative 1 is approximately 25% less expensive than Alternative 4. Alternative 4 would add significant weight to the bridge and would require a rating update to verify the existing bridge members are adequate for the additional loading. Extensive doweling is required for Alternative 4 and the dowels may conflict with the existing reinforcement and curb plate anchors.

Due to cost, weight, and connection considerations, Alternative 1 without vandal protection fence is recommended by E.L. Robinson for the repair of the existing railing.

TABLE 1 - RAILING ALTERNATIVE EVALUATION MATRIX

Railing Type and Identification			Crash Worthiness	Pedestrian Protection	Weight (lb/ft)[4]	Cost[1]	Pedestrian Clearances	Traffic Clearances	Post Spacing	Invasiveness of Connection	Framing Modification	Existing Rebar Conflict[3]	Rating Update Required	Light Conduit Impact	Aesthetics
Railing at Sidewalk Fascia Beam	Repair Existing Railing	1	Unknown	None	86	$0.9 million $1.5 million[2]	5'-0"±	No change	8'-4"	None	None	None	No	None	Decorative Panels
	Side Mounted TST-1-99 on New Fascia Beam	2	TL-4	None	96	$2.5 million $2.8 million[2]	5'-6"±[2] 6'-3"±	No change	6'-3"	Cast In Place	New Beam and Sidewalk	None	No	Yes	See-Through
	Top Mounted TST-1-99 on New Fascia Beam	3	TL-4	None	90	$2.5 million $2.8 million[2]	5'-0"±	No change	6'-3"	Cast In Place	New Beam and Sidewalk	None	No	Yes	See-Through
Railing at Curb Beam	BR-2-15 without TST	4	TL-4	Yes	320	$1.1 million	5'-1"±	No Change	Continuous	Two #5 Dowels every 12"	None	Possible	Yes	Yes	Form Liners Optional

Notes:

1. Includes 20% contingency.
2. With a Vandal Protection Fence added.
3. "Existing Rebar Conflict" refers to amount of reinforcing that may be cut due to the "Invasiveness of Connection" information. For instance, dowels may conflict with existing rebar but it may be possible to move the dowel to avoid the conflict.
4. The weight of the existing railing is approximately 86 lbs/ft.

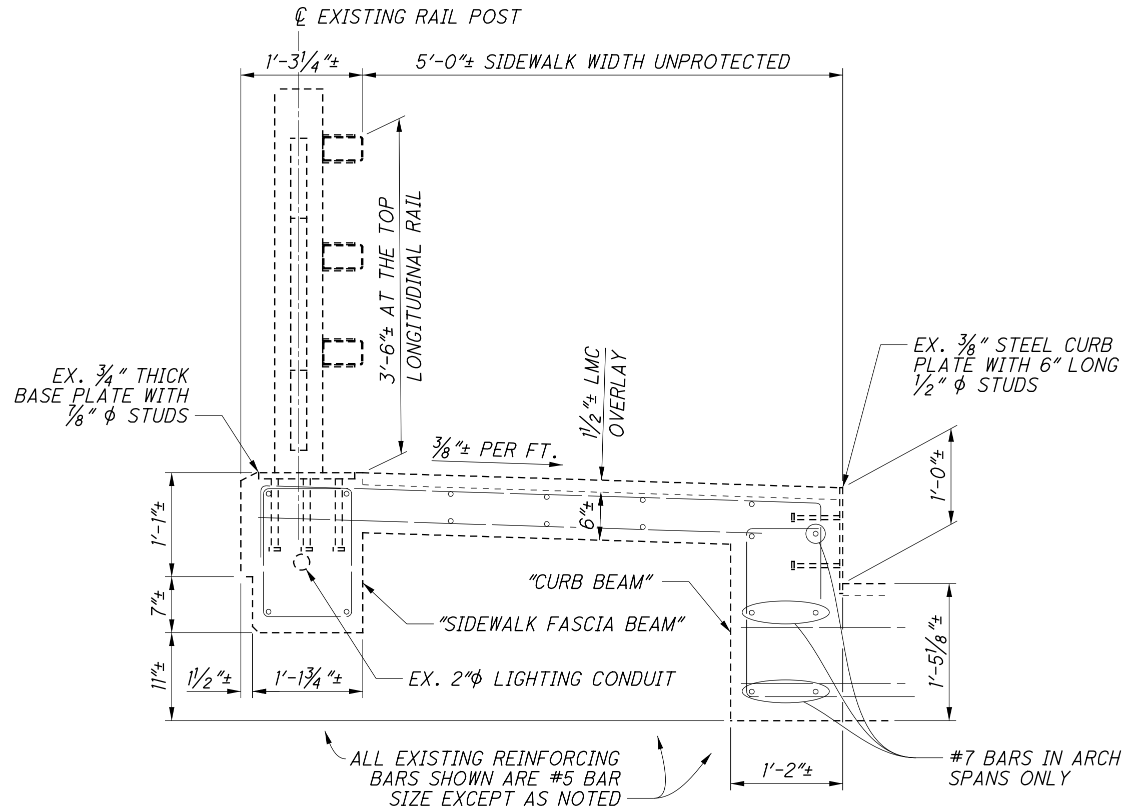
APPENDIX A DETAILED COST ESTIMATE

DETAILED COST ESTIMATE

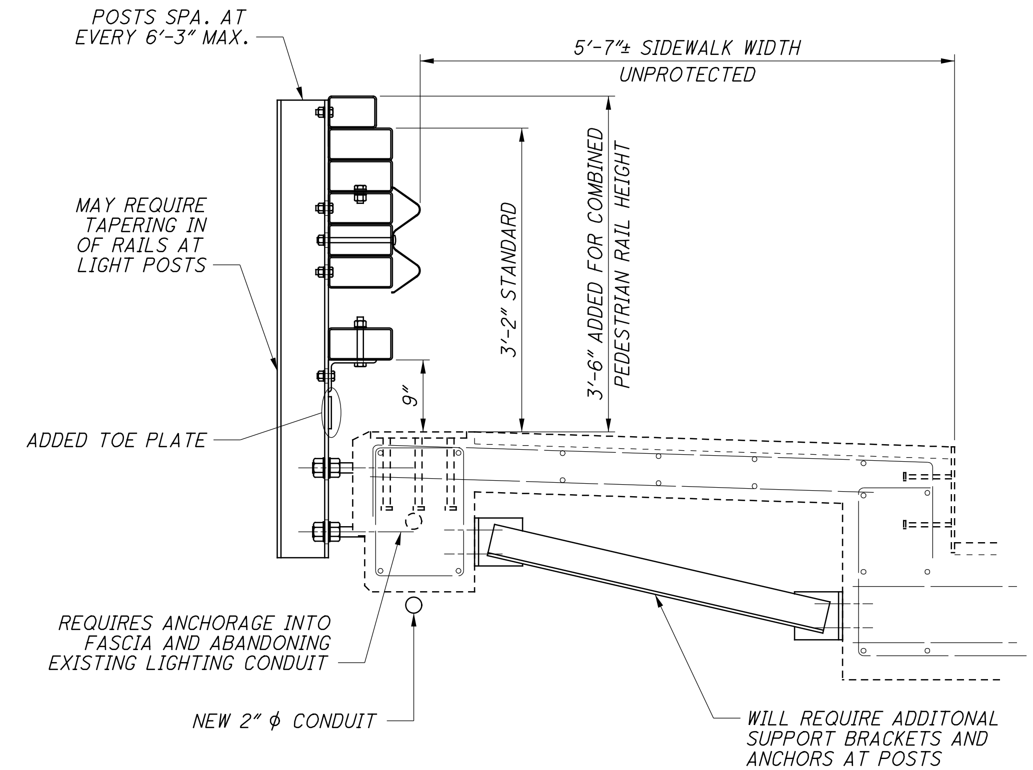
Item	Extension	Description	Unit	Unit Price	Alternative 1a Repair the Existing Steel Railing without VPF		Alternative 1b Repair the Existing Steel Railing with VPF		Alternative 2a Side Mounted TST-1-99 on New Fascia Beam without VPF		Alternative 2b Side Mounted TST-1-99 on New Fascia Beam with VPF		Alternative 3a Top Mounted TST-1-99 on New Fascia Beam without VPF		Alternative 3b Top Mounted TST-1-99 on New Fascia Beam with VPF		Alternative 4 BR-2-15 Concrete Barrier on Existing Curb Edge Beam	
					Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost	Quantity	Cost
202	11203	PORTIONS OF STRUCTURE REMOVED, OVER 20 FOOT SPAN, AS PER PLAN	LS		1	$30,000.00	1	$30,000.00	1	$519,000.00	1	$519,000.00	1	$519,000.00	1	$519,000.00	1	$39,000.00
510	10000	DOWEL HOLES WITH NONSHRINK, NONMETALLIC GROUT	EACH	$15.00		$0.00	2200	$33,000.00		$0.00		$0.00		$0.00		$0.00	9900	$148,500.00
509	10000	EPOXY COATED REINFORCING STEEL	LB	$1.00		$0.00		$0.00	222900	$222,900.00	222900	$222,900.00	222900	$222,900.00	222900	$222,900.00	49700	$49,700.00
511	21522	CLASS QC2 CONCRETE WITH QC/QA, SUPERSTRUCTURE	CY	$750.00		$0.00		$0.00	660	$495,000.00	660	$495,000.00	660	$495,000.00	660	$495,000.00		$0.00
511	34450	CLASS QC2 CONCRETE WITH QC/QA, BRIDGE DECK (PARAPET)	CY	$650.00		$0.00		$0.00		$0.00		$0.00		$0.00		$0.00	290	$188,500.00
513	10200	STRUCTURAL STEEL MEMBERS, LEVEL UF	LB	$1.90	280200	$532,400.00	280200	$532,400.00		$0.00		$0.00		$0.00		$0.00		$0.00
514	00050	SURFACE PREPARATION OF EXISTING STRUCTURAL STEEL	SF	$7.00	5900	$41,300.00	5900	$41,300.00		$0.00		$0.00		$0.00		$0.00		$0.00
514	00056	FIELD PAINTING OF EXISTING STRUCTURAL STEEL, PRIME COAT	SF	$2.50	5900	$14,800.00	5900	$14,800.00		$0.00		$0.00		$0.00		$0.00		$0.00
514	00060	FIELD PAINTING STRUCTURAL STEEL, INTERMEDIATE COAT	SF	$1.60	44300	$70,900.00	44300	$70,900.00		$0.00		$0.00		$0.00		$0.00		$0.00
514	00066	FIELD PAINTING STRUCTURAL STEEL, FINISH COAT	SF	$1.50	44300	$66,500.00	44300	$66,500.00		$0.00		$0.00		$0.00		$0.00		$0.00
517	70000	RAILING (TWIN STEEL TUBE)	FT	$150.00		$0.00		$0.00		$0.00	3840	$576,000.00		$0.00	3840	$576,000.00		$0.00
517	70001	RAILING (TWIN STEEL TUBE), AS PER PLAN	FT	$190.00		$0.00		$0.00	3840	$729,600.00		$0.00	3840	$729,600.00		$0.00		$0.00
606	35002	MGS BRIDGE TERMINAL ASSEMBLY, TYPE 1	EACH	$2,000.00		$0.00		$0.00		$0.00		$0.00		$0.00		$0.00	2	$4,000.00
606	35102	MGS BRIDGE TERMINAL ASSEMBLY, TYPE 2	EACH	$400.00		$0.00		$0.00		$0.00		$0.00		$0.00		$0.00	2	$800.00
607	39931	VANDAL PROTECTION FENCE, 12' CURVED, COATED FABRIC, AS PER PLAN	FT	$120.00		$0.00	3840	$460,800.00		$0.00	3840	$460,800.00		$0.00	3840	$460,800.00	3840	$460,800.00
625	10490	LIGHT POLE, CONVENTIONAL	EACH	$2,200.00		$0.00		$0.00	10	$22,000.00	10	$22,000.00	10	$22,000.00	10	$22,000.00		$0.00
625	22910	NO. 2/0 AWG 2400 VOLT DISTRIBUTION CABLE	FT	$6.50		$0.00		$0.00	3310	$21,500.00	3310	$21,500.00	3310	$21,500.00	3310	$21,500.00	3310	$21,500.00
625	23200	NO. 4 AWG 2400 VOLT DISTRIBUTION CABLE	FT	$2.50		$0.00		$0.00	3920	$9,800.00	3920	$9,800.00	3920	$9,800.00	3920	$9,800.00	3920	$9,800.00
625	23400	NO. 10 AWG FT POLE AND BRACKET CABLE	FT	$1.30		$0.00		$0.00	1000	$1,300.00	1000	$1,300.00	1000	$1,300.00	1000	$1,300.00		$0.00
625	25400	CONDUIT, 2", 725.04	FT	$8.50		$0.00		$0.00	3840	$32,600.00	3840	$32,600.00	3840	$32,600.00	3840	$32,600.00	3840	$32,600.00
625	26250	LUMINAIRE, CONVENTIONAL	EACH	$350.00		$0.00		$0.00	10	$3,500.00	10	$3,500.00	10	$3,500.00	10	$3,500.00		$0.00
		Subtotal				$755,900.00		$1,249,700.00		$2,057,200.00		$2,364,400.00		$2,057,200.00		$2,364,400.00		$955,200.00
		20% Contigency				$151,180.00		$249,940.00		$411,440.00		$472,880.00		$411,440.00		$472,880.00		$191,040.00
		GRAND TOTAL				**$907,080.00**		**$1,499,640.00**		**$2,468,640.00**		**$2,837,280.00**		**$2,468,640.00**		**$2,837,280.00**		**$1,146,240.00**

APPENDIX B PRELIMINARY RAILING CONCEPTS

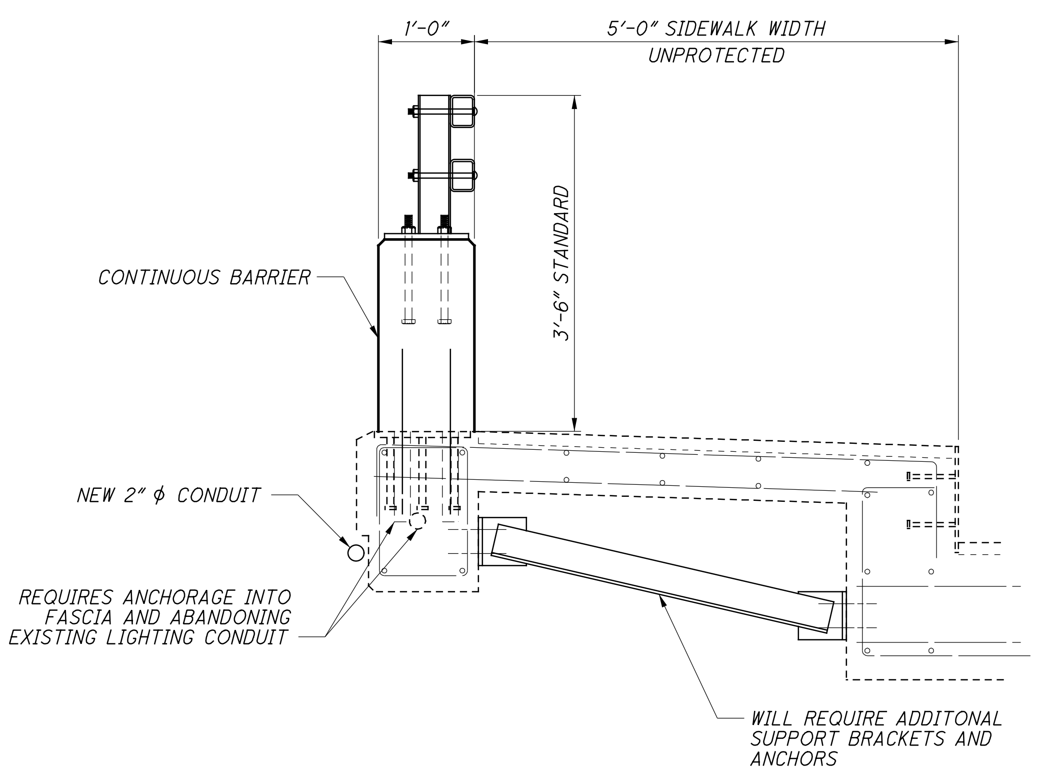
The following preliminary railing concepts were developed for the initial consideration on this project. In consultation with ODOT in a meeting held on 3/31/16, the list of alternatives was reduced down to the four alternatives discussed in detail in the main body of this report. Alternatives were eliminated due to considerations including feasibility of structural connections, aesthetics, weight, and conformance to ODOT standards.



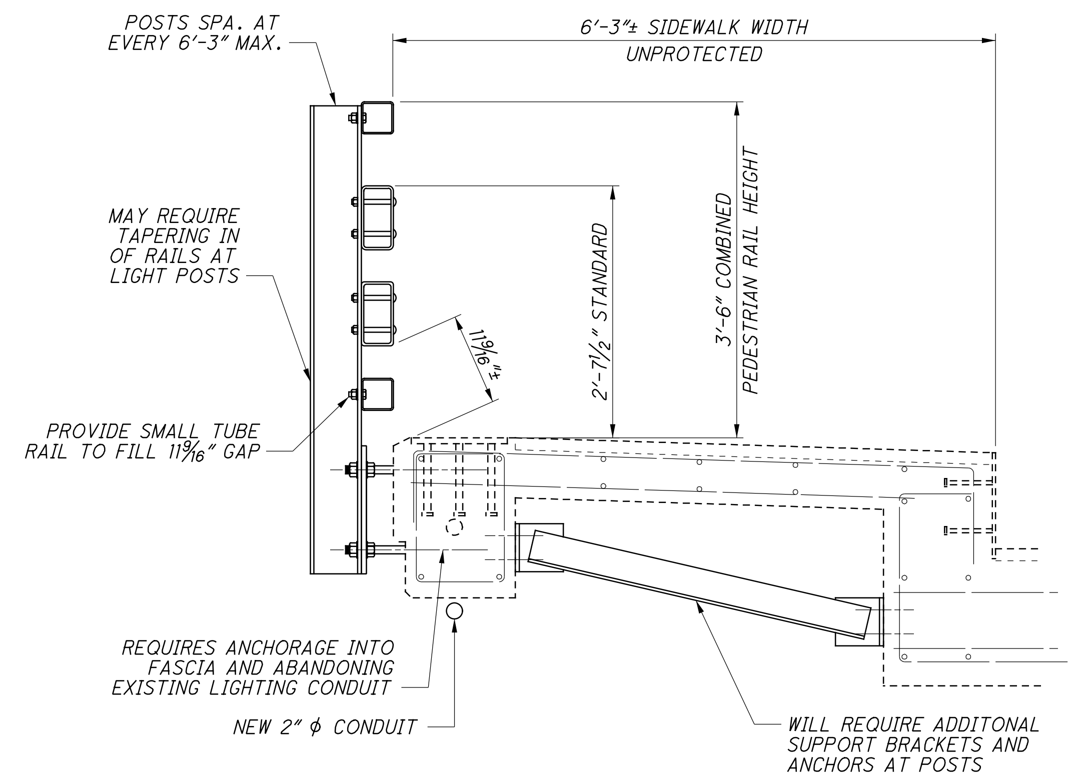
(A) TYPICAL EXISTING SIDEWALK SECTION BETWEEN SUPPORT BRACKETS



(B) DEEP BEAM GUARDRAIL RETROFIT STANDARD



(C) BR-2-15 BARRIER ON THE FASCIA CURB



(D) SIDE MOUNTED TST-1-99 RAILING

NOTE:

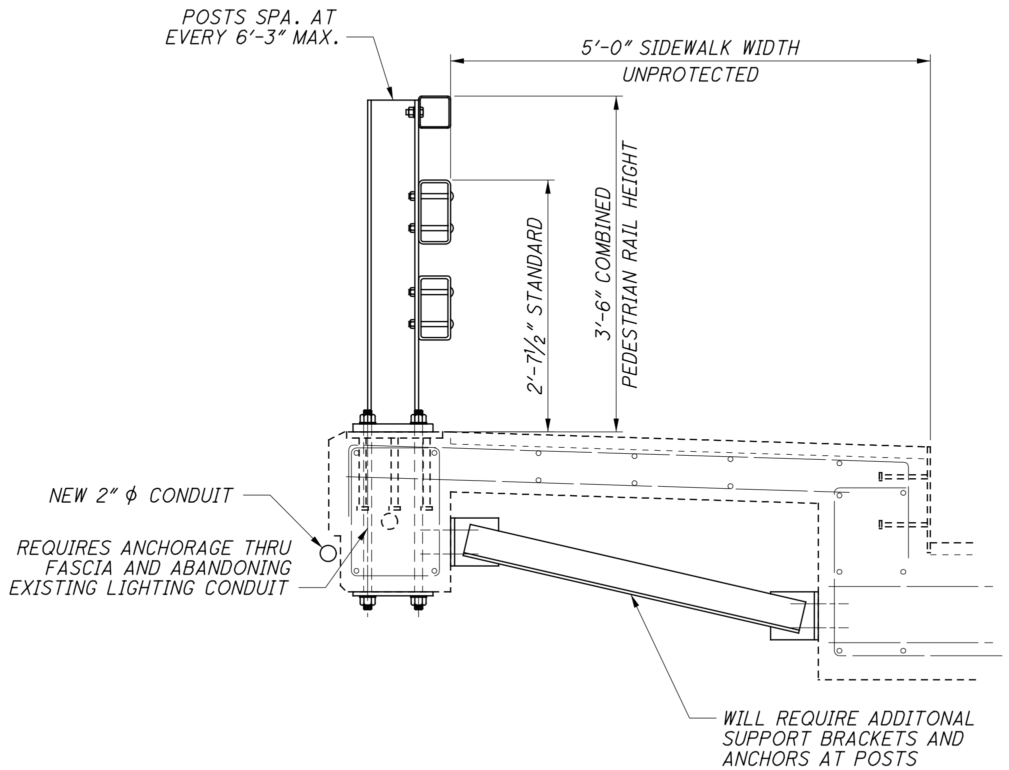
1. VANDAL PROTECTION FENCE MAY BE PLACED ON ALL ALTERNATIVES.

DESIGN AGENCY
E.L. ROBINSON ENGINEERING
1468 West 9th Street · Cleveland, Ohio 44113
www.elrobinsonengineering.com

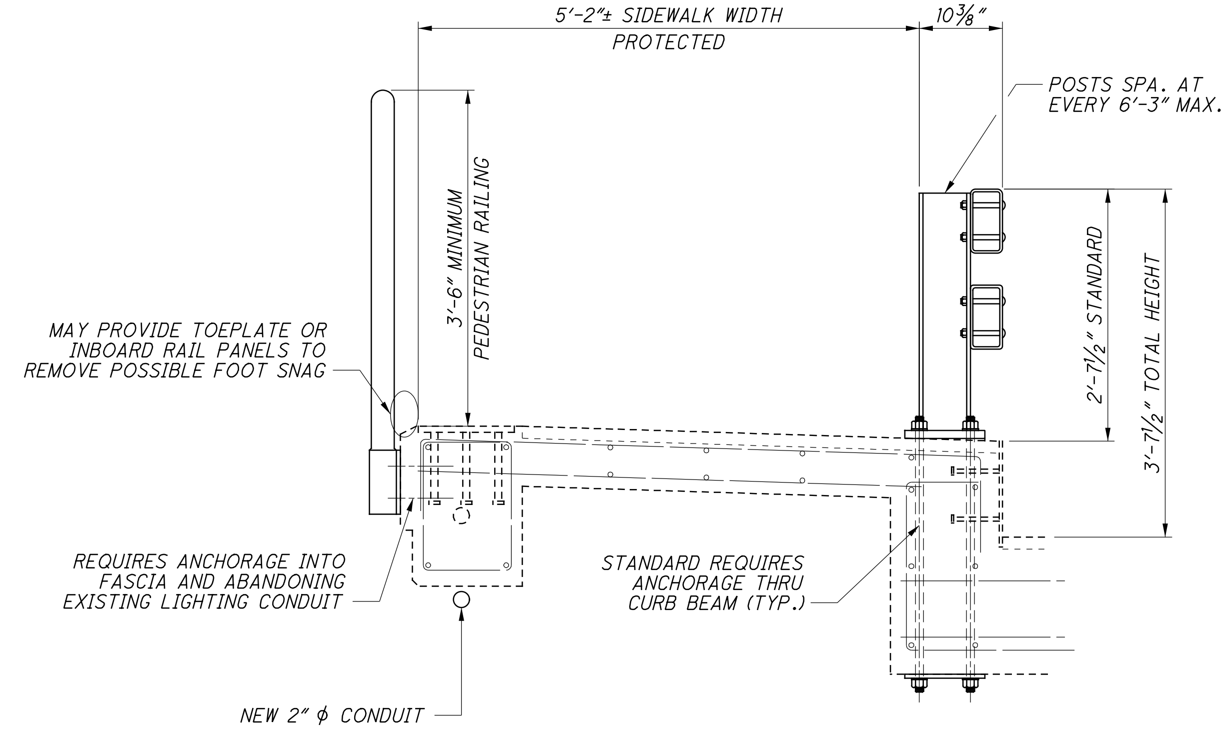
DESIGNED	DRAWN	REVIEWED	DATE
NBR	NBR	RER	02-19-2016
CHECKED	REVISED	STRUCTURE FILE NUMBER	
JOL		1802046	

RAILING ALTERNATIVES A THROUGH D
CUY-17-0283
S.R. 17 BROOKPARK ROAD OVER THE ROCKY RIVER

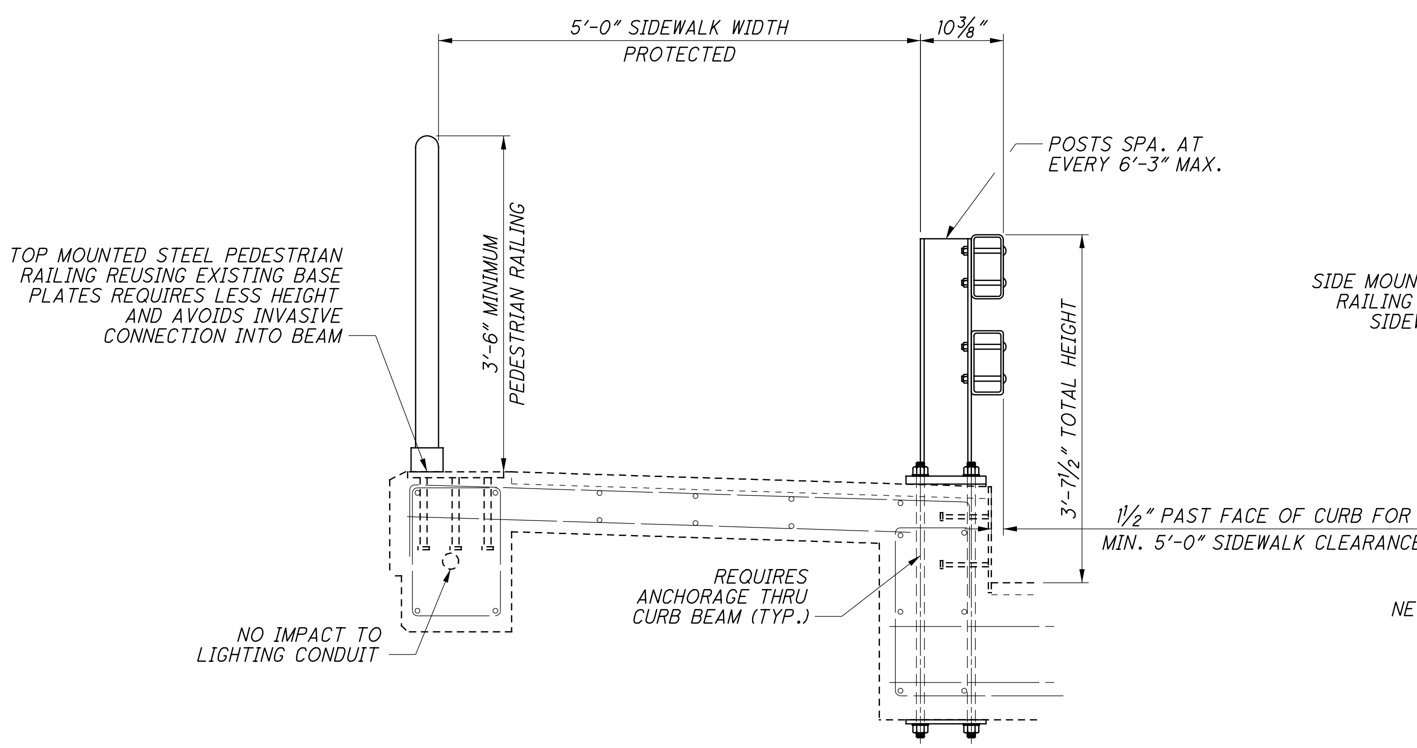
CUY-17-02.83
PID No. 101682



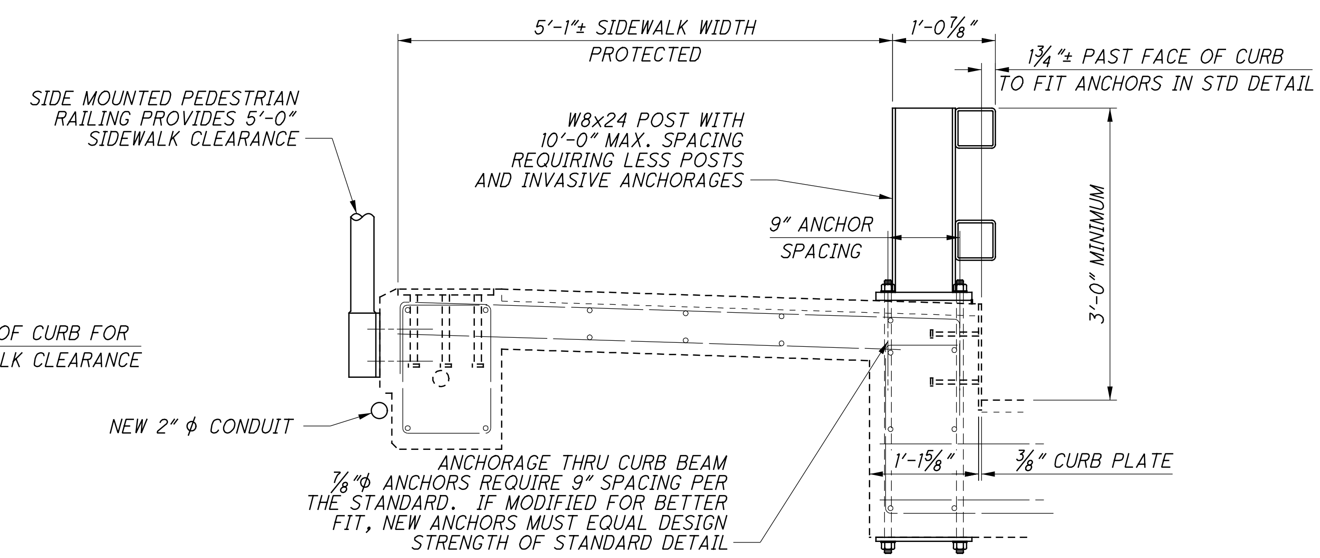
Ⓔ TOP MOUNTED TST-1-99 AT FASCIA BEAM



Ⓕ TOP MOUNTED TST-1-99 AT CURB BEAM
(SHOWN WITH SIDE MOUNTED PEDESTRIAN RAILING)



Ⓕ TOP MOUNTED TST-1-99 AT CURB BEAM
(SHOWN WITH TOP MOUNTED PEDESTRIAN RAILING)



Ⓖ CALIFORNIA ST-30 TWIN STEEL TUBE RAILNG
(RAILING IS NORMALLY ON A 7" CURB WHICH IS OMITTED DUE TO THE EX. 12" CURB)

NOTE:

1. VANDAL PROTECTION FENCE MAY BE PLACED ON ALL ALTERNATIVES.

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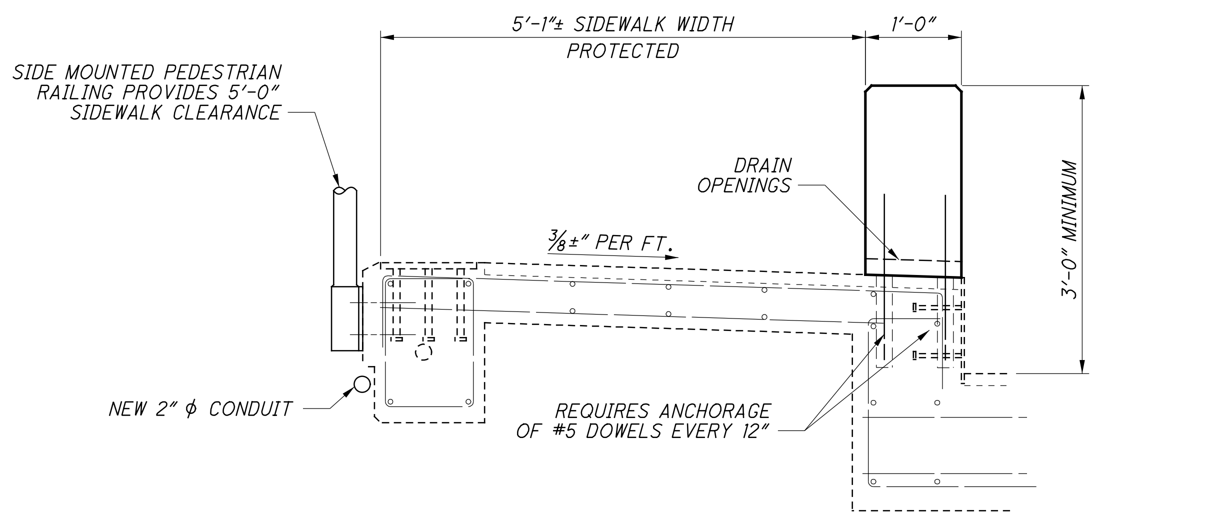
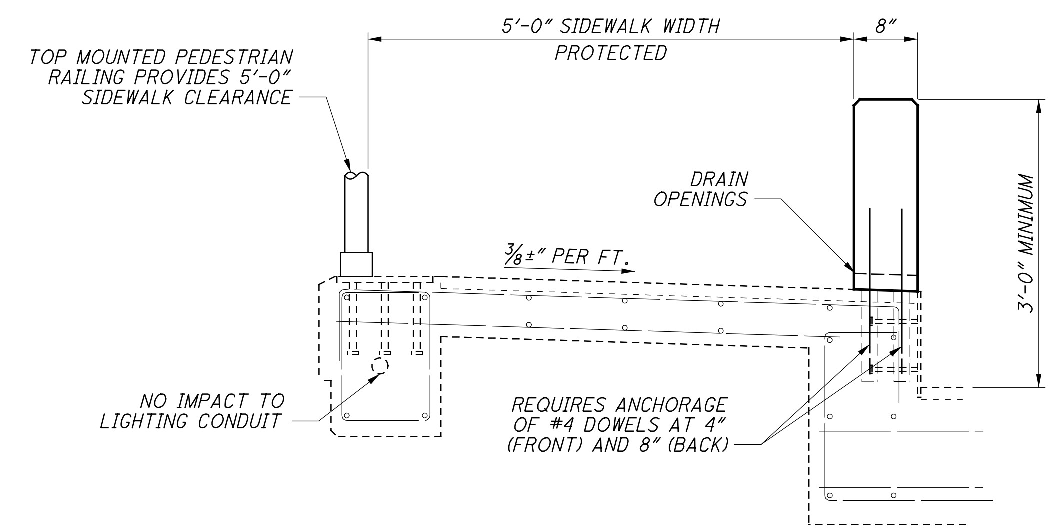
DRAWN	REVISED	DESIGNED	CHECKED
NBR		NBR	JOL

RAILING ALTERNATIVES E THROUGH G
CUY-17-0283
S.R. 17 BROOKPARK ROAD OVER THE ROCKY RIVER

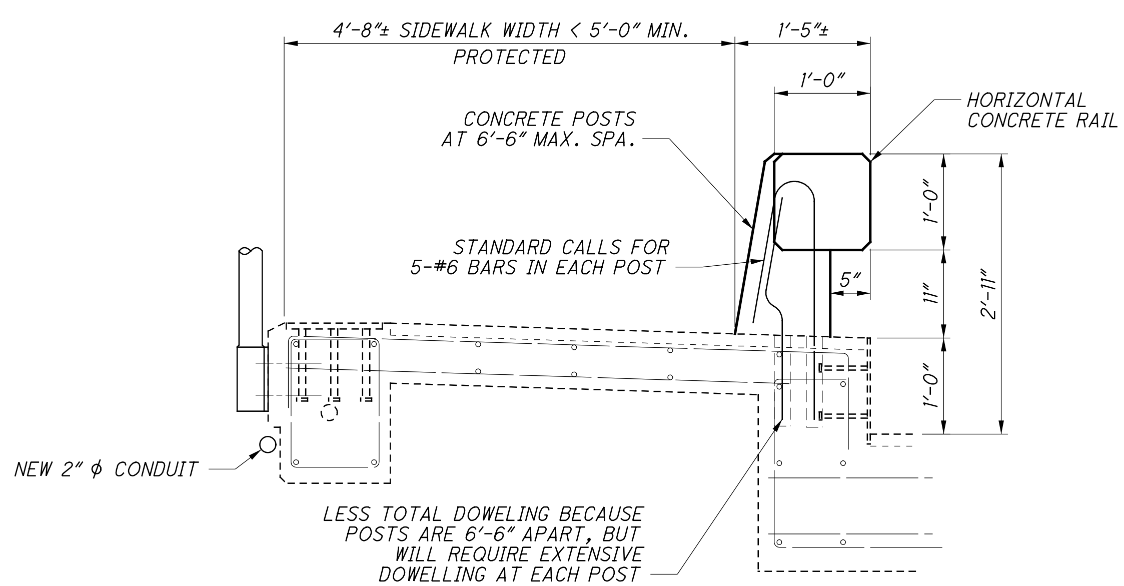
CUY-17-02.83
PID No. 101682



(H) BR-2-15 BARRIER

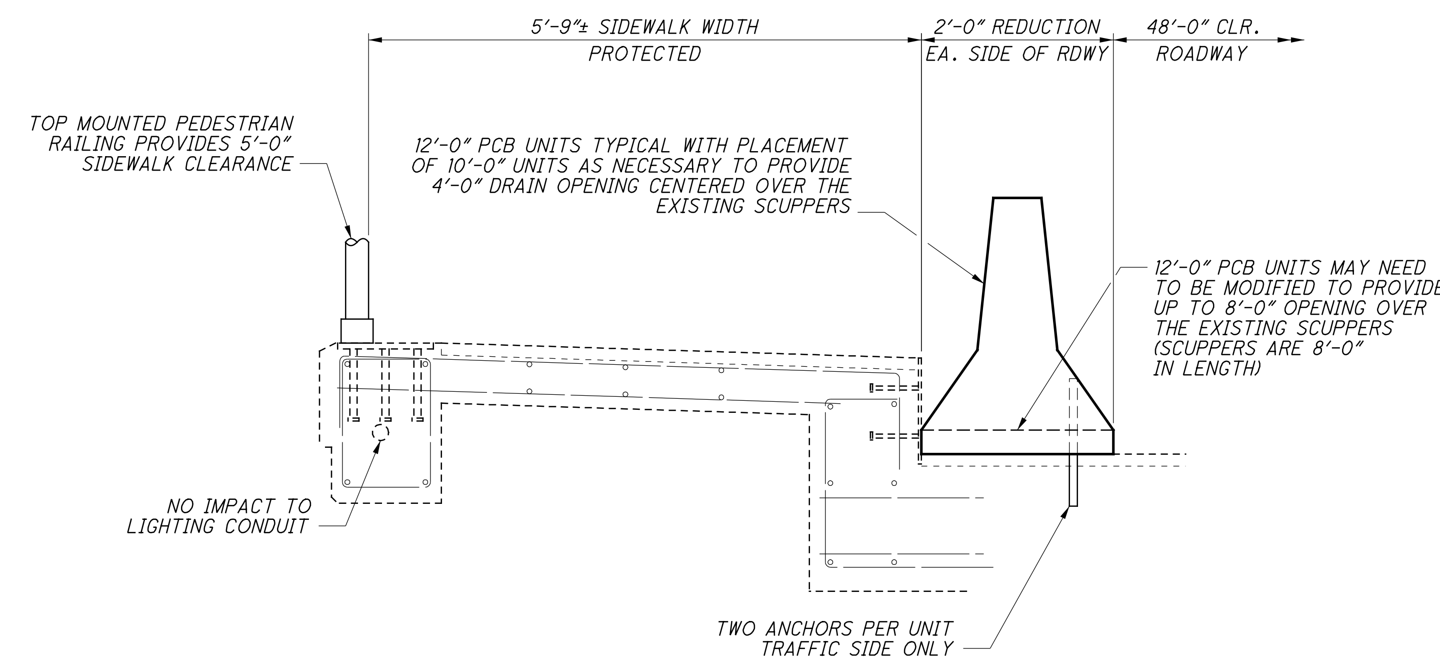


(I) VERTICAL CONCRETE BARRIER



(J) CALIFORNIA CONCRETE BARRIER TYPE 80, "CORRAL" TYPE

(BARRIER IS NORMALLY ON A 9" CURB WHICH IS OMITTED DUE TO THE EX. 12" CURB)



(K) UNANCHORED PCB-91

(REQUIRES FOUR 11'-0" LANES AND TWO 2'-0" SHOULDERS)

NOTE:

1. VANDAL PROTECTION FENCE MAY BE PLACED ON ALL ALTERNATIVES.

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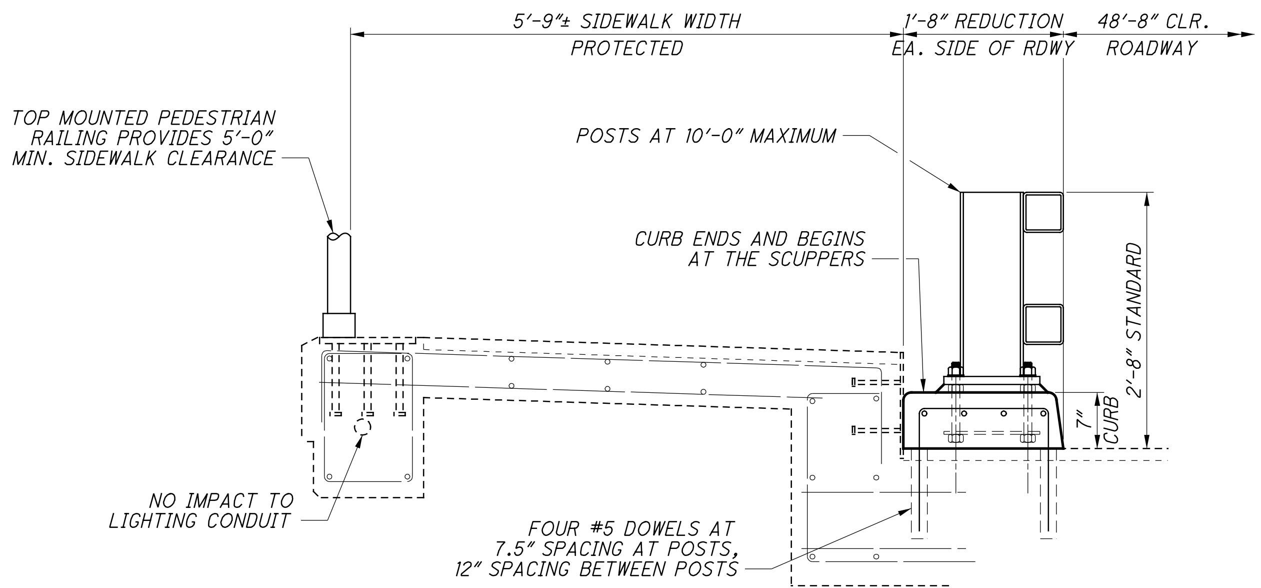
JOL		1802046	

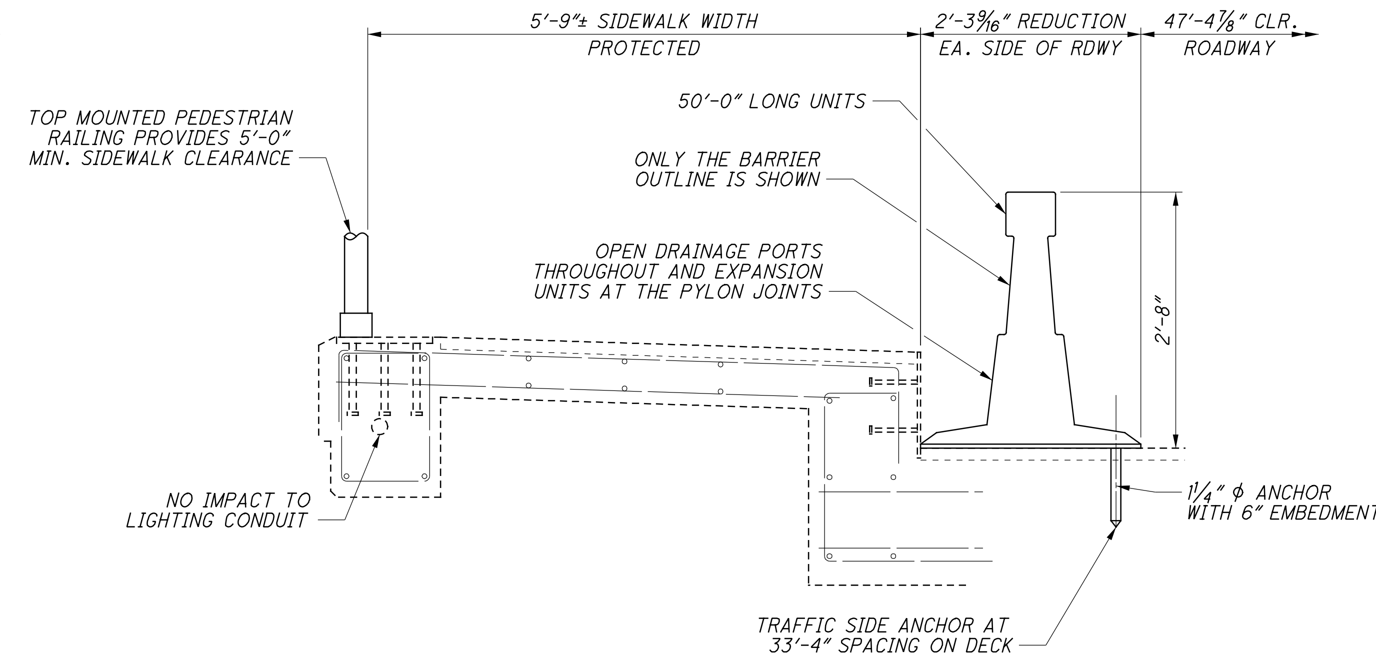
RAILING ALTERNATIVES H THROUGH K
CUY-17-0283
S.R. 17 BROOKPARK ROAD OVER THE ROCKY RIVER

CUY-17-02.83
PID No. 101682



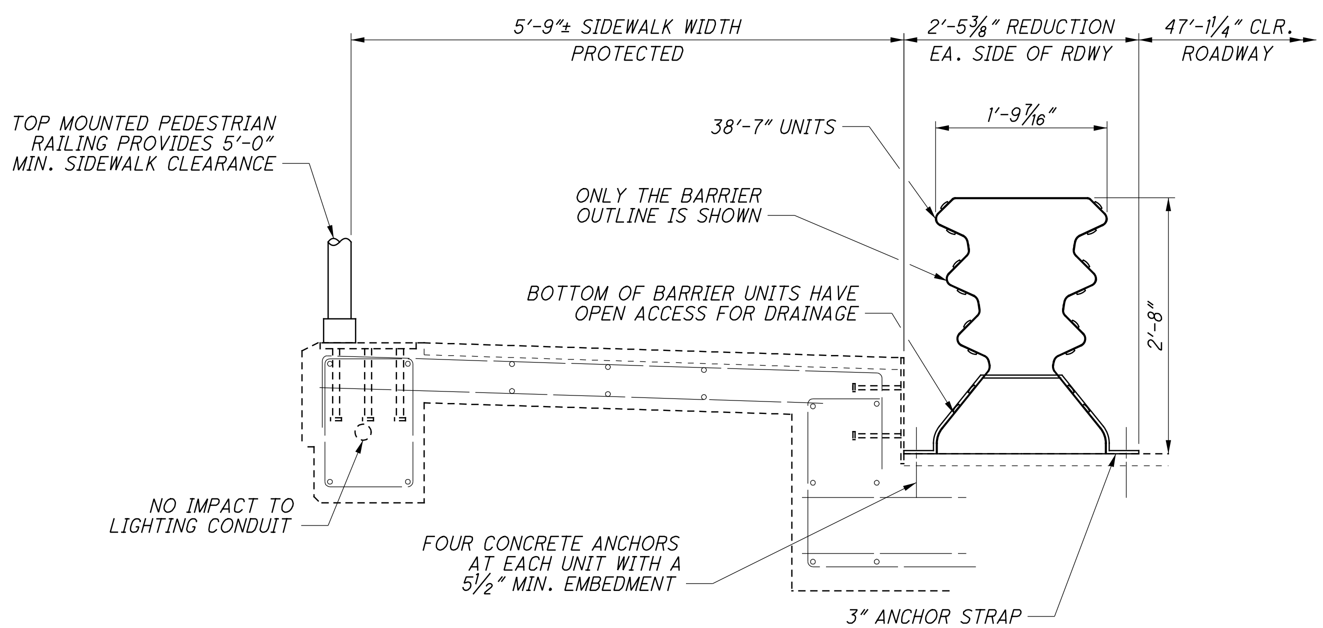
L CALIFORNIA STANDARD ST-30 TWIN STEEL TUBE RAILNG

(REQUIRES FOUR 11'-0" LANES AND TWO 2'-4" SHOULDERS)



M ZONEGUARD® PORTABLE STEEL BARRIER

(REQUIRES FOUR 11'-0" LANES AND TWO 1'-8 7/16" SHOULDERS)
(ODOT APPROVED PRODUCT)



N VULCAN BARRIER™ TL-3 PORTABLE STEEL SAFETY BARRIER

(REQUIRES FOUR 11'-0" LANES AND TWO 1'-6 5/8" SHOULDERS)
(ODOT APPROVED PRODUCT)

NOTE:

1. VANDAL PROTECTION FENCE MAY BE PLACED ON ALL ALTERNATIVES.

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DESIGNED	DRAWN	REVIEWED	DATE
NBR	NBR	RER	02-19-2016
CHECKED	REVISED	STRUCTURE FILE NUMBER	
JOL		1802046	

RAILING ALTERNATIVES L THROUGH O
CUY-17-0283
S.R. 17 BROOKPARK ROAD OVER THE ROCKY RIVER

CUY-17-02.83
PID No. 101682

Railing Type and Identification			Crash Worthiness	Pedestrian Protection	Weight (lb/ft)[1]	Cost ($/ft)	Pedestrian Clearances	Traffic Clearances	Post Spacing	Invasiveness of Connection	Framing Modification	Existing Rebar Conflict[8]	Rating Update Required	Light Conduit Impact	Aesthetics
Railing at Sidewalk Fascia Beam	Existing Railing	A	Unknown	None	86	$0.00	5'-0"±	No change	8'-4"	None	None	None	No	None	Decorative Panels
	DBR-3-11	B	TL-3	None	95 + 10 = 105	$220.00	5'-7"±	No change	6'-3"	4 anchors every 6'-3"	Additional brackets @ posts	Intermediate	No	Yes	None
	BR-2-15	C	TL-4	None	329 + 10 = 339	$235.00	5'-0"±	No Change	Continuous	2 dowels every 12"	Additional brackets	Intermediate	Yes	Yes	Form Liners Optional
	Side Mounted TST-1-99	D	TL-4	None	86 + 10 = 96	$210.00	6'-3"±	No change	6'-3"	4 side anchors every 6'-3"	Additional brackets @ posts	Intermediate	No	Yes	See-Through
	Top Mounted TST-1-99	E	TL-4	None	80 + 10 = 90	$200.00	5'-0"±	No change	6'-3"	4 top anchors every 6'-3"[9]	Additional brackets @ posts	Maximum	No	Yes	See-Through
Railing at Curb Beam (Fascia Pedestrian Handrail)	TST-1-99	F	TL-4	Yes	67 + 20 = 87	$225.00	5'-2"/5'-0"±[2]	No Change	6'-3"	4 anchors every 6'-3"[9]	None	Maximum	No	Depends on Handrail Conn	See-Through
	California ST-30 Twin Steel Tube	G	TL-4	Yes	50 + 20 = 70	$220.00	5'-1"±	Roadway Reduction of 3.5"	10'-0"	4 anchors every 10'-0"[9]	None	Maximum	No	Yes	See-Through
	BR-2-15 without TST	H	TL-4	Yes	300 + 20 = 320	$275.00	5'-1"±	No Change	Continuous	Two #5 Dowels every 12"	None	Minimum	Yes	Yes	Form Liners Optional
	Vertical Concrete Barrier	I	TL-4	Yes	200 + 20 = 220	$215.00	5'-0"±	No Change	Continuous	#4 Dowels @ 4" FF, @ 8" BF	None	Minimum	Yes	Depends on Handrail Conn	Form Liners Optional
	Concrete Corral Barrier	J	TL-4	Yes	180 + 20 = 200	$190.00	4'-8"±[3]	No Change	6'-6"	5 - #6 dowels EF every 6'-6"	None	Intermediate	Yes	Yes	See-Through
Railing on Deck (Fascia Pedestrian Handrail)	Unanchored PCB-91	K	TL-3	Yes	411 + 20 = 431	$105.00	5'-9"±	Roadway reduction of 4'-0"[4]	Continuous	None	None	None	Yes	No	None
	California Standard ST-30 Twin Steel Tube	L	TL-4	Yes	203 + 20 = 223	$275.00	5'-9"±	Roadway reduction of 3'-4"[5]	10'-0"	Two #5 Dowels every 12" Min.	None	Intermediate	Yes	No	None
	Zoneguard® Portable Steel Barrier	M	TL-4	Yes	63 + 20 = 83	$215.00	5'-9"±	Rdwy reduction of 4'-7 1/8"[6]	Continuous	None (on Bridge)	None	None (on Bridge)	No	No	None
	Vulcan™ Portable Steel Barrier	N	TL-3	Yes	70 + 20 = 90	$300.00	5'-9"±	Rdwy reduction of 4'-10 3/4"±[7]	Continuous	2 Anchors Each End of Units	None	Minimum	No	No	None

Notes:

1. The first weight number is the railing dead load for all alternatives. The second number for Railings B through E is the approximate weight of support brackets. The second number for Alternatives F through J is the approximate weight of the pedestrian railing.
2. The clearance is 5'-2" for side mounted pedestrian rail, 5'-0" for the top mounted rail.
3. Design Exception required for the sidewalk width.
4. Requires a roadway of four 11'-0" lanes and two 2'-0" shoulders.
5. Requires a roadway of four 11'-0" lanes and two 2'-4" shoulders.
6. Requires a roadway of four 11'-0" lanes and two 1'-8 7/16" shoulders. Will need a design exception.
7. Requires a roadway of four 11'-0" lanes and two 1'-6 5/8" shoulders. Will need a design exception.
8. "Existing Rebar Conflict" refers to amount of reinforcing that is cut due to the "Invasiveness of Connection" and "Framing Modification" information. For instance, dowels may be placed to minimize rebar conflicts and through bolts typically will conflit with all rebar mats.
9. Requires through bolts.

APPENDIX C PSI CORE TEST REPORT

Information To Build On
Engineering • Consulting • Testing

January 26, 2016 (Revised: February 9, 2016)

Mr. James A. Marszal, P.E.
Pavement & Geotechnical Engineer
ODOT District 12
Ohio Department of Transportation
5500 Transportation Boulevard
Garfield Heights, Ohio 44125-5396

Re: ODOT - District 12 - GES Pavement and Structure Investigation
Sidewalk Coring Report
Cuy-17-2.83
PID No.: 101682
Task Order No.: 19048-4
Cleveland, Cuyahoga County, Ohio
PSI Project No.: 01412277

Dear Mr. Marszal:

Enclosed is PSI's Report of Pavement Cores regarding the cores that were obtained from the site at the above-referenced project. PSI's services for this project were performed in accordance with PSI's Proposal No. 0142-167882, dated December 2, 2015. Authorization to perform this exploration was in the form of an emailed authorization letter to PSI acknowledged by Mr. James A. Marszal of Ohio Department of Transportation – District 12, on December 30, 2015.

The scope of services for this project included pavement coring at twelve (12) specified locations, taking photographs of the existing pavement condition, measuring the GPS readings at each core location, measuring the thickness and condition of the pavement sections, and taking photographs of each core. Laboratory test results include acid soluble chloride ion content and compressive strength test.

The number and locations of the pavement cores were selected by the representatives of ODOT – District 12, and were field located by others. Enclosed with this report are the following:

- Pavement Core Location Plans, showing the approximate locations of each pavement core;
- Core Photo Logs: showing the core number, approximate GPS reading, approximate thickness, composition, and condition of the pavement cores;
- Pavement Photo Logs: Show the existing condition of pavement at core locations.

Compressive strength testing was conducted on each core sample in general accordance to ASTM C42/C42M-13 Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete. Test results can be found summarized in the table below.

Core Number	Diameter (in)	Height (in)	Area (in^2)	H/D	Load (lbs)	Correction Factor	Compressive Strength (psi)
C-1	3.66	4.77	10.52	1.30	81010	0.94	**7240**
C-2	3.67	6.99	10.58	1.90	82420	1.00	**7790**
C-3	3.67	4.55	10.58	1.24	98070	0.92	**8530**
C-4	3.66	7.80	10.52	2.13	60520	1.00	**5750**
C-5	3.67	3.73	10.58	1.02	98170	0.87	**8070**
C-6	3.67	7.80	10.58	2.13	68540	1.00	**6480**
C-7	3.67	4.17	10.58	1.14	69670	0.90	**5930**
C-8	3.67	7.69	10.58	2.10	95080	1.00	**8990**
C-9	3.67	4.60	10.58	1.25	80500	0.93	**7080**
C-10	3.67	5.82	10.58	1.59	95870	0.97	**8790**
C-11	3.67	4.18	10.58	1.14	86800	0.90	**7380**
C-12	3.67	7.85	10.58	2.14	81160	1.00	**7670**

Acid Soluble Chloride Ion Content testing was conducted on each sample in general accordance to AASHTO T-260. Test results can be found summarized in the table below.

Core Number	Depth (in)	Acid Soluble Chlorides (lbs/cy^3)**	Acid Soluble Chlorides (%)	Core Number	Depth (in)	Acid Soluble Chlorides (lbs/cy^3)**	Acid Soluble Chlorides (%)
C-1	3"	**0.838**	**0.022**	**C-7**	3"	**2.893**	**0.076**
C-2	3"	**0.761**	**0.02**	**C-8**	3"	**1.980**	**0.052**
C-2	10"	**0.685**	**0.018**	**C-8**	12"	**0.419**	**0.011**
C-3	3"	**0.952**	**0.025**	**C-9**	3"	**1.142**	**0.03**
C-4	3"	**2.208**	**0.058**	**C-10**	3"	**1.066**	**0.028**
C-4	12"	**0.533**	**0.014**	**C-10**	12"	**0.419**	**0.011**
C-5	3"	**2.132**	**0.056**	**C-11**	3"	**1.066**	**0.028**
C-6	3"	**4.911**	**0.129**	**C-12**	3"	**0.799**	**0.021**
C-6	12"	**1.066**	**0.028**	**C-12**	10.5"	**0.647**	**0.017**

**Based on an assumed concrete unit weight of 141 lbs/ft^3.

PSI assumes no responsibility for interpretation made by others. The collected pavement core samples are available for inspection. The cores will be retained for a period of 30 days after the date of this report and disposed thereof.

PSI appreciates the opportunity to have been of service to you on this project. If we can be of further assistance, please do not hesitate to contact us at 216-447-1335.

Respectfully submitted,

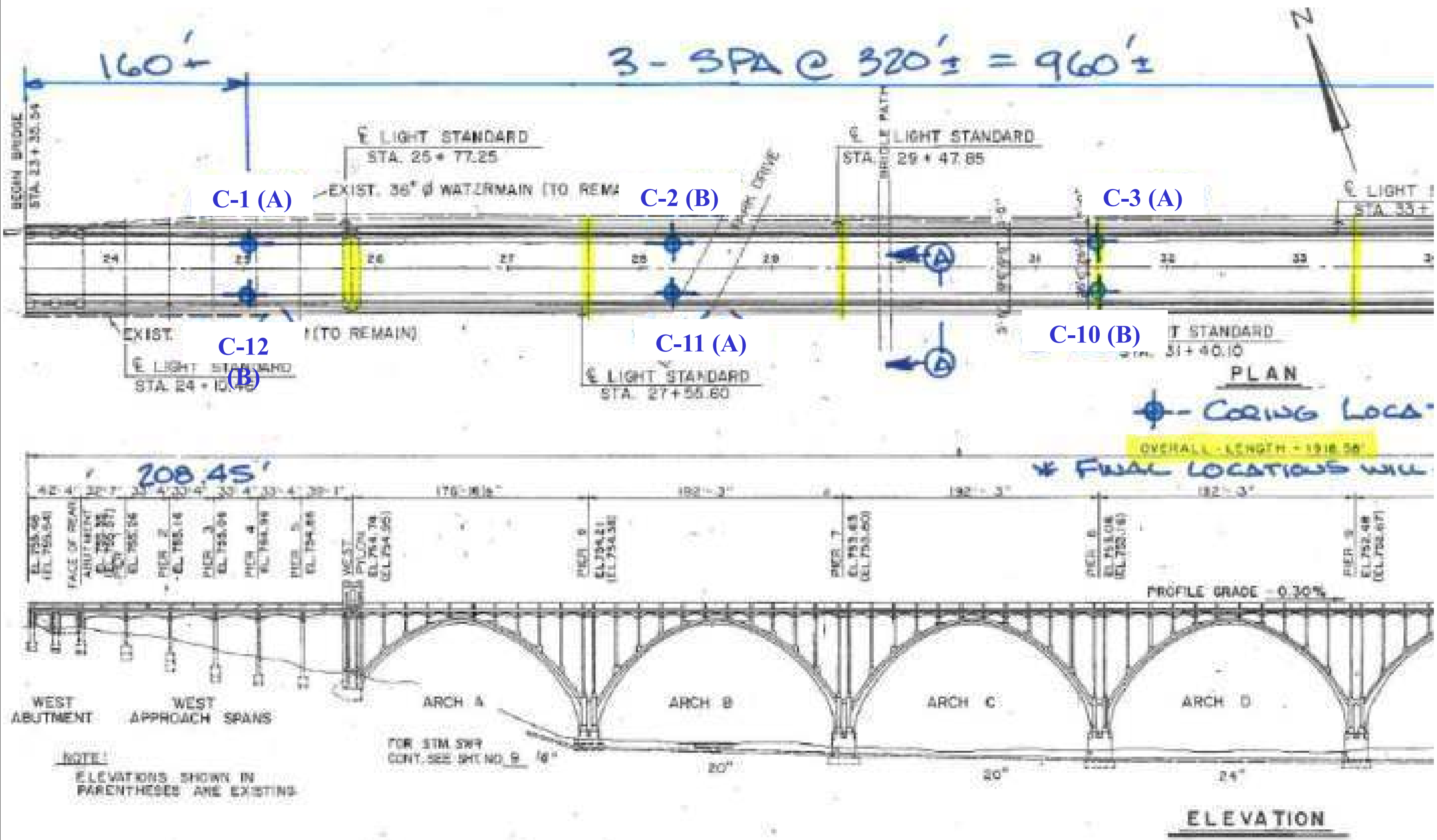
PROFESSIONAL SERVICE INDUSTRIES, INC.

Andrew Croasmun
Laboratory Supervisor

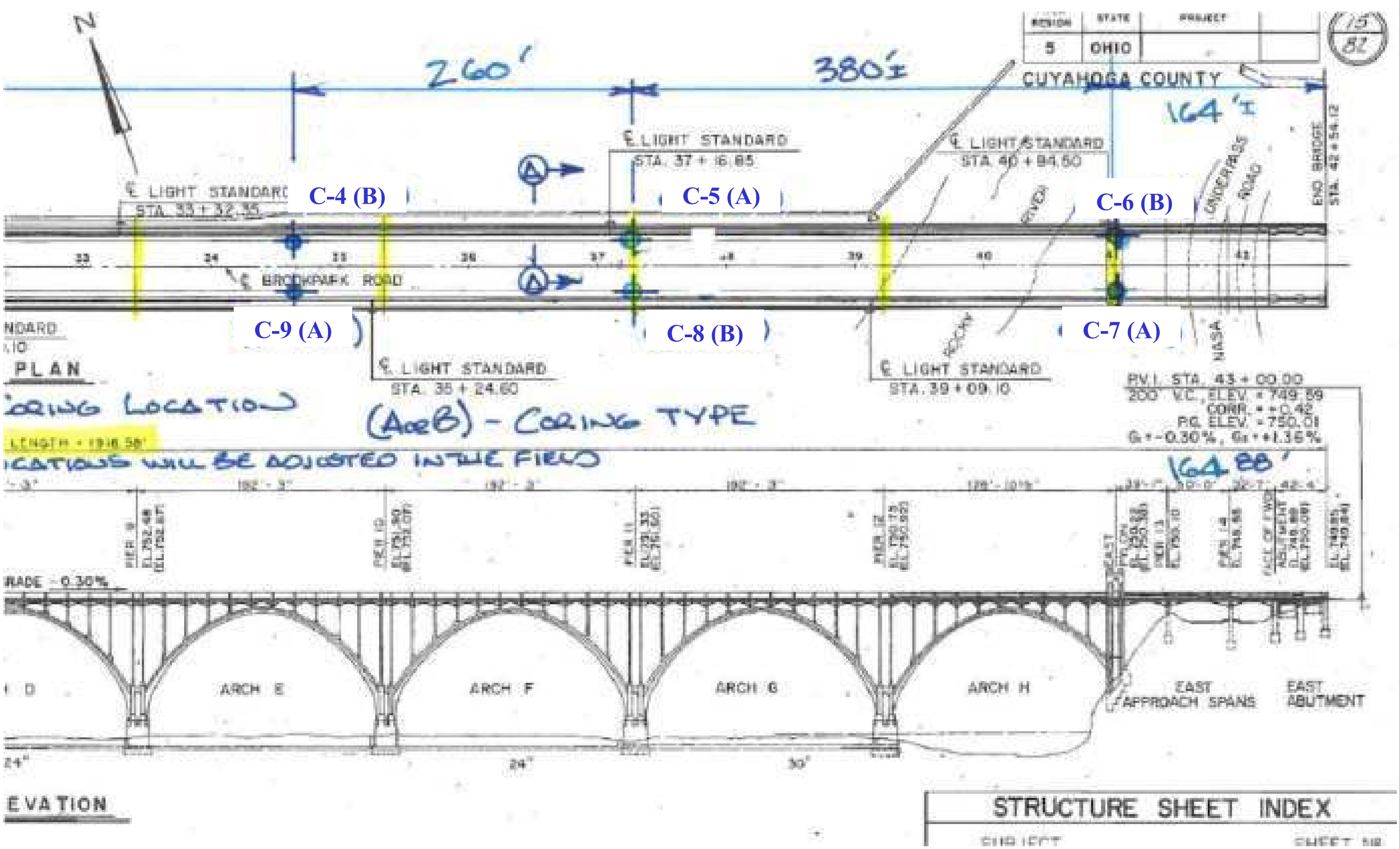
A. Veeramani, P.E.
Vice President

Enclosures:

- Pavement Core Location Plans
- Core Photo Logs with Core Descriptions
- Pavement Photo Logs



psi *Information To Build On* Engineering • Consulting • Testing	Sidewalk Coring CUY-17-2.83 (PID No.: 101682) Task Order No.: 19048-4 Cuyahoga County, Ohio	Date: 1/26/2016 Taken By: AC Scale: NA	Core Location Plan PSI Project No.: 01412277



psi Information To Build On Engineering • Consulting • Testing	**Sidewalk Coring** **CUY-17-2.83 (PID No.: 101682)** **Task Order No.: 19048-4** **Cuyahoga County, Ohio**	Date: 1/26/2016	**Core Location Plan**
		Taken By: AC	PSI Project No.: 01412277
		Scale: NA	

Core Number	Location	Layers	Core Composition		Remarks
			LMC Overlay	Bridge Deck	
C-1	**CUY-17-2.83** **SIDEWALK (WB)** Latitude : 41.4205° Longitude : -81.8611°	A	1 ½"	--	Good Condition
		B	--	4 ¾"	Good Condition

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Sidewalk Coring
CUY-17-2.83 (PID No.: 101682)
Task Order No.: 19048-4
Cuyahoga County, Ohio

Date: 1/26/2016

Taken By: AC

Scale: NA

Core Photo Log

PSI Project No.: 01412277

Core Number	Location	Layers	Core Composition		Remarks
			LMC Overlay	Bridge Deck	
C-2	**CUY-17-2.83** **SIDEWALK (WB)** Latitude : 41.4202° Longitude : -81.8600°	A	1 ½"	--	Good Condition
		B	--	10 ½"	Good Condition

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Sidewalk Coring
CUY-17-2.83 (PID No.: 101682)
Task Order No.: 19048-4
Cuyahoga County, Ohio

Date: 1/26/2016	**Core Photo Log**
Taken By: AC	PSI Project No.: 01412277
Scale: NA	

Core Number	Location	Layers	Core Composition		Remarks
			LMC Overlay	Bridge Deck	
C-3	**CUY-17-2.83** **SIDEWALK (WB)** Latitude : 41.4199° Longitude : -81.8588°	A	1 ¾"	--	Good Condition
		B	--	4 ¾"	Good Condition

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Sidewalk Coring
CUY-17-2.83 (PID No.: 101682)
Task Order No.: 19048-4
Cuyahoga County, Ohio

Date: 1/26/2016

Taken By: AC

Scale: NA

Core Photo Log

PSI Project No.: 01412277

Core Number	Location	Layers	Core Composition		Remarks
			LMC Overlay	Bridge Deck	
C-4	CUY-17-2.83 SIDEWALK (WB) Latitude : 41.4196° Longitude : -81.8577°	A	1 ¾"	--	Good Condition
		B	--	12 ¼"	Good Condition

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Sidewalk Coring
CUY-17-2.83 (PID No.: 101682)
Task Order No.: 19048-4
Cuyahoga County, Ohio

Date: 1/26/2016
Taken By: AC
Scale: NA

Core Photo Log

PSI Project No.: 01412277

Core Number	Location	Layers	Core Composition		Remarks
			LMC Overlay	Bridge Deck	
C-5	**CUY-17-2.83** **SIDEWALK (WB)** Latitude : 41.4194° Longitude : -81.8568°	A	2”	--	Good Condition
		B	--	3 ¾”	Good Condition

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Sidewalk Coring
CUY-17-2.83 (PID No.: 101682)
Task Order No.: 19048-4
Cuyahoga County, Ohio

Date: 1/26/2016
Taken By: AC
Scale: NA

Core Photo Log

PSI Project No.: 01412277

Core Number	Location	Layers	Core Composition		Remarks
			LMC Overlay	Bridge Deck	
C-6	CUY-17-2.83 SIDEWALK (WB) Latitude : 41.4190° Longitude : -81.8555°	A	1 ½"	--	Good Condition
		B	--	12 ¾"	Good Condition

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Sidewalk Coring
CUY-17-2.83 (PID No.: 101682)
Task Order No.: 19048-4
Cuyahoga County, Ohio

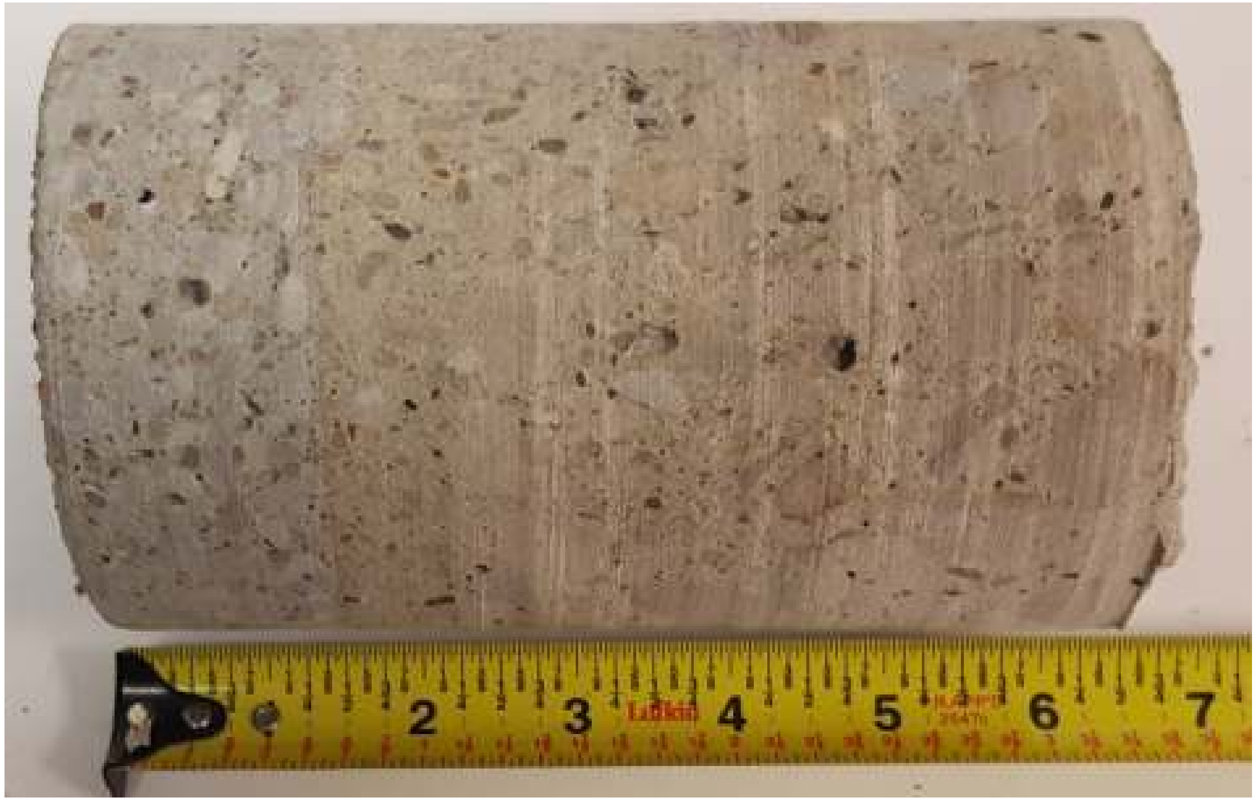
Date: 1/26/2016

Taken By: AC

Scale: NA

Core Photo Log

PSI Project No.: 01412277



Core Number	Location	Layers	Core Composition		Remarks
			LMC Overlay	Bridge Deck	
C-7	CUY-17-2.83 SIDEWALK (EB) Latitude : 41.4189° Longitude : -81.8556°	A	1 ½”	--	Good Condition
		B	--	4 ¾”	Good Condition

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CUY-17-2.83 (PID No.: 101682)
Task Order No.: 19048-4
Cuyahoga County, Ohio

Date: 1/26/2016
Taken By: AC
Scale: NA

Core Photo Log

PSI Project No.: 01412277

Core Number	Location	Layers	Core Composition		Remarks
			LMC Overlay	Bridge Deck	
C-8	CUY-17-2.83 SIDEWALK (EB) Latitude : 41.4192° Longitude : -81.8569°	A	1 ½”	--	Good Condition
		B	--	12 ¼”	Good Condition

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Engineering • Consulting • Testing

Sidewalk Coring
CUY-17-2.83 (PID No.: 101682)
Task Order No.: 19048-4
Cuyahoga County, Ohio

Date: 1/26/2016
Taken By: AC
Scale: NA

Core Photo Log

PSI Project No.: 01412277

<table>
<tr><th rowspan="2">Core Number</th><th rowspan="2">Location</th><th rowspan="2">Layers</th><th colspan="2">Core Composition</th><th rowspan="2">Remarks</th></tr>
<tr><th>LMC Overlay</th><th>Bridge Deck</th></tr>
<tr><td rowspan="2">C-9</td><td rowspan="2">CUY-17-2.83
SIDEWALK (EB)
Latitude : 41.4195°
Longitude : -81.8578°</td><td>A</td><td>1 ¾”</td><td>--</td><td>Good Condition</td></tr>
<tr><td>B</td><td>--</td><td>4 ½”</td><td>Good Condition</td></tr>
</table>

psi Information To Build On
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Core Number	Location	Layers	Core Composition		Remarks
			LMC Overlay	Bridge Deck	
C-10	CUY-17-2.83 SIDEWALK (EB) Latitude : 41.4198° Longitude : -81.8598°	A	1 ½"	--	Good Condition
		B	--	12 ¾"	Good Condition, Cracked During Coring

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Core Number	Location	Layers	Core Composition		Remarks
			LMC Overlay	Bridge Deck	
C-11	CUY-17-2.83 SIDEWALK (EB) Latitude : 41.4200° Longitude : -81.8600°	A	2"	--	Good Condition
		B	--	4 ¼"	Good Condition

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Core Number	Location	Layers	Core Composition		Remarks
			LMC Overlay	Bridge Deck	
C-12	CUY-17-2.83 SIDEWALK (EB) Latitude : 41.4203° Longitude : -81.8611°	A	1 ¾”	--	Good Condition
		B	--	10 ¾”	Good Condition

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Cuyahoga County, Ohio

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Scale: NA

Core Photo Log

PSI Project No.: 01412277

Pavement Photo C-1

Pavement Photo C-2

psi Information To Build On Engineering • Consulting • Testing	Sidewalk Coring CUY-17-2.83 (PID No.: 101682) Task Order No.: 19048-4 Cuyahoga County, Ohio		Pavement Photo Log
	Scale: NA	Taken By: AC	Date: 1/26/2015	PSI Project No: 01412277

Pavement Photo C-3

Pavement Photo C-4

psi Information To Build On Engineering • Consulting • Testing	Sidewalk Coring CUY-17-2.83 (PID No.: 101682) Task Order No.: 19048-4 Cuyahoga County, Ohio		Pavement Photo Log
Scale: NA	Taken By: AC	Date: 1/26/2015	PSI Project No: 01412277

Pavement Photo C-5

Pavement Photo C-6

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	Scale: NA	Taken By: AC	Date: 1/26/2015	PSI Project No: 01412277

Pavement Photo C-7

Pavement Photo C-8

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	Scale: NA	Taken By: AC	Date: 1/26/2015
			PSI Project No: 01412277

Pavement Photo C-9

Pavement Photo C-10

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	Scale: NA	Taken By: AC	Date: 1/26/2015

PSI Project No: 01412277

Pavement Photo C-11

Pavement Photo C-12

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