MSE Walls Retrofit

Design and Construction

110th Annual Road School 2024

3/12/2024

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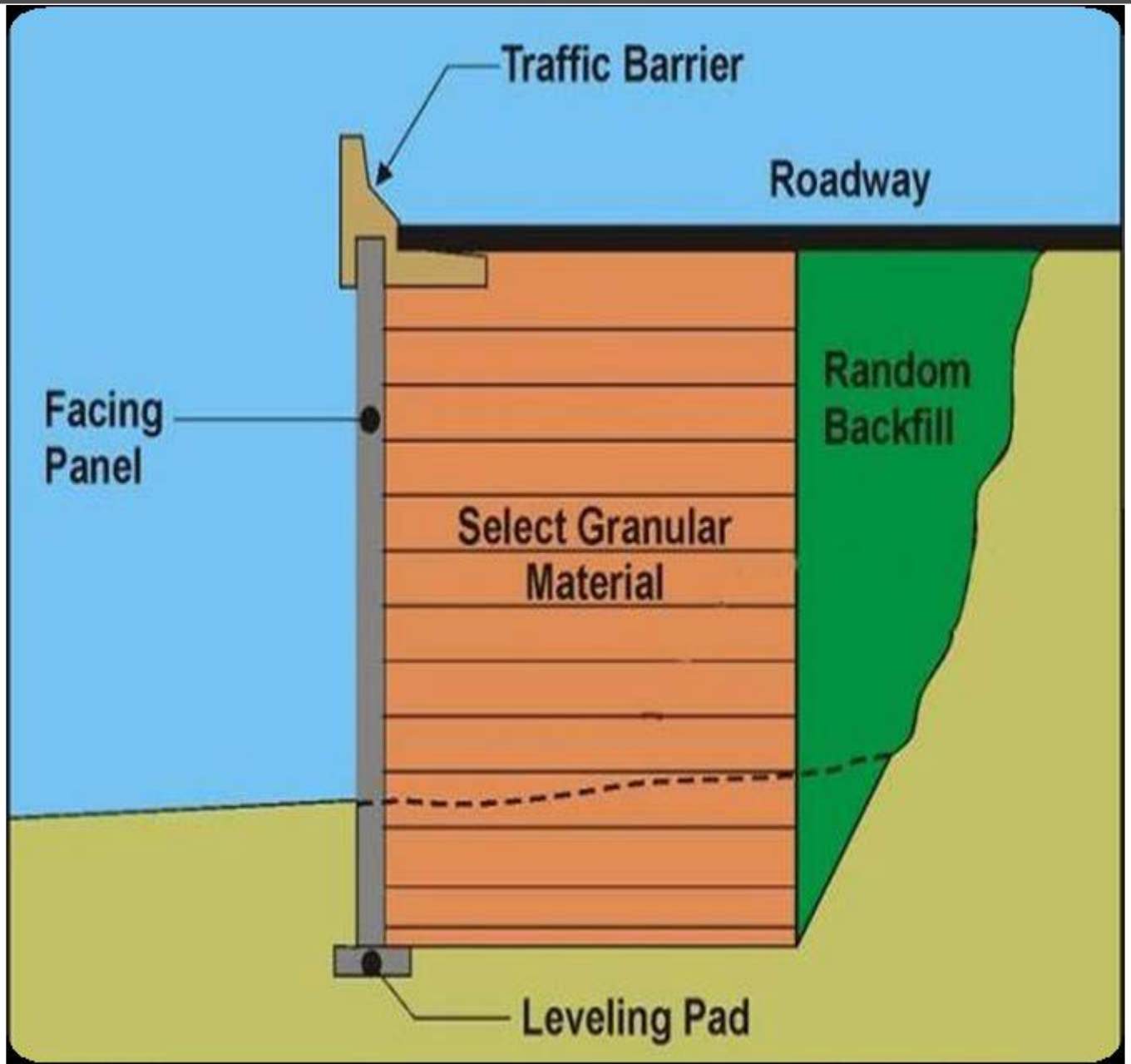
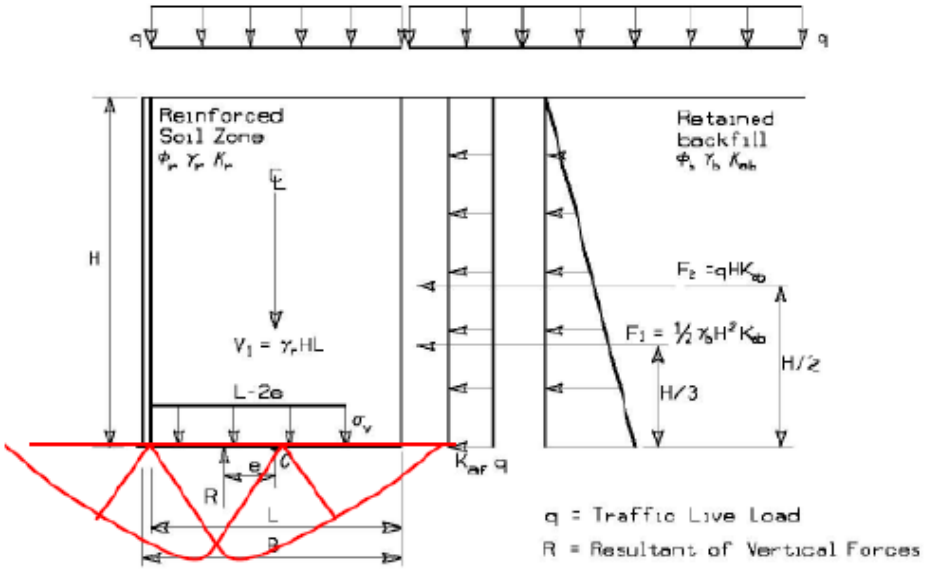
Typical section & components of MSE structures



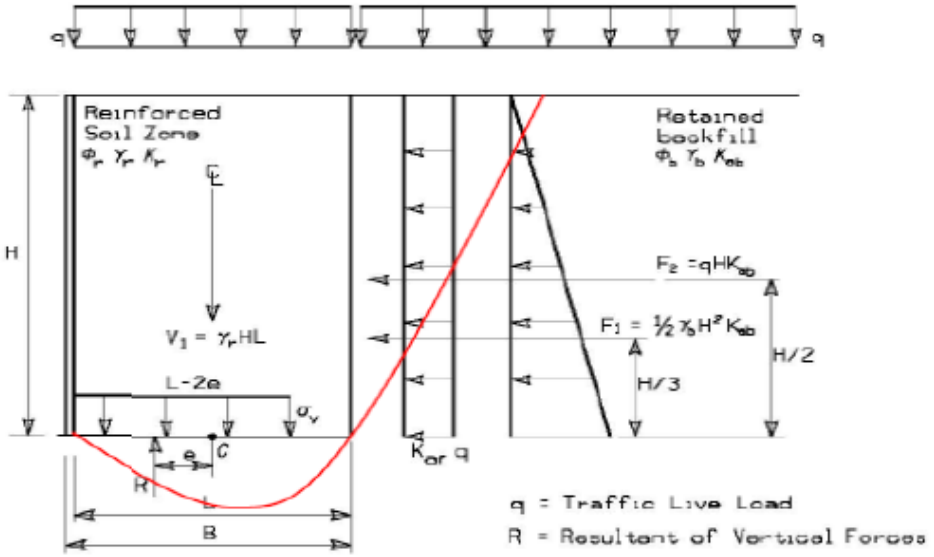
External Stability

- Bearing resistance
- Settlement
- Sliding
- Overturning
- Overall Stability

Bearing Failure



(a) Assumed Bearing Failure Zone of Current Practice

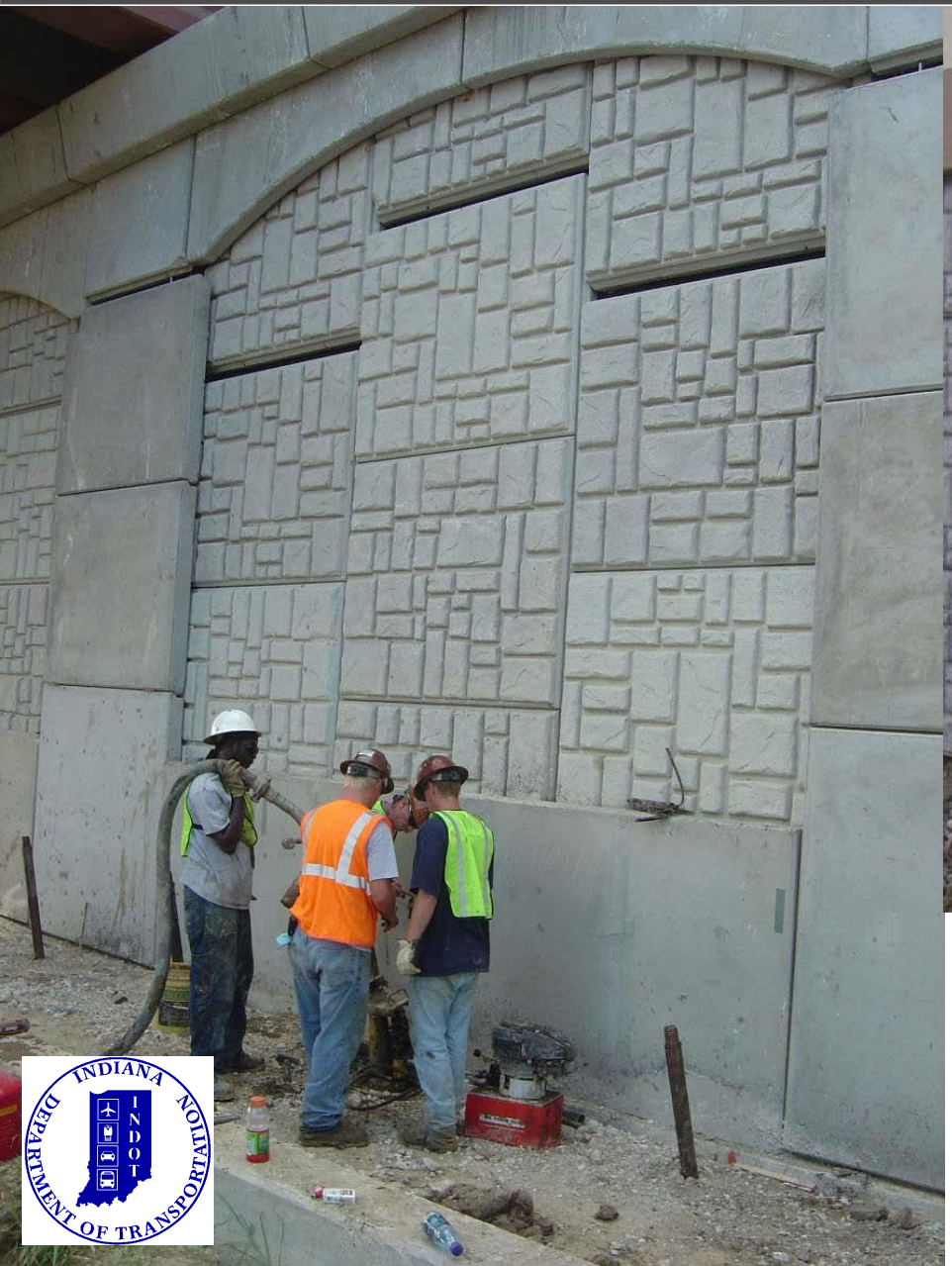


(b) Possible Failure Zone

Bearing Capacity of Retaining Walls

Bearing Failure

External Stability



Settlement

Flexibility of Wall Systems

TYPE OF FACING	LIMIT OF DIFFERENTIAL SETTLEMENT	
CIP Gravity Wall	1/500	2 In. in 100 Ft.
Welded Wire Facing	1/50	2 Ft. in 100 Ft.
5’ x 5’ Panels with ¾” Joints	1/100	1 Ft. in 100 Ft.
5’ x 10’ Panels with ¾” Joints	1/200	6 In. in 100 Ft.
Modular Block Walls	1/200	6 In. in 100 Ft.
Full Height Facing Panels	1/500	2 In. in 100 Ft.

Differential Settlement

Sliding Failure

External Stability

Wall Embedment

Slope in Front of Wall	Minimum to Top of Leveling Pad
Horizontal (walls)	H / 20
Horizontal (abutments)	H / 10
3 Horiz : 1 Vert	H / 10
2 Horiz : 1 Vert	H / 7
3 Horiz : 2 Vert	H / 5

H = 100 ft
Embed.
10 ft

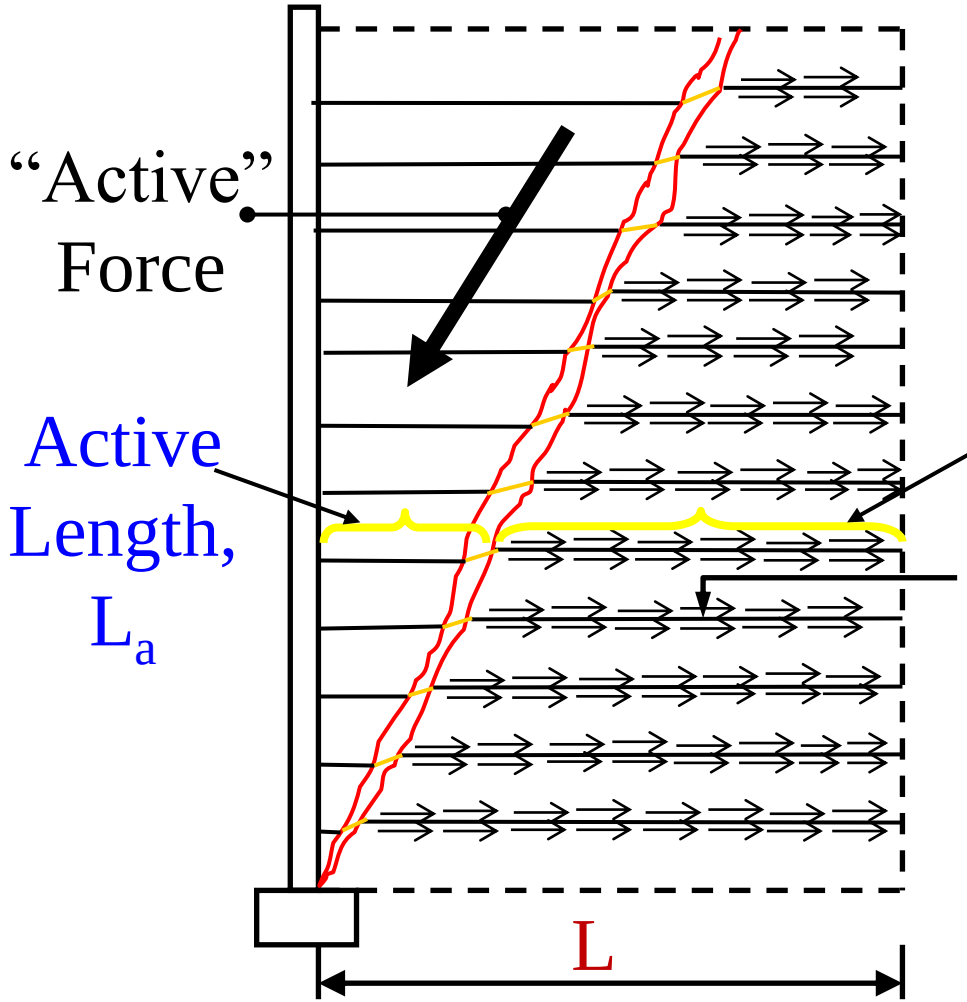
- For sloping ground provide a bench 4 ft bench in front of wall
- Embed at least 2 ft below anticipated scour depth
- Embed below frost depth, Indiana 3 ft

Overturning

Overall Stability

Internal Stability

How do Reinforcements Hold Up the Wall ?



Internal Stability Reinforcement Failure Modes

- Pull out
- Reinforcement tensile strength
- Connection

Internal Failure

MSE Walls Failures Survey for 30 States

Survey done by Texas A&M in 2013 for TxDOT

• Massachusetts DOT. • Oregon DOT. • Nevada DOT. • Idaho DOT. • Indiana DOT. • Missouri DOT. • New Mexico DOT. • Alabama DOT. • Kansas DOT. • Connecticut DOT. • Illinois DOT. • Iowa DOT. • Maryland DOT. • New Hampshire DOT. • New York DOT. • South Carolina DOT. • Washington DOT. • Wisconsin DOT. • California DOT. • Minnesota DOT. • Missouri DOT. • Montana DOT. • North Carolina DOT. • Vermont DOT. • Wyoming DOT. • Nebraska DOT. • Louisianan DOT. Texas DOT.

- All the DOTs have indicated that the FHWA design methodology has been followed to design the MSE walls.
- The minimum reinforcement length used for design is 0.7H or 8 ft, whichever is longer.
- In all, DOTs have different backfill specifications from FHWA guidelines. However, many of them have higher quality of material than the FHWA guidelines.

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MSE Walls Failures Survey for 30 States

Survey Results

- According to the frequency of the failure modes being seen, the ranking of the failure modes with frequency descending is:
- **Bearing Capacity.**
- **Sliding.**
- **Global Stability.**
- **Compound Failure.**
- **Overturning.**

MSE Walls Retrofit

Retrofit that did not Work I-10

I-10 in Beaumont, Texas - Distressed Portion of the Roadway

MSE Walls Retrofit

Retrofit that did not Work I-10

The separation ran about 100 ft long and up to 3 inches wide. Cracking was also observed at the connection between the copping/barrier and the MSE wall panels. To prevent the propagation of the settlement and further separation, a retrofit measure was taken by dowelling the shoulder to the adjacent travel lanes. After the retrofit, cracks appeared in the same travel lanes again, but were shifted toward the centerline of the roadway

MSE Walls Retrofit

General Identified Failure Distress Modes in MSE Walls

- 1. Pavement cracking.
- 2. Pavement depression and separation.
- 3. MSE wall lateral movement.
- 4. MSE wall and bridge separation.
- 5. MSE wall longitudinal movement.
- 6. MSE wall panel dislocation.
- 7. MSE wall sliding.

Possible Causes of Failures in MSE Walls

- 1. Unsuitable backfill material.
- 2. Sizeable void within backfill.
- 3. Drainage and Erosion.
- 4. Foundation soil.
- 5. Tension failure of the reinforcements.
- 6. Failure of connection of the reinforcement

The sizeable void may be the result of poor construction, inappropriate gradation of backfill material or poor drainage.

MSE Walls Retrofit

When Visiting MSE Wall that has Issues (What to look for per minimum)

- 1. Check all drainage and erosions issues.
- 2. Check for any excessive settlements.
- 3. Check precast concrete panel facing do they need rejection or repair.
- 4. Check field modification limitations (e.g., cutting panels, resting panels, anchoring panels, use nails, etc.).
- 5. Check any backfill migration from facings.
- 6. Check backfill void mitigation and void-filling techniques.
- 7. Wall condition monitoring methods if needed.
- 8. Check distressed joint openings.
- 9. Check local facing repair or replacement strategies.
- 10. Check global repair or replacement strategies.
- 11. Check global wall stabilization.

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MSE Walls Retrofit

Check List - Wall and Slope Distress Visual Indicators

Slopes or Slope / Paving Above Wall				
Observed				CHECKS (characteristics)
Yes	No	NA		
☐	☐	☐	1.	Cracks in slope/pavement (circle size: marble, golf ball, tennis ball, football, _____)
☐	☐	☐	2.	For cracks, circle: new/previous, sealed/unsealed, previously treated Approximate distance from wall face:_____ ft.)
☐	☐	☐	3.	Formation of shallow surface slides, depressions near top, bulging near bottom?
☐	☐	☐	4.	New or increased dip in paving, curb, gutter line or slope?
☐	☐	☐	5.	Landscape areas (Yes/No) – Working irrigation (Yes/No)
☐	☐	☐	6.	Ponding water?
☐	☐	☐	7.	Joint separation in pavement and shoulder joint pavement?
☐	☐	☐	8.	Erosion of soil on slope or around flatwork, flumes, guardrails, light fixture base, electrical communication bores?
☐	☐	☐	9.	Soft and / or wet soil (greener grass, ruts)?
☐	☐	☐	10.	Washout areas, silt buildup?
☐	☐	☐	11.	Signs, structures or rails next to wall (plumb, leaning to/away from wall face ___inches over ___ft.)
Wall Face				
Observed				CHECKS (characteristics)
Yes	No	NA		
☐	☐	☐	12.	Bulging of panels?
☐	☐	☐	13.	New or increased cracks in panels?

Retrofit Options

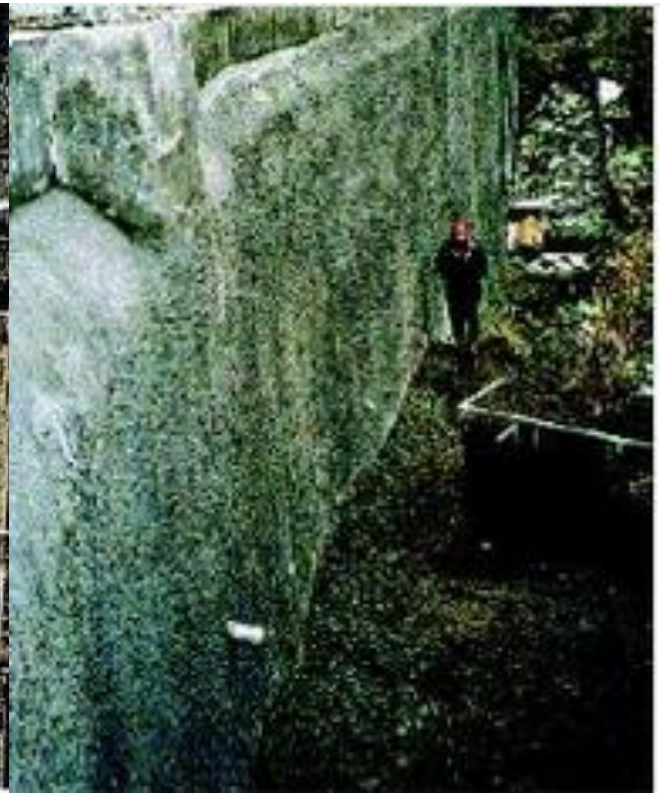
- 1. All drainage and erosions issues shall be resolved, such as sealing all opening, install curbs & riprap channels to divert water from the wall .
- 2. Weep holes to provide an outlet for water to drain and escape.
- 3. Near the top of the wall if the reinforcements overstressed, it may be feasible to add additional reinforcements.
- 4. If access to the backfill is a problem, soil nails drilled through the existing wall face may be used. (Needs deformation to activate soil nails).

Retrofit Options

- 5. Bearing plates may be used to distribute nail loads at the wall face.
- 6. If the increase in lateral thrust and the potential for a sliding failure is a problem, the front of the wall may be buttressed.
- 7. Backfill may be modified to reduce the driving forces, such as grouting, partial replacement with lightweight fill, flowable fill, or decreasing the slope angle of the backfill surface.
- 8. Foundation soil treatment to stop settlement or strengthen the soil.

MSE Walls Retrofit

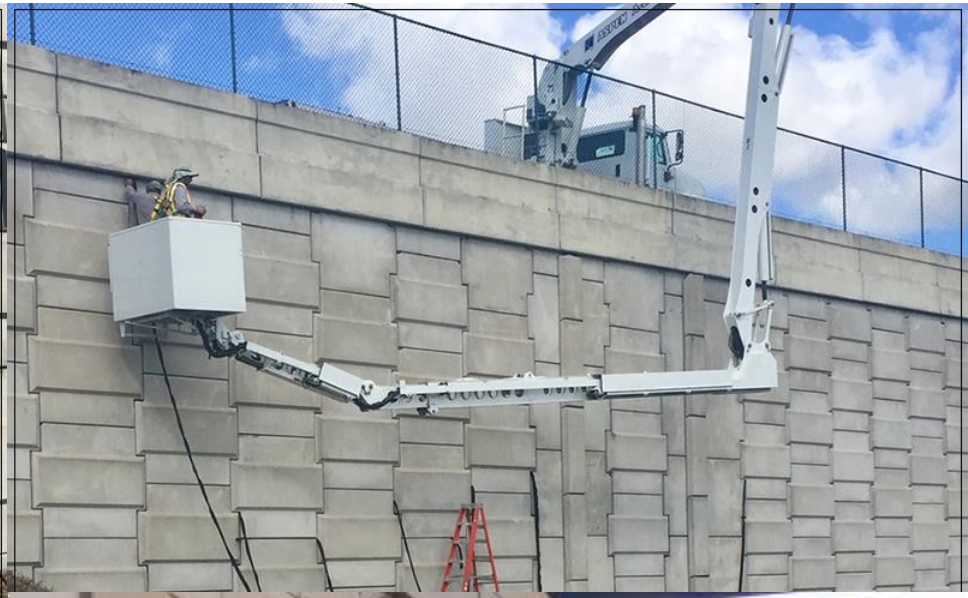
Shotcrete Retrofit of MSE Wall



British Columbia, Canada, the MSE wall was 26 ft high and 230 ft long, the backfill is fine dredged river sand

MSE Walls Retrofit

Free Draining Seal (Foam pieces wrapped in a fabric cloth)



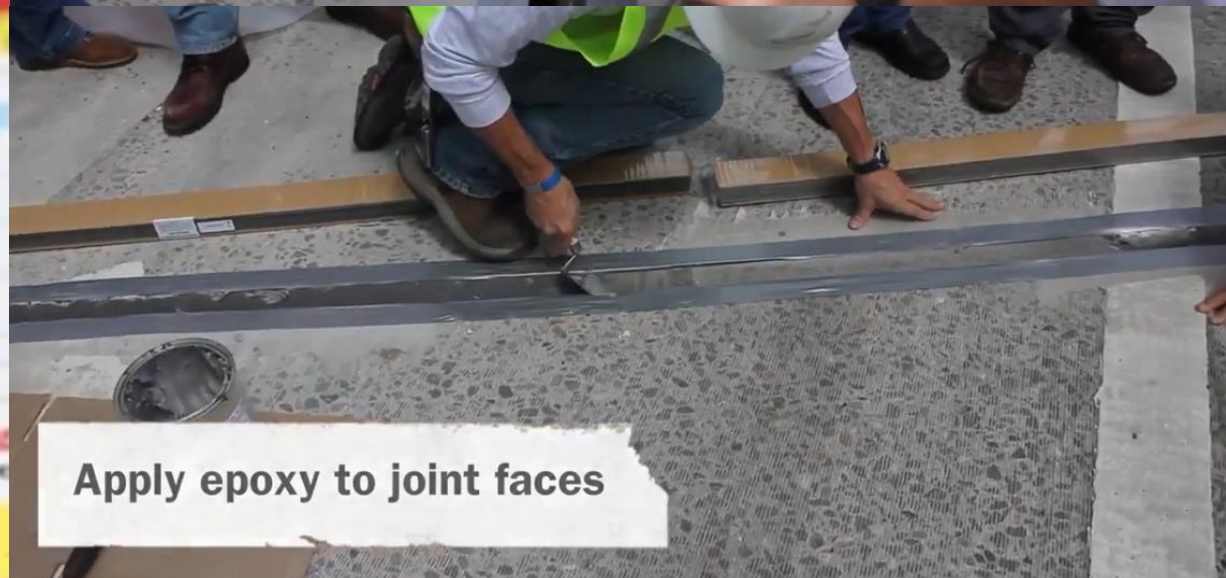
MSE Walls Retrofit

MSE Walls Retrofit

EMSEAL

BEJS

Bridge Expansion Joint System



MSE Walls Retrofit – INDOT Indiana

B-43196 (40 MSE Wall Repair Statewide INDOT)

Project Development Process for IDIQ MSE Wall Rehabilitation Projects

- Phase 1: Project **Initiation** and Programming.
- Phase 2: Project **Letting** and Post Award.
- Phase 3: **Initiate Work** Order requests and Site Visit.
- Phase 4: **Process Work** Order and Schedule Construction Activities.
- **Finalize work** at site and provide district Asset Management Staff as-built of completed work.
- Contractor **submits as-built plans** to ERMS for final record keeping.

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MSE Walls Retrofit – INDOT Indiana

B-43196 (40 MSE Wall Repair Statewide INDOT) Projects List

- 01- 82nd St Over I465
- 02- Kenilworth Road over US31
- 03- SR168 Over I-69
- 04- SR 56-61 over I-69
- 05- SR 57 over I-69
- 06 US31 Over CR125
- 07 US31 & SR 32 Hamilton Co
- 08 US-24 at 154+89 Over Burick Rd
- 09 US-24 at 156+96-N Webster
- 10 US-24 at RP153+49 over Doyle Rd
- [illegible]. I-69 over CR 710 S
- 12- Cline Ave under I-80 & I-94
- 13- US41 over Norfolk Southern
- 14- New Road US31 & US20
- 15- US-31 Over Main Street
- 16- US-31 Over Kern Road
- 17- US-6 Bridge over CSX R & Tracy Rd
- 18- US31 over 1st Road
- 19- US31 over 3A Road (LaPorte)
- 20- Ameriplex and I-70
- 21-10th St over I-465
- 22- US31 over 3A Rd
- 23- US31 over 1st Rd
- 24- Bridge over CSX RR & Tracy Rd US-6
- 25- Burr St over I-8094
- Lloyd Expressway & 9th Ave.
- 27- I-69 & CR1250S (Nobel Chapel Rd)
- 28- I-69 at N CR450 E
- 29-I-69 at MM77.5 over RR
- 30- 136th and 31 damage
- 31- US-31 over SR-931

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MSE Walls Retrofit – INDOT Indiana

B-43196 (40 MSE Wall Repair Statewide INDOT) Projects List

- 32- 80-94 EB near Cline Ave
- 33- I74-over-white-river
- 34- SR641 Over McDaniel Rd
- 35- SR641 Over Indiana R.R
- 36- I-65 and I-80-I-94-Wall #41
- 37- SBL of I-465 under NBL of Shadeland Avenue
- 38- US 31 over Creek close to 156th
- 39- SR 66 (Lloyd Expressway)
- 40-SR 46 & SR 11, SW of Colombus

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MSE Walls Retrofit – INDOT Indiana

Most Issues & Problems that have been Noticed

- Sand leaking from joints.
- Settlement and tilting of panels.
- Uncontrolled drainage.
- Deteriorating panels.
- Tilting.
- Differential movement.
- Voids, Erosion & Approach Slabs.
- Corrosion.

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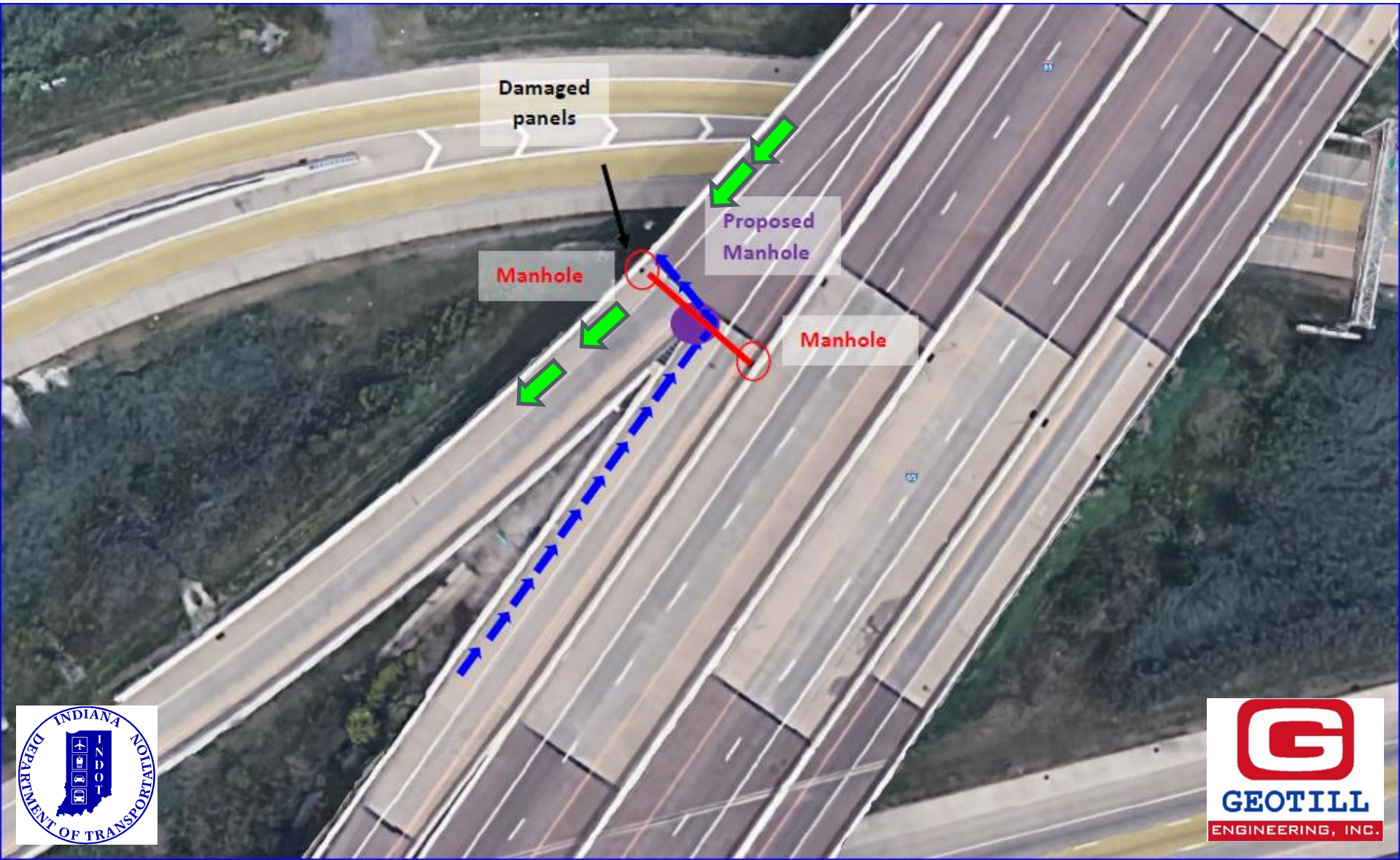
MSE Walls Retrofit - I-65 and I-80-I-94-Wall #41

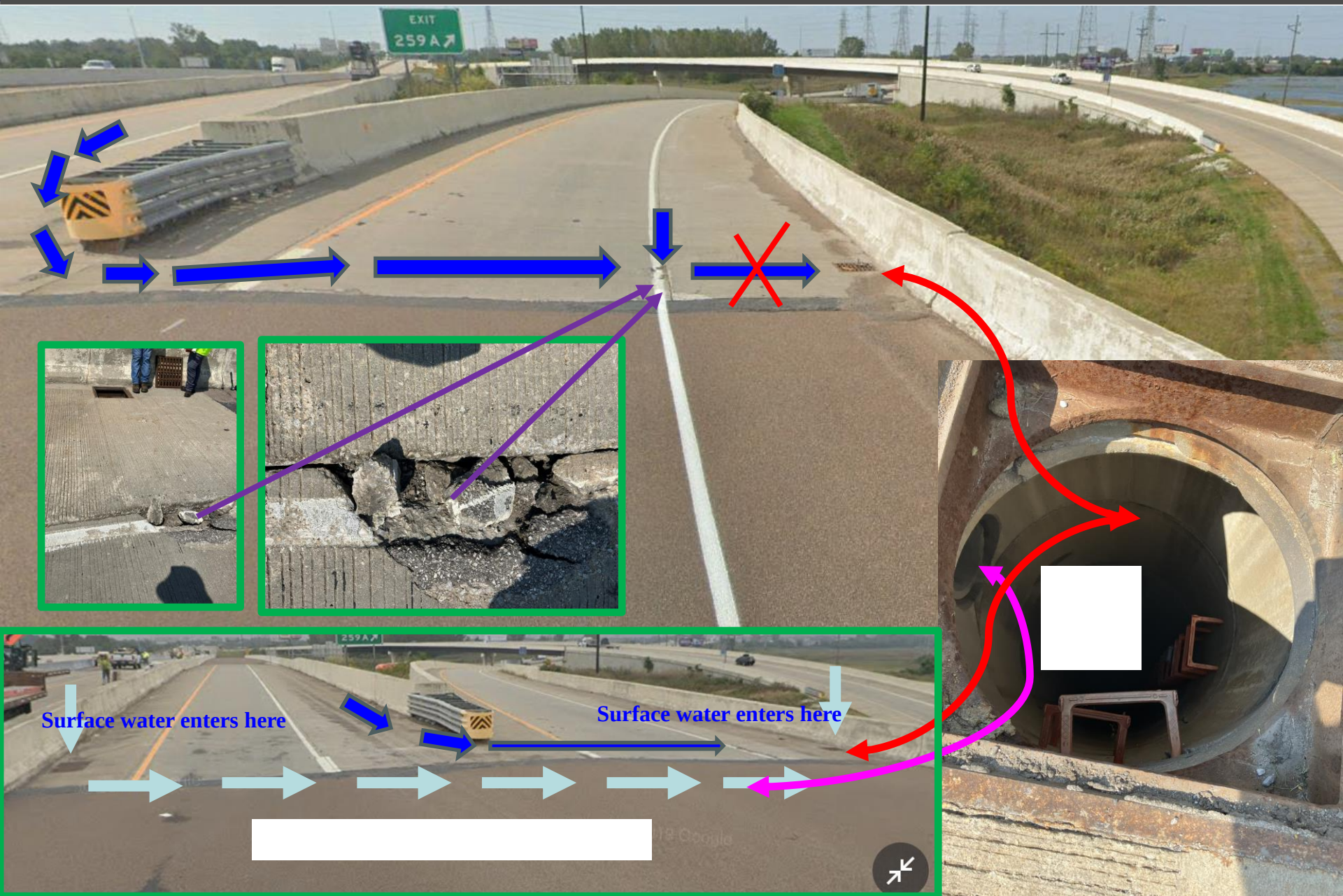
MSE Walls Retrofit - I-65 and I-80-I-94-Wall #41

MSE Walls Retrofit - I-65 and I-80-I-94-Wall #41

Going I-65 South to I-80 West



MSE Walls Retrofit - I-65 and I-80-I-94-Wall #41



MSE Walls Retrofit - I-65 and I-80-I-94-Wall #41

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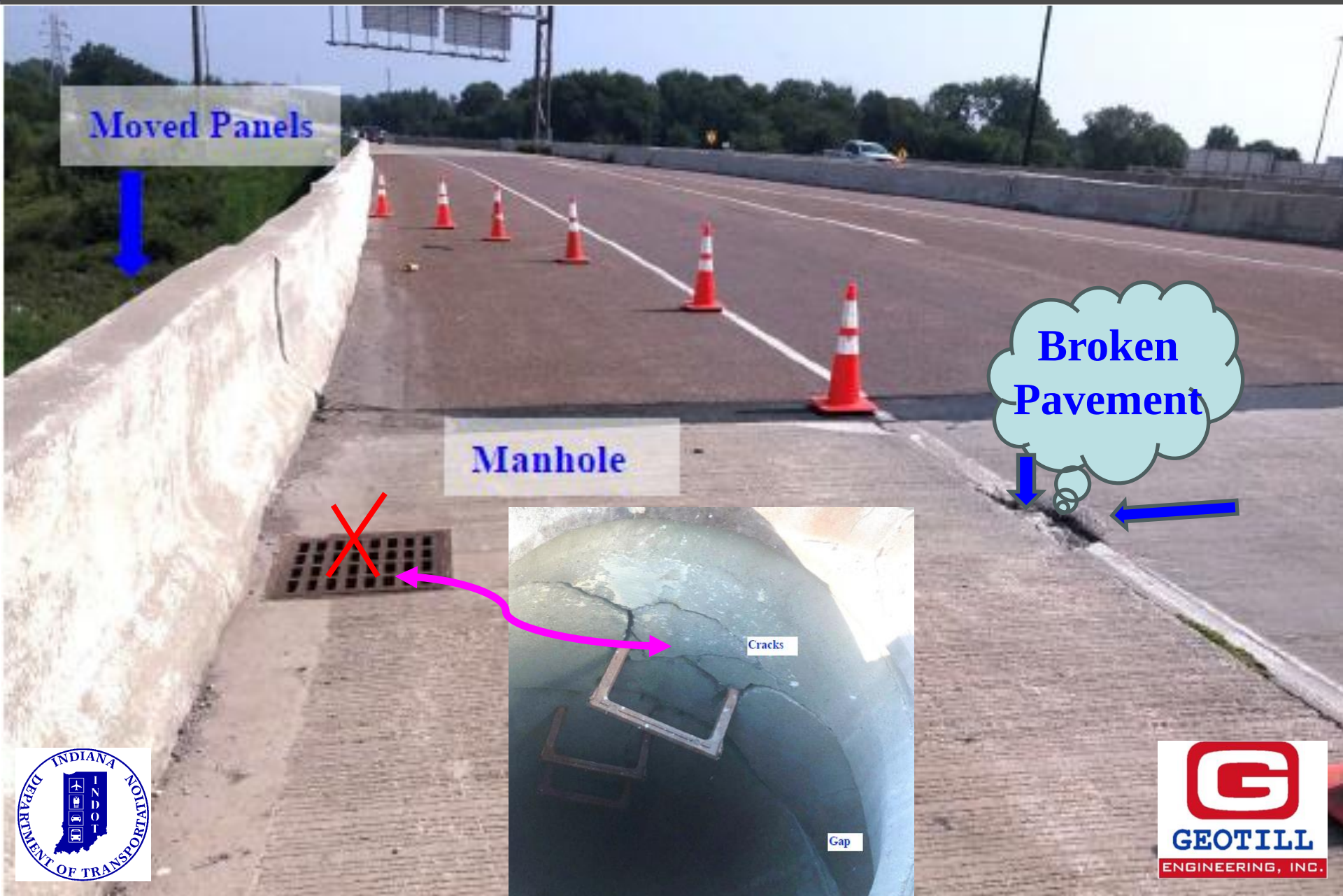
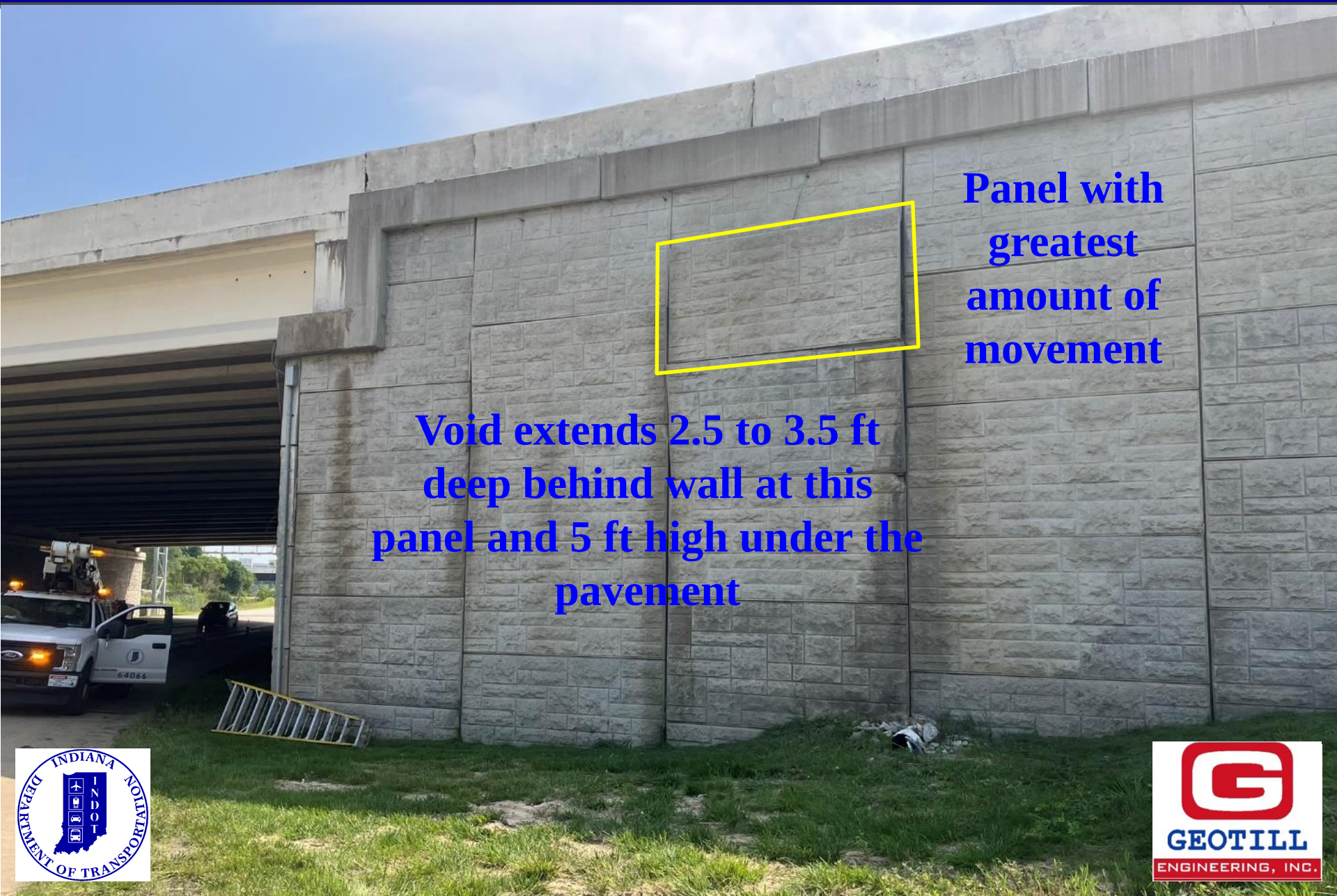
MSE Walls Retrofit - I-65 and I-80-I-94-Wall #41



MSE Walls Retrofit - I-65 and I-80-I-94-Wall #41



MSE Walls Retrofit - I-65 and I-80-I-94-Wall #41

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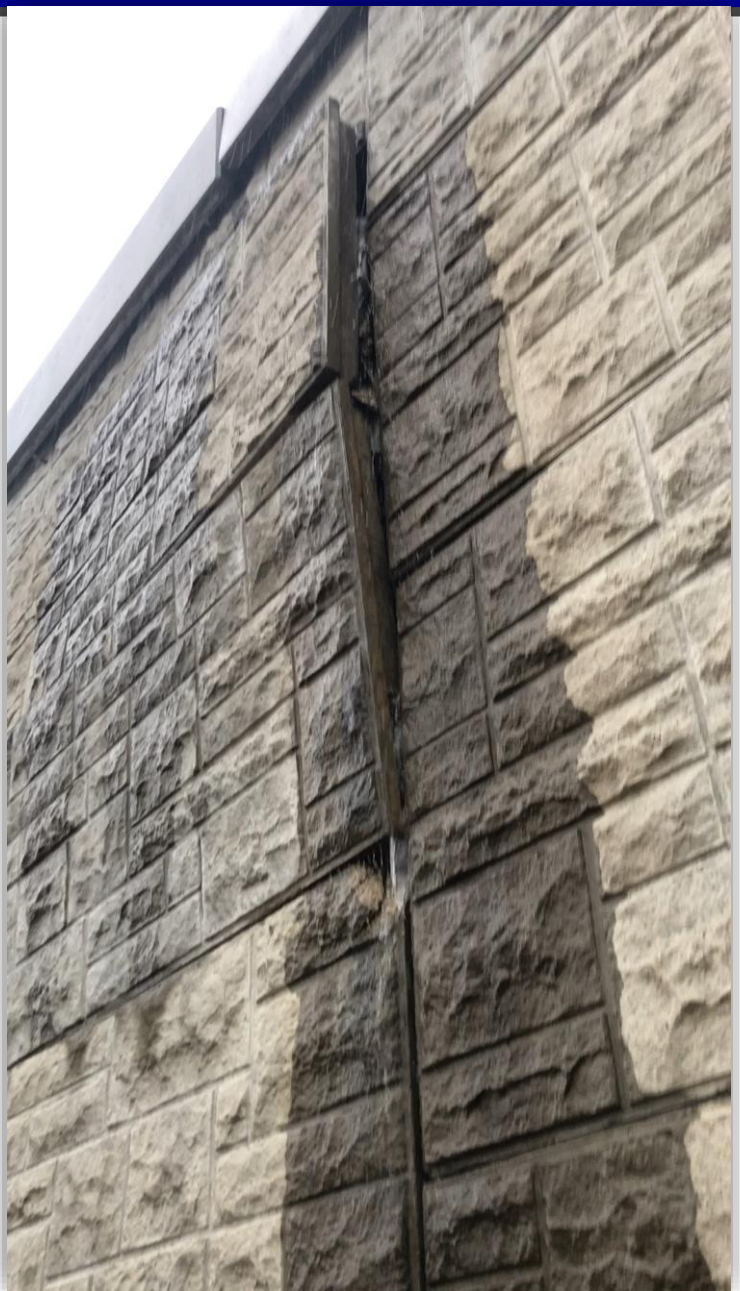

MSE Walls Retrofit - I-65 and I-80-I-94-Wall #41

MSE Walls Retrofit - I-65 and I-80-I-94-Wall #41

Void

5 ft High

3.5 Wide

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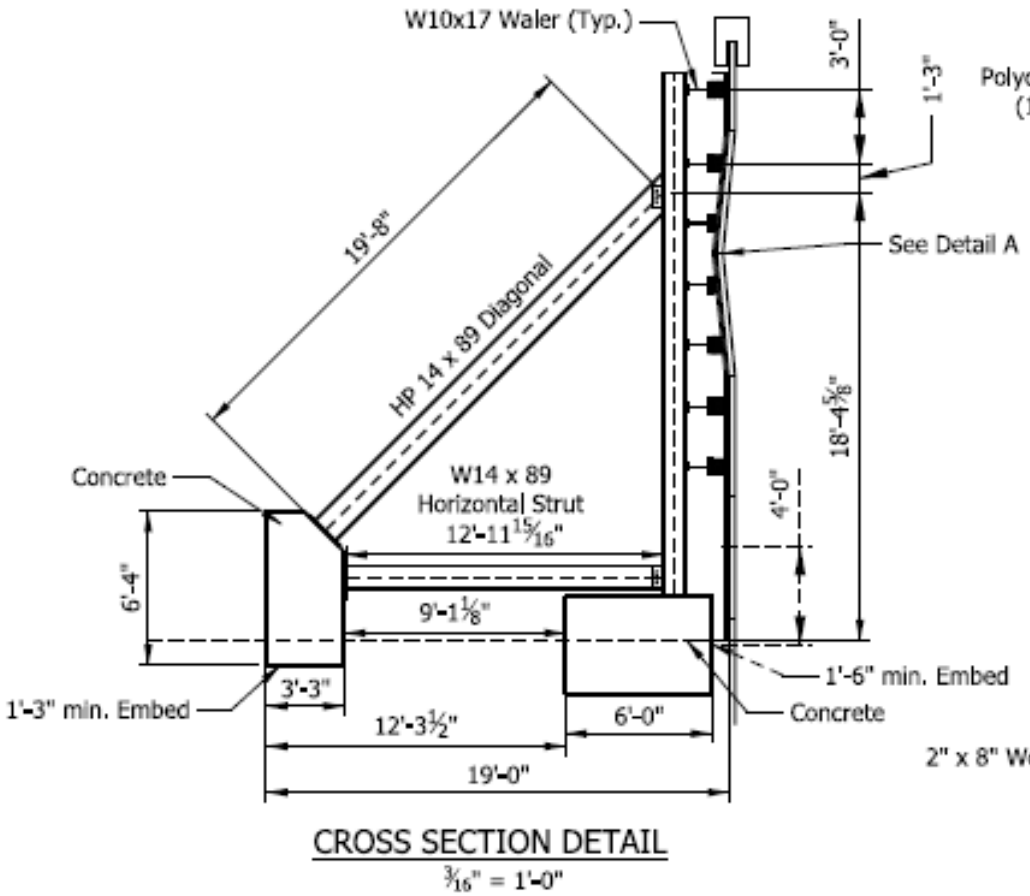
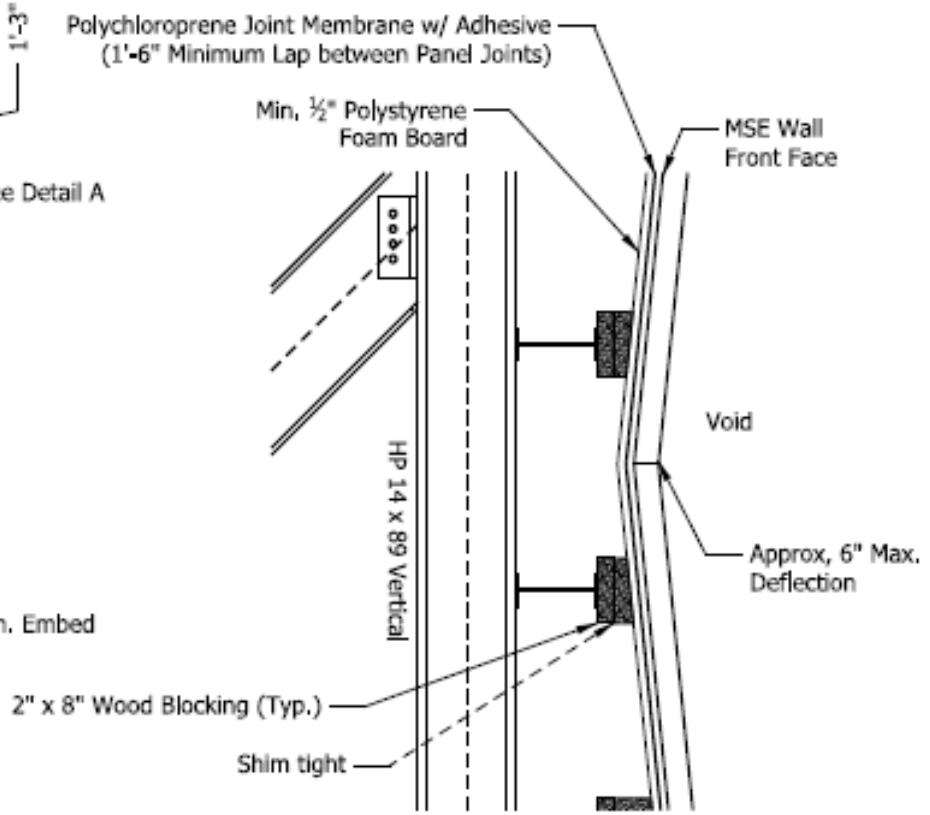
MSE Walls Retrofit - I-65 and I-80-I-94-Wall #41

MSE Walls Retrofit - I-65 and I-80-I-94-Wall #41



CROSS SECTION DETAIL

3/16" = 1'-0"



DETAIL A

½" = 1'-0"

Temporary Fix

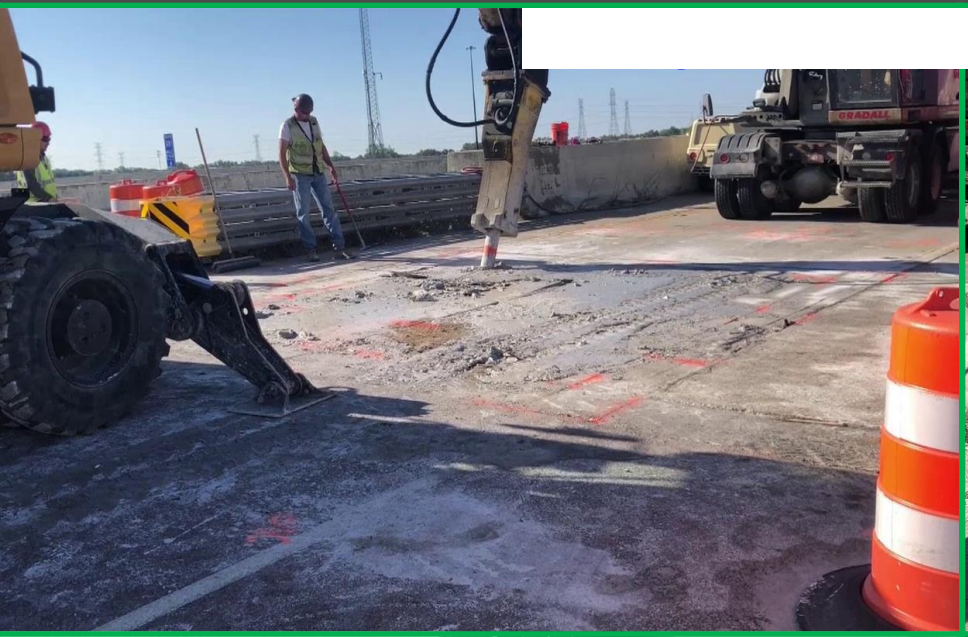
MSE Walls Retrofit - I-65 and I-80-I-94-Wall #41

Temporary Bracing System

MSE Walls Retrofit - I-65 and I-80-I-94-Wall #41

Temporary Bracing System

MSE Walls Retrofit - I-65 and I-80-I-94-Wall #41



MSE Walls Retrofit - I-69 over SR 57

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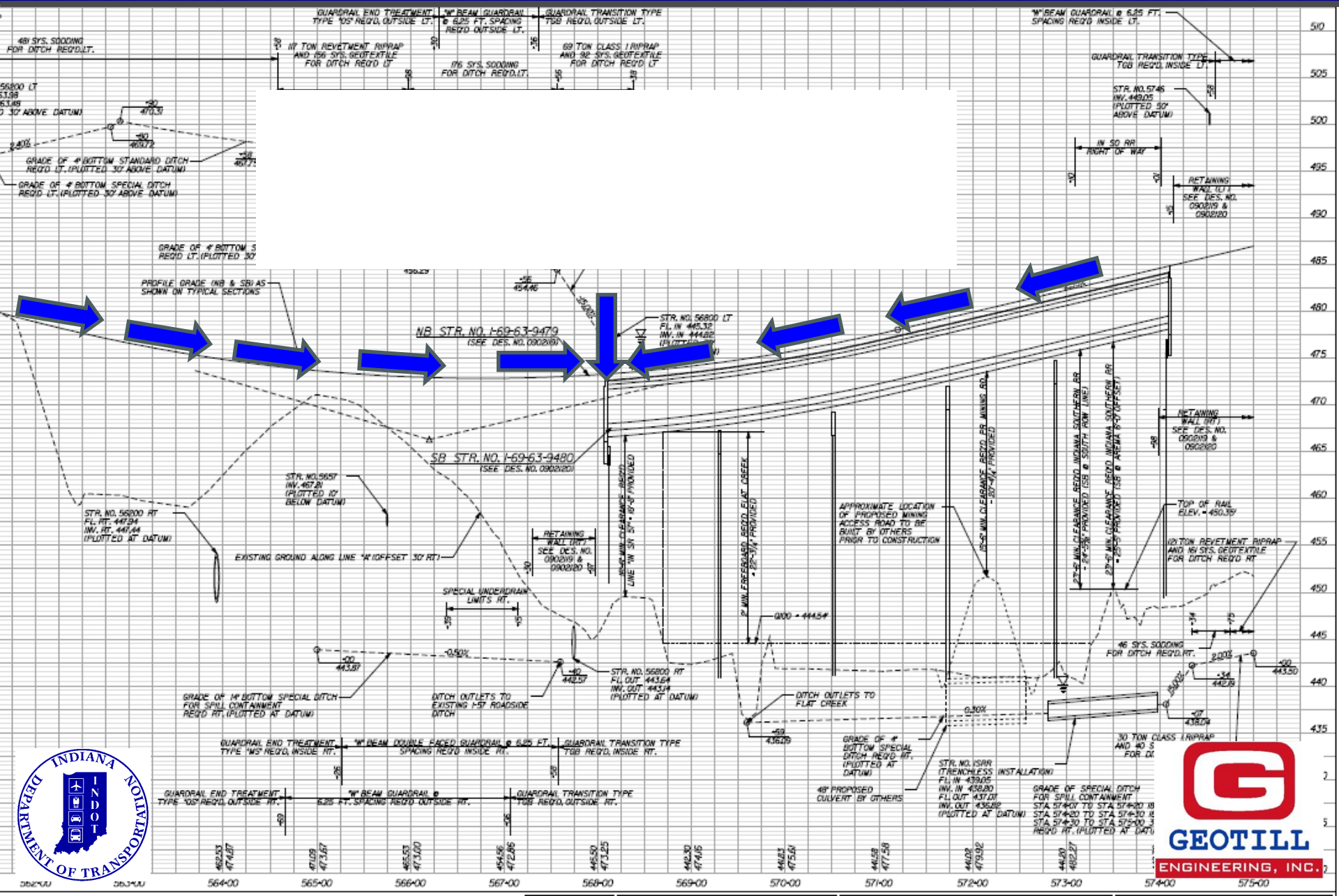

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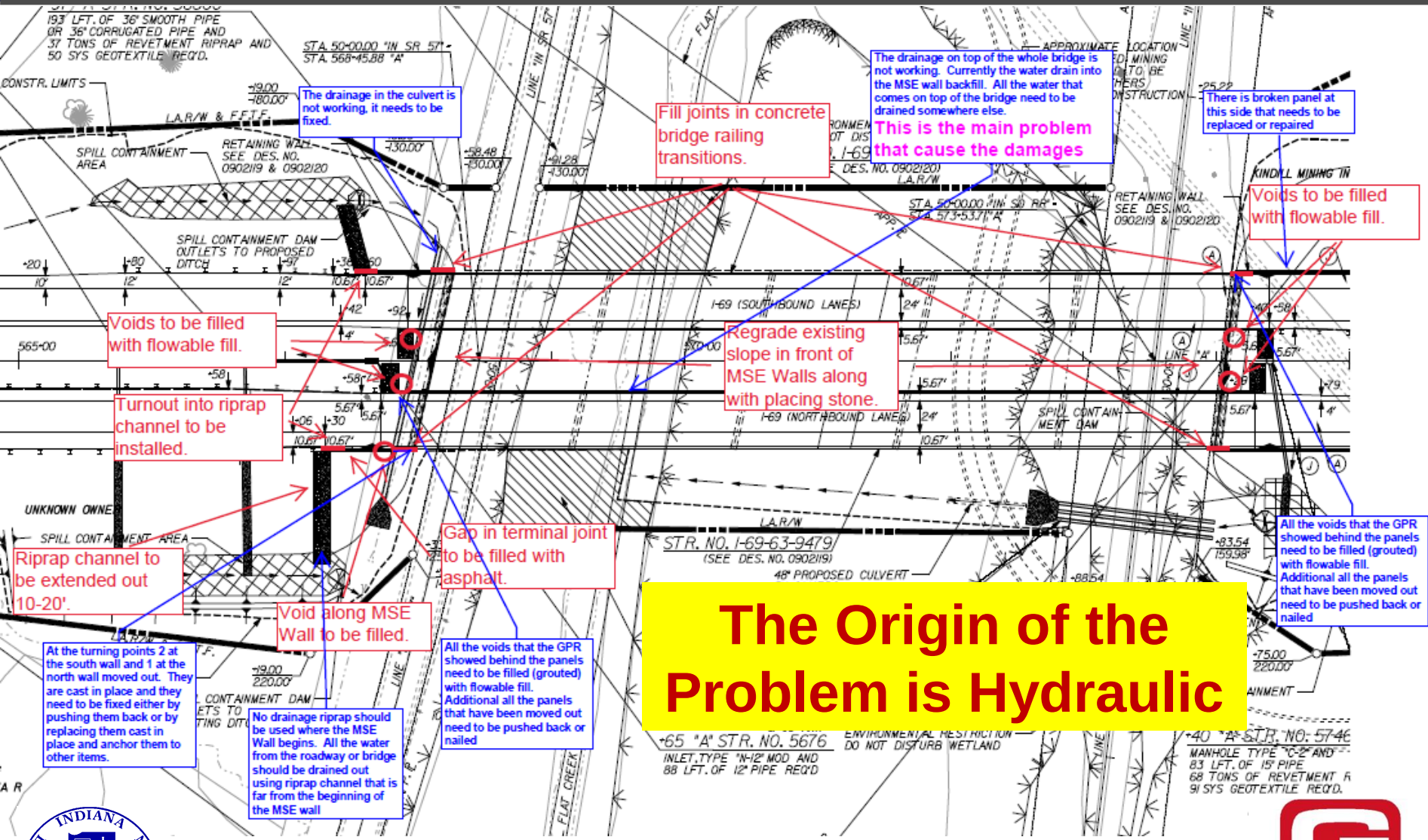
MSE Walls Retrofit - I-69 over SR 57

MSE wall panel movement

MSE Walls Retrofit - I-69 over SR 57

MSE Walls Retrofit - I-69 over SR 57



Retrofit Recommendation

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MSE Walls Retrofit - I-69 over SR 57

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MSE Walls Retrofit - I-69 over SR 57

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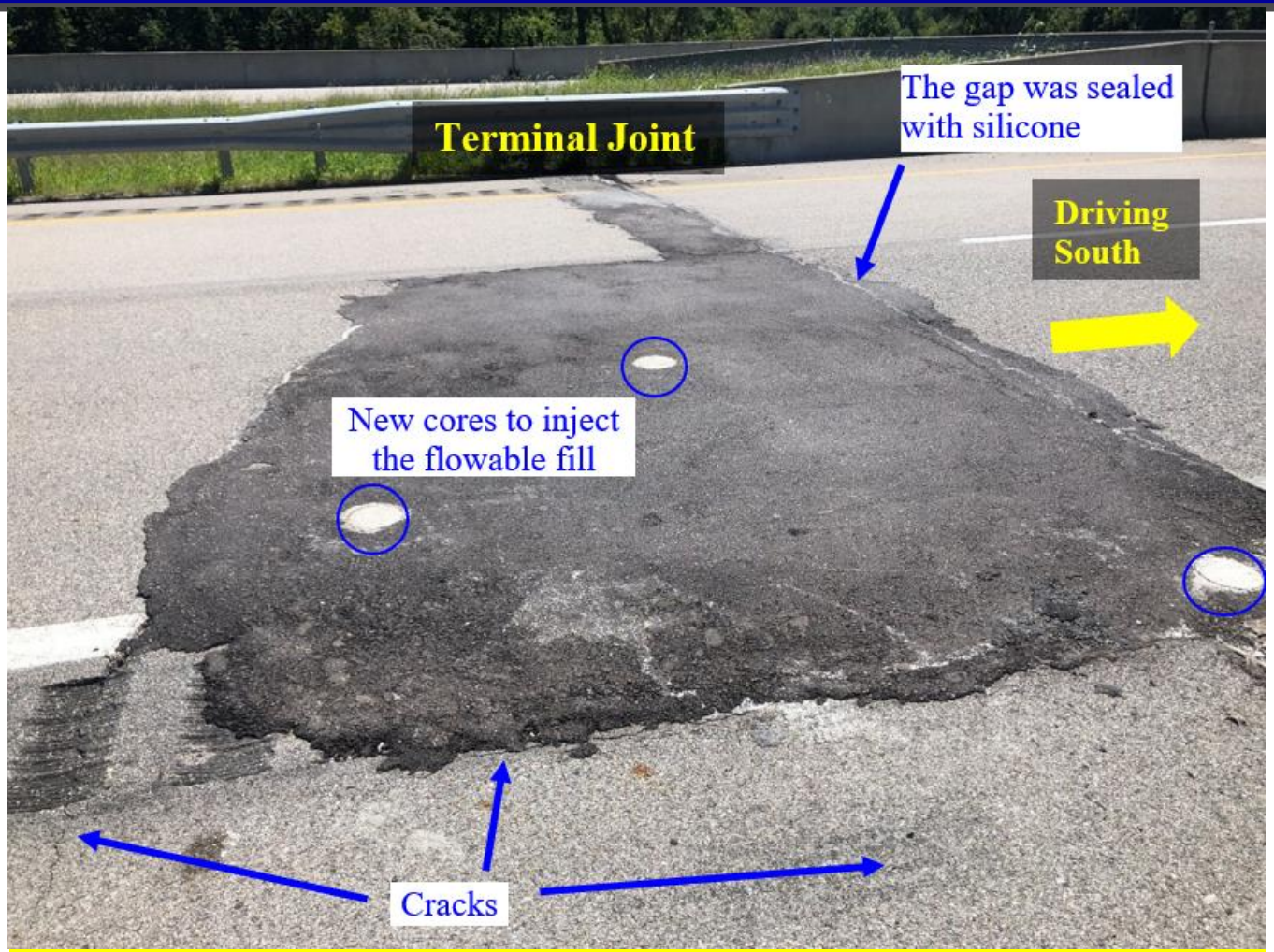
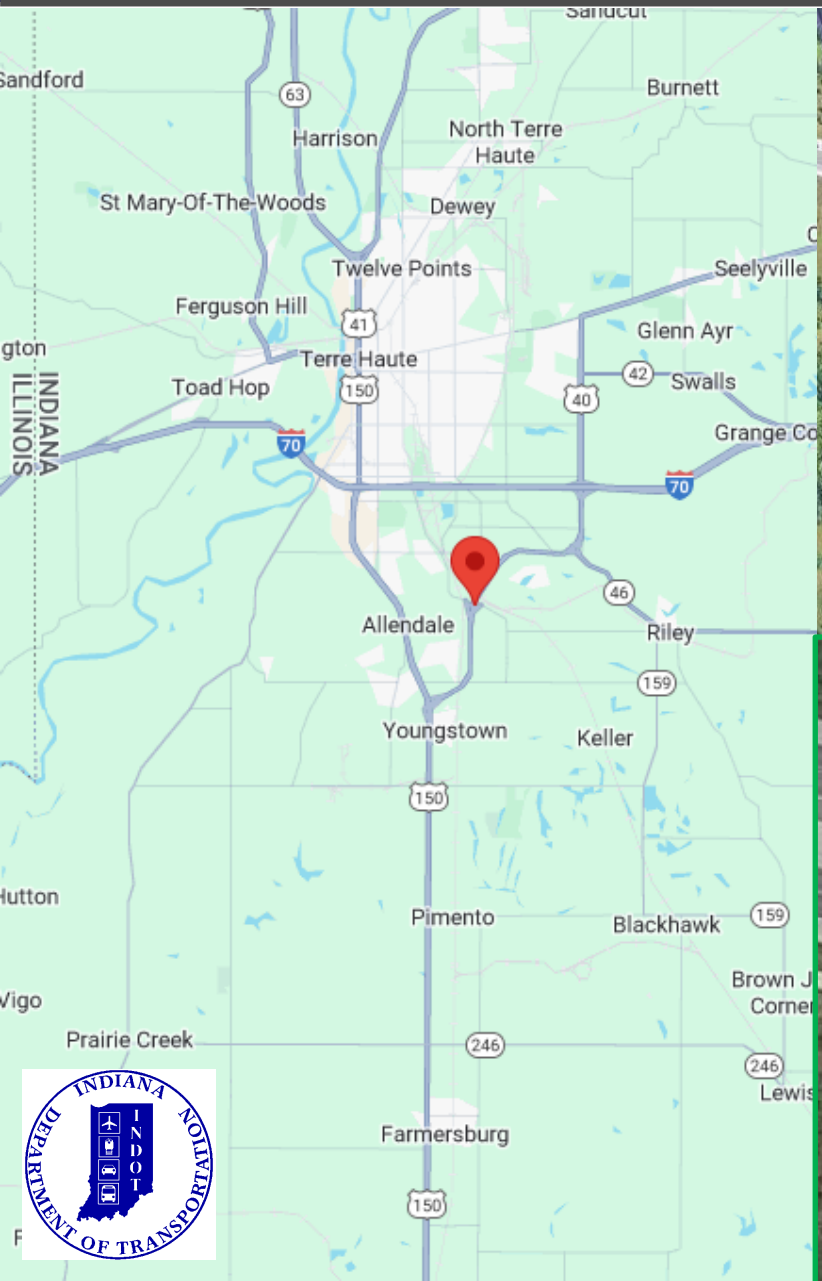
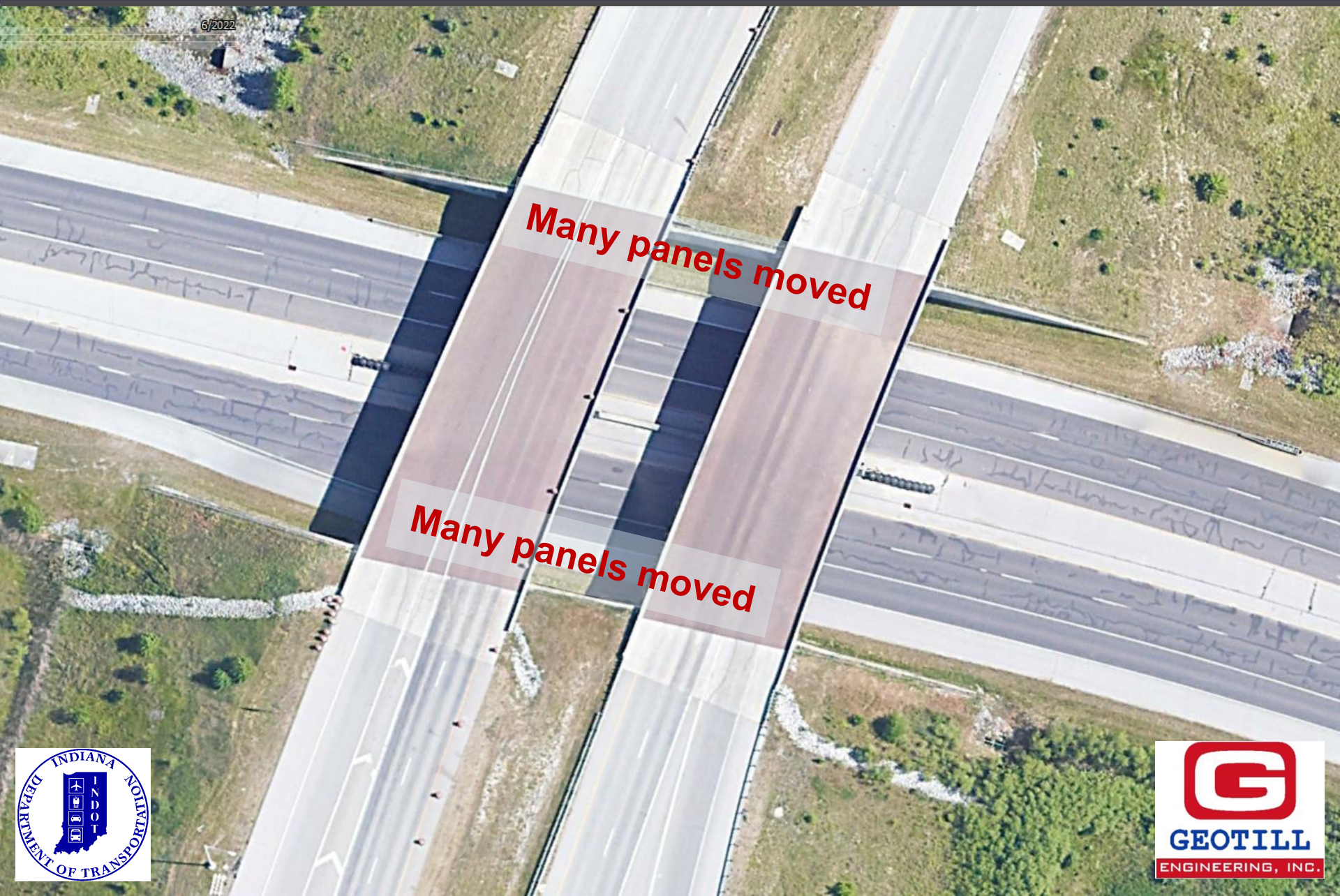


Since the origin of the problem is Hydraulic, permanent repair is scheduled to be done by the summer of 2024. The permanent repair will involve replacing the bridge approaches and installing a new drain system that can handle the amount of water that come on the top of the bridge.

MSE Walls Retrofit – SR-641 Over McDaniel Rd.

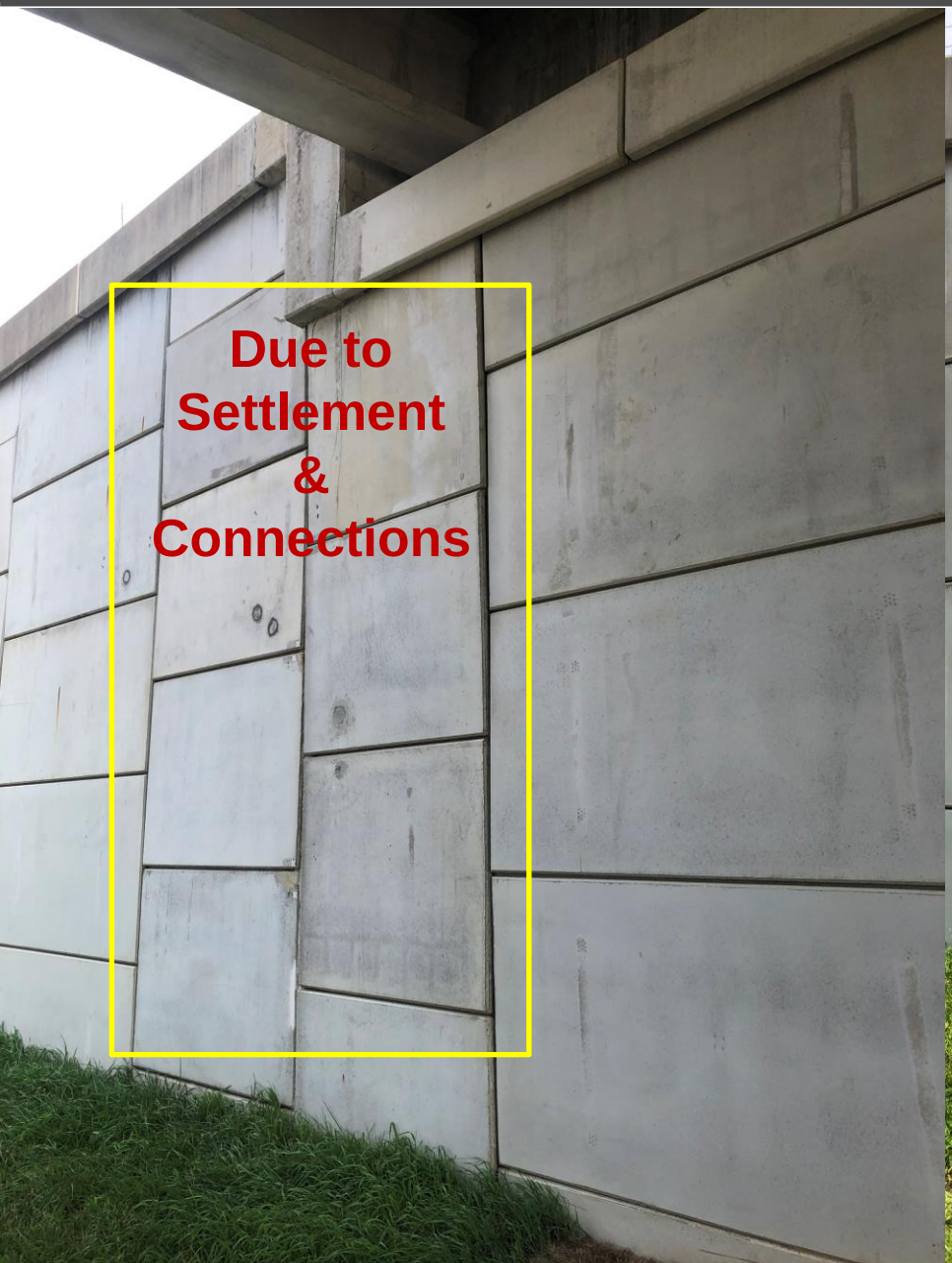


MSE Walls Retrofit – SR-641 Over McDaniel Rd.

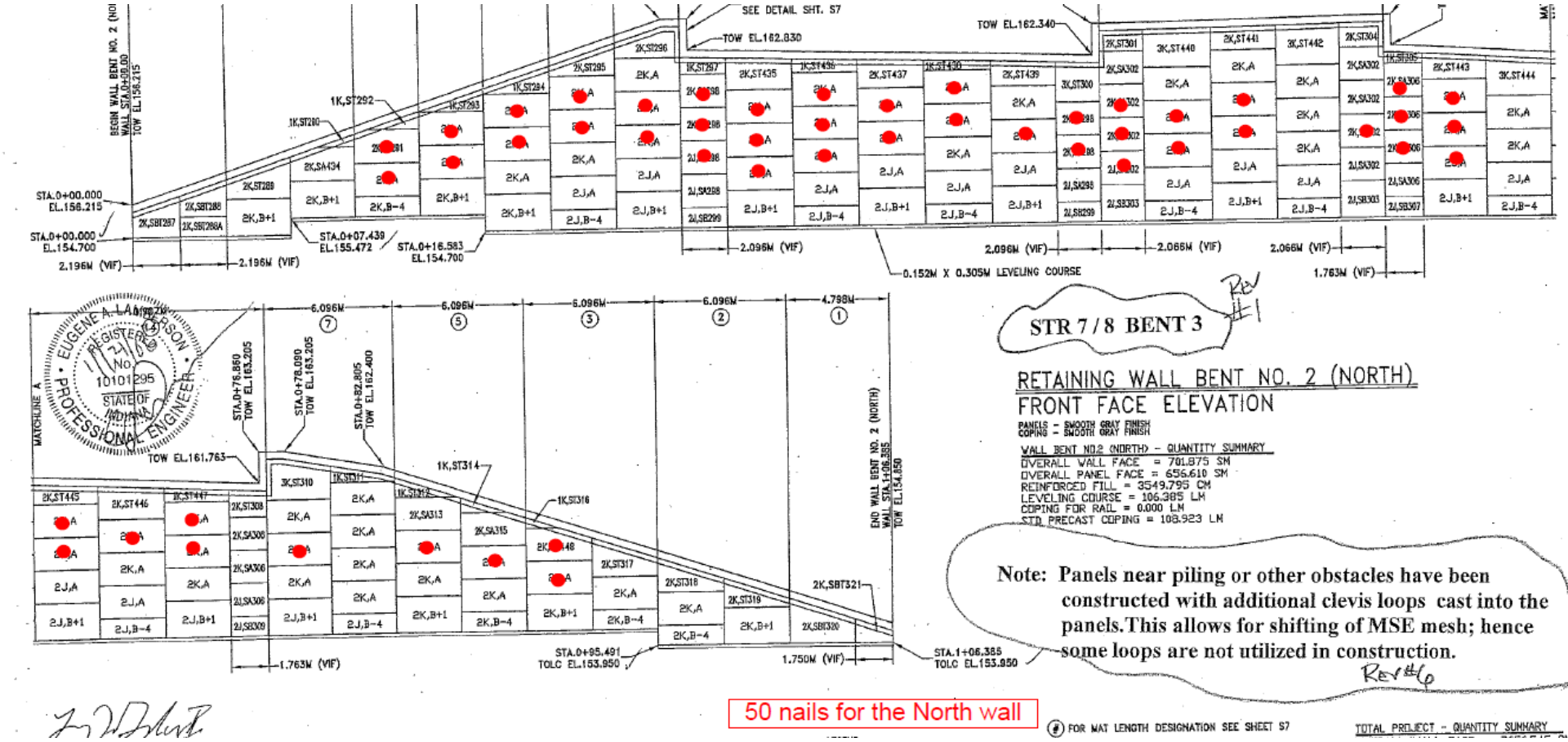


MSE Walls Retrofit – SR-641 Over McDaniel Rd.

MSE Walls Retrofit – SR-641 Over McDaniel Rd.

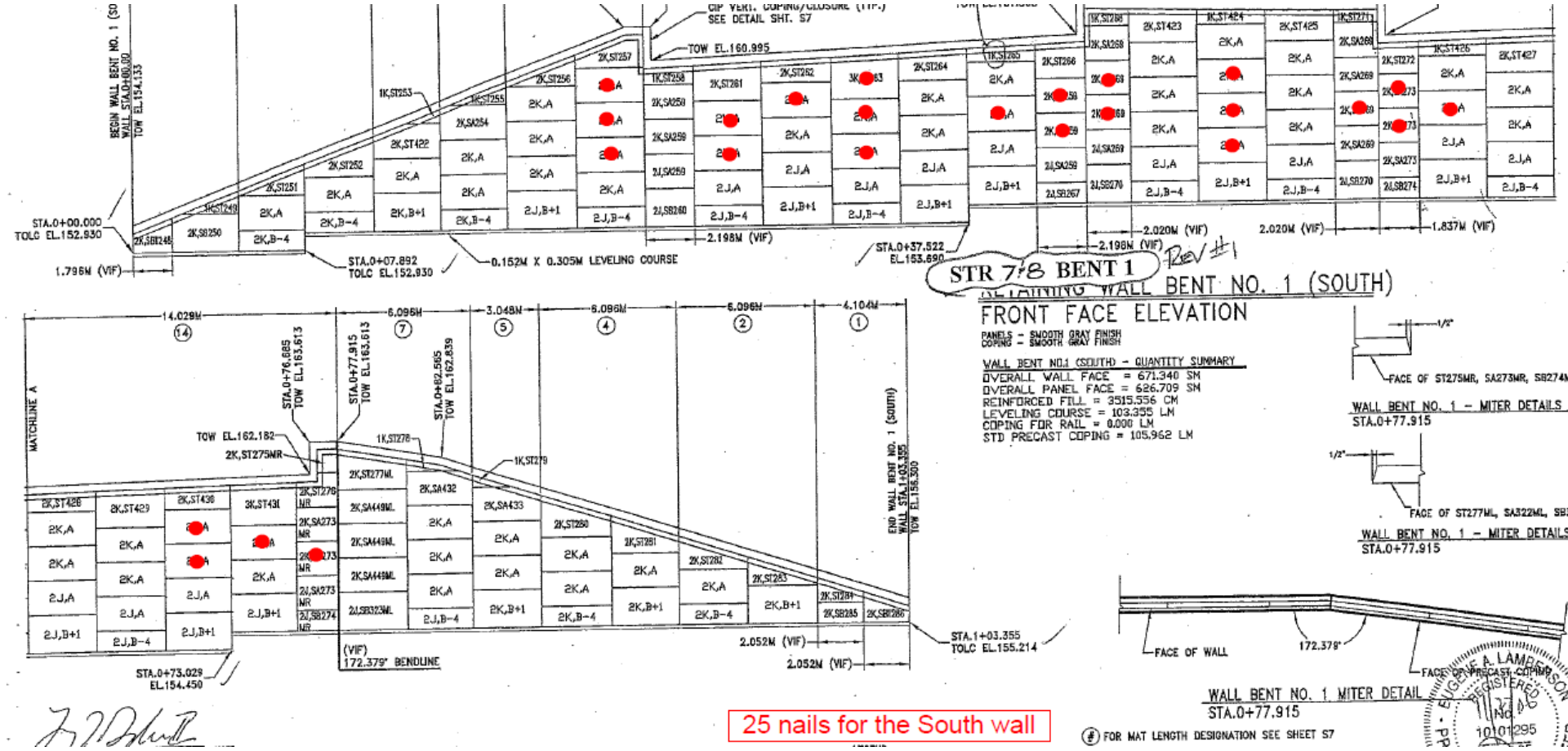


MSE Walls Retrofit – SR-641 Over McDaniel Rd.



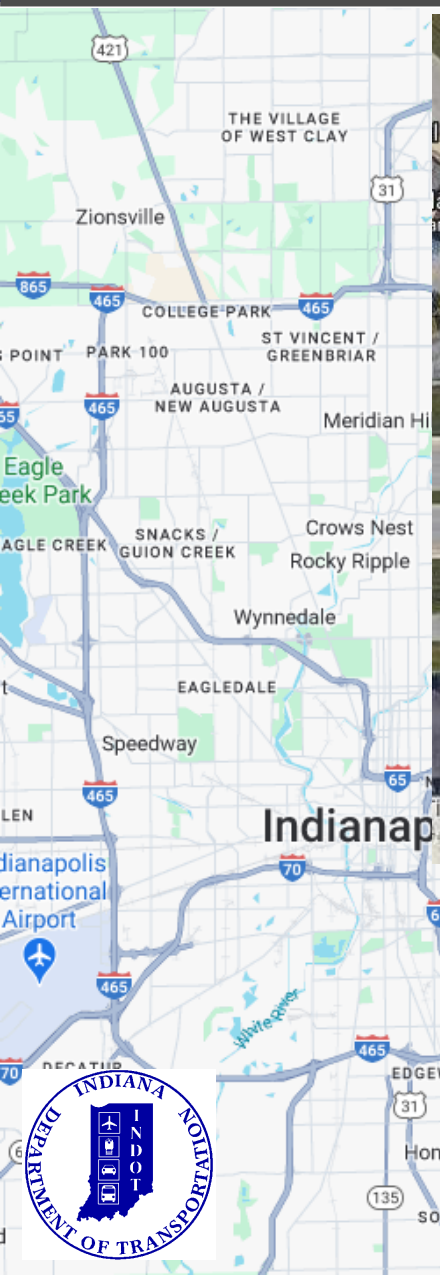
Soil Nail Locations (50 Nails) for the North Wall by INDOT & Geotill

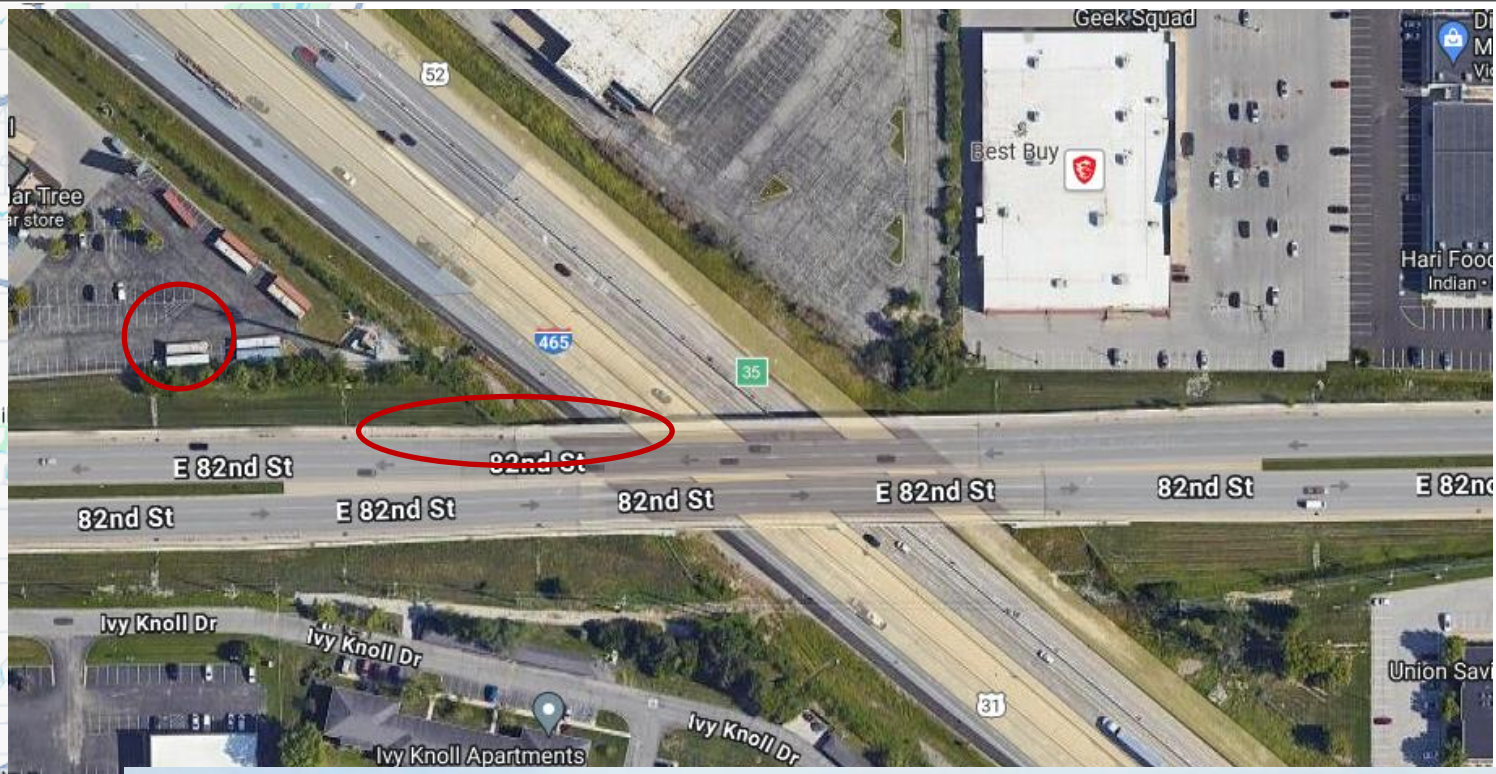
MSE Walls Retrofit – SR-641 Over McDaniel Rd.



Soil Nail Locations (25 Nails) for the South Wall by INDOT & Geotill

MSE Walls Retrofit – 82nd St Over I-465





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Issues Observed

- Backfill leak from Northwest side.
- Broken CIP copings.
- Some bulging panels.
- Pavement issues probably voids.
- Widen and tighten panel gaps, possibly because of settlement.
- Some blocked underdrain

MSE Walls Retrofit – 82nd St Over I-465

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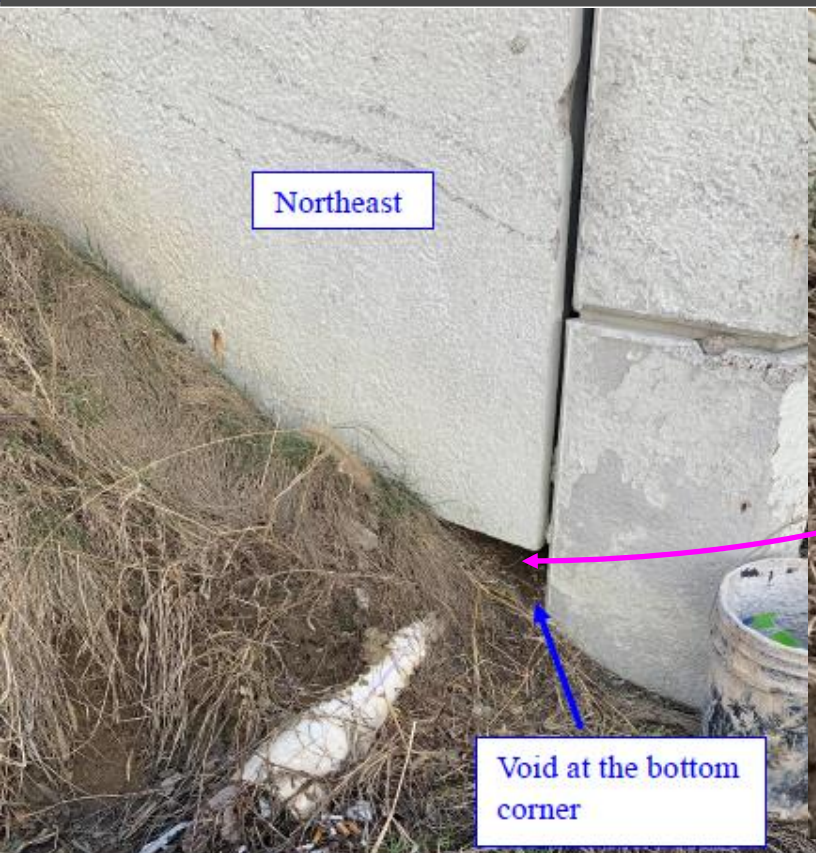
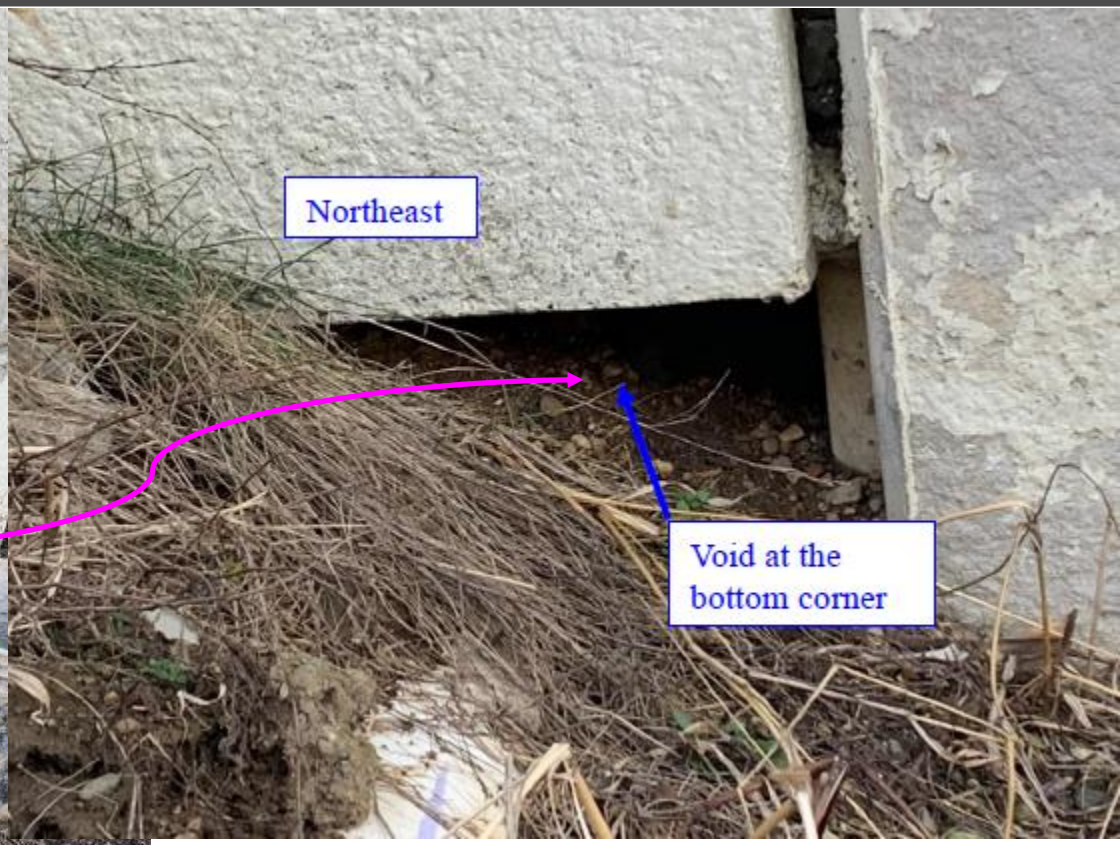
MSE Walls Retrofit – 82nd St Over I-465





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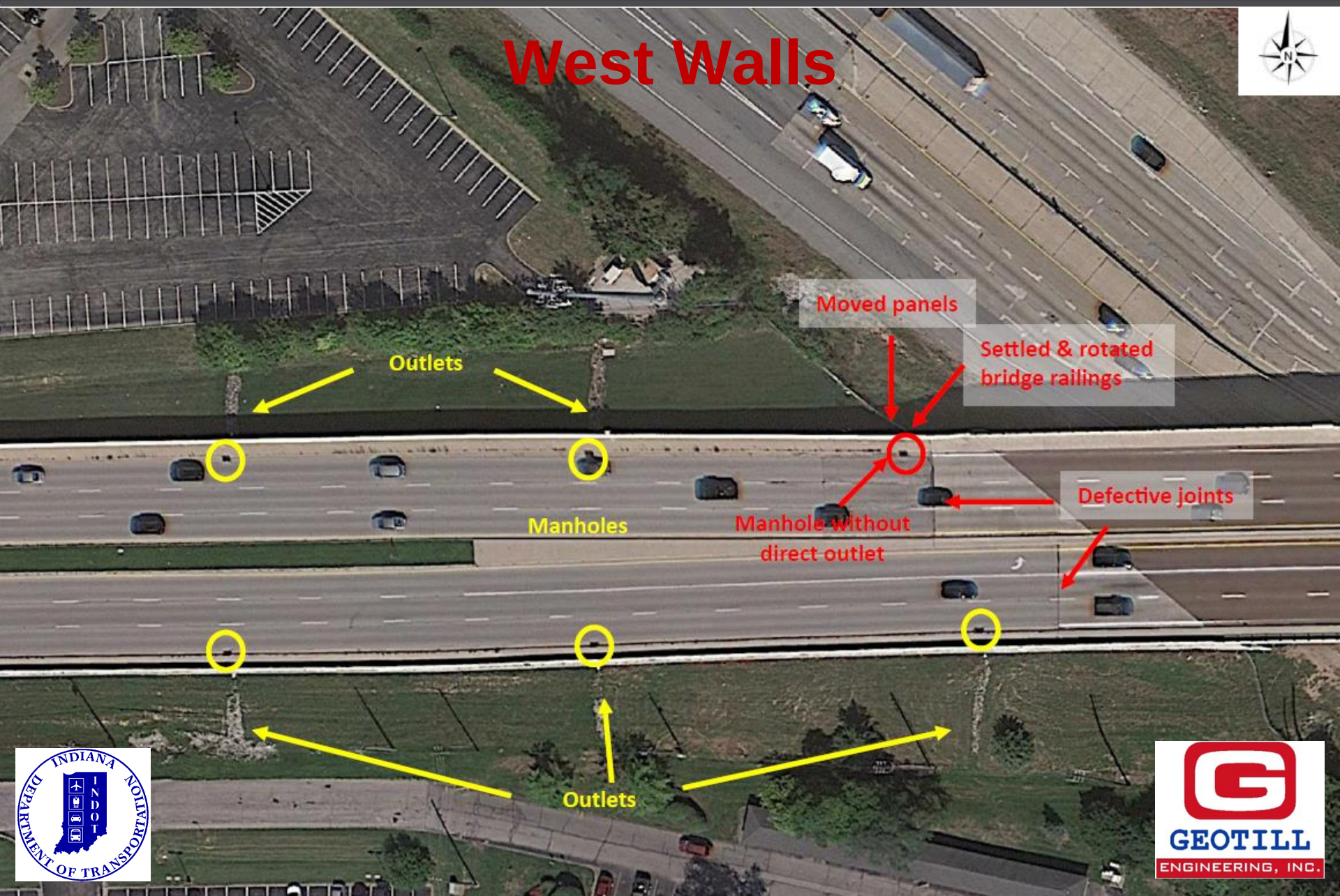
MSE Walls Retrofit – 82nd St Over I-465

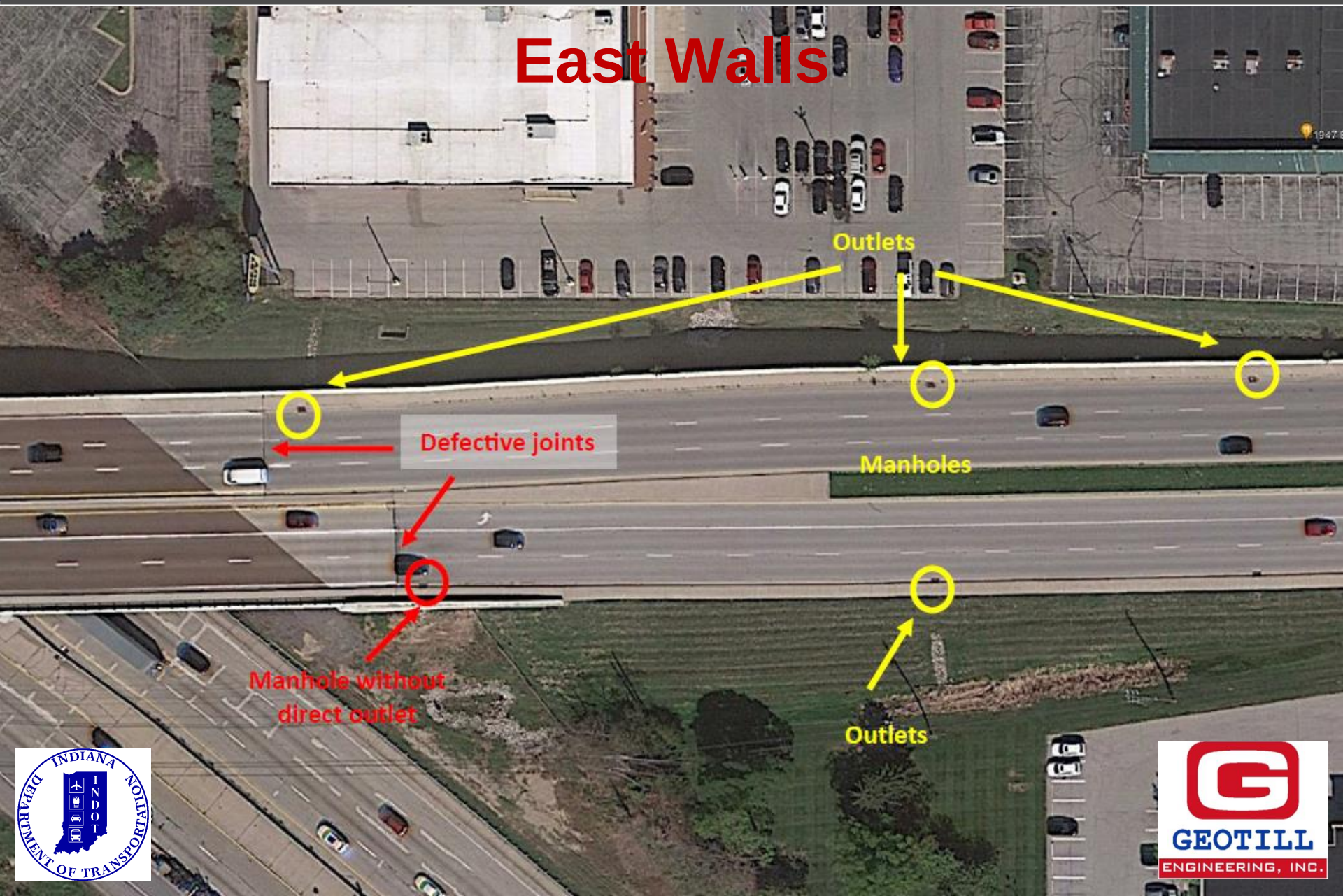
MSE Walls Retrofit – 82nd St Over I-465

The main problem for this location is that the drainage system is not able to drain all the water away from the MSE walls. The water seeps through the damaged expansion joints and some manholes and then seep on top of the MSE walls especially at the northwest wall. In addition, to the known connections problems that Tricon MSE Wall system has.

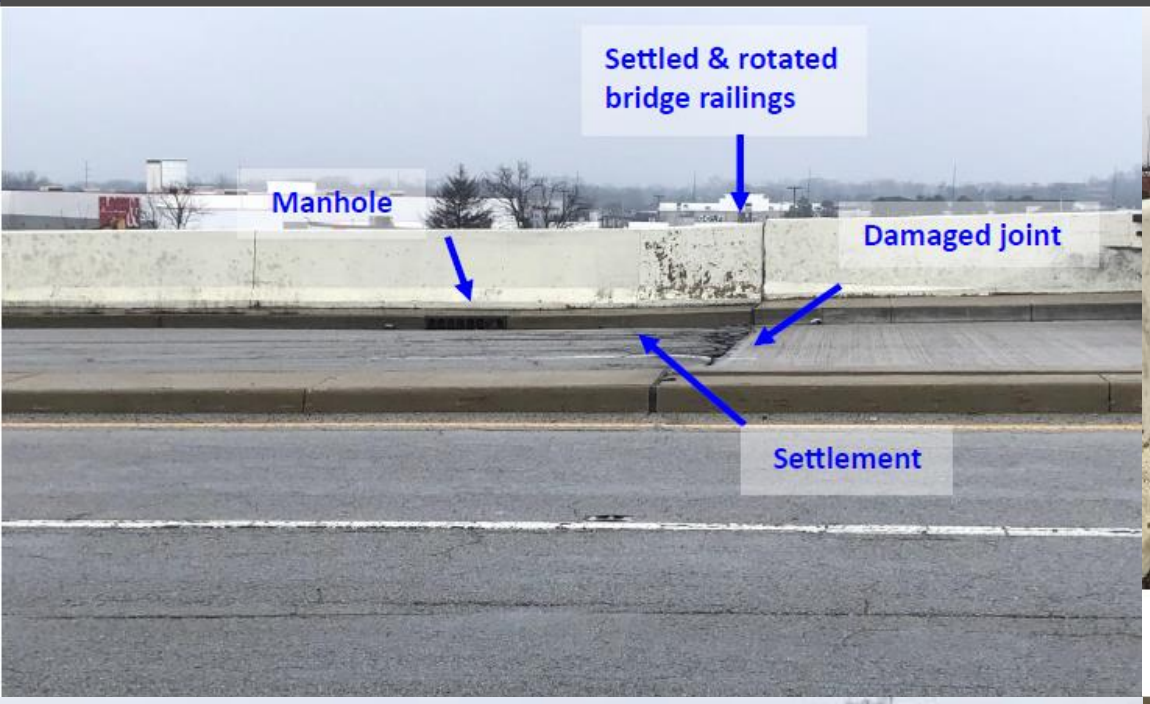
MSE Walls Retrofit – 82nd St Over I-465



MSE Walls Retrofit – 82nd St Over I-465

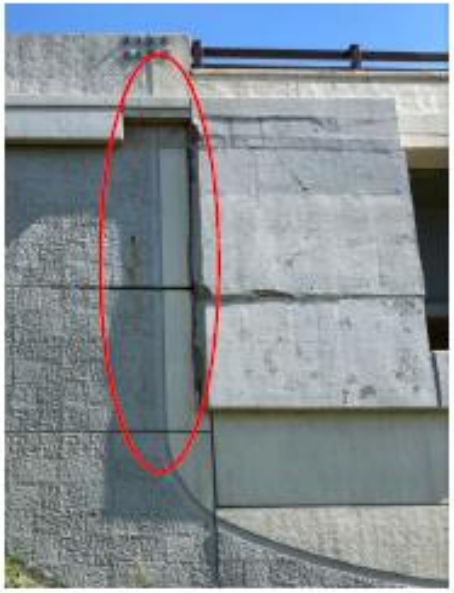


MSE Walls Retrofit – 82nd St Over I-465



MSE Walls Retrofit – 82nd St Over I-465

MSE Walls Retrofit – 82nd St Over I-465



MSE Walls Retrofit – 82nd St Over I-465

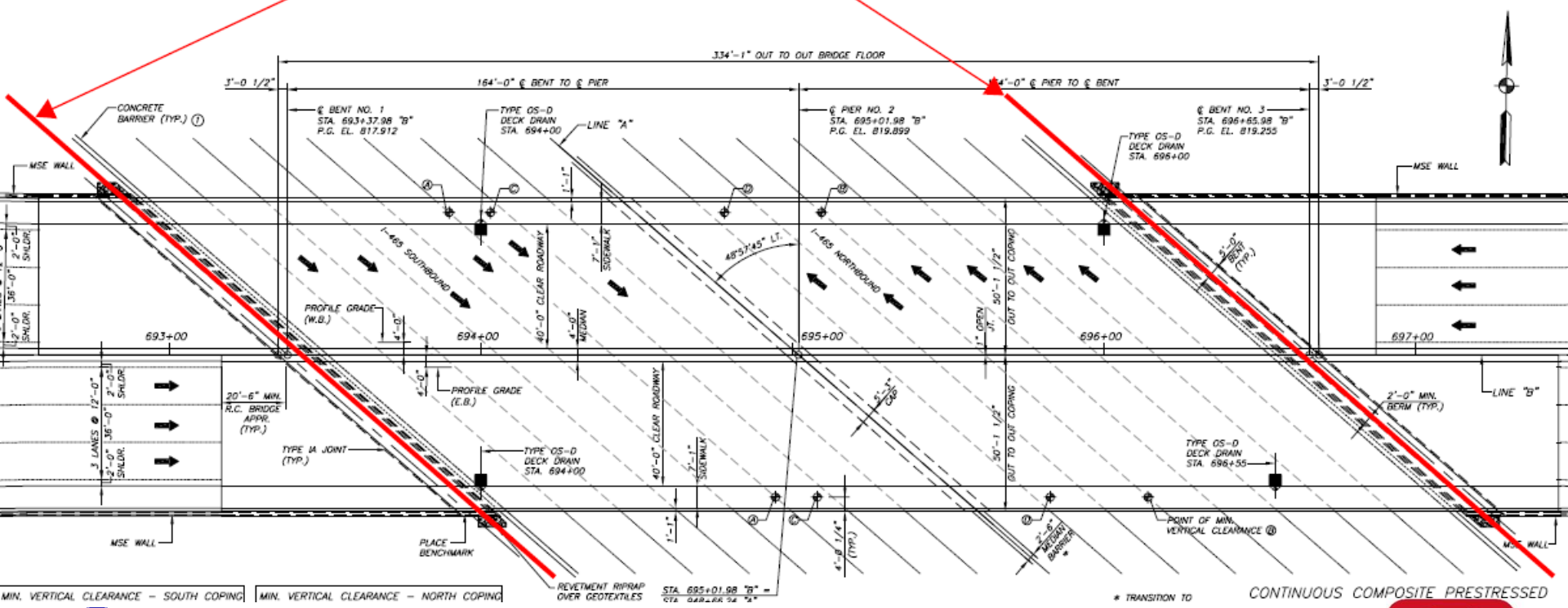
Image showing the wing wall and panels with air gap GPR signatures (red).

MSE Walls Retrofit – 82nd St Over I-465

Drainage Extension

Proposed Retrofit

Extend and trench drainage to the nearest ditches to prevent ponding at abutments (see next page)



INDIANA DEPARTMENT OF TRANSPORTATION INDOT

GEOTILL ENGINEERING, INC.

MSE Walls Retrofit – 82nd St Over I-465

Drainage Extension

Proposed Retrofit

Abutment 3: Northeast Corner

Abutment 1: Standing water due to inadequate drainage

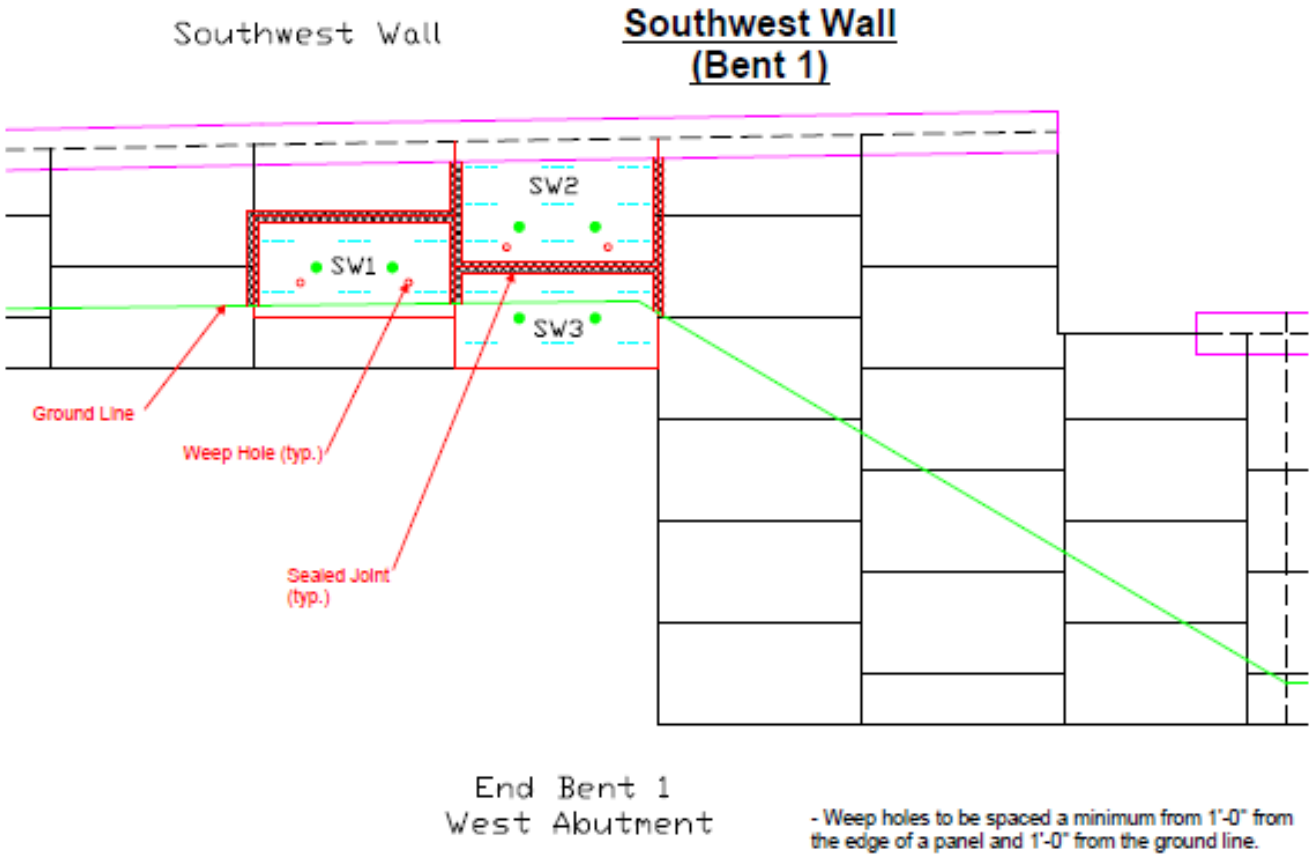
Extend Drains to nearest ditch

Abutment 1: Northwest Corner

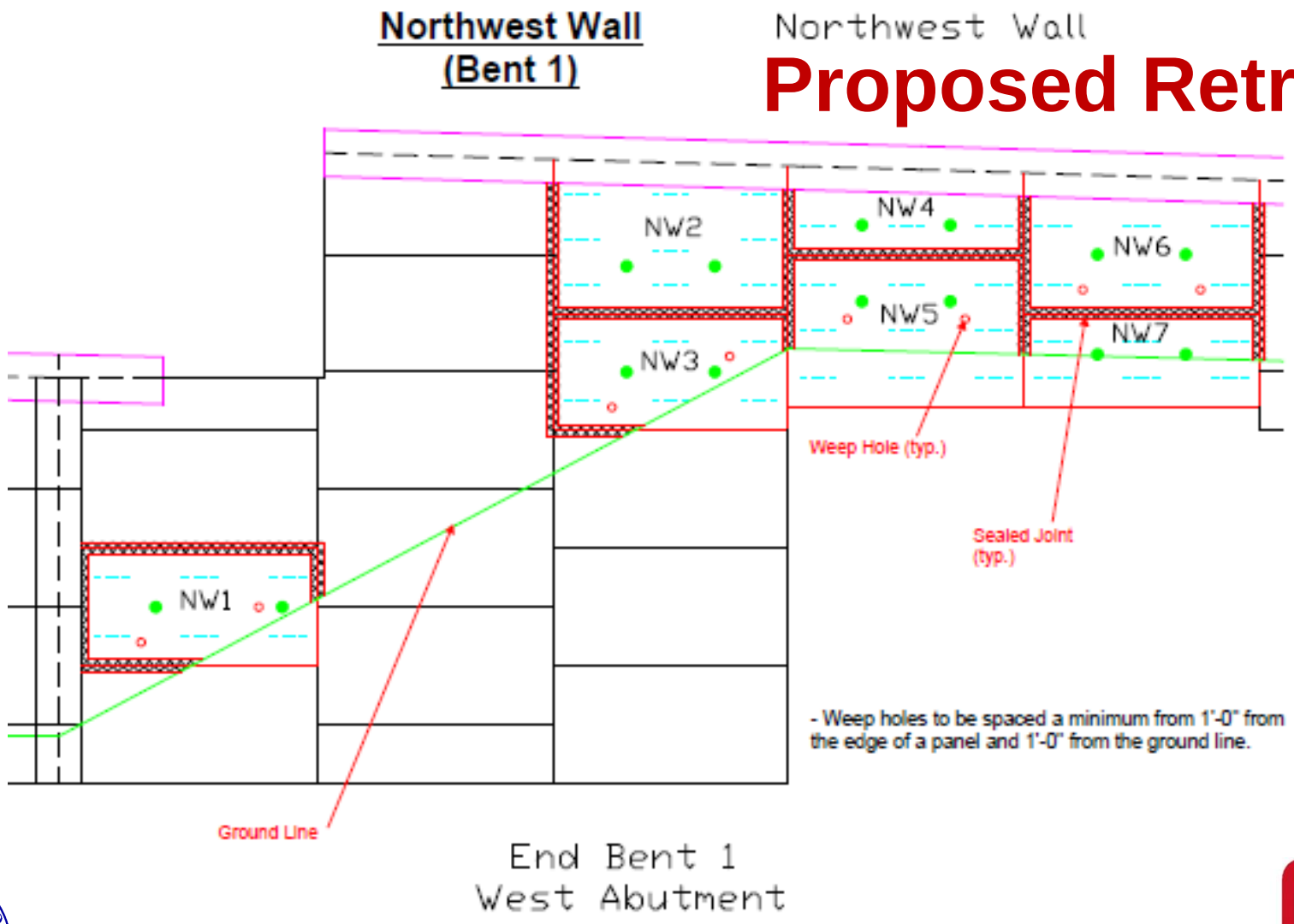
Abutment 1: Southwest Corner

MSE Walls Retrofit – 82nd St Over I-465

Proposed Retrofit



MSE Walls Retrofit – 82nd St Over I-465



MSE Walls Retrofit – 82nd St Over I-465

Hollow Bar Anchor System

Geo-Drill Injection Anchor System

Proposed Retrofit

The Williams Geo-Drill Injection Anchor System is today's solution for a fast and efficient anchoring system into virtually any type of soil. The system has historically been known as a "self-drilling anchoring" because the hollow fully-threaded bar serves as both the drill string and the grouted anchor, thus installation is performed in a single operation. The sacrificial drill bit is threaded onto the end of the Hollow Injection Bar and left in place following drilling. The drilling fluid (air, water, or grout) is introduced through the hollow bar and allows the spoils to flush from the borehole.

The Geo-Drill System is particularly suitable for soils that do not allow for open-hole drilling (i.e. granular soils that are collapsible in nature). In such cases, drilling with a grout fluid serves the purpose of flushing spoils from the borehole and prevents looser, surrounding material from collapsing due to the higher relative density of the grout. Williams Geo-Drill Injection Anchor System should be considered on any project requiring fast production that would otherwise need to involve a casing system in order to maintain borehole stability.

Advantages of the Williams Geo-Drill Injection Anchor System

- **Fully domestic system available.**
- Fast, single-step anchoring system with simple equipment.
- Eliminates the need for a cased borehole in collapsing soils.
- Efficient installation since drilling and grouting can be performed in a single operation, saving both time and money.
- Continuously drilling and grouting under high pressure causes the grout to permeate into looser soils and creates a bulb-effect for increased bond capacity.
- Suitable for working in limited space and areas of difficult access.
- Multiple ranges of drill bits suitable for most soil conditions.
- Installed with standard track drill (top hammer) or hand-held drilling equipment, eliminating the need for larger casing rigs.
- Continuously threaded bar pattern can be cut and coupled anywhere along its length.
- Domestic available in 10' or 20' lengths, non-domestic available in 3 meter lengths only.
- Corrosion protection systems available upon request.
- FHWA approved for use as a micro pile or soil nail (Domestic Hollow Injection Bar only)

B7X1 Domestic Hollow Injection Bar

Bar Diameter	Minimum Net Area Through Threads	Minimum Ultimate Strength	Minimum Yield Strength	Nominal Weight	Average Inner Diameter	Part Number
32 mm (1-1/4")	0.556 in² (359 mm²)	58.4 kips (260 kN)	47.2 kips (210 kN)	2.1 lbs/ft (3.1 Kg/M)	0.787" (20.0 mm)	B7X1-32
32X mm (1-1/4")	0.776 in² (501 mm²)	81.5 kips (363 kN)	66.0 kips (294 kN)	2.7 lbs/ft (4.0 Kg/M)	0.626" (15.9 mm)	B7X1-32X
38 mm (1-1/2")	1.067 in² (688 mm²)	112 kips (498 kN)	90.7 kips (404 kN)	3.76 lbs/ft (5.6 Kg/M)	0.830" (21.1 mm)	B7X1-38
51 mm (2")	1.795 in² (1158 mm²)	188 kips (837 kN)	152 kips (677 kN)	6.26 lbs/ft (9.3 Kg/M)	1.187" (30.1 mm)	B7X1-51
76 mm (3")	3.880 in² (2503 mm²)	407 kips (1811 kN)	329 kips (1466 kN)	13.79 lbs/ft (20.5 Kg/M)	1.890" (48.0 mm)	B7X1-76

INDIANA DEPARTMENT OF TRANSPORTATION — INDOT

GEOTILL ENGINEERING, INC.

MSE Walls Retrofit – 82nd St Over I-465

Proposed Retrofit

B7XB Drill Bits

HC Hardened Bit
Hardened cross cut drill bit, suitable for the majority of applications including narrow bands of soft rock.
Soil Types: Fills and Medium Dense Gravels

CC Carbide Bit
Tungsten carbide cross-cut drill bit. Excellent choice for majority of granular soils with mixed hard formations.
Soil Types: Fills, Gravels, Shale & Seamy Rock Formations.

SB Sand/Clay Bit
Two stage cross cut drill bit, suitable for loose to medium dense ground and fills.
Soil Types: Sand, Clay and Light Gravels

BB Button Bit
Tungsten carbide hemispherical button drill bit for moderately strong to strong rock, boulders and rubble.
Rock Types: Mudstone, Limestone, and Granite

CB Cobble Bit
Offset face cross cut drill bit suitable for drilling in cobbles with silt and gravel as well as sedimentary bedrock material.

Nominal Bar Diameter	Available Drill Bit Diameters				
	HC	CC	SB	BB	CB
32 mm (1-1/4")	2" (51 mm)	2" (51 mm)	5" (127 mm)	2-1/2" (65 mm)	4" (102 mm)
	2-1/2" (65 mm)	2-1/2" (65 mm)		3" (76 mm)	
	3" (76 mm)	3" (76 mm)		3-1/2" (89 mm)	
	3-1/2" (89 mm)	3-1/2" (89 mm)		4" (102 mm)	
	4" (102 mm)	4" (102 mm)			
38 mm (1-1/2")	2-1/2" (65 mm)	2-1/2" (65 mm)	5" (127 mm)	2-1/2" (65 mm)	4" (102 mm)
	3" (76 mm)	3" (76 mm)		3" (76 mm)	
	3-1/2" (89 mm)	3-1/2" (89 mm)		3-1/2" (89 mm)	
	4" (102 mm)	4" (102 mm)	6" (152 mm)	4" (102 mm)	
		4-1/2" (114 mm)		5" (127 mm)	
51 mm (2")	-	3" (76 mm)	6" (152 mm)	3" (76 mm)	4-3/4" (121 mm)
		3-1/2" (90 mm)		3-1/2" (90 mm)	
		4" (102 mm)			
		4-1/2" (114 mm)	8" (203 mm)	4" (102 mm)	6" (152 mm)
		5" (127 mm)		5" (127 mm)	
		6" (152 mm)			
76 mm (3")	-	5" (125 mm)	7" (175 mm)	5" (125 mm)	-
		6" (152 mm)			
		7" (175 mm)	10" (254 mm)	6" (152 mm)	
T40	-	3" (76 mm)	6" (152 mm)	2-1/2" (65 mm)	-
		4" (102 mm)		3" (76 mm)	
T52	-	4" (102 mm)	7" (178 mm)	-	-

MSE Walls Retrofit – 82nd St Over I-465

Northwest MSE Wall

- Seven panels were repaired by installing two nails in each panel. Two weepholes were installed at each bottom panel, a total of 8 weepholes.
- The damaged and spalling concrete in the MSE wall and abutment area, caused by expansion was repaired by removing the damaged and unsound concrete, followed by cast-in-place concrete panel to restore the structural integrity of the wall and prevent the backfill loss.

Southwest MSE Wall

- Three panels were repaired by installing two nails in each panel. Two weepholes were installed at each bottom panel, a total of 4 weepholes.
- The damaged and spalling concrete in the MSE wall and abutment area, caused by expansion was repaired by removing the damaged and unsound concrete, followed by cast-in-place concrete panel to restore the structural integrity of the wall and prevent the backfill loss.
- The chipped coping was patched with concrete. It has been difficult to verify if pins or rebar anchors were used to anchor the patched concrete. `

Items that have been Repaired

MSE Walls Retrofit – 82nd St Over I-465

Southeast MSE Wall

- The damaged and spalling concrete in the MSE wall and abutment area, caused by expansion was repaired by removing the damaged and unsound concrete, followed by cast-in-place concrete panel to restore the structural integrity of the wall and prevent the backfill loss.

Northeast MSE Wall

- Vegetation and trees grown between the coping and the bridge railing were trimmed.

East end bent:

- The joint between the phased walls has been sealed using a conventional sealant.

West end bent:

- The joint between the phased walls has been sealed using a conventional sealant.

Items that have been Repaired

MSE Walls Retrofit – 82nd St Over I-465

MSE Walls Retrofit – 82nd St Over I-465

Coring for Soil Nails and Weep Holes

MSE Walls Retrofit – 82nd St Over I-465

MSE Walls Retrofit – 82nd St Over I-465

Soil Nail Proof Test Report

Project: B-43196 82nd St over I-465
Location: Indianapolis
Client: INDOT
Project #: 05-111

Tie Back #:	SW1-R
Date Installed:	3/4/2023
Date Tested:	3/8/2023
Design Load (Kips)	20.6
Bonded Length (ft)	17.5
Unbonded length (ft)	1
Free Length (ft)	3
32mm Hollow Bar	0.776
Modulus of Elasticity (ksi)	28700

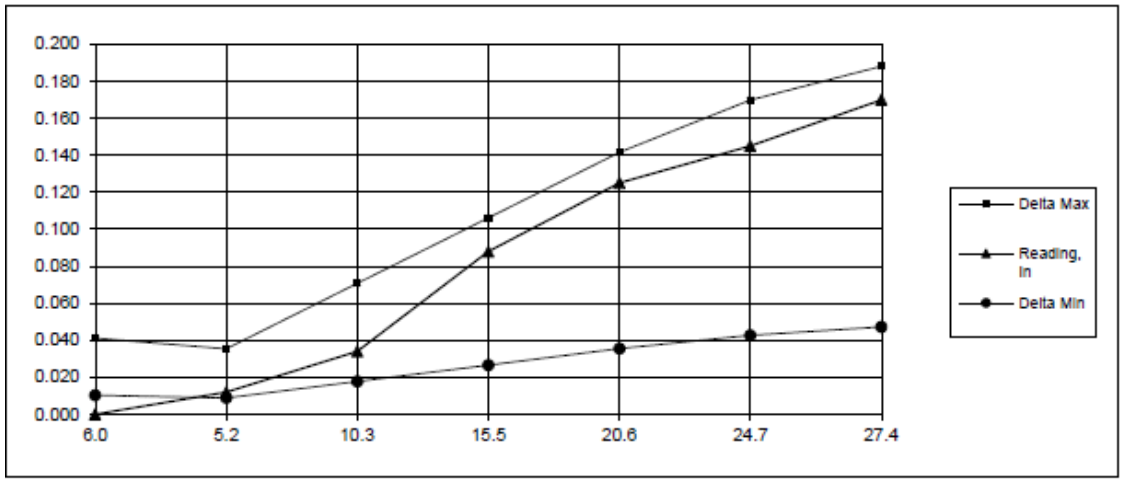
Equipment

Pump: PE554 Jack No. S16993
Gauge: 5405OVPJ 1 Kip= 83.77 PSI
Tested By: ESB

Boring Information

Diameter _____ Inches
Yards of cement _____ External
Cubic feet of grout _____ Internal

Value of Design Load	Loading Kips	Gauge Pressure, PSI	Movement Reading, In	Delta, Min Inches		Delta, Max Inches	Ten Minute Hold Minutes	Ten Minute Hold Reading, In
Alignment	6.0	503	0.000	0.010		0.041	1	0.170
0.25	5.2	431	0.012	0.009		0.035	2	0.170
0.50	10.3	863	0.034	0.018		0.071	3	0.170
0.75	15.5	1294	0.088	0.027		0.106	4	0.170
1.00	20.6	1726	0.125	0.036		0.142	5	0.170
1.20	24.7	2071	0.145	0.043		0.170	6	0.170
1.33	27.4	2295	0.170	0.047		0.188	10	0.170
							Creep =	0.000
	Lock Off at 21 Kips, Dial Reading =		0.132				Result =	PASS



MSE Walls Retrofit – 82nd St Over I-465

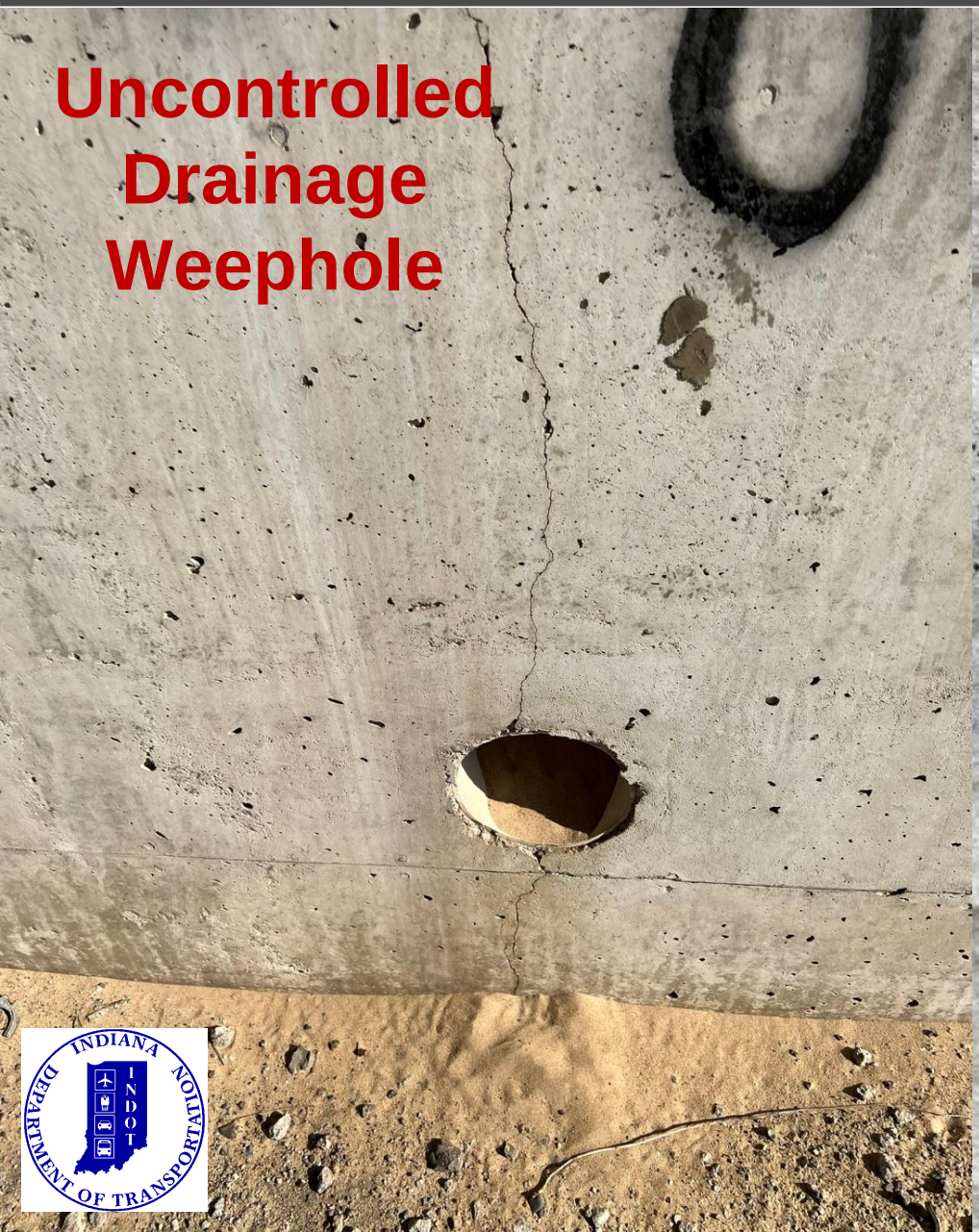
MSE Walls Retrofit – INDOT Various Projects

Settlement of Panels

MSE Walls Retrofit – INDOT Various Projects

MSE Walls Retrofit – INDOT Various Projects

MSE Walls Retrofit – INDOT Various Projects



MSE Walls Retrofit – INDOT Various Projects

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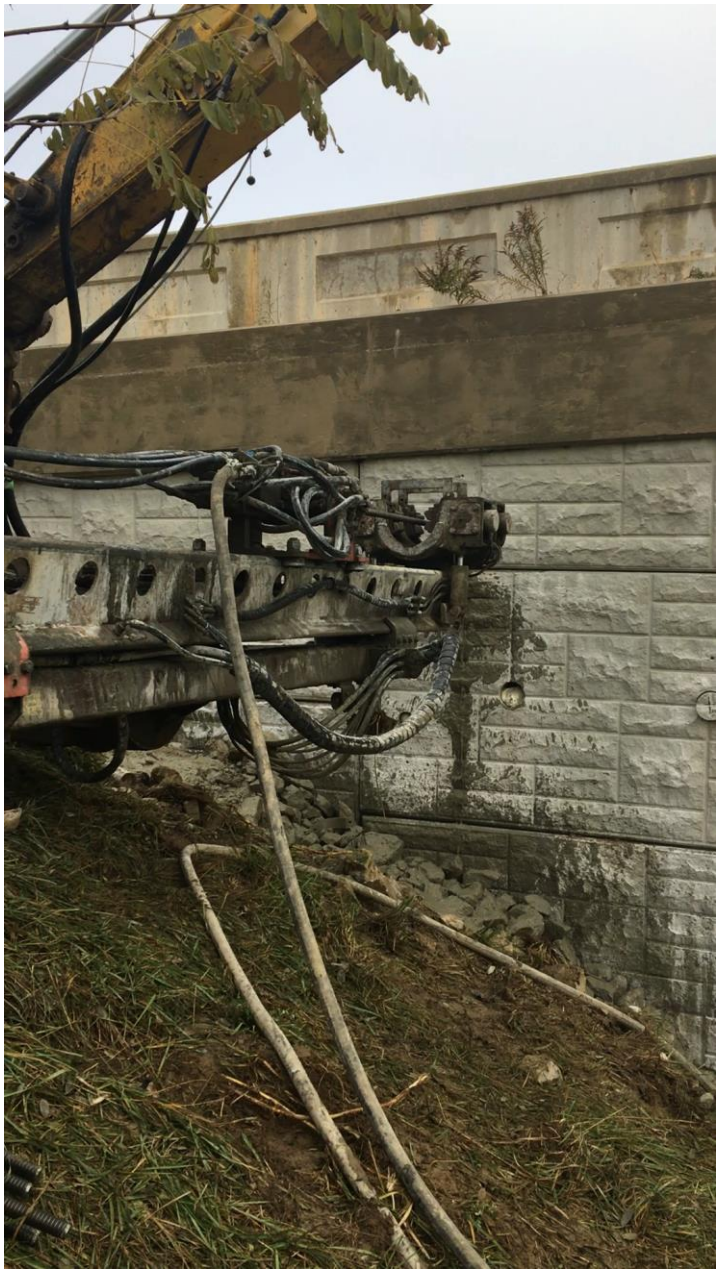

MSE Wall Repair with Soil Nail

MSE Walls Retrofit – INDOT Various Projects

MSE Wall Repair with Soil Nail

Soil Nail Pull Test

MSE Walls Retrofit – INDOT Various Projects

MSE Wall Repair Sealing Separation at the Concrete Jersey Barrier to Control Drainage

When Should We Evaluate Retaining Wall Assets?

- During construction (QA/QC).
- Periodic (routine) performance inspections.
- Extreme events (seismic, flood, impact).
- Before widening, load changes, rehabilitation.
- As part of plan to extend useful life – as part of asset management.

Questions ?

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