9th Geo³T² Conference

Drilled Shaft Instrumentation

Jamal Nusairat, Ph.D., P.E.
Richard L. Engel, P.E.

April 11, 2017

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Presentation Outline

1. Pomeroy Mason Bridge
2. Ironton Russell Bridge
3. Load Test Database
4. CUY-90 Bridge – Slope Failure
5. ERI-60 - Slope Failure
6. HUR-99-13.77 - Tieback VE
7. MOT-75-12.00 - Piling VE
8. FRA-Dodridge St. -Tiedown

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1. Pomeroy Mason Bridge Over the Ohio River

Drilled Shaft Load Testing 2003

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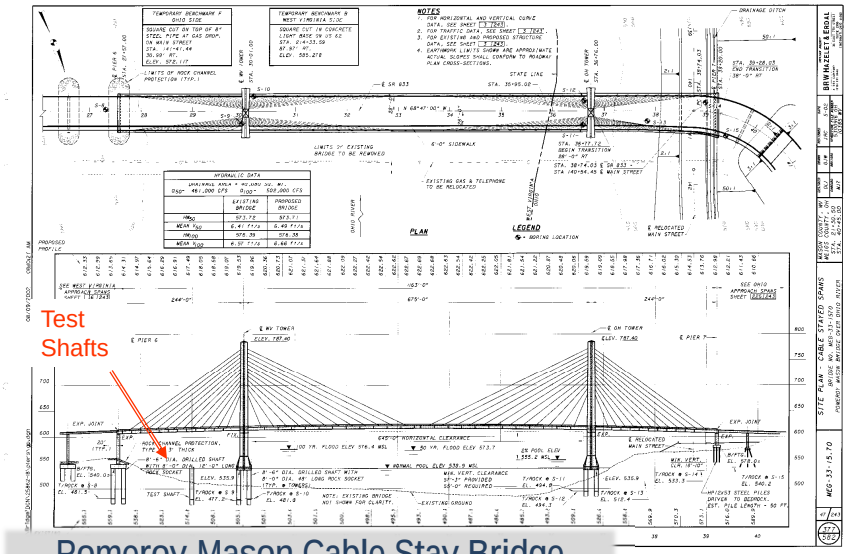

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Pomeroy-Mason Cable Stay Bridge
Vertical and Lateral Load Testing

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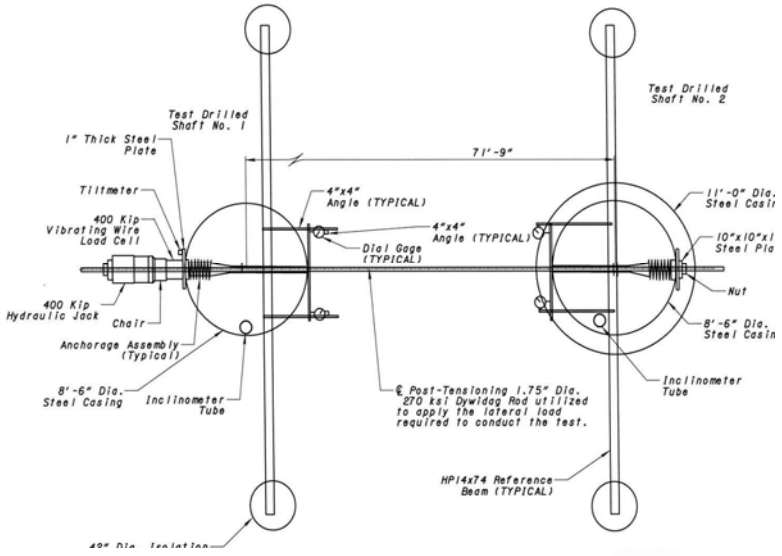

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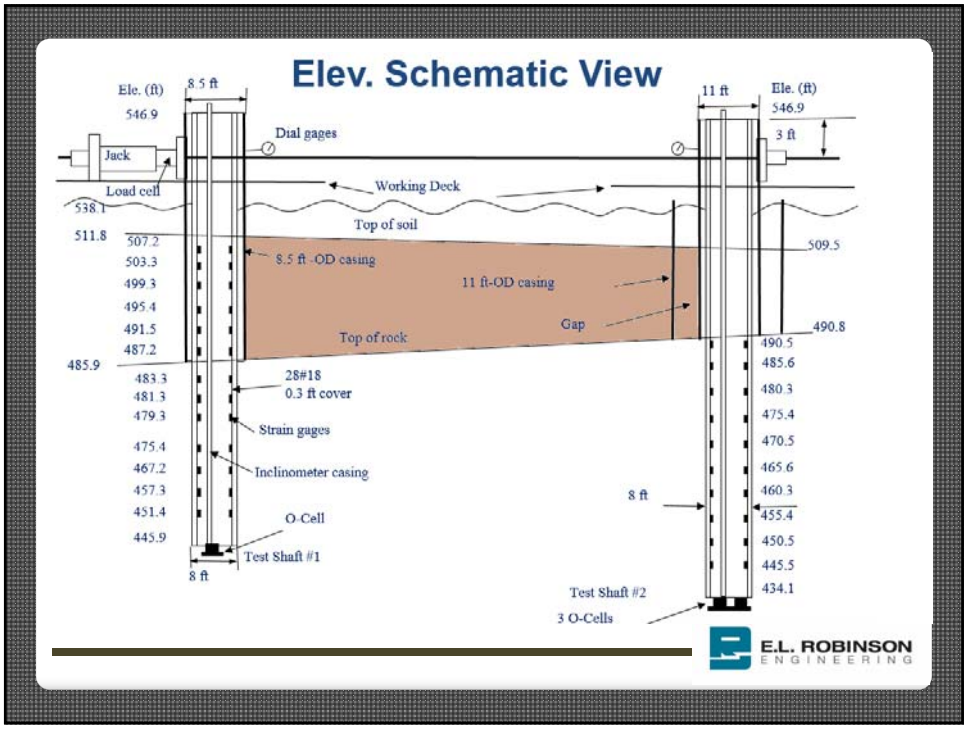
Elev. Schematic View
Ele. (ft)
546.9
8.5 ft
Dial gages
Jack
Load cell
538.1
Working Deck
Top of soil
511.8
507.2
503.3
499.3
495.4
491.5
487.2
485.9
8.5 ft -OD casing
11 ft-OD casing
Gap
Top of rock
483.3
481.3
479.3
475.4
467.2
457.3
451.4
445.9
28#18
0.3 ft cover
Strain gages
Inclinometer casing
O-Cell
Test Shaft #1
8 ft
11 ft
Ele. (ft)
546.9
3 ft
509.5
490.8
490.5
485.6
480.3
475.4
470.5
465.6
460.3
455.4
450.5
445.5
434.1
8 ft
Test Shaft #2
3 O-Cells
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Table 14. Calculated Allowable Unit Base Resistances

Bedrock Horizon	Approximate Elevation Range		Allowable Unit Base Resistance	
	WV Tower	Ohio Tower	(psi)	(tsf)
Shale With Interbedded Siltstone	478 to 463	491 to 473	44.4	3.2
Shale (Mudstone)	463 to 435	473 to 448	44.4	3.2
Siltstone (6' Diameter Shafts)	435 to 421	448 to 434	497.2	35.8
Siltstone (8' Diameter Shafts)	435 to 421	448 to 434	466.7	33.6
Siltstone (10' Diameter Shafts)	435 to 421	448 to 434	448.6	32.3

O-Cell Test at Jack
Limit = 100 TSF

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Table 13. Calculated Allowable Unit Side Resistances

Bedrock Horizon	Approximate Elevation Range		Allowable Unit Side Resistance	
	WV Tower	Ohio Tower	(psi)	(tsf)
Shale With Interbedded Siltstone	478 to 463	491 to 473	69.4	5.0
Shale (Mudstone)	463 to 435	473 to 448	2.8	0.2
Siltstone	435 to 421	448 to 434	130.6	9.4

O-Cell Average Ultimate Side Friction = 11.2 tsf
Allowable = 5.6 tsf

O-Cell Average Ultimate Side Friction = 4.3 tsf
Allowable = 2.15 tsf

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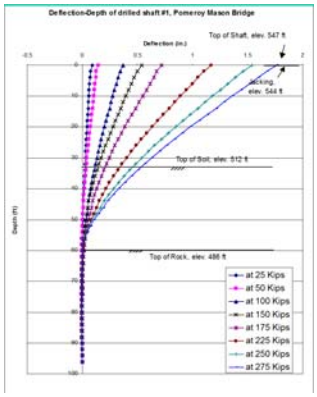

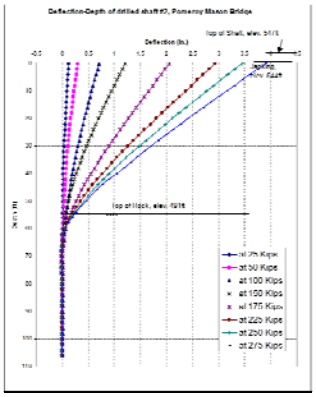

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2. Ironton Russell Bridge Over the Ohio River

Drilled Shaft Load Testing 2012

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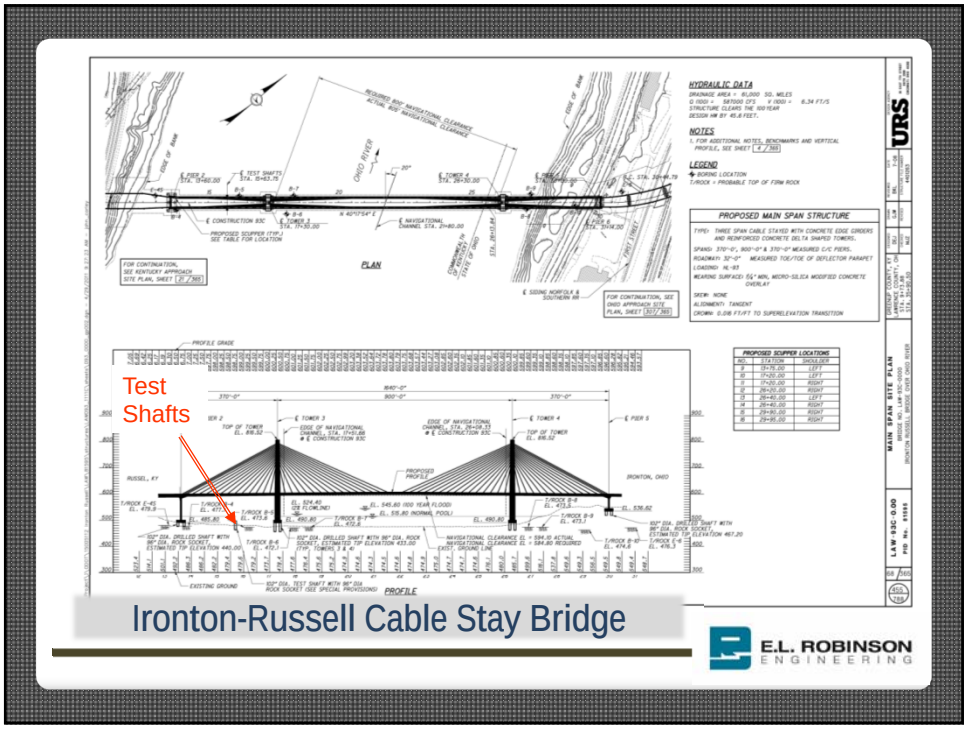

Test Planning and Preparation

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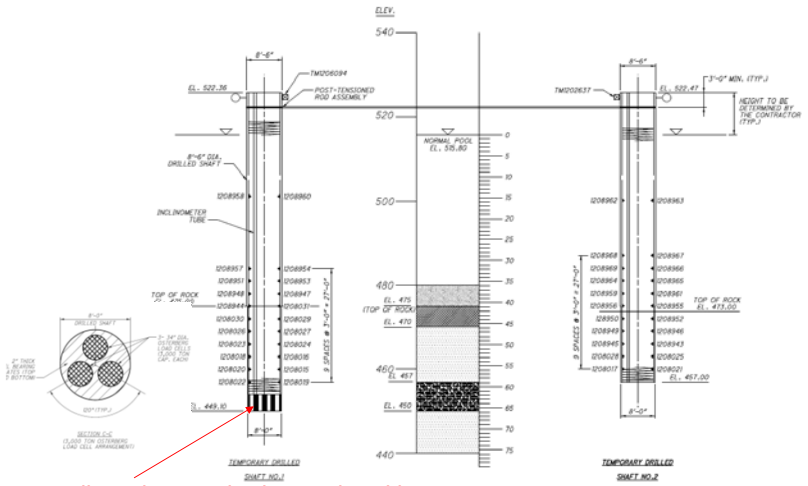
Test Shafts Instrumentation



O-Cell Testing reached capacity without moving the tip beyond 1" (~ 100 TSF)

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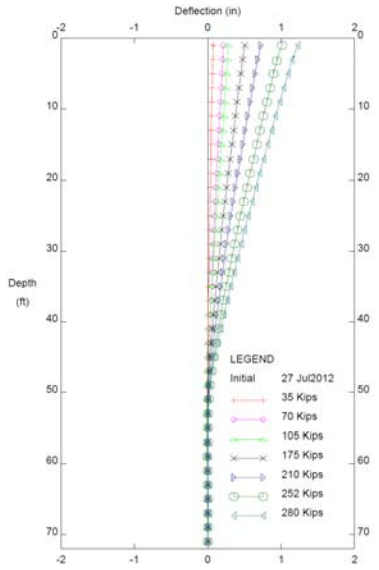

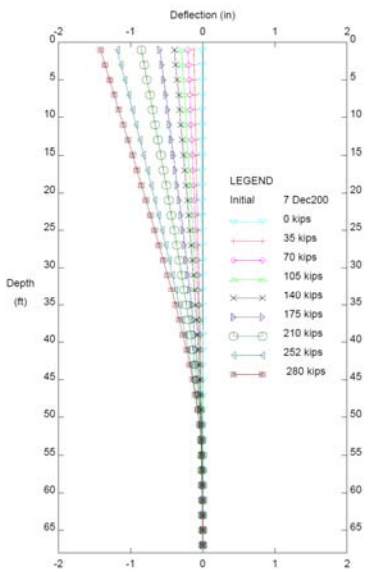

T.S. # 1 Deflection with Depth **T.S. # 2**

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3. Load Test Database

26 Lateral Load Tests 1994 - 2012

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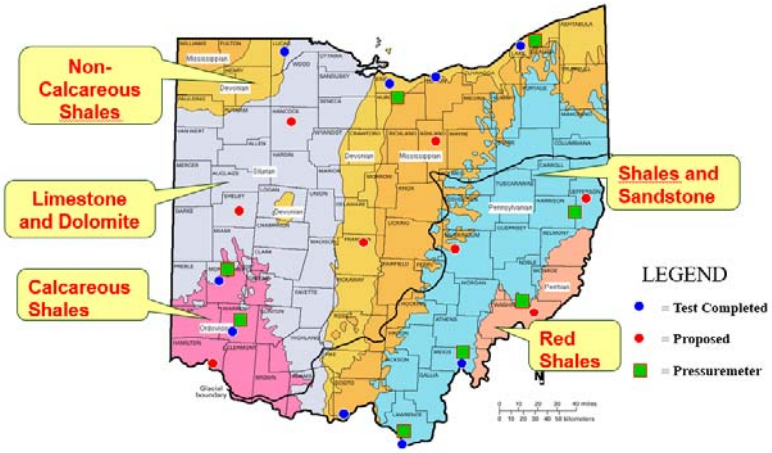
Ohio Bedrock – Map of Testing

The bedrock map is from the ODNR website



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4. *CUY-90 Bridge*
Cleveland, Ohio - 1998

CLEVELAND'S INNERBELT BRIDGE
90
OHIO DEPARTMENT OF TRANSPORTATION

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CUY-90-Innerbelt Bridge

GAS IN THE DRILLED SHAFT EXCAVATION

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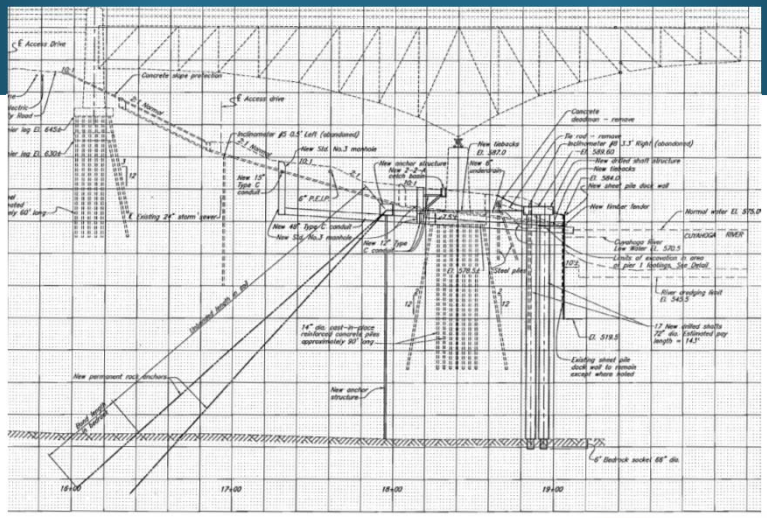
Stabilization Structure



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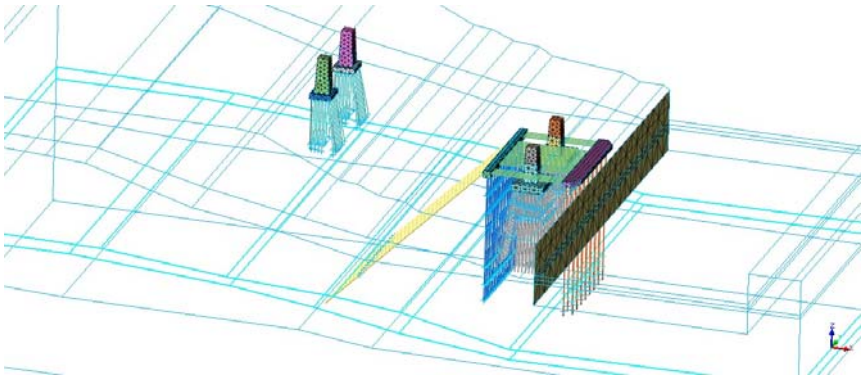
3-D Stability Analysis



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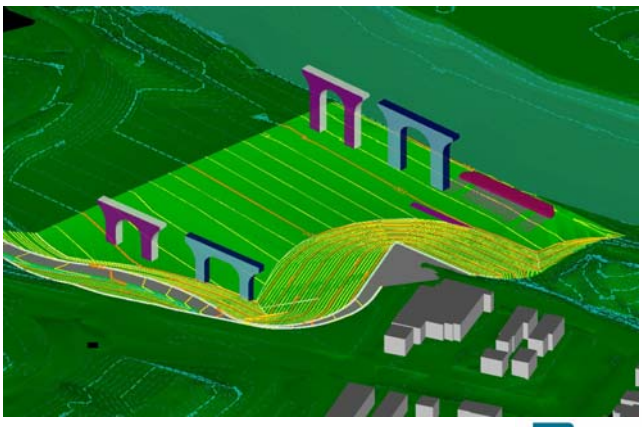
CCG2 Alternative 1



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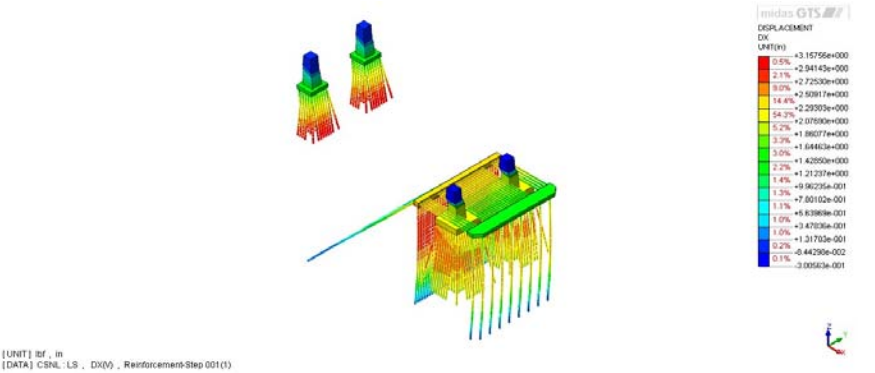
3-D Stability Analysis



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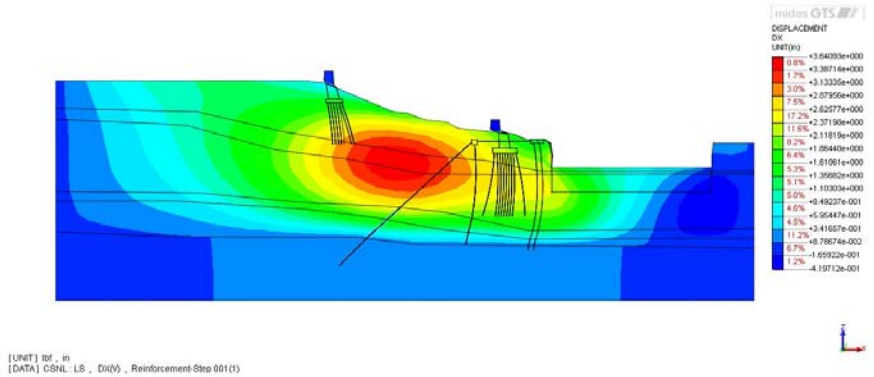
3-D Stability Analysis



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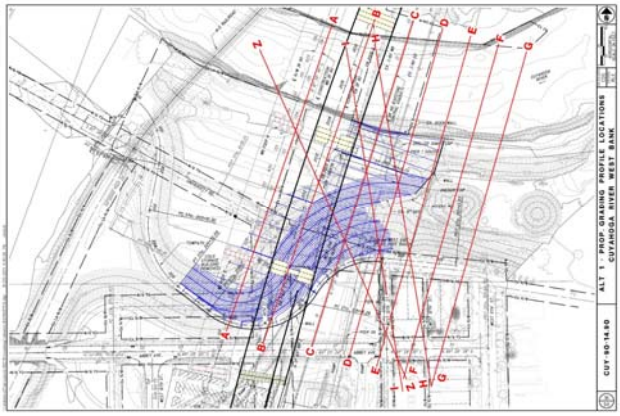
CCG2 Alternative 1



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CCG2 Alternative 1

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CCG2 Alternative 1

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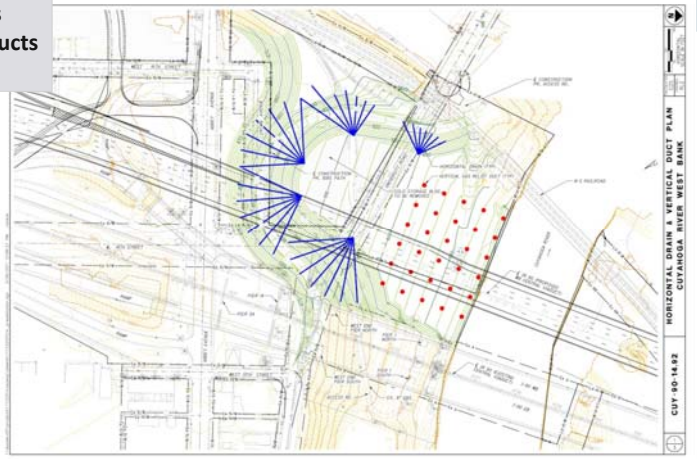
CCG1 – Grading

- Horizontal Drains
- Pressure Relief Ducts
- Unloading



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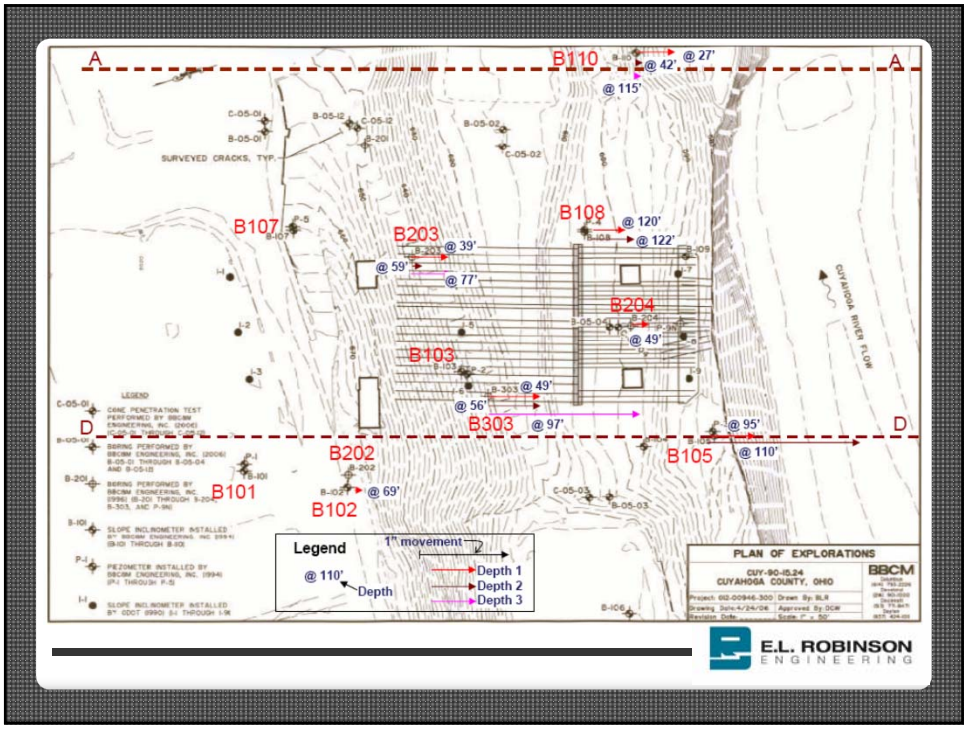

	Area (in2)	Ixx (in4)	Iyy	tf & tw (in)
HP 10x42	12.4	119	40.3	0.445
HP 14x117	34.4	1220	443	0.805
HP 18x204	60.2	3480	1120	1.130

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CUY-90 Bridge

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5. ERI-60-Slope Failure

Drilled Shaft Design Instrumentation

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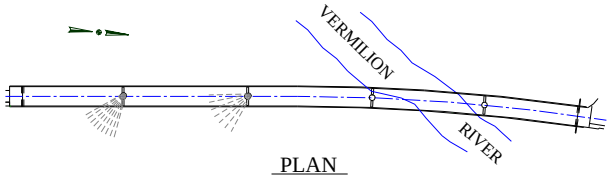
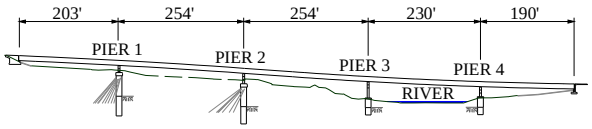
ERI-60 Elevation



PLAN



ELEVATION

SR 60 Over
Vermilion River

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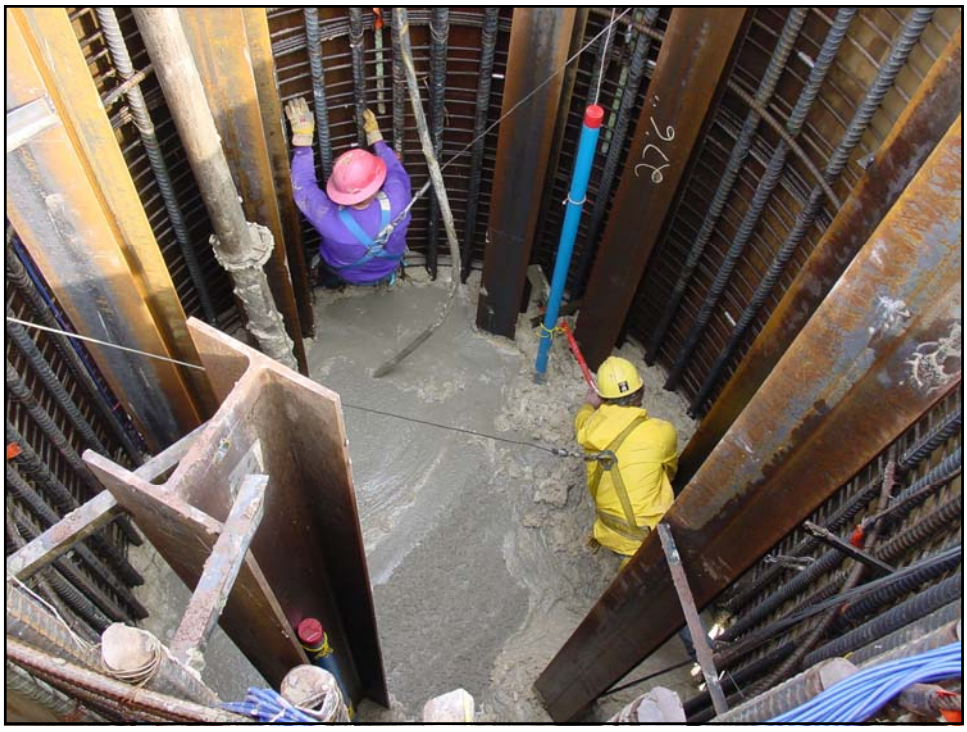
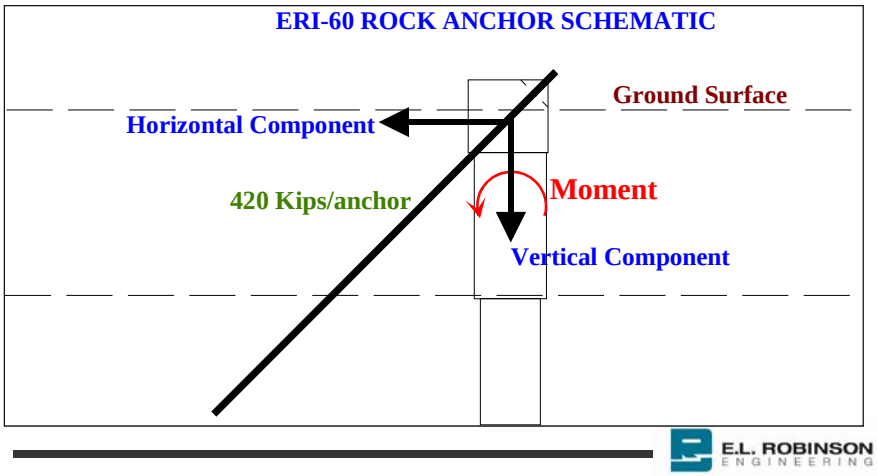
12 feet
diameter
80 feet long
40 feet into
Ohio Shale



Force Diagram



6. HUR-99-13.77 VE

Innovative retaining wall with narrow footing and vertical rock anchors

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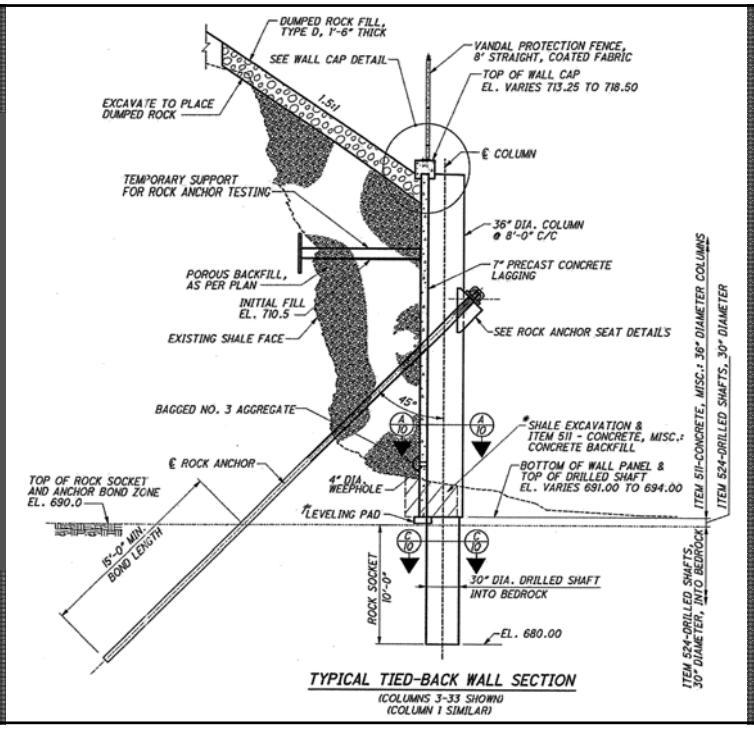
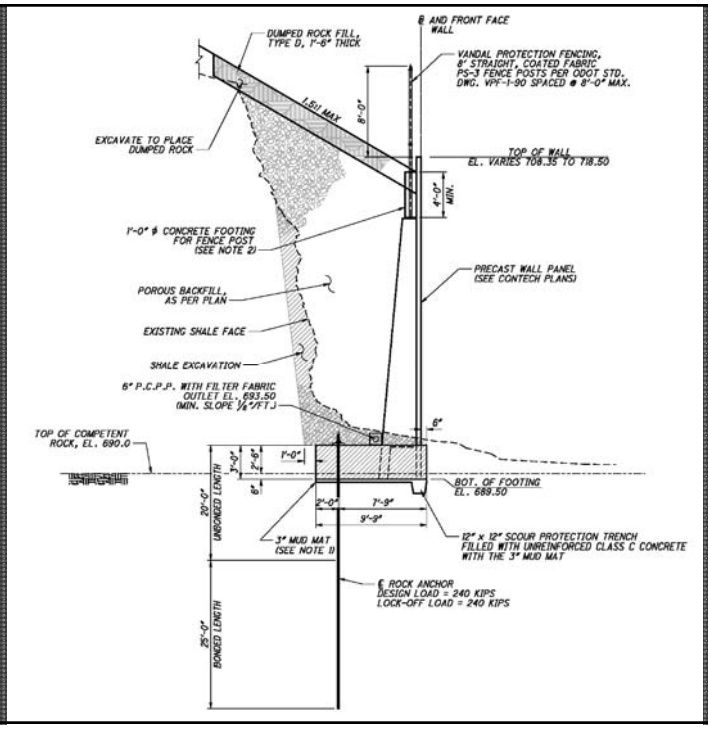
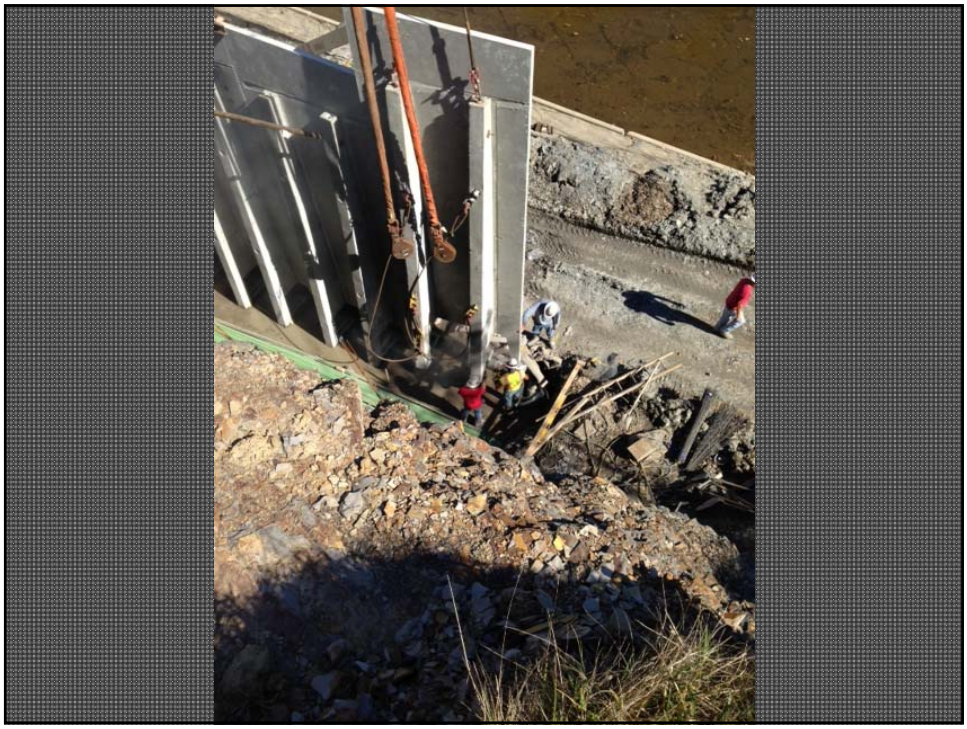
Original Design



Final design





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7. MOT-75-12.00 VE
Dayton, Ohio
2013

Perfect Pile

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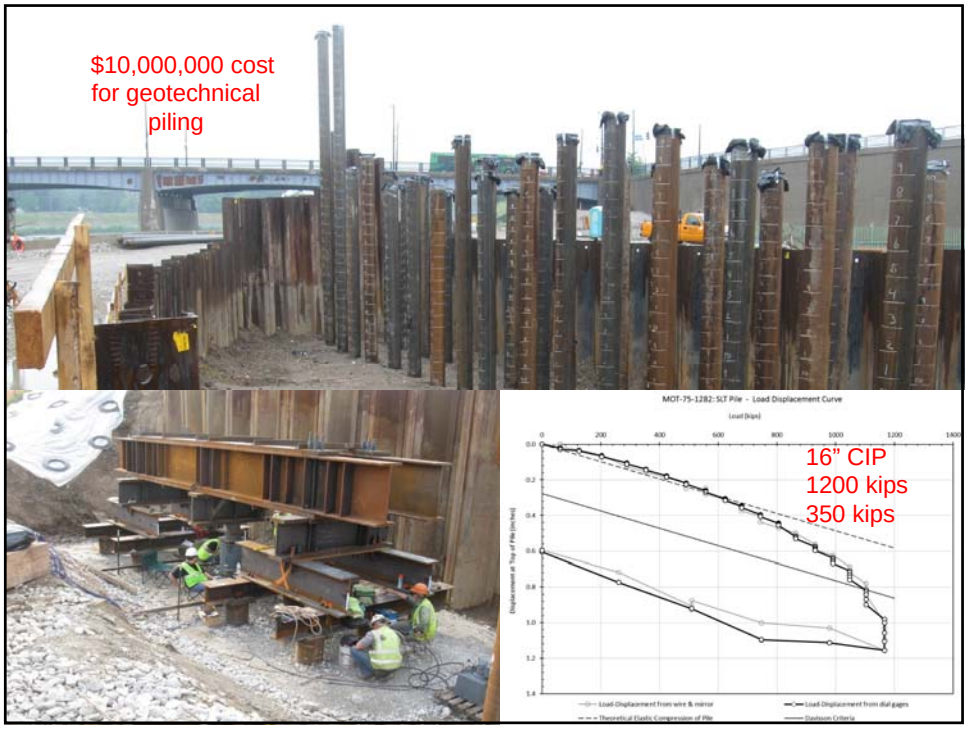

Cost components

- Pile
- Pile points
- Crew time to unload the piles
- Crew time and cost to drive the pile
- Time and material for splices
- Crew time to fill with concrete

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Foundation Costs
MOT-75-12.00 VE
Bridge No. MOT-75-1227

Pipe pile material is ASTM A252, Grade 3, Fy=45 ksi
Driving stresses limited to 0.85 Fy = 38.25 ksi

Total service load on pier (approximate) 13,125 tons
Based on Boring B7-8

(Lowest 3 in cost are in bold text)

Pile dia. (inch)	Wall thickness (inch)	Min. wall thickness -3% (inch)	Closed or Open End	UBV (kips)	Hammer Model	Hammer Energy (kip-ft)	Est. Length (feet)	Order Length (feet)	Time to drive (min.)	$ / pile (matl')	$ / pile (labor)	No. of piles /pier	Total cost $	$ / ton
14	0.250	0.243	Closed	200	D 19-32	47	45	50	10	$ 1,227	$ 534	264	$ 464,870	$ 17.61
14	0.312	0.303	Closed	280	D 19-32	47	50	55	10	$ 1,636	$ 542	188	$ 409,566	$ 15.56
14	0.312	0.303	Closed	300	D 19-32	47	50	55	10	$ 1,636	$ 542	176	$ 383,412	$ 14.52
14	0.375	0.364	Closed	450	D 19-32	47	50	55	10	$ 1,876	$ 545	118	**$ 285,636**	**$ 10.76**
14	0.438	0.425	Closed	500	D 25-32	62	50	55	10	$ 2,123	$ 657	106	$ 294,727	$ 11.12
14	0.500	0.485	Closed	550	D 36-42	89	50	55	5	$ 2,412	$ 682	96	$ 296,970	$ 11.25
14	0.625	0.606	Closed	700	D 36-42	89	80	85	50	$ 4,273	$ 897	76	$ 392,972	$ 14.77
16	0.250	0.243	Closed	250	D 19-32	47	45	50	15	$ 1,549	$ 544	210	$ 439,611	$ 16.75
16	0.312	0.303	Closed	400	D 19-32	47	50	55	15	$ 1,987	$ 554	132	$ 335,361	$ 12.70
16	0.375	0.364	Closed	500	D 25-32	62	50	55	15	$ 2,276	$ 669	106	$ 312,084	$ 11.78
16	0.438	0.425	Closed	550	D 25-32	62	50	55	15	$ 2,570	$ 673	96	$ 311,275	$ 11.79
16	0.500	0.485	Closed	650	D 36-42	89	50	55	10	$ 2,845	$ 698	82	**$ 290,489**	$ 10.90
16	0.625	0.606	Closed	800	D 36-42	89	70	75	25	$ 4,549	$ 743	66	$ 349,228	$ 13.23
18	0.312	0.303	Closed	450	D 25-32	62	50	55	15	$ 2,337	$ 679	118	$ 355,874	$ 13.40
18	0.375	0.364	Closed	550	D 25-32	62	50	55	15	$ 2,667	$ 685	96	$ 321,828	$ 12.19
18	0.438	0.425	Closed	600	D 36-42	89	50	55	10	$ 2,989	$ 709	88	$ 325,413	$ 12.33
18	0.500	0.485	Closed	700	D 36-42	89	50	55	10	$ 3,292	$ 715	76	$ 304,510	$ 11.45
18	0.625	0.606	Closed	800	D 36-42	89	50	55	10	$ 3,930	$ 726	66	$ 307,282	$ 11.64
18	0.625	0.606	Closed	900	D 46-32	114	55	60	15	$ 4,252	$ 811	60	$ 303,792	$ 11.25
18	0.750	0.728	Closed	1000	D 46-32	114	75	80	30	$ 6,383	$ 878	54	$ 392,087	$ 14.52
18	1.000	0.970	Closed	1250	D 62-42	153	90	95	90	$ 9,425	$ 1,450	42	$ 456,741	$ 17.40
24	0.375	0.364	Closed	750	D 36-42	89	50	55	15	$ 3,657	$ 762	70	$ 309,308	$ 11.78
24	0.438	0.425	Closed	800	D 36-42	89	50	55	15	$ 4,088	$ 769	66	$ 320,581	$ 12.14
24	0.438	0.425	Closed	900	D 46-32	114	50	55	10	$ 4,088	$ 847	60	$ 296,109	$ 10.97
24	0.500	0.485	Closed	1000	D 62-42	153	50	55	10	$ 4,528	$ 885	54	**$ 292,321**	**$ 10.83**
24	0.625	0.606	Closed	1100	D 80-42	198	50	55	5	$ 5,364	$ 951	48	$ 303,126	$ 11.48

2013-01-07.MOT-75-12.00.Pile Study.xlsx[Pile cost per ton] 1/7/2013 - 9:21 AM

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8. *FRA- Dodridge Street*
Columbus, Ohio
2008
Rock Anchors

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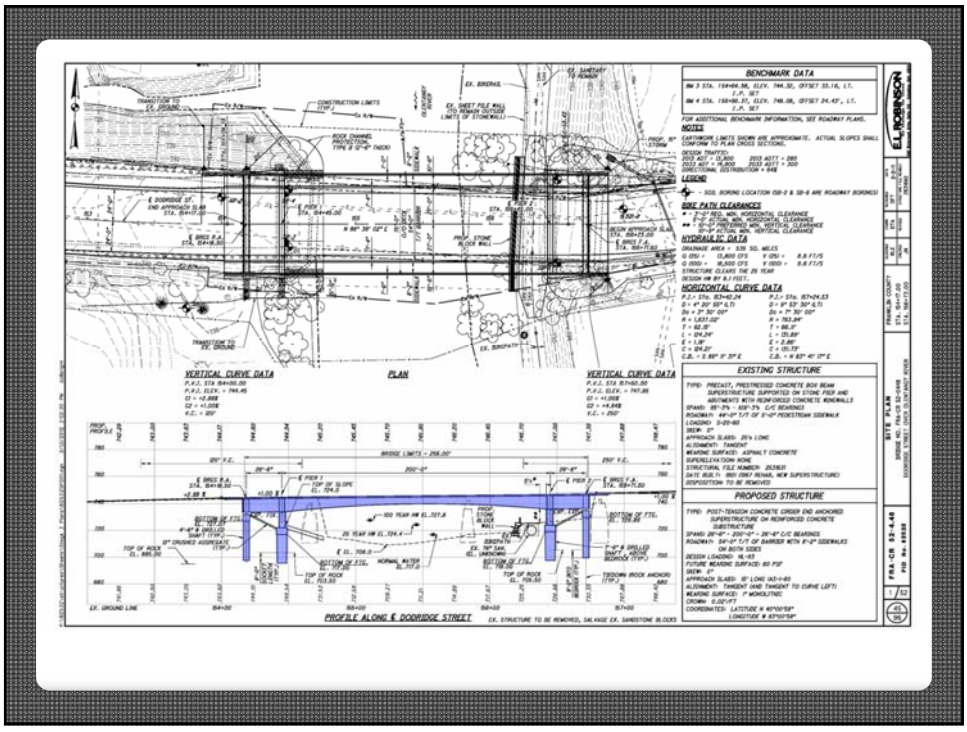
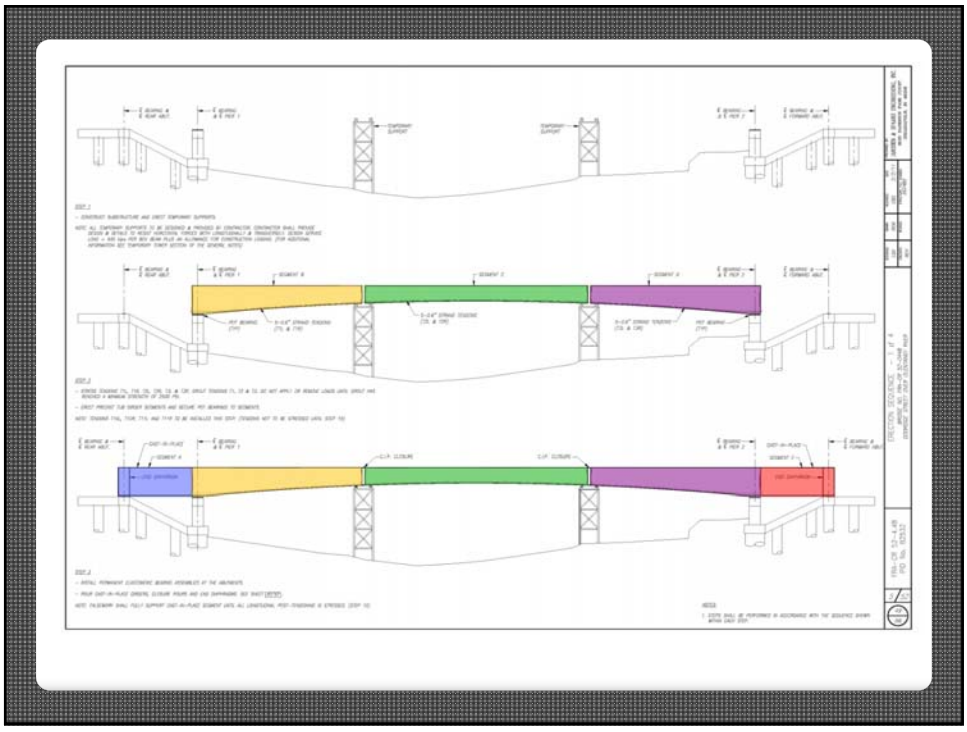
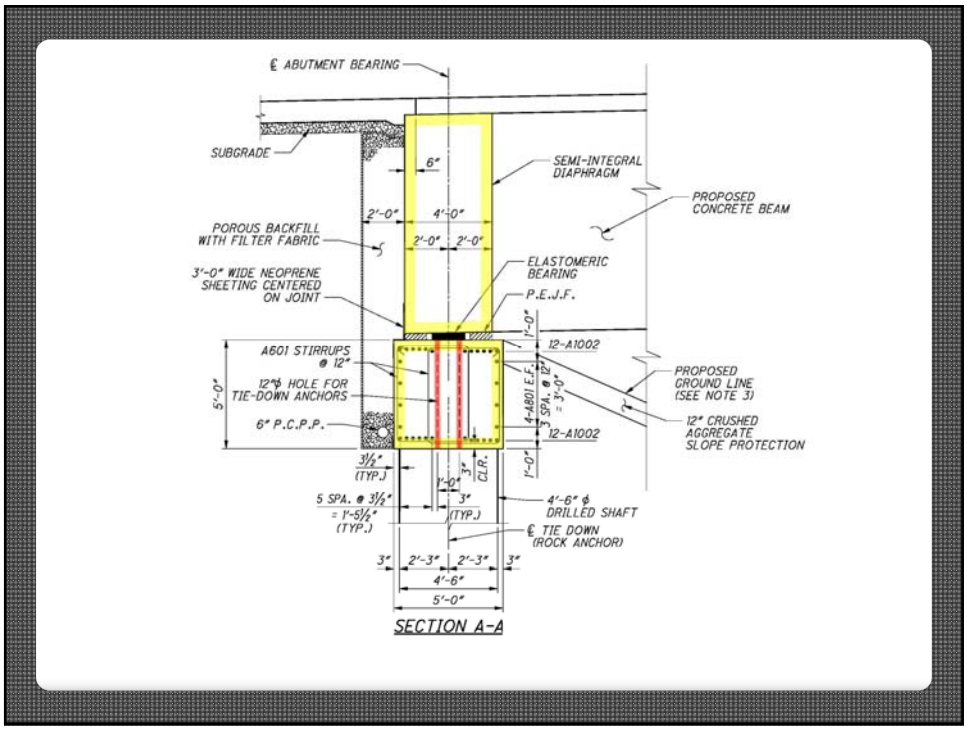
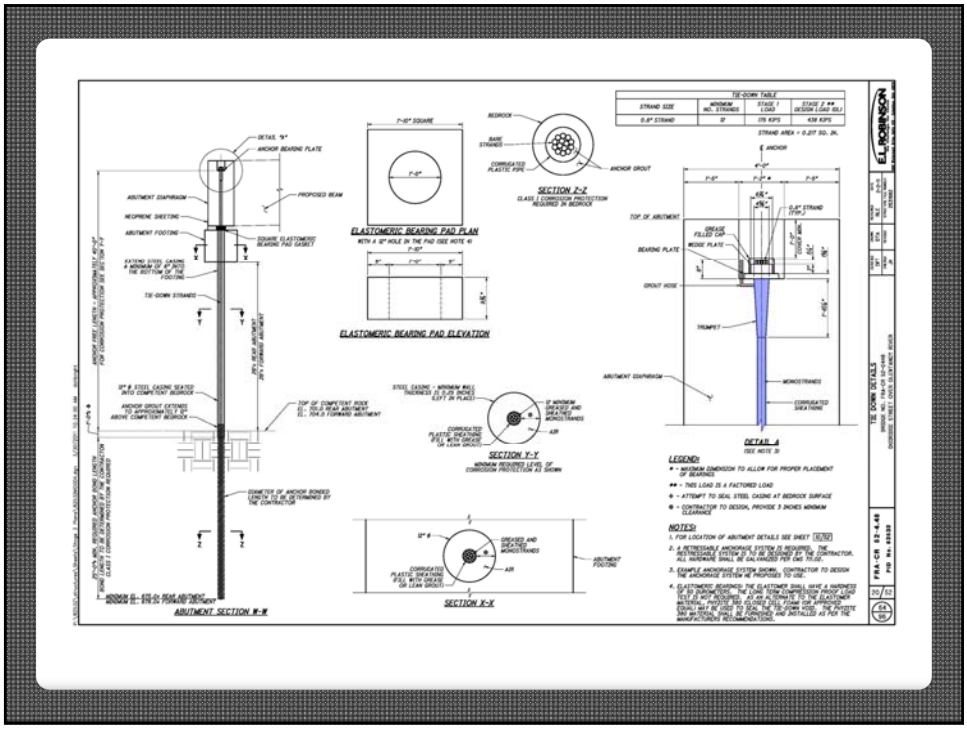

BENCHMARK DATA
NOTES
LEGEND
BIKE PATH CLEARANCES
HYDRAULIC DATA
HORIZONTAL CURVE DATA
EXISTING STRUCTURE
PROPOSED STRUCTURE
VERTICAL CURVE DATA
PLAN
VERTICAL CURVE DATA
PROFILE ALONG ℄ DOORIDGE STREET
SITE PLAN
FRA-CR 33-4.48




℄ ABUTMENT BEARING
SUBGRADE
6"
SEMI-INTEGRAL DIAPHRAGM
PROPOSED CONCRETE BEAM
2'-0"
4'-0"
2'-0"
2'-0"
POROUS BACKFILL WITH FILTER FABRIC
3'-0" WIDE NEOPRENE SHEETING CENTERED ON JOINT
ELASTOMERIC BEARING
P.E.J.F.
1'-0"
12-A1002
A601 STIRRUPS @ 12"
12"ϕ HOLE FOR TIE-DOWN ANCHORS
5'-0"
6" P.C.P.P.
4-A801 E.F. 3 SPA. @ 12" = 3'-0"
PROPOSED GROUND LINE (SEE NOTE 3)
12" CRUSHED AGGREGATE SLOPE PROTECTION
12-A1002
1'-0"
3½" (TYP.)
3" CLR.
1'-0"
5 SPA. @ 3½" = 1'-5½" (TYP.)
3" (TYP.)
4'-6" ϕ DRILLED SHAFT
℄ TIE DOWN (ROCK ANCHOR)
3"
2'-3"
2'-3"
3"
4'-6"
5'-0"
SECTION A-A


TIE-DOWN TABLE
STRAND SIZE
MINIMUM NO. STRANDS
STAGE 1 LOAD
STAGE 2 ** DESIGN LOAD (DL)
0.6" STRAND
12
175 KIPS
438 KIPS
STRAND AREA = 0.217 SQ. IN.
E.L. ROBINSON
ELASTOMERIC BEARING PAD PLAN
WITH A 12" HOLE IN THE PAD (SEE NOTE 4)
ELASTOMERIC BEARING PAD ELEVATION
SECTION Z-Z
CLASS C CORROSION PROTECTION REQUIRED IN BEDROCK
SECTION Y-Y
MINIMUM REQUIRED LEVEL OF CORROSION PROTECTION AS SHOWN
SECTION X-X
DETAIL A
SEE NOTE 3)
ABUTMENT SECTION W-W
LEGEND:
* = MINIMUM DIMENSION TO ALLOW FOR PROPER PLACEMENT OF BEARINGS
** = THIS LOAD IS A FACTORED LOAD
◆ = ATTEMPT TO SEAL STEEL CASING AT BEDROCK SURFACE
● = CONTRACTOR TO DESIGN, PROVIDE 3 INCHES MINIMUM CLEARANCE
NOTES:
1. FOR LOCATION OF ABUTMENT DETAILS SEE SHEET 10/10
2. A RETRESSABLE ANCHORAGE SYSTEM IS REQUIRED. THE RETRESSABLE SYSTEM IS TO BE DESIGNED BY THE CONTRACTOR. ALL HARDWARE SHALL BE GALVANIZED PER CMD 711.02.
3. EXAMPLE ANCHORAGE SYSTEM SHOWN. CONTRACTOR TO DESIGN THE ANCHORAGE SYSTEM HE PROPOSES TO USE.
4. ELASTOMERIC BEARINGS: THE ELASTOMER SHALL HAVE A HARDNESS OF 50 DUROMETER. THE LONG TERM COMPRESSION PROOF LOAD TEST IS NOT REQUIRED. AS AN ALTERNATE TO THE ELASTOMER MATERIAL, THE CONTRACTOR MAY USE A PREFORMED FABRIC PAD. IF THE CONTRACTOR ELECTS TO USE A PREFORMED FABRIC PAD FOR THE ELASTOMERIC BEARING PAD, THE PREFORMED FABRIC PAD SHALL BE FURNISHED AND INSTALLED AS PER THE MANUFACTURERS RECOMMENDATIONS.
TIE DOWN DETAILS
FRA-CR 02-4.46
PID No. 83930

Ohio DOT Research Project

State Job Number 134137 and 134348: Design of Rock Socketed Drilled Shafts

- Final Reports are available in PDF at Ohio DOT website:

  http://www.dot.state.oh.us/Divisions/Planning/SPR/Research/reportsandplans/Pages/StructuresReports.aspx

E.L. ROBINSON ENGINEERING