Innovative retaining wall with narrow footing and vertical rock anchors

October 26, 2016

HUR-99-13.77

a Value Engineering Change Proposal

Peter Narsavage, PE

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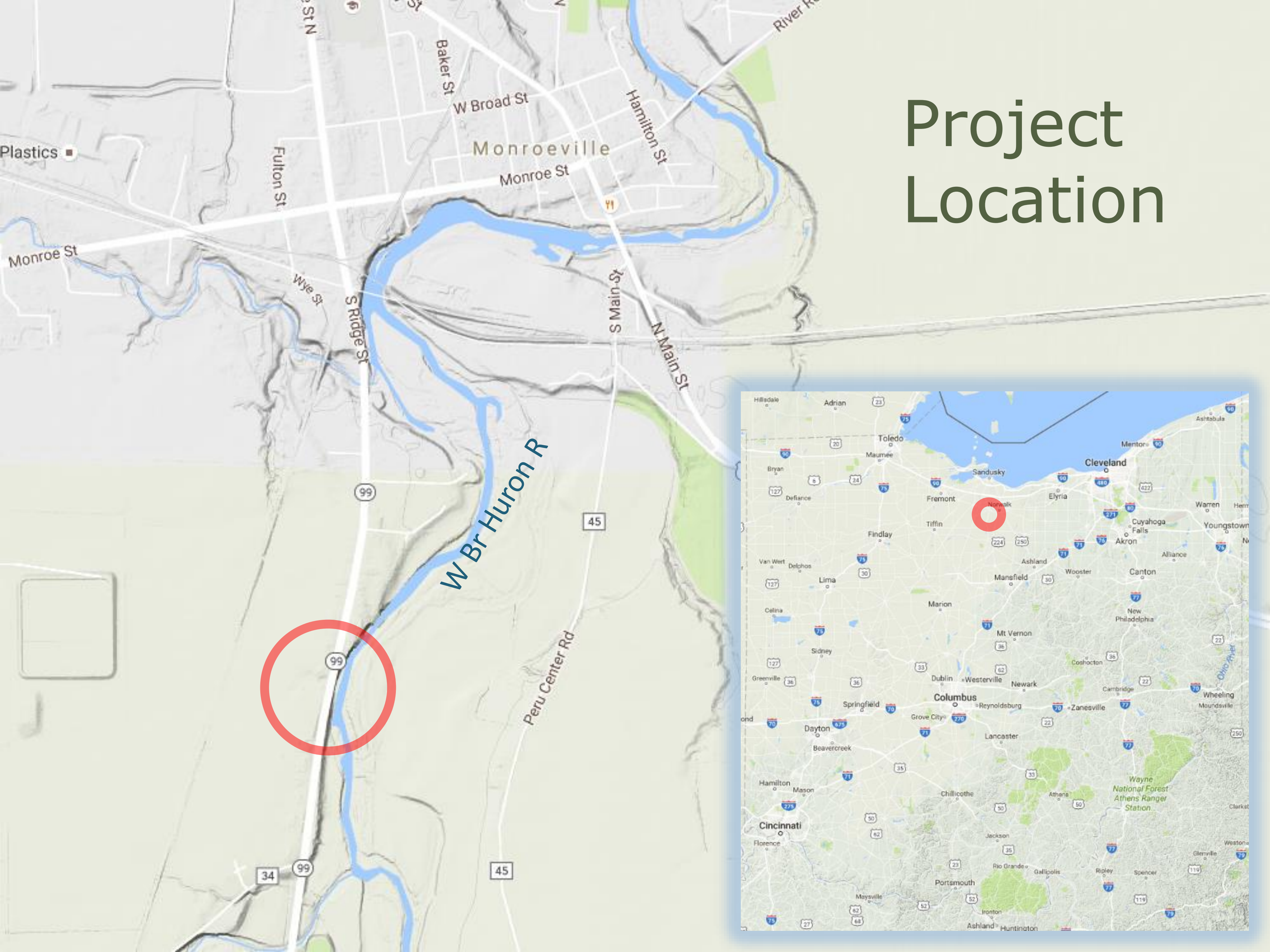
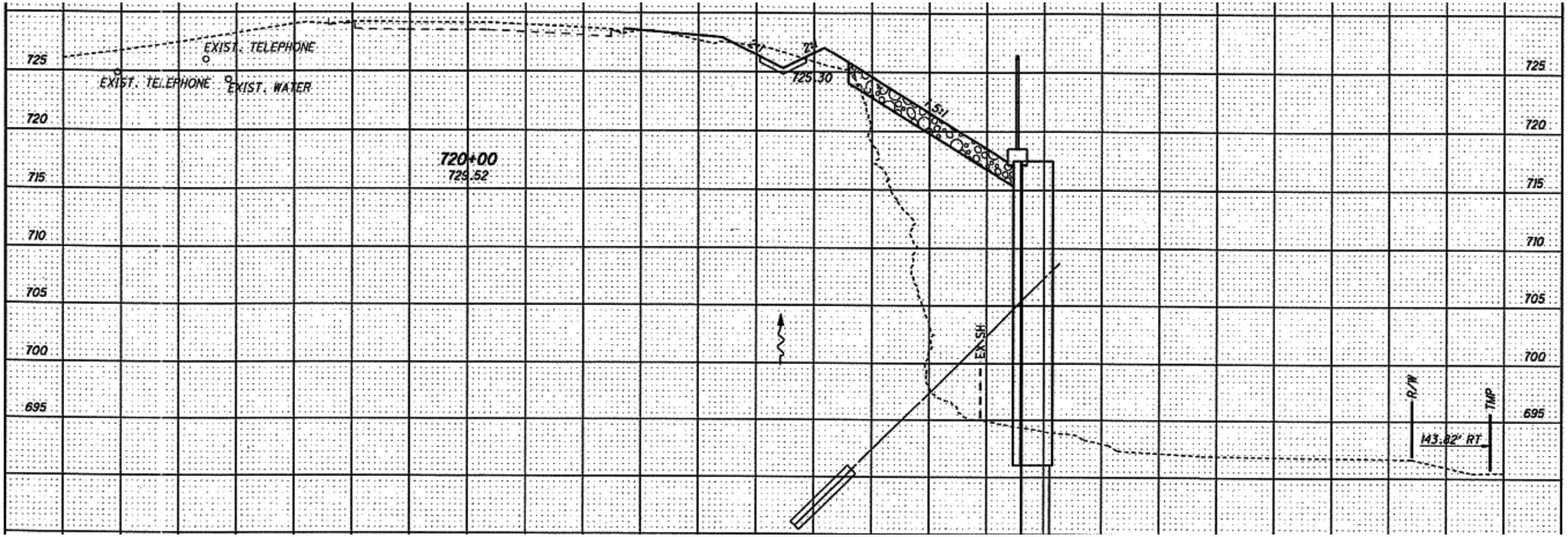
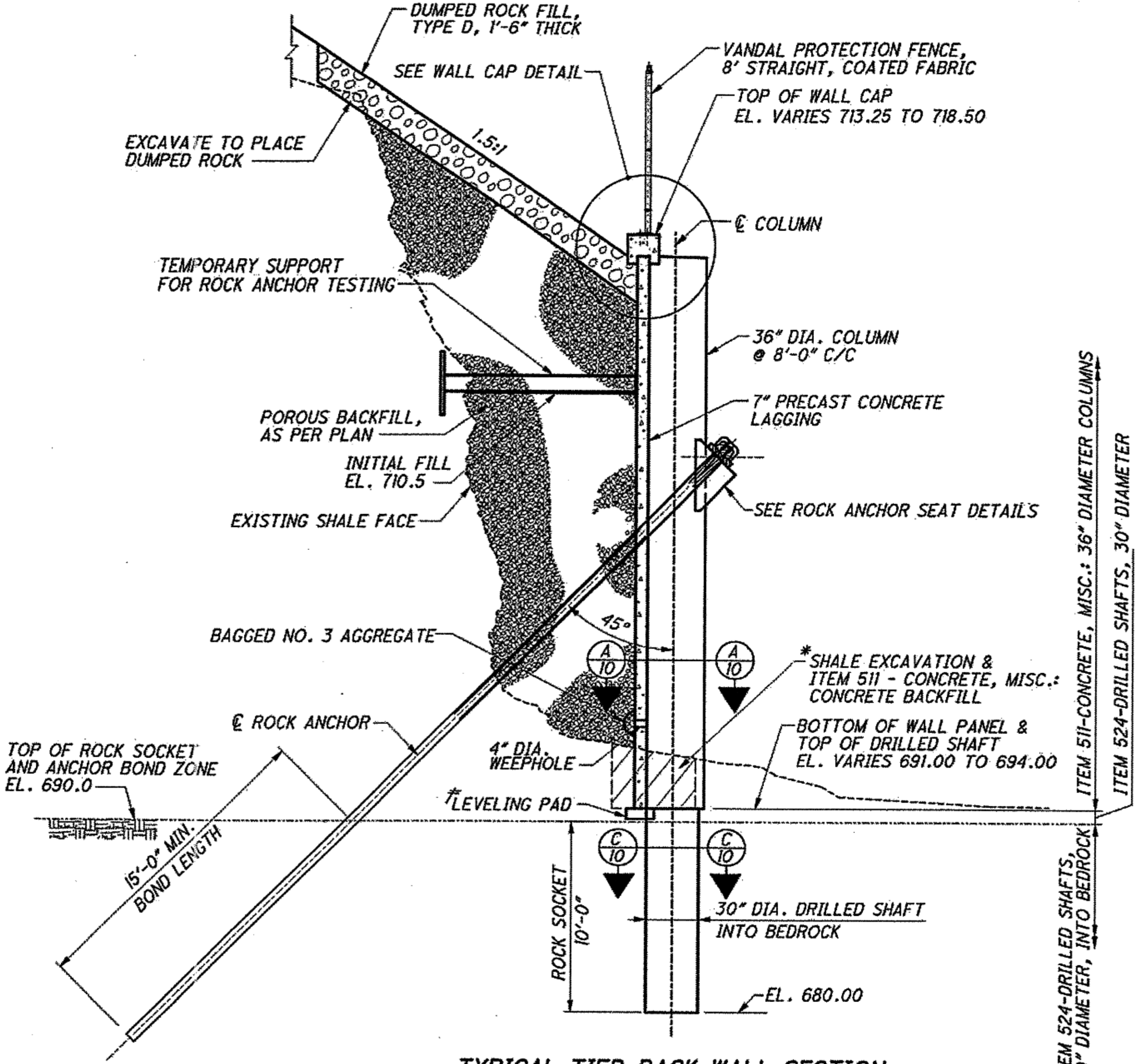
Project Location



Original Design

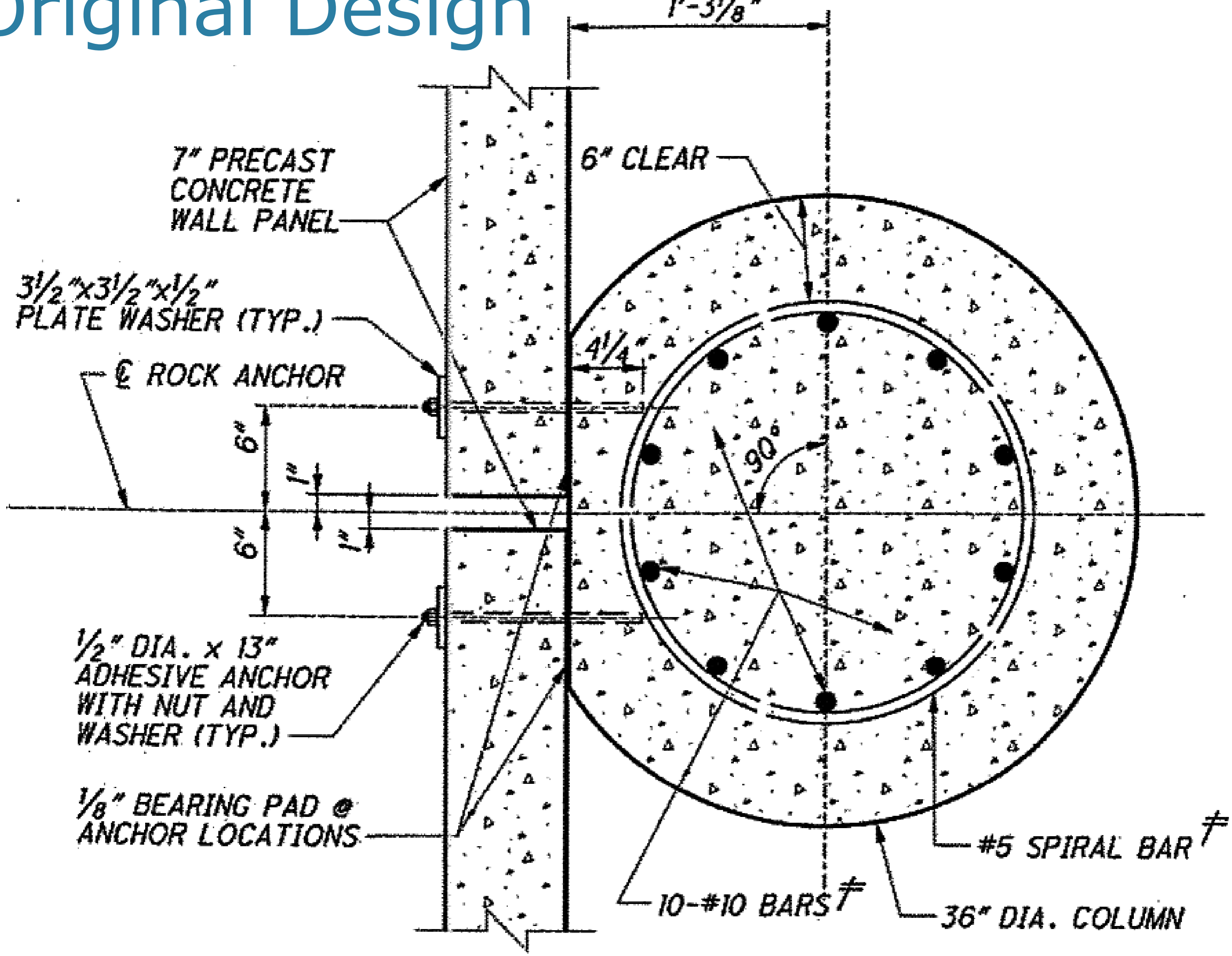


Original Design

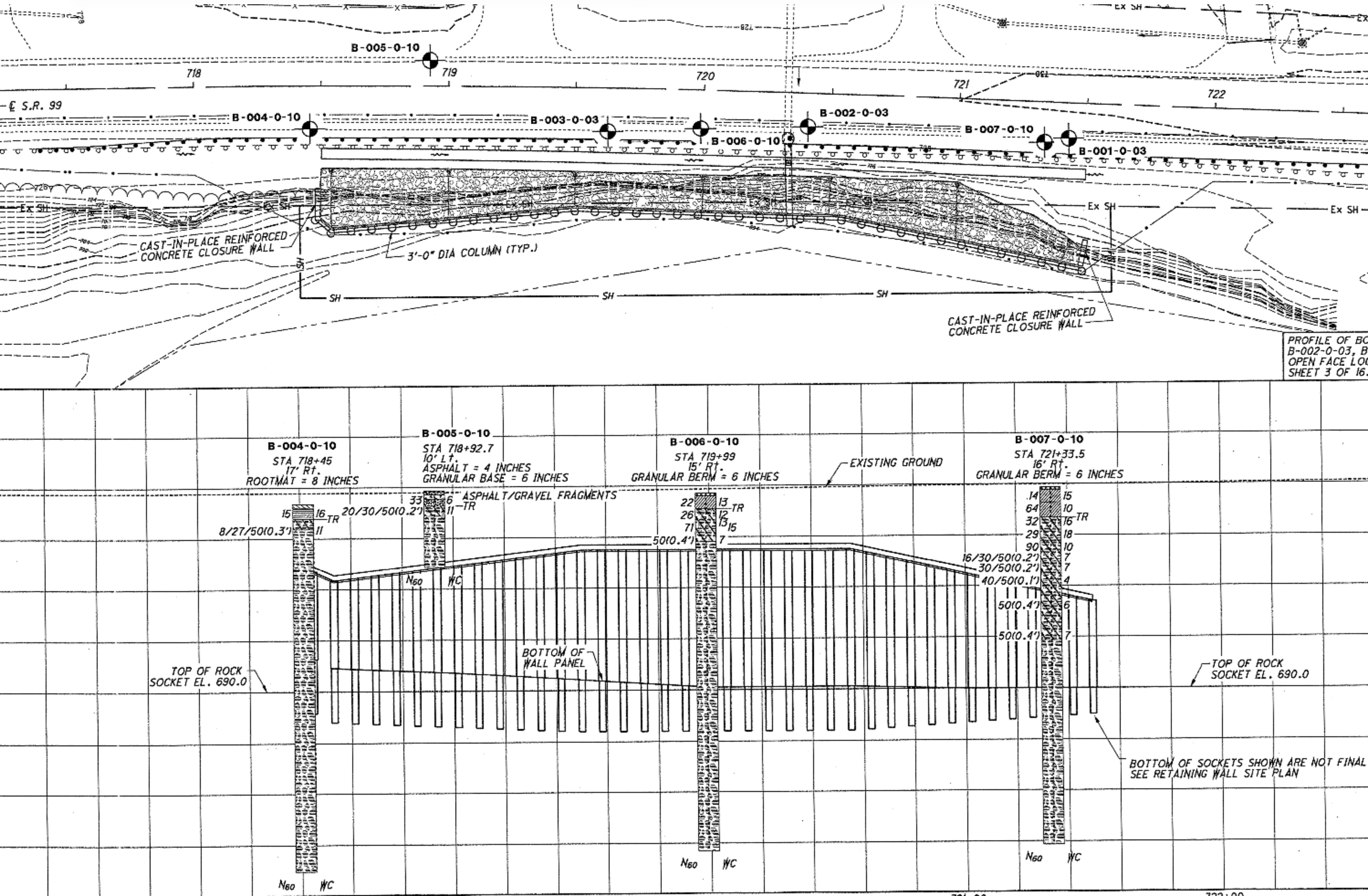


TYPICAL TIED-BACK WALL SECTION
(COLUMNS 3-33 SHOWN)
(COLUMN 1 SIMILAR)

Original Design



Geotechnical Exploration



Rock Quality

STREET, COLUMBUS, OHIO 43215.

SUMMARY OF UNCONFINED COMPRESSION STRENGTH (UCS) TESTING DATA

BORING NO.	SAMPLE NO.	SAMPLE DEPTH	SAMPLE ELEVATION (MSL)	RECOVERY OF TESTED CORE RUN (%)	RQD OF TESTED CORE RUN (%)	UNCONFINED COMPRESSIVE STRENGTH (psi)
B-004-0-10	NQ2-8	27.2' - 27.7'	699.1 - 699.6	97	62	84
B-004-0-10	NQ2-10	37.3' - 37.8'	689.0 - 689.5	100	72	2,342
B-006-0-10	NQ2-8	23.0' - 23.5'	705.0 - 705.5	100	62	62
B-006-0-10	NQ2-9	30.3' - 30.8'	697.7 - 698.2	100	63	25
B-006-0-10	NQ2-12	43.2' - 43.7'	684.8 - 685.3	100	75	8,775
B-007-0-10	NQ2-12	35.8' - 36.3'	693.0 - 693.5	93	40	213
B-007-0-10	NQ2-12	42.3' - 42.8'	686.5 - 687.0	93	74	8,060
B-001-0-03		27.1' - 27.6'	702.0 - 702.5	100	29	1,260
B-002-0-03		26.7' - 27.1'	701.8 - 702.2	100	37	7,930
B-002-0-03		40.1' - 40.5'	688.4 - 688.8	100	67	1,480
B-002-0-03		41.3' - 41.8'	687.1 - 687.6	100	67	11,340

NOTE: DATA FOR BORINGS B-001-0-03, B-002-0-03, AND B-003-0-03 OBTAINED FROM FMSM REPORT DATED SEPTEMBER 6, 2005.

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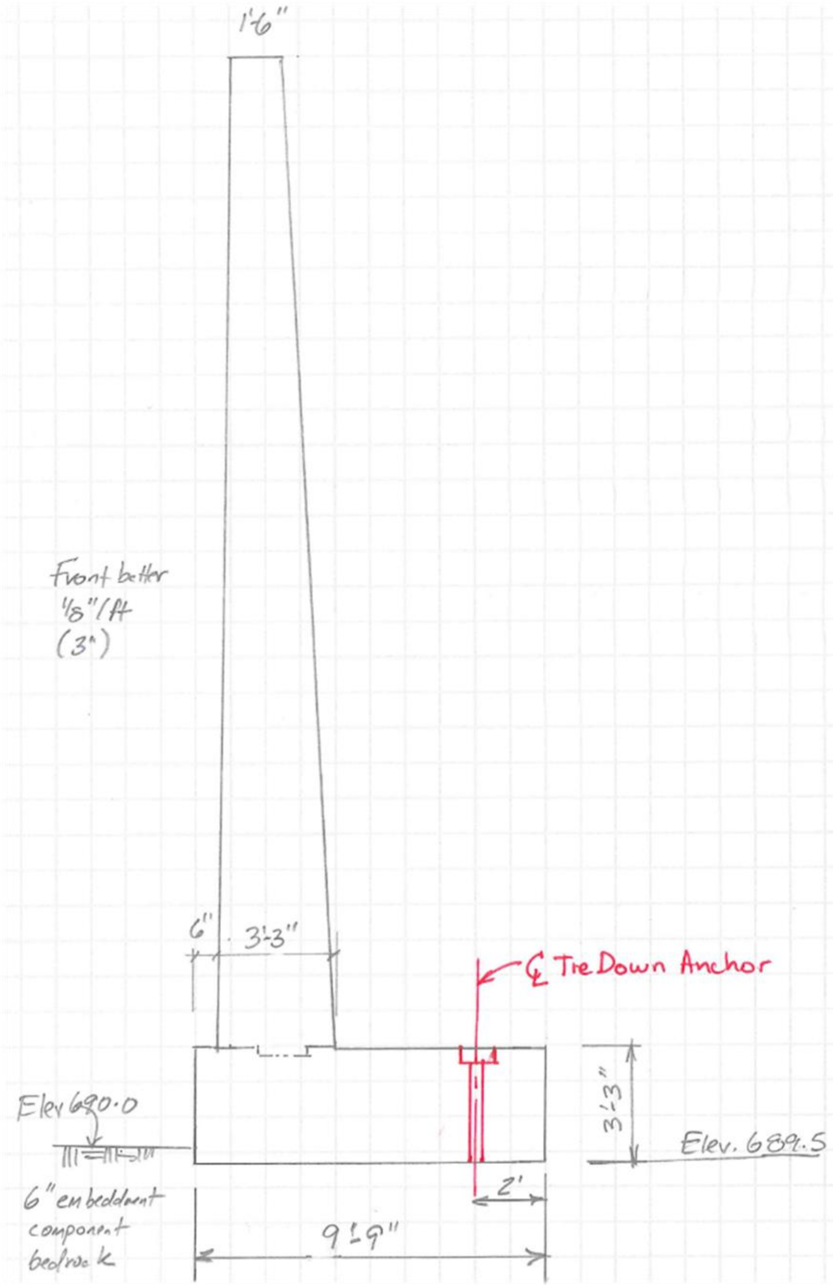
VECP Design



Initial Concept

- Narrow footing
- Tie down anchor to resist overturning and increase vertical force for sliding

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REJECTED

Photo - globalite - http://www.flickr.com/photos/globalite/6234411351/

ODOT District 3’s concerns

- Footing is 6” into shale while bid design has 10 ft rock socket for drilled shaft
- Lack of redundant load paths
- Cannot inspect tie-down anchors
- $45,000 shared savings is small

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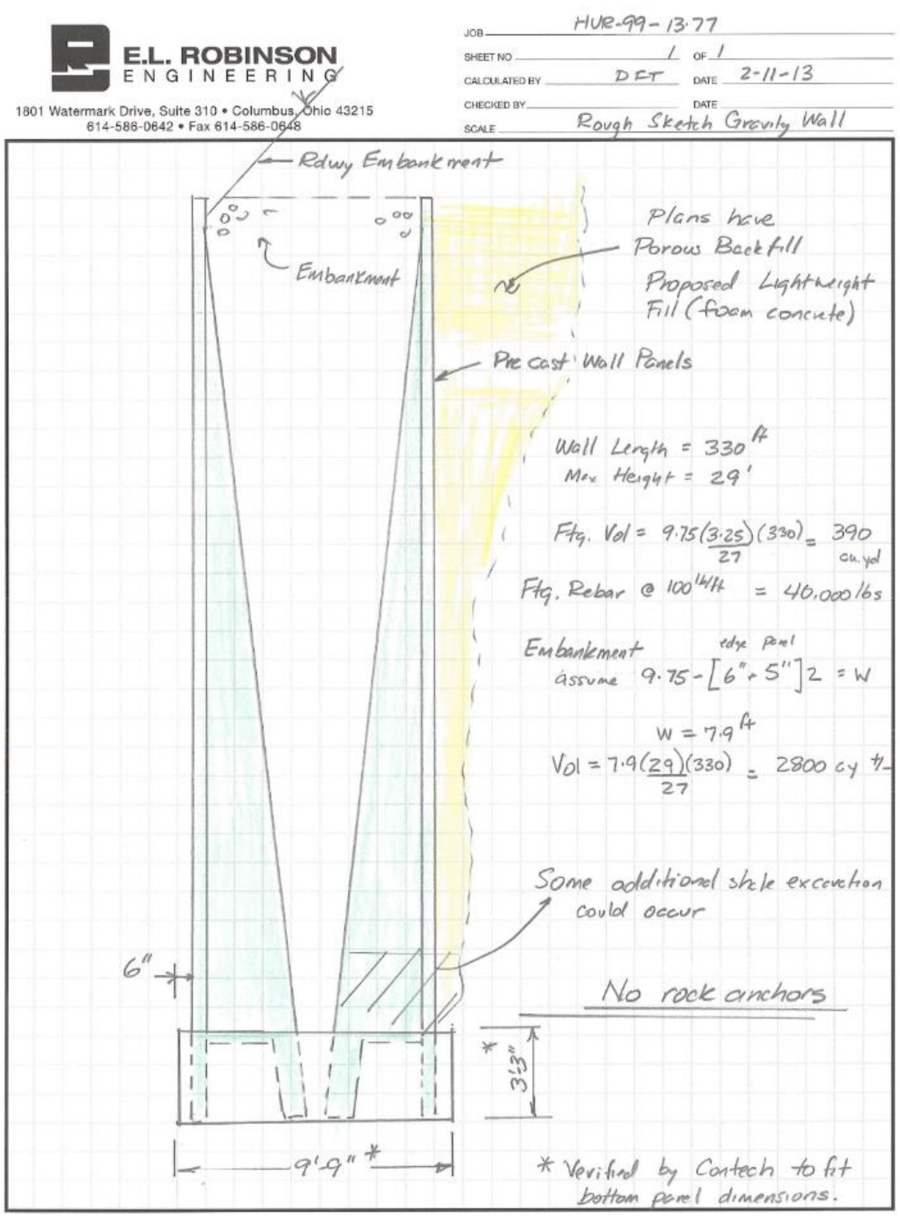
Contech MurEbal Precast Walls



Other ideas

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If at first you don’t succeed, Try, try again

“The Department has reviewed your response to the rejection of the Conceptual VECP Proposal … The Department does agree that a monolithic wall has some benefits when exposed to debris and flow in the river.”

Still concerned about:

- Scour and erosion
- Rock anchors totally inaccessible at completion

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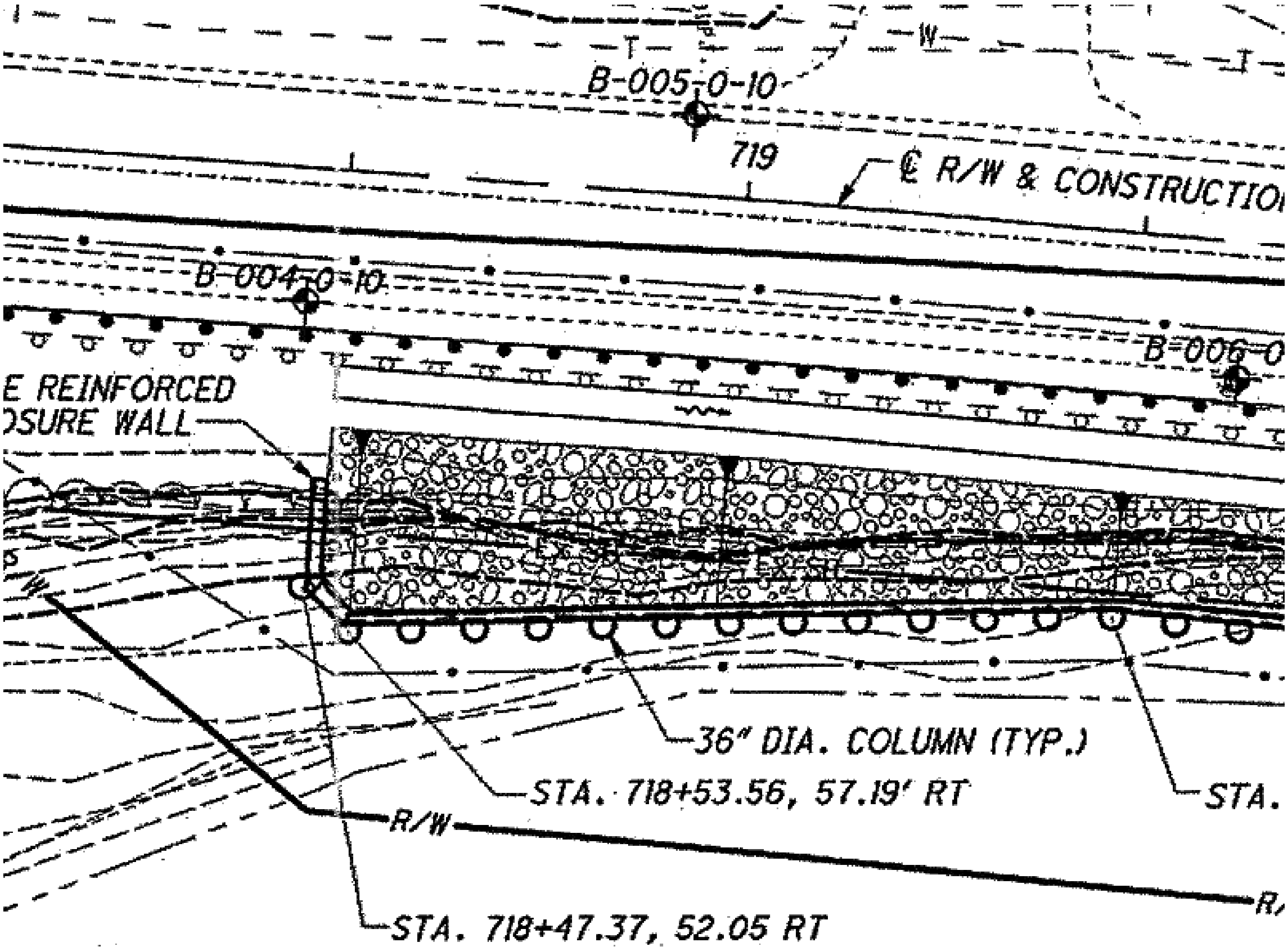
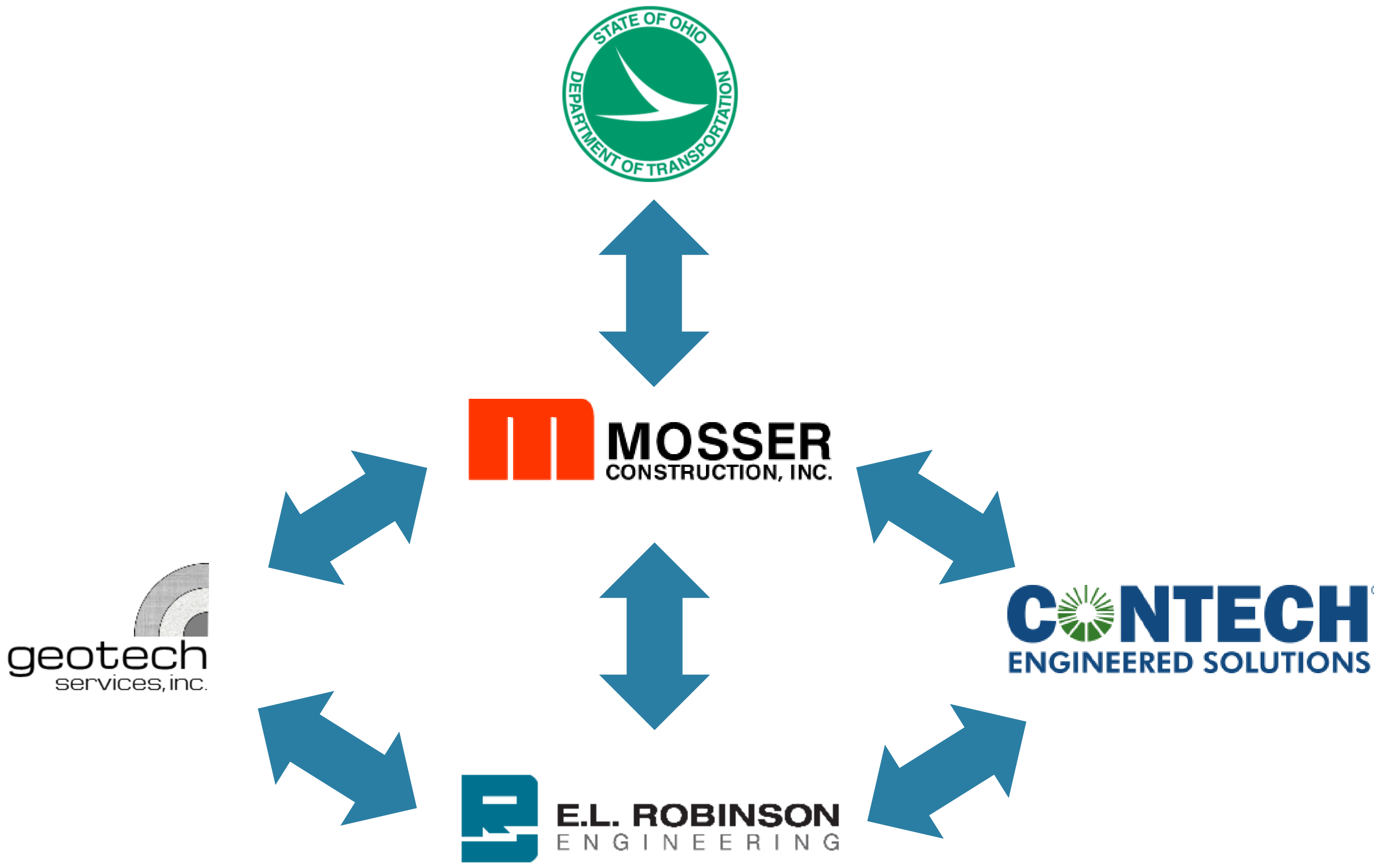
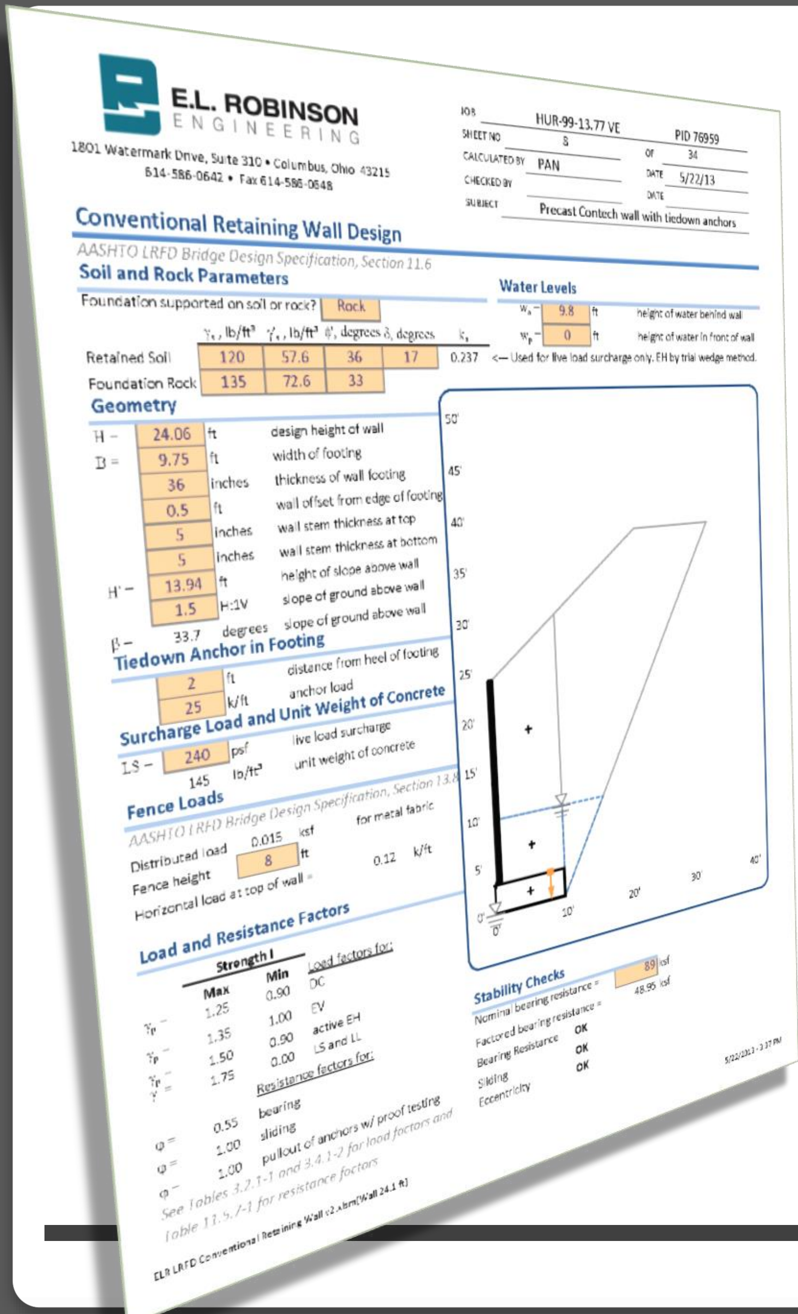

B-005-0-10
719
℄ R/W & CONSTRUCTIO
B-004-0-10
B-006-0
E REINFORCED
OSURE WALL
36" DIA. COLUMN (TYP.)
STA. 718+53.56, 57.19' RT
STA.
R/W
STA. 718+47.37, 52.05 RT

Design Coordination

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JOB HUR-99-13.77 VE PID 76959
SHEET NO 8 OF 34
CALCULATED BY PAN DATE 5/22/13
CHECKED BY DATE
SUBJECT Precast Contech wall with tiedown anchors

Conventional Retaining Wall Design

AASHTO LRFD Bridge Design Specification, Section 11.6

Soil and Rock Parameters

Foundation supported on soil or rock? Rock

	γ_t, lb/ft³	γ'_t, lb/ft³	ϕ', degrees	δ, degrees	k_a
Retained Soil	120	57.6	36	17	0.237
Foundation Rock	135	72.6	33		

<-- Used for live load surcharge only. EH by trial wedge method.

Water Levels

w_a = 9.8 ft height of water behind wall
w_p = 0 ft height of water in front of wall

Geometry

H =	24.06	ft	design height of wall
B =	9.75	ft	width of footing
	36	inches	thickness of wall footing
	0.5	ft	wall offset from edge of footing
	5	inches	wall stem thickness at top
	5	inches	wall stem thickness at bottom
H' =	13.94	ft	height of slope above wall
	1.5	H:1V	slope of ground above wall
β =	33.7	degrees	slope of ground above wall

Tiedown Anchor in Footing

2	ft	distance from heel of footing
25	k/ft	anchor load

Surcharge Load and Unit Weight of Concrete

LS =	240	psf	live load surcharge
	145	lb/ft³	unit weight of concrete

Fence Loads

AASHTO LRFD Bridge Design Specification, Section 13.8

Distributed load 0.015 ksf for metal fabric
Fence height 8 ft
Horizontal load at top of wall = 0.12 k/ft

Load and Resistance Factors

	Strength I Max	Strength I Min	Load factors for:
γ_p =	1.25	0.90	DC
γ_p =	1.35	1.00	EV
γ_p =	1.50	0.90	active EH
γ =	1.75	0.00	LS and LL

Resistance factors for:

φ =	0.55	bearing
φ =	1.00	sliding
φ =	1.00	pullout of anchors w/ proof testing

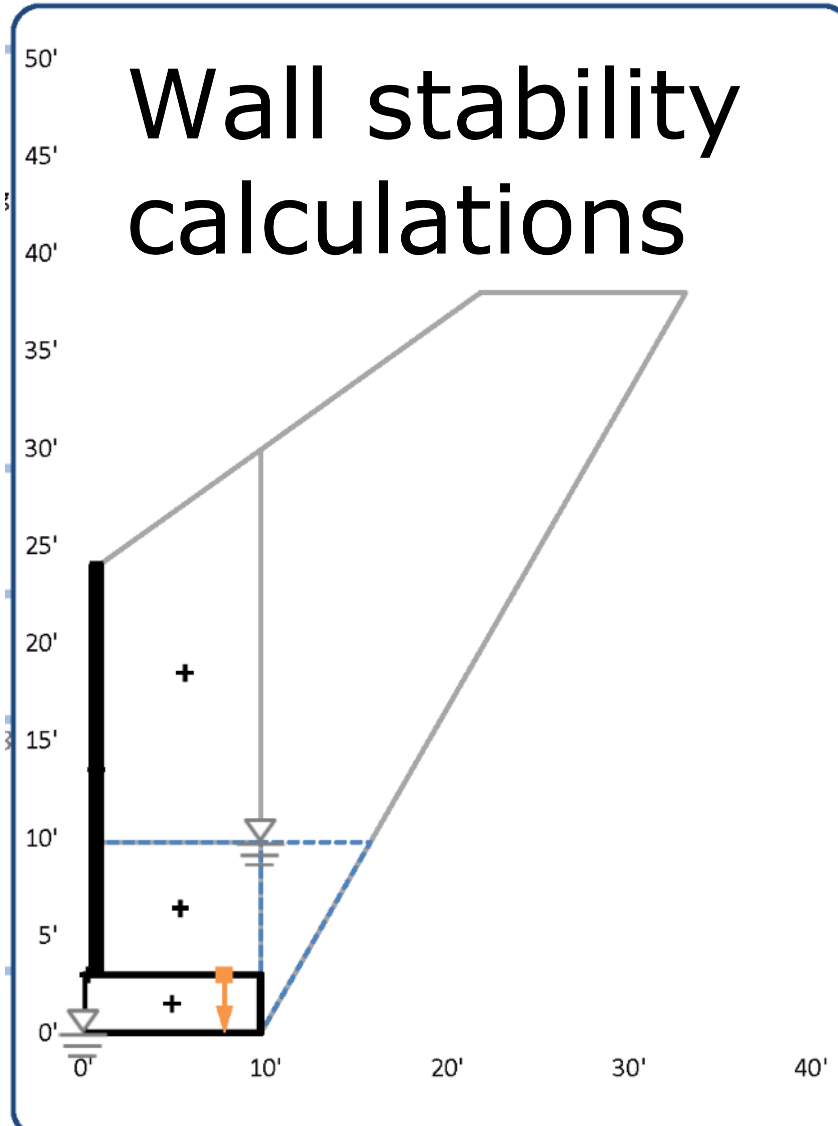
See Tables 3.4.1-1 and 3.4.1-2 for load factors and Table 11.5.7-1 for resistance factors

Stability Checks

Nominal bearing resistance = 89 ksf
Factored bearing resistance = 48.95 ksf
Bearing Resistance OK
Sliding OK
Eccentricity OK

5/22/2013 - 3:37 PM
ELR LRFD Conventional Retaining Wall v2.xlsm[Wall 24.1 ft]

Wall stability calculations



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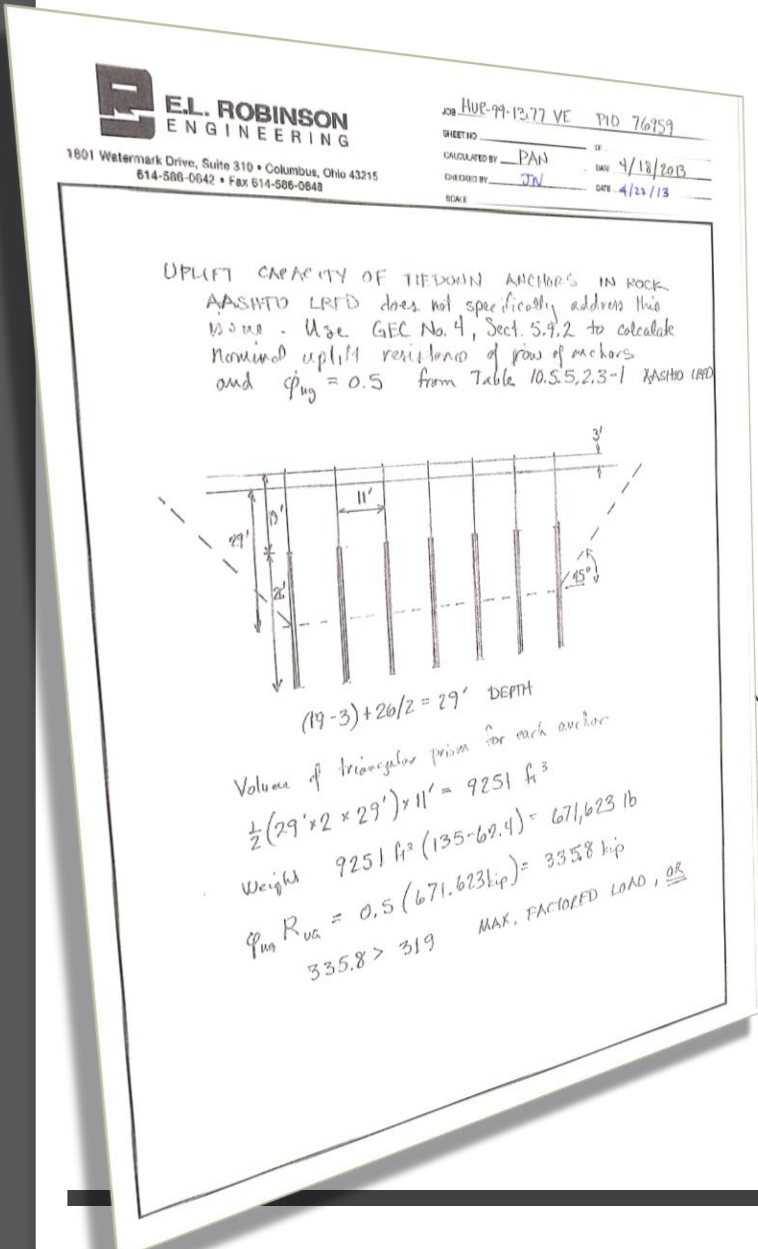
Uplift anchor calculations



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SHEET NO. OF
CALCULATED BY PAN DATE 4/18/2013
CHECKED BY JN DATE 4/22/13
SCALE

UPLIFT CAPACITY OF TIEDOWN ANCHORS IN ROCK
AASHTO LRFD does not specifically address this issue. Use GEC No. 4, Sect. 5.9.2 to calculate nominal uplift resistance of row of anchors and $\varphi_{ug} = 0.5$ from Table 10.5.5.2.3-1 AASHTO LRFD

3' 11' 19' 29' 26' 45°

(19-3) + 26/2 = 29' DEPTH

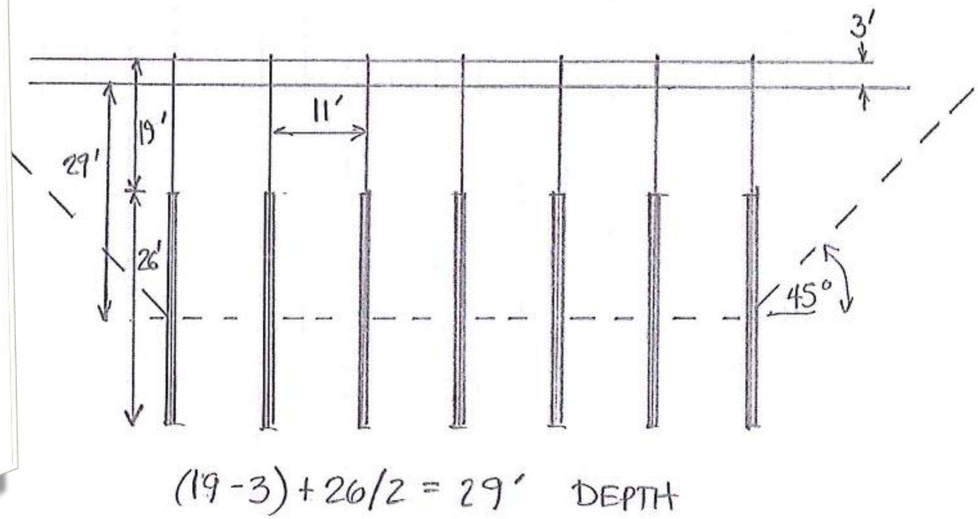
Volume of triangular prism for each anchor

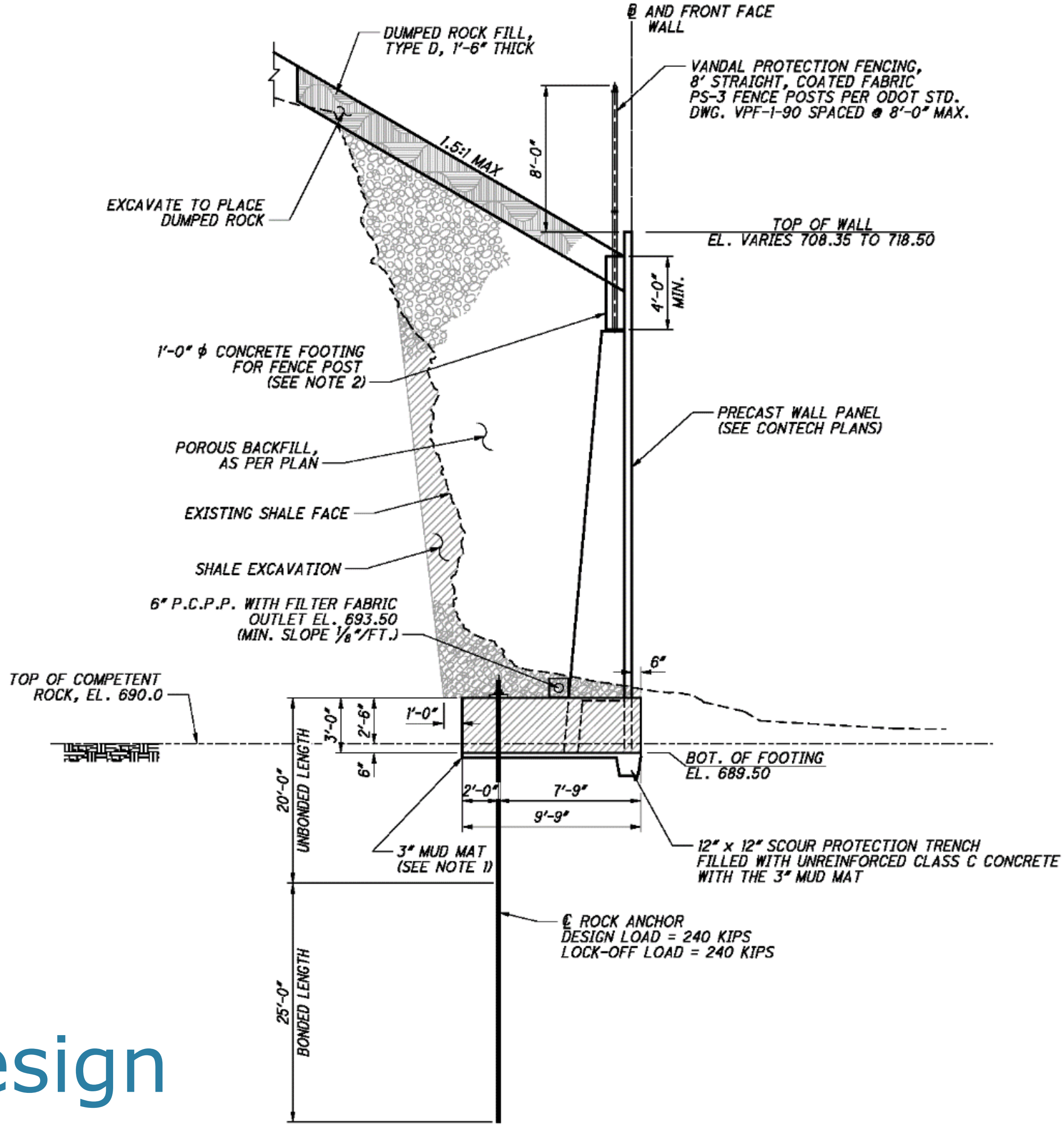
$\frac{1}{2}(29' \times 2 \times 29') \times 11' = 9251\ ft^3$

Weight $9251\ ft^3 (135-62.4) = 671,623\ lb$

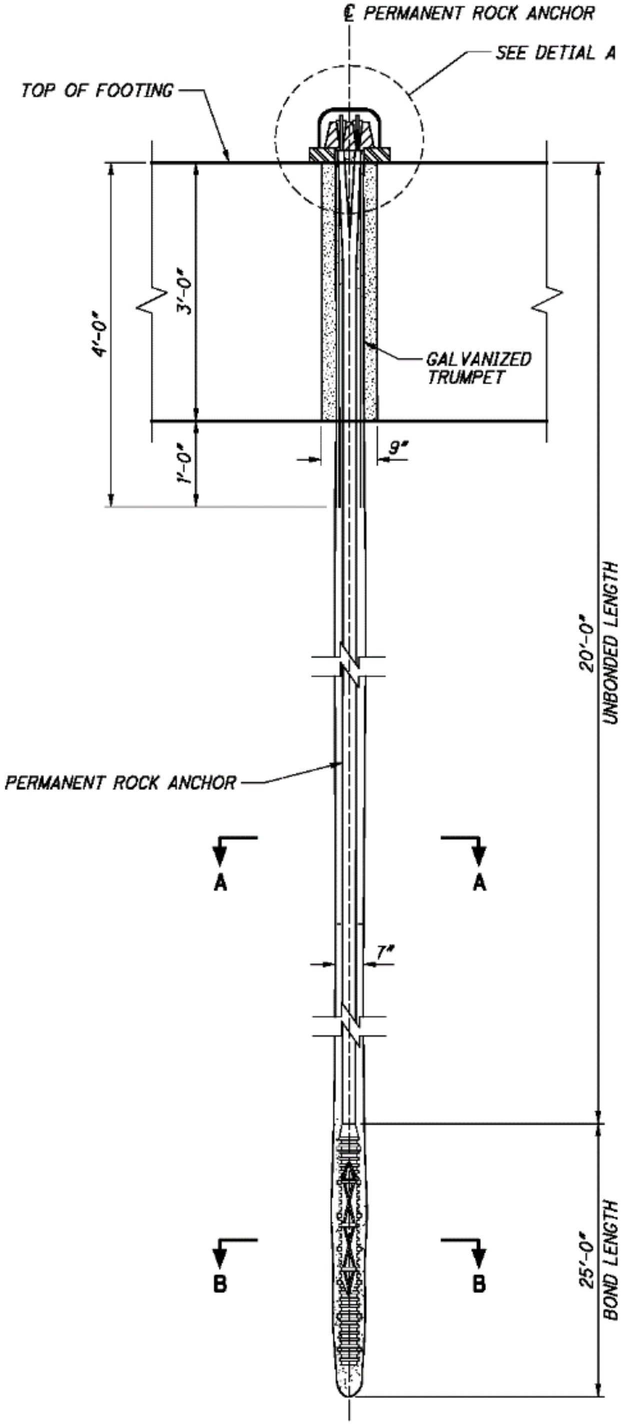
$\varphi_{ug} R_{UG} = 0.5\,(671.623\ kip) = 335.8\ kip$ MAX. FACTORED LOAD, OR

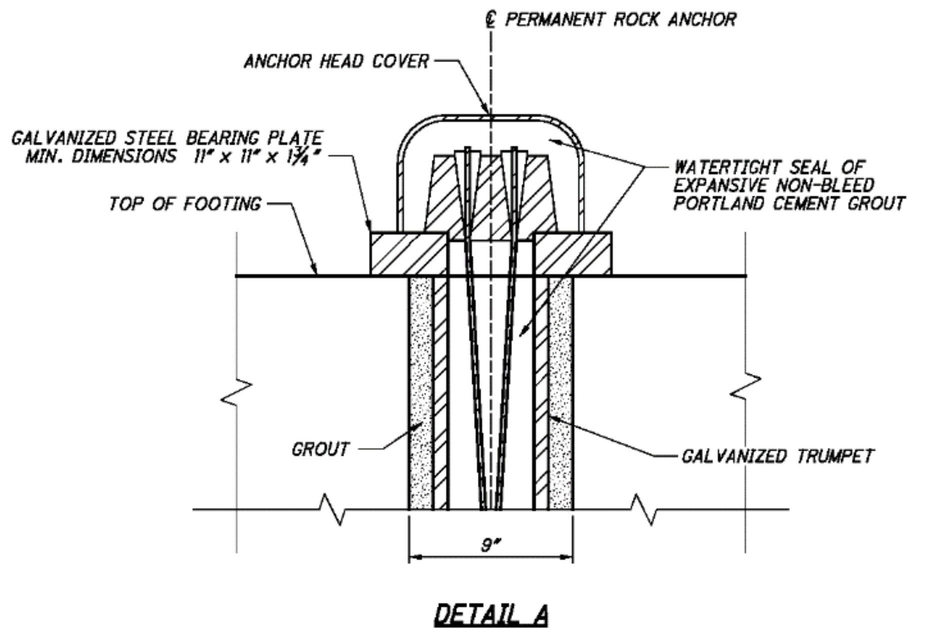
$335.8 > 319$





Final design





Anchor design

Construction


SCHUG'S
HOLSTEINS
VOLVO


CDI
CDI

Present Day


41.23017, -82.70344, 181.0m,
09/08/2016 9:47:34


41.23032, -82.70307, 176.0m, 251°
09/08/2016 9:57:01 AM


41.23033, -82.70306, 174.0m, 13°
09/08/2016 9:57:22 AM

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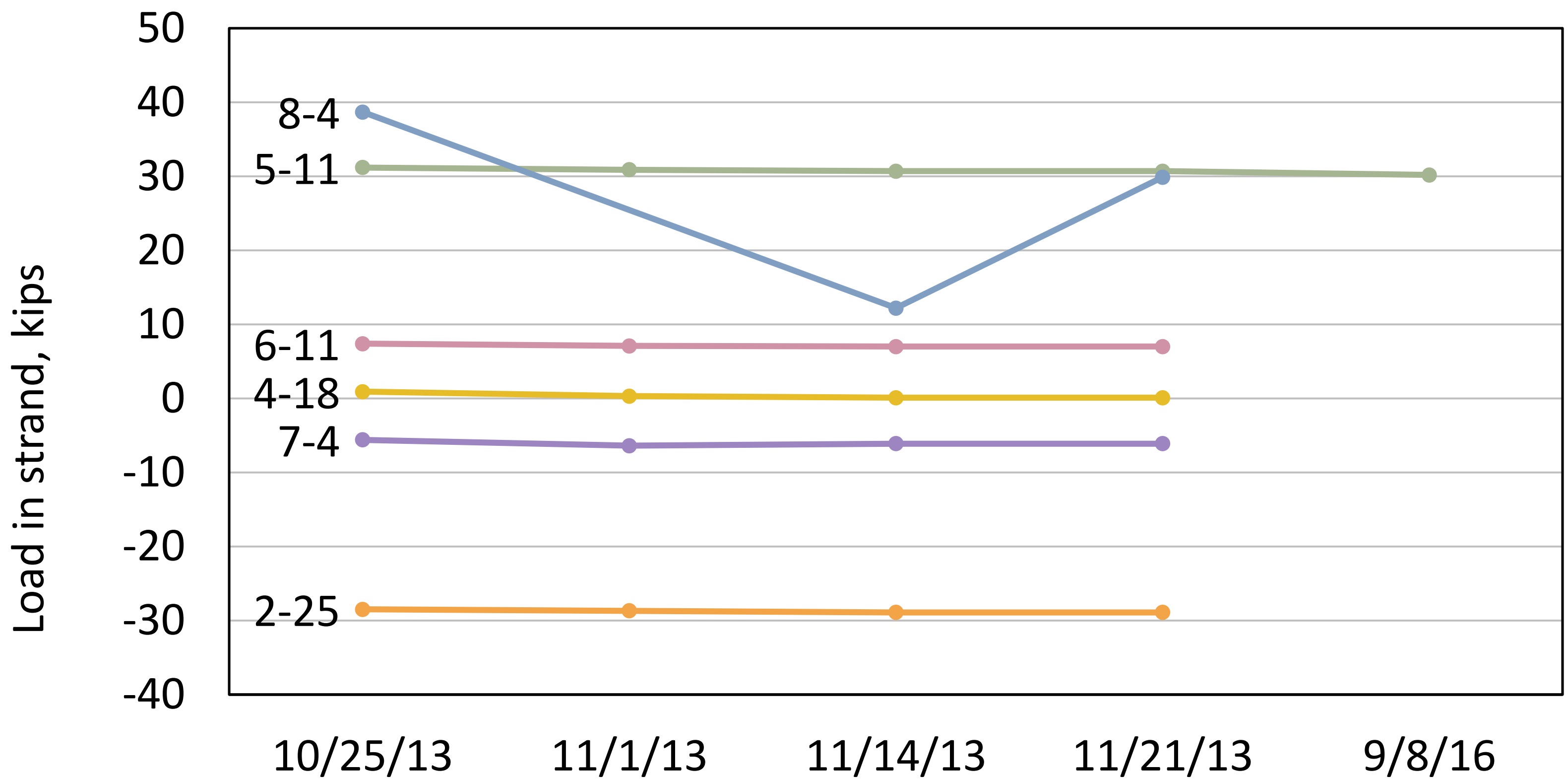
Strand gage readings



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SCHUG'S
HOLSTEINS


ASK MORE
QUESTIONS
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