Geotechnical Design & Construction

Mir Zaheer P.E.
INDOT Geotechnical Services Division

NextLevel INDIANA

Geotechnical Report

A tool used to communicate the site conditions and design and construction recommendations to the roadway design, bridge design, and construction personnel.

- Comprehensive Geotechnical Reports (GRs):
  - Results of all office studies, site investigations, laboratory test results, analyses of conditions relevant to multiple design elements (e.g., structures, roadway, drainage, etc.) and recommendations for design and construction.
- Geotechnical Reports/Technical Memos:
  - Focused on one phase of the design, (e.g., preliminary, intermediate, final).
- Geotechnical Reports/Technical Memos:
  - Focused on one design element, such as a bridge or retaining wall, a drainage culvert or a stormwater retention pond.

NextLevel INDIANA

Geotechnical Report

- Geotechnical Data Reports (GDRs):
  - Contains factual information and data from an office and field investigation and laboratory testing program for design elements of a project. These are typically developed by, or for, the owner and are used for Design-Build (DB) contracts. They are provided to proposal teams as a basis for developing designs and costs for the pursuit phase of the project. Owner agencies typically indicate any supplemental investigations required are the responsibility of the contractor.
- Geotechnical Reports/Technical Memos:
  - Can be developed as technical memos or even emails, for covering a single design element or the modification of an element covered in a previous GR.
- Geotechnical Reports Using existing previous data:
  - Analyses and recommendations for relatively minor or localized modifications to a previously submitted GR could also be incorporated as an Addendum to that GR. This could allow the modification to be included in the final document and not require duplication of background information contained in the initial GR.

Purposes of Geotechnical Reports:

- Provide information used during project programming to establish the scope of work for projects with significant geotechnical features
- Provide project management personnel and owners an adequate pre-construction understanding of impacts that geotechnical considerations will/may have on cost and schedule, as well as other project considerations such as environmental, traffic and constructability
- Provide design disciplines with the geotechnical information they need to develop their designs, as well as construction plans and specifications
- Provide contractors with the information they need to develop a complete and competitive bid with an acceptable level of risk that is also cost effective for the owner
- Provide information that will allow project construction staff to recognize and understand site subsurface conditions at the time of design development prior to construction
- Provide owners with information that the contractor has met minimum accepted levels of investigations and design requirements, as well as provide information for future design elements, improvements, new construction, and maintenance

Basic Information Needed in a Geotechnical Report

All Geotechnical Reports shall contain certain basic information including:

- Summary of all subsurface exploration data, including a subsurface soil and/or rock profile, exploration logs, laboratory or in-situ test results and groundwater information;
- Interpretation and analysis of subsurface data;
- Specific engineering recommendations for design;
- Summary of limit states as well as loading conditions;
- Performance requirements (post-construction deformations and phase construction or sequencing);
- Discussion of conditions for solution of anticipated problems; and
- Recommended geotechnical special provisions.

Suggested Format of a Geotechnical Report

- Title Page
- Table of Contents
- Executive Summary
- Introduction
- Procedures and Results
- Field Investigations
- Laboratory Testing
- Summary of Analyses
- Discussion of subsurface conditions and design considerations, including geology, seismicity and geologic hazards.
- Recommendations (for design and construction of project elements)
- Construction Recommendations (including construction observations, testing and instrumentation)
- Figures (e.g., Location Map, Drawings, etc.)
- Appendices
  - A - Boring and Test Pit logs, etc.
  - B - In-situ Test Results
  - C - Laboratory Test Results
  - Other Appendices as necessary: photos, instrumentation data, analyses, etc

NextLevel INDIANA

INDOT'S EXPECTATIONS

- Be responsible stewards of these investments
- Ensure high quality and cost effective services
- Obtain the greatest value for the money we spend
- Horizontal and vertical communication
- Better the specifications GREATER are the expectation of a BETTER bid
- The greater the risk for the contractor (the more he will charge us to do the work)
- Trade-offs among alternative designs
- All these are basically Asset Management

NextLevel INDIANA

VALUE – RISK - EXPECTATIONS

- Cost effective Asset Management
- Good economics and engineering
- Good communication
- Invest more in initial investigations
- What if analyses
- Cost effective design decisions
- Trade offs among alternative design and investigation options
- Technical information to support decision making

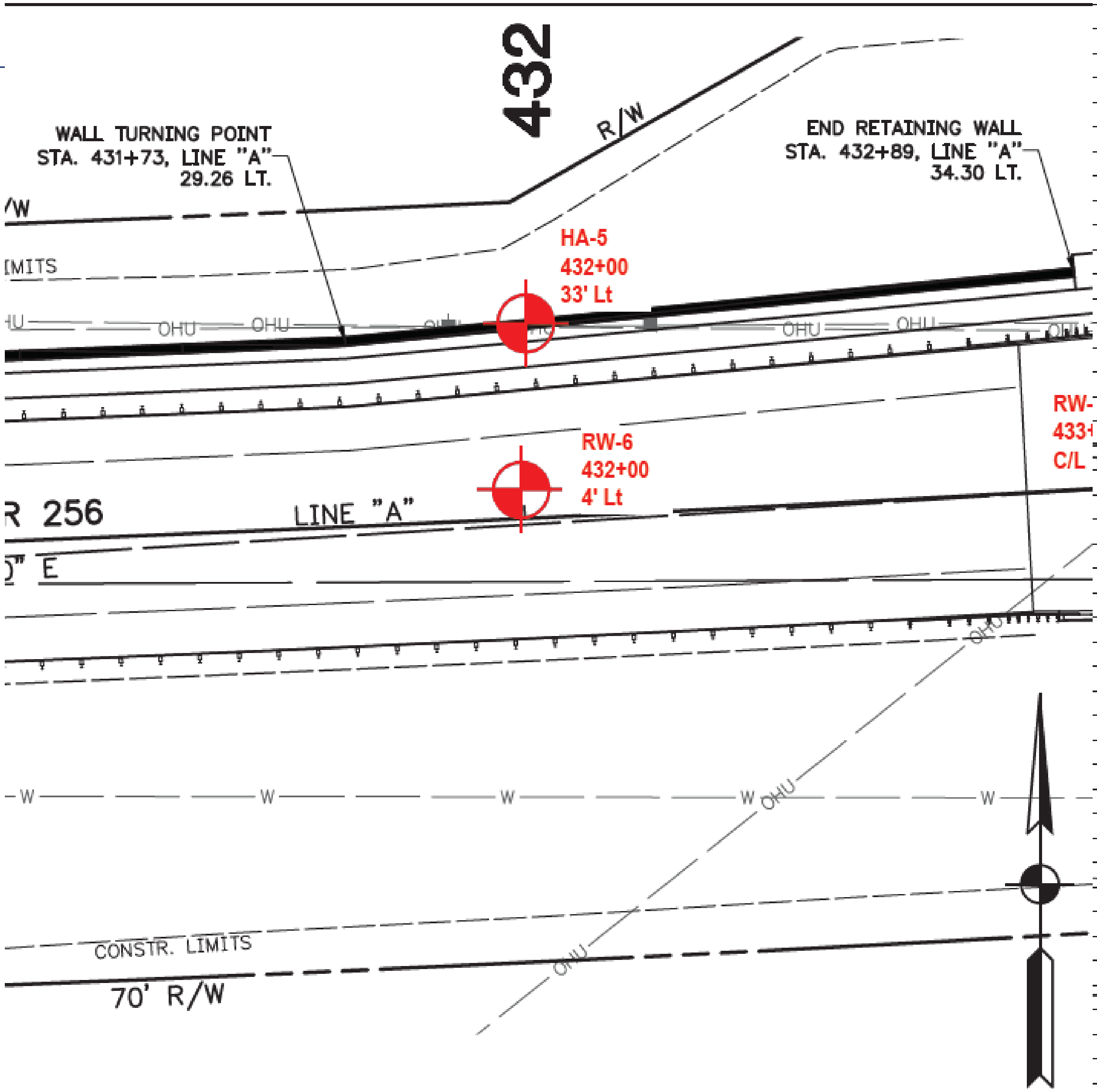
Example

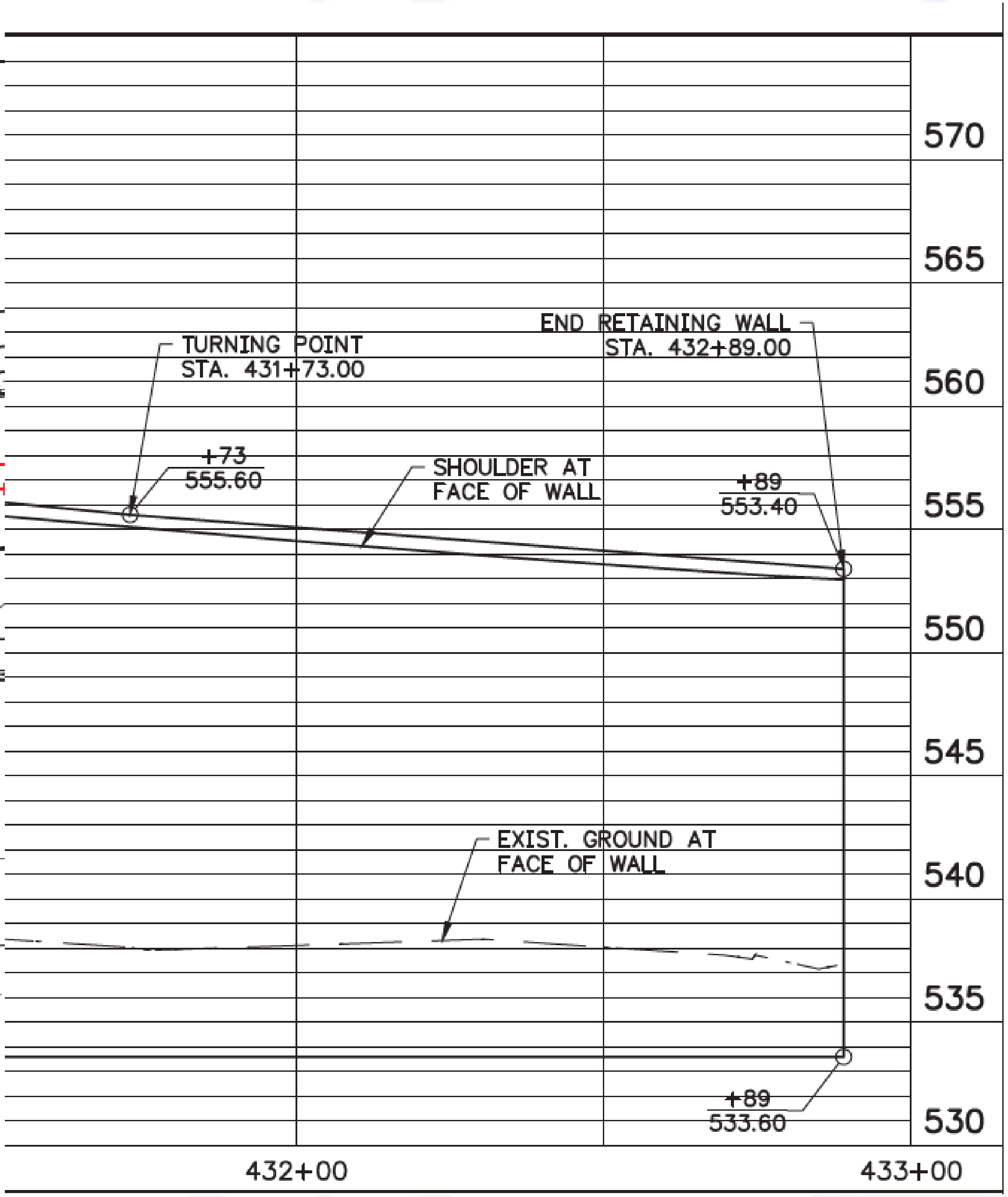
CRI – SR 256 Improvements, Scott County

- Geotechnical report estimated 11.3 inches consolidation settlement (57 weeks).
- Aggregate columns recommended for MSE walls

- CRI report estimated 3.77 inches consolidation settlement (5.1 month/ 22 weeks)
- 2 feet Undercut recommended for MSE walls

Geotechnical Report


432
R/W
WALL TURNING POINT
STA. 431+73, LINE "A"
29.26 LT.
END RETAINING WALL
STA. 432+89, LINE "A"
34.30 LT.
HA-5
432+00
33' Lt
OHU
RW-6
432+00
4' Lt
LINE "A"
W
CONSTR. LIMITS
70' R/W


570
565
560
555
550
545
540
535
530
END RETAINING WALL
STA. 432+89.00
TURNING POINT
STA. 431+73.00
+73
555.60
SHOULDER AT
FACE OF WALL
+89
553.40
EXIST. GROUND AT
FACE OF WALL
+89
533.60
432+00
433+00

TEST BORING RECORD

CLIENT : Indiana Department of Transportation
PROJECT : Roadway Rehabilitation
ROUTE NO. : SR 256 COUNTY : Scott & Jefferson
LOCATION : SR 256 from US 31 to SR 62 in Scott & Jefferson Counties
DES NO. : 0200035 PROJECT NO: 0200035

BORING NO. : RW- 6
SHEET : 1 OF 2
DATE STARTED : 06-17-09
DATE COMPLETED : 06-17-09
CTL PROJECT NO : 09050022IND

BORING ELEVATION : 545.0
STATION : 432+00
OFFSET : 4.0 feet Lt
LINE : 'A'
DEPTH : 36.9 feet

BORING METHOD : HSA
RIG TYPE : CME-75 Truck
CASING DIA. : 3.25" I.D.
CORE SIZE : ---

HAMMER : Automatic
DRILLER : TN
TEMPERATURE : 80° F
WEATHER : Sunny

GROUNDWATER: Encountered at 20.0 feet At completion 19.0 feet 6.9 feet After 24 hours Caved in at 28.5 feet

Stratum Elevation	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12" (N)	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	LL	PL	PI
544.1	**ASPHALT CONCRETE** (11") (Visual)	0.9										
543.6	**CEMENT CONCRETE** (5.5") (Visual)	1.4										
542.7	Brown and Gray, Moist, Medium Stiff, **CLAY (FILL)** A-6, As Lab 2	2.3	SS-1	2 3 4	7	100	17.5					
	Brown changing to Gray, Moist, Very Stiff to Very Soft, **SILTY CLAY LOAM** with Traces of Gravel, Roots, Organic Matter and Asphalt Fragments in SS-2 **(FILL)** A-6, As Lab 1		SS-2	3 3 16	19	100	19.8					
			SS-3	3 3 3	6	100	21.0	128.0	2.075 @ 15.0%			
536.0		9.0										
	Gray, Moist, Very Soft, **SILTY CLAY LOAM** with Traces of Organic Matter and Shale Fragments A-6, As Lab 5		SS-4	2 1 2	3	100	25.1					
531.9		13.2										
	Brown and Gray, Very Moist to Moist, Soft to Very Soft, **SILTY CLAY LOAM** A-6, As Lab 9		SS-5	2 2 2	4	100	26.2					
			SS-6	2 1 3	4	100	24.2					

Continued on next page

TEST BORING RECORD

CLIENT : Indiana Department of Transportation
PROJECT : Roadway Rehabilitation
BORING NO. : RW- 6
SHEET : 2 OF 2

Stratum Elevation	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12" (N)	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	LL	PL	PI
520.3	Brown and Gray, Very Moist to Moist, Soft to Very Soft, **SILTY CLAY LOAM** A-6, As Lab 9	24.7	SS-7	2 1 2	3	100	21.8					
	Gray, Moist, Very Soft to Stiff, **SILTY CLAY LOAM** with Shale Fragments A-6, As Lab 9		SS-8	1 2 3	5	100	28.0	124.7	1.113 @ 15.0%			
510.7		34.3	SS-9	3 3 9	12	100						
508.1	Black, Highly Weathered, **SHALE** (Visual)	36.9	SS-10	41 50/2"		100						

Bottom of Boring at 36.9 feet

Auger refusal on Shale at 36.9 feet.

Pavement restored with concrete patch.

Boring backfilled with soil cuttings.

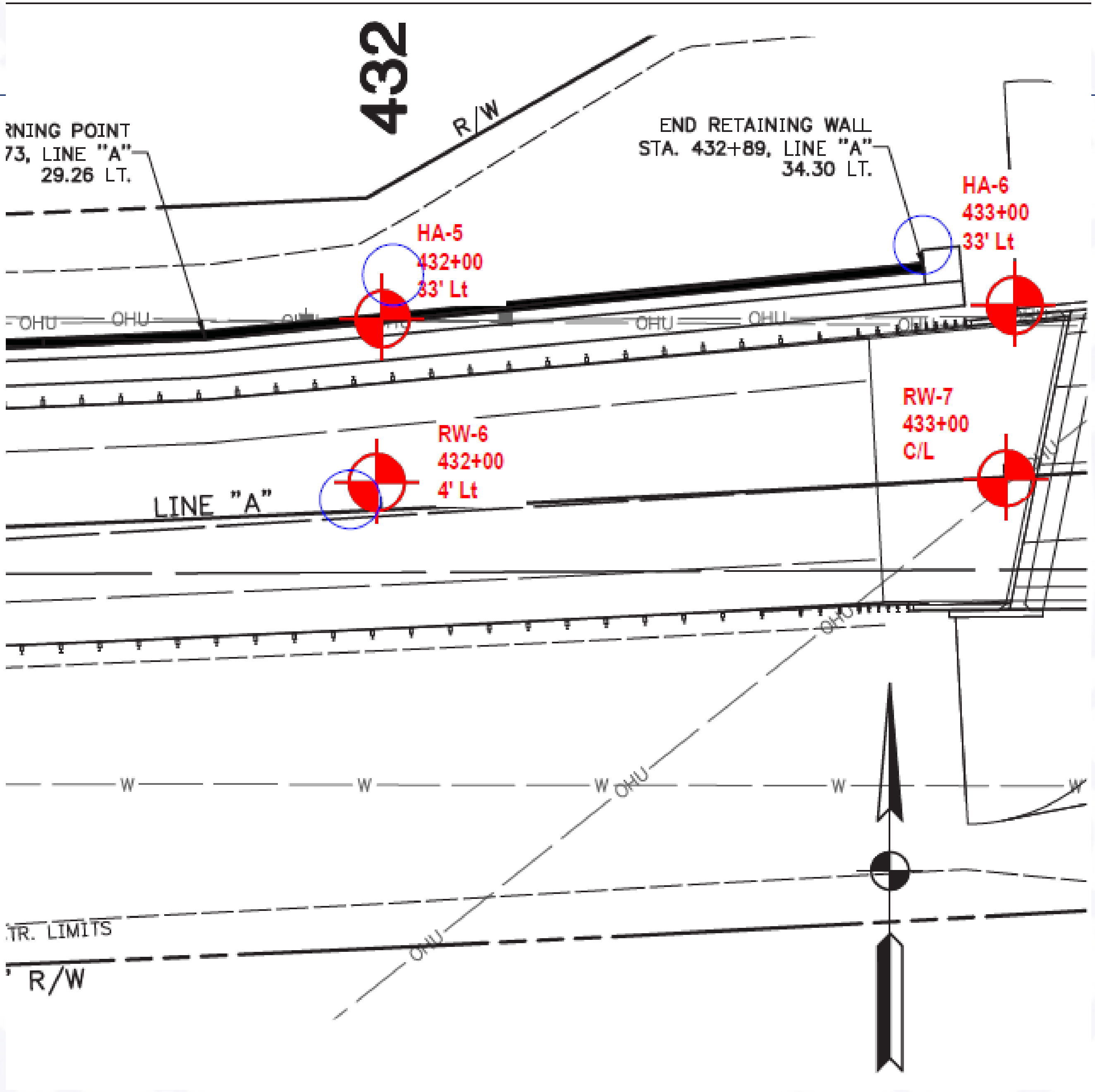
Moisture Content, w	25	26	23	26							
Specific Gravity, Gs	2.70	2.70	2.70	2.70							
Soil Total Unit Weight (d), pcf	120.0	120.0	120.0	120.0							
Effective Soil Unit Weight (d'), pcf	57.6	57.6	57.6	57.6							
Liquid Limit, LL	---	33	33	33							
Plastic Limit, PL	---	17	18	18							
Average Blowcounts, N	---	---	---	---							
Average Corrected Blowcount, N160	---	---	---	---							

Void Ratio, eo = (Gs * w) / 100	---	0.702	0.621	0.702							
Compression Index, Cc* = 0.156*eo + 0.0107	---	0.12	0.11	0.12							
Compression Index, Cr* = w / 1000	---	0.03	0.02	0.03							
Undrained Shear Strength, S_u (psf)	---	500	500	500							
S_u/P_0	---	1.302	0.659	0.392							
OCR	---	3.000	2.000	1.000							
Preconsolidation Pressure, Pc (psf)*	---	**1152**	**1517**	**1274**							
BCI' (FHWA)	---	---	---	---							
Overburden Pressure, Po (psf)	240	384	758	1274							

Soil parameters eo, Cc, Cr, OCR and C' were estimated using FHWA-NHI-05-123 and FHWA-06-088

Soil Layer	Above Footing	A	B	C	D	E	F	G			
Soil Type	SCL	SCL	SCL	SCL							
Strata Top Elevation (E1)	535.6	533.6	528.6	520.6							
Strata Bottom Elevation (E2)	533.6	528.6	520.6	510.7							
Soil Strata Thickness (H = E1-E2)), feet	2.0	5.0	8.0	9.9							
Footing Half Width (B_1), feet		10.7	10.7	10.7							
Depth to Mid-point (z), feet		2.5	9.0	18.0							
Ratio B_1/z		4.3	1.2	0.6							
Influence Factor for half loading, I'		0.49	0.44	0.32							
Influence Factor, I (Osterberg) Check		0.98	0.87	0.63							
Influence Factor, I (Boussinesq)		0.99	0.87	0.62							
Pressure Increase, Delta P = Qn x I		4770	4163	2983							
Settlement/Layer (inches)		3.2	3.7	4.4							
Estimated Total Settlement (inches)		11.3									
Immediate Settlement		0.0									
Longterm Settlement		11.3									

CRI Report



NextLevel INDIANA

ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	SAMPLE NUMBER	SPT per 6"	% RECOVERY	MOISTURE CONTENT	DRY DENSITY, pcf	POCKET PEN., tsf	UNCONF. COMP., tsf	ATTERBERG LIMITS LL	PL	PI	REMARKS
535.0	2.5	**Silty Clay**, soft, moist, brown, with slag to 3 ft	SS 1	2-2-2	22	26.3	104.4	0.5					
	5.0	5.0	ST 1		100	22.6		<0.25 2.25		27	19	8	4.5, UU = 0.772 tsf
530.0	7.5	**Silty Loam**, soft, moist, brown, A-4(4), Lab No. 25198 8.0	SS 2	1-2-2	56	24.5 22.6		0.5 0.25		25	18	7	6.0, SS-2T/B : pH = 6.4, S.G. = 2.72
	10.0	**Silty Loam**, moist, brown, A-4(3), Lab No. 25199 10.0	ST 2		100	20.5		<0.25 <0.25		24	18	6	8.0, ST-2 : pH = 7.6, S.G. = 2.70 9.0, UU = 0.285 tsf
525.0	12.5	**Silty Clay Loam**, soft, moist, brown, with silty clay seam near 11 ft, A-6, Lab No. 25204	SS 3	1-2-3	67	29.0 27.9	100.3	0.5 2.0					
	15.0	15.0	ST 3		100	26.9 24.7		<0.25 1.25		47 43 39	17 17 19	30 26 20	
520.0	17.5	**Silty Loam**, very soft, moist, gray, A-4, Lab No. 25198 18.0	SS 4	1-1-2	28	27.9		2.0		28	20	8	
	20.0	**Silty Loam**, moist, gray, with some organic matter, with trace marl, A-6(10), Lab No. 25200 20.0	ST 4		100	25.8		0.5 1.25		33	22	11	18.0, ST-4 : pH = 7.5, S.G. = 2.68, LOI = 5.2 percent, $CaCo_3$ = 7.5 percent 19.0, UU = 0.637 tsf
	22.5	**Sandy Loam**, stiff, moist, gray, with weathered fragments throughout, with silty loam seam near 28 ft, with some organic matter, with trace marl, A-2-4(0), Lab No. 25201	SS 5	3-5-7	33	21.0		<0.25					
515.0	25.0		SS 6	3-5-6	56	29.7 19.6		<0.25 0.25		33	26	7	23.5, SS-6T/B : pH = 7.5, S.G. = 2.61, LOI = 8.6 percent, $CaCo_3$ = 4.8 percent
510.0	27.5	29.2	SS 7	16-50/4	21	15.3		0.25					
	30.0	Bottom of Boring at 29.2 ft											
505.0	32.5 35.0												

TEST BORING RECORD

CLIENT : Indiana Department of Transportation		BORING NO. :	**RW- 6**
PROJECT : Roadway Rehabilitation		SHEET :	1 OF 2
ROUTE NO. : SR 256	COUNTY : Scott & Jefferson	DATE STARTED :	06-17-09
LOCATION : SR 256 from US 31 to SR 62 in Scott & Jefferson Counties		DATE COMPLETED :	06-17-09
DES NO. : 0200035	PROJECT NO: 0200035	CTL PROJECT NO :	09050022IND

BORING			
ELEVATION : 545.0	BORING METHOD : HSA	HAMMER : Automatic	
STATION : 432+00	RIG TYPE : CME-75 Truck	DRILLER : TN	
OFFSET : 4.0 feet Lt	CASING DIA. : 3.25" I.D.	TEMPERATURE : 80° F	
LINE : 'A'			
DEPTH : 36.9 feet	CORE SIZE : ---	WEATHER : Sunny	

GROUNDWATER: Encountered at 20.0 feet; At completion 19.0 feet; 6.9 feet After 24 hours; Caved in at 28.5 feet

Stratum Elevation	Sample Depth	SOIL/MATERIAL DESCRIPTION	Stratum Depth	Sample Number	SPT per 6"	SPT per 12" (N)	Recovery (%)	Moisture Content (%)	Total Unit Weight (pcf)	Unconfined Compression (ksf)	Atterberg Limits LL	PL	PI
544.1		**ASPHALT CONCRETE** (11") (Visual)	0.9										
543.6		**CEMENT CONCRETE** (5.5") (Visual)	1.4										
542.7	2.5	Brown and Gray, Moist, Medium Stiff, **CLAY (FILL)** A-6, As Lab 2	2.3	SS-1	2 3 4	7	100	17.5					
	5.0	Brown changing to Gray, Moist, Very Stiff to Very Soft, **SILTY CLAY LOAM** with Traces of Gravel, Roots, Organic Matter and Asphalt Fragments in SS-2 **(FILL)** A-6, As Lab 1		SS-2	3 3 16	19	100	19.8					
536.0	7.5		9.0	SS-3	3 3 3	6	100	21.0	128.0	2.075 @ 15.0%			
531.9	10.0 12.5	Gray, Moist, Very Soft, **SILTY CLAY LOAM** with Traces of Organic Matter and Shale Fragments A-6, As Lab 5	13.2	SS-4	2 1 2	3	100	25.1					
	15.0 17.5	Brown and Gray, Very Moist to Moist, Soft to Very Soft, **SILTY CLAY LOAM** A-6, As Lab 9		SS-5	2 2 2	4	100	26.2					
	20.0			SS-6	2 1 3	4	100	24.2					

Continued on next page

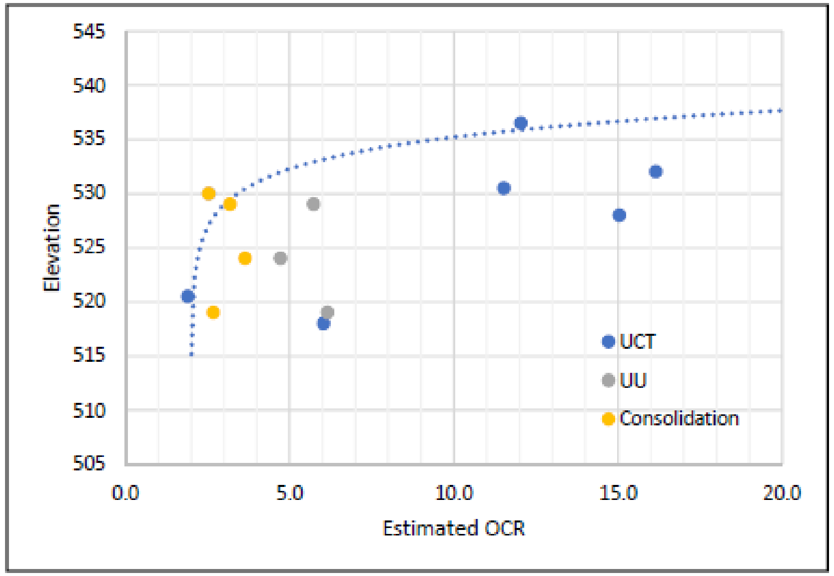
Evaluation of settlement of embankment fill using consolidation theory

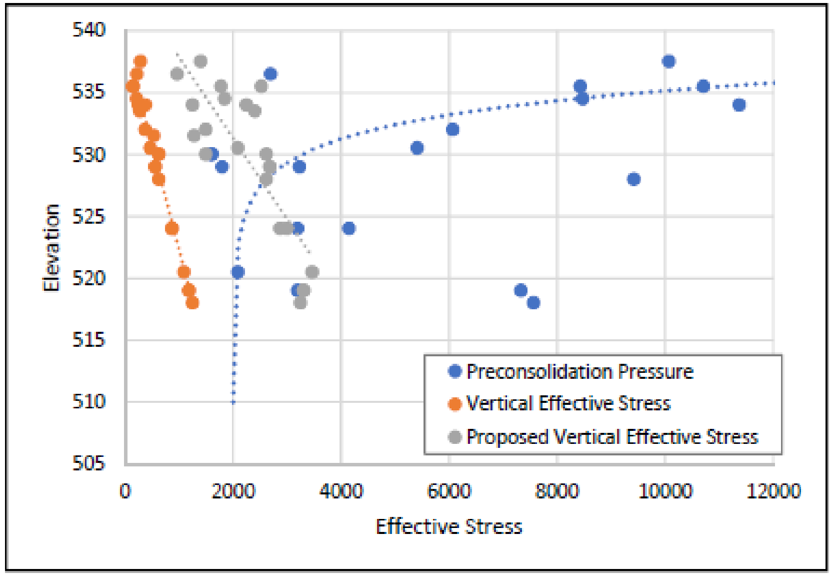
Cc (A-4 Silty Loam) =	0.11	ilty Clay Loam) =	0.27	A-4 Silty Loam) =	0.11	Cc (A-6 Silty Loam) =	0.18
Cr (A-4 Silty Loam) =	0.008	ilty Clay Loam) =	0.045	A-4 Silty Loam) =	0.008	Cr (A-6 Silty Loam) =	0.018
e (A-4 Silty Loam) =	0.67	ilty Clay Loam) =	0.84	A-4 Silty Loam) =	0.67	e (A-6 Silty Loam) =	0.81

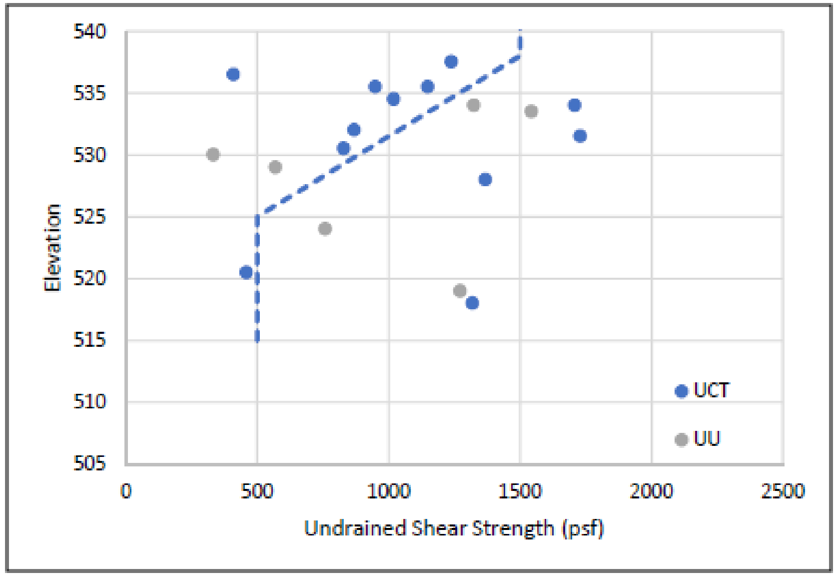
Cα '(Secondary Compression Index)= 5% of Cc

Depth (ft)	Elevation	Soil Profile	Po (psf)	Westergaard Factor	Delta P (psf)	Po midlayer	Delta P midlayer	Po + Delta P midlayer	Pre-cons. (psf)	Incremental S (in.)	Accum. S (in.)	Accumulative Predicted Settlement (in.)	Secondary S 6 mos - 5 yr (in)	Secondary S 6 mos - 10 yr (in)	Secondary S 6 mos - 50 yr (in)
0	538	A-4 Silty Loam	0	1.000	2125	-	-	-	-	-	-	-			
1	537	A-4 Silty Loam	63	1.000	2125	31	2125	2156	12000	0.11	0.11	0.11	0.07	0.09	0.13
2	536	A-4 Silty Loam	125	0.990	2104	94	2114	2208	12000	0.08	0.18	0.18	0.07	0.09	0.13
3	535	A-4 Silty Loam	188	0.970	2061	157	2083	2239	10000	0.07	0.25	0.25	0.07	0.09	0.13
4	534	A-4 Silty Loam	250	0.960	2040	219	2051	2270	8500	0.06	0.31	0.31	0.07	0.09	0.13
5	533	A-4 Silty Loam	313	0.940	1998	282	2019	2300	7000	0.05	0.36	0.36	0.07	0.09	0.13
6	532	A-4 Silty Loam	376	0.930	1976	344	1987	2331	5500	0.05	0.41	0.41	0.07	0.09	0.13
7	531	A-4 Silty Loam	438	0.910	1934	407	1955	2362	4000	0.04	0.45	0.45	0.07	0.09	0.13
8	530	A-4 Silty Loam	501	0.901	1915	470	1924	2394	3000	0.04	0.49	0.49	0.07	0.09	0.13
9	529	A-4 Silty Loam	563	0.888	1887	532	1901	2433	2800	0.04	0.53	0.53	0.07	0.09	0.13
10	528	A-4 Silty Loam	626	0.874	1857	595	1872	2467	2600	0.04	0.57	0.57	0.07	0.09	0.13
11	527	A-6 Silty Clay Loam	689	0.864	1836	657	1847	2504	2400	0.20	0.76	0.76	0.16	0.21	0.32
12	526	A-6 Silty Clay Loam	751	0.853	1813	720	1824	2544	2200	0.25	1.02	1.02	0.16	0.21	0.32
13	525	A-6 Silty Clay Loam	814	0.835	1774	783	1794	2576	2000	0.31	1.33	1.33	0.16	0.21	0.32
14	524	A-6 Silty Clay Loam	876	0.824	1751	845	1763	2608	1752.8	0.40	1.73	1.73	0.16	0.21	0.32
15	523	A-6 Silty Clay Loam	939	0.810	1721	908	1736	2644	1878	0.35	2.08	2.08	0.16	0.21	0.32
16	522	A-4 Silty Loam	1002	0.807	1715	970	1718	2688	2003.2	0.12	2.20	2.20	0.07	0.09	0.13
17	521	A-4 Silty Loam	1064	0.795	1689	1033	1702	2735	2128.4	0.10	2.31	2.31	0.07	0.09	0.13
18	520	A-4 Silty Loam	1127	0.784	1666	1096	1678	2773	2253.6	0.09	2.40	2.40	0.07	0.09	0.13
19	519	A-6 Silty Loam	1189	0.775	1647	1158	1656	2815	2378.8	0.12	2.52	2.52	0.11	0.14	0.22
20	518	A-6 Silty Loam	1252	0.756	1607	1221	1627	2847	2504	0.10	2.62	2.62	0.11	0.14	0.22
21	517	A-2-4 Sandy Loam	1315	0.744	1581	1283	1594	2877			A-2-4 Sandy Loam treated as drainage layer (no consolidation settlement)				
												Total	**1.88**	**2.45**	**3.77**

Westergaard factor based on embankment width of 70 ft and a strip load
Say OCR = 2 below Elevation 525



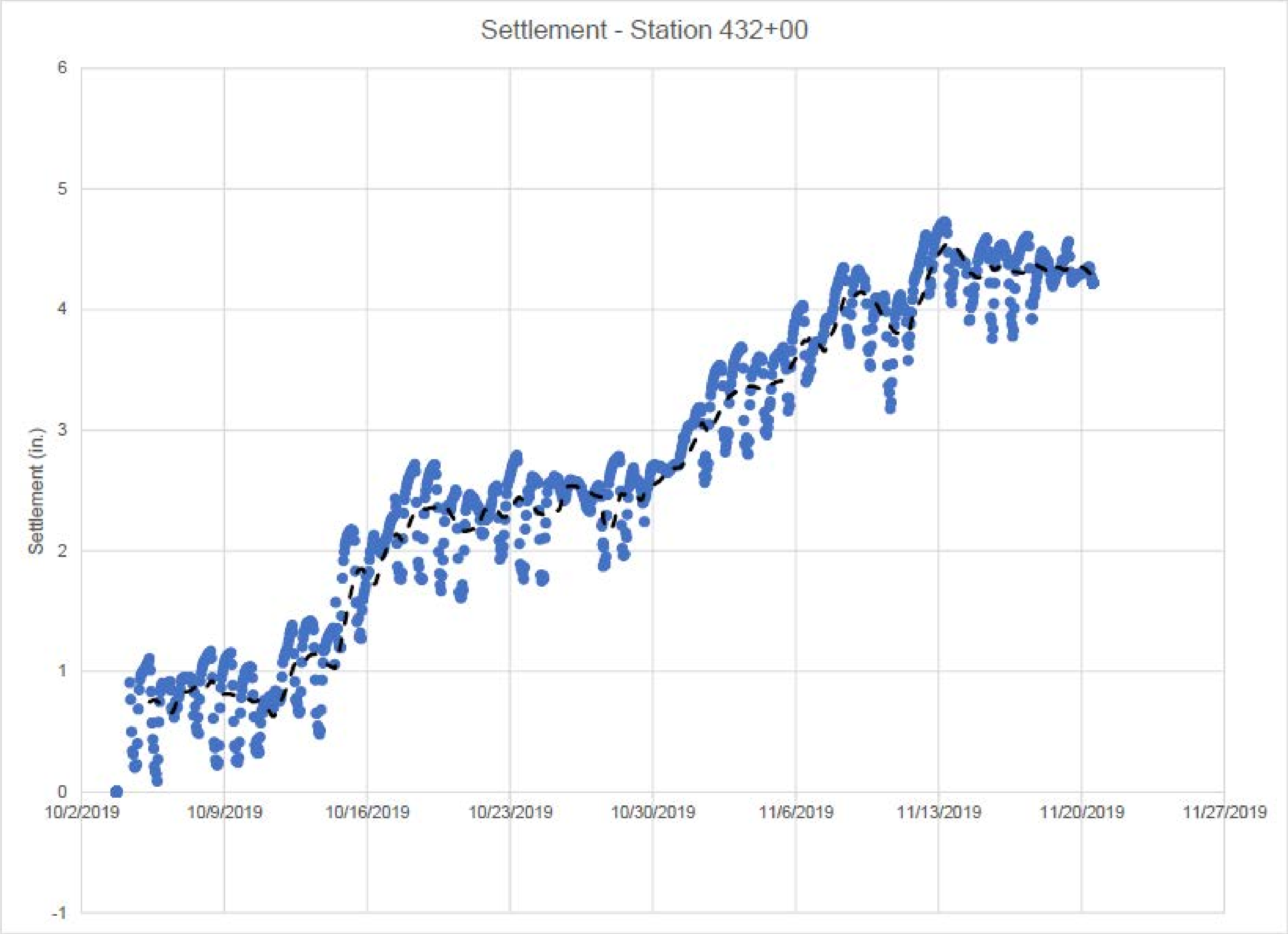




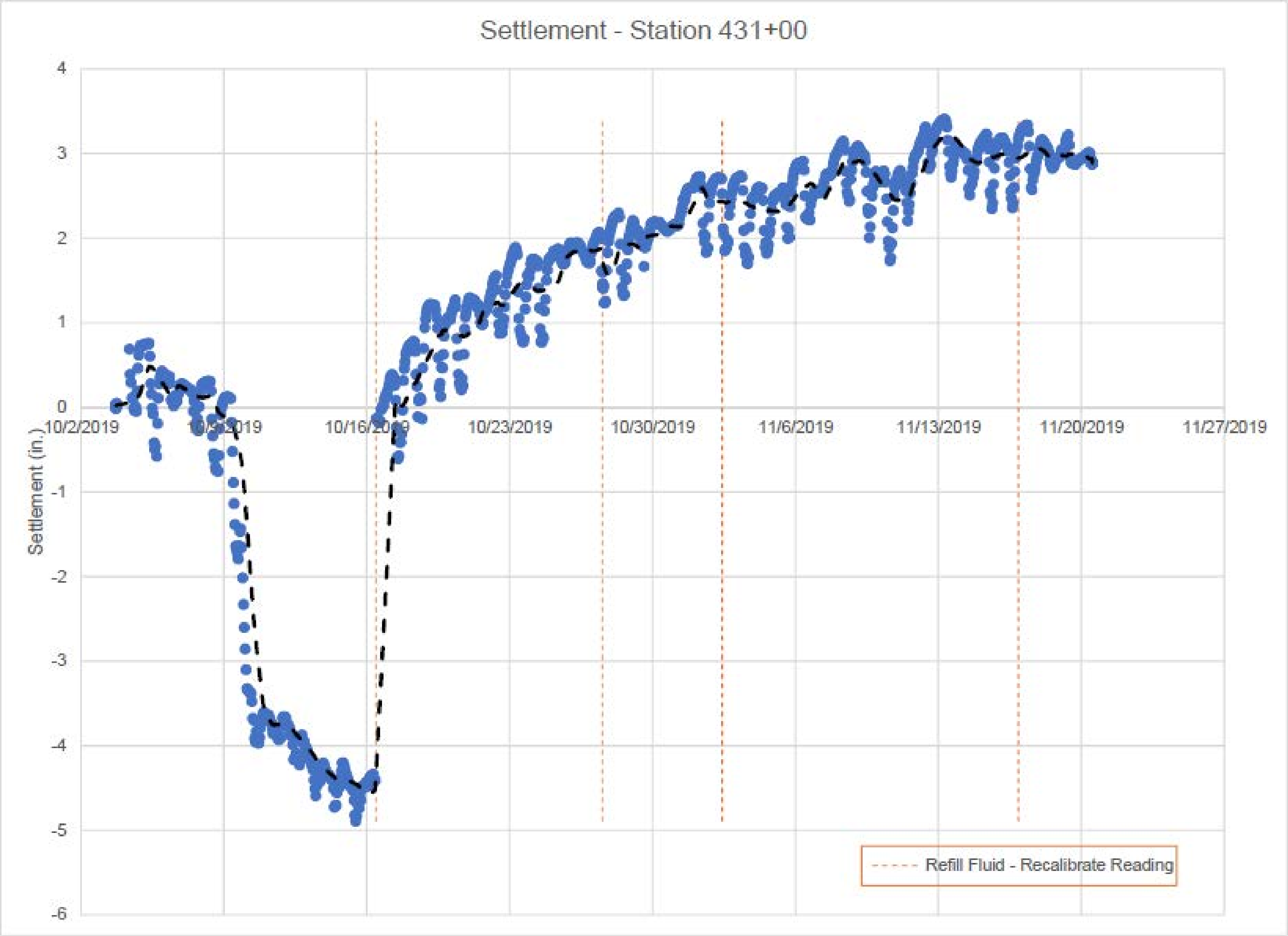
Correlation between undrained shear strength (Su) and OCR based on the following approximation with S = 0.25 and m = 0.8.

$$\frac{S_u}{\sigma'_v} = S(OCR)^m$$

Monitoring Data



NextLevel INDIANA



NextLevel INDIANA

Pile Driving & Construction

Pile Hammer Performance During Pile Driving

No two pile hammers perform the same way. Below are the examples of two Pileco D30-32 hammers used on one contract and also on hammer that came back after maintenance was also monitored during PDA testing. The results are below:

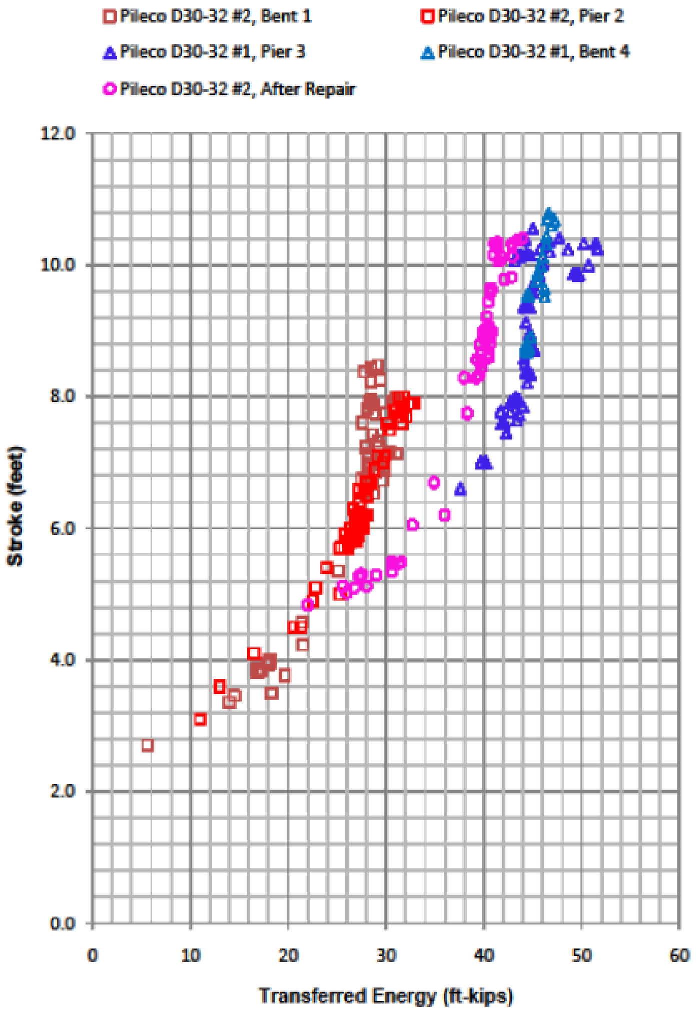


Figure 2. Hammer Performance Comparison Including Repaired Pileco D30-32

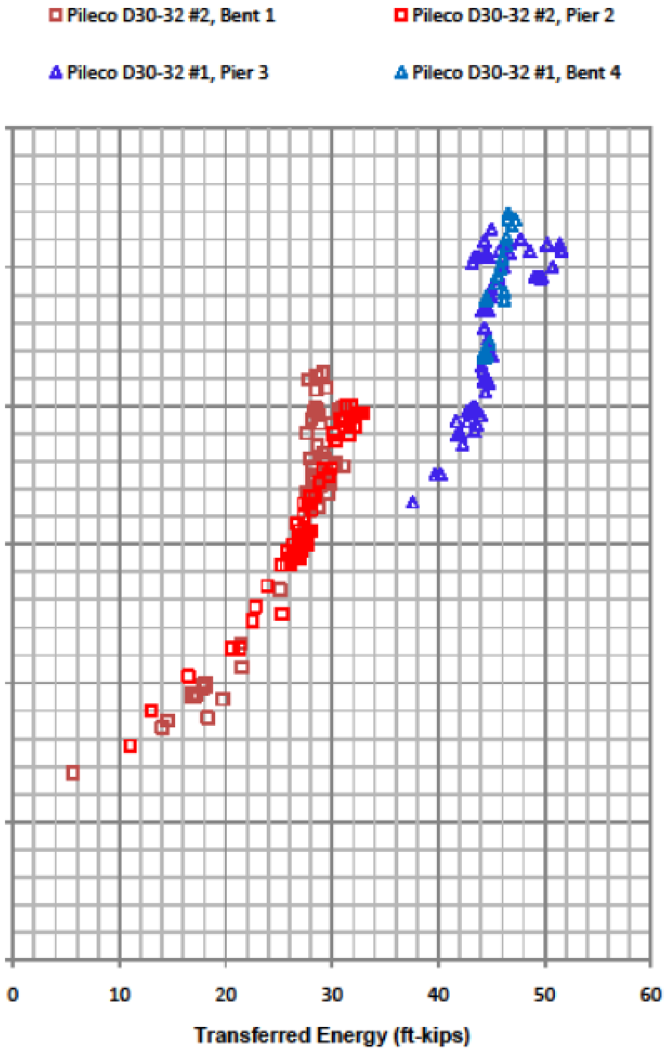


Figure 1. Hammer Performance Comparison

Piling Cost for Pile Driven by Formula Testing Paid to the Contractor for FY 2009 thru 2014 as of May 28, 2015

FY	Number of Contracts	Test Pile Indicator Production (ft)	Test Pile Indicator Restrike (#)	Cost of Indicator Test Pile Production (701-09558)	Cost of Test Pile Indicator Restrike (701-09560)	Paid Pile lengths (ft)	Cost of Piling	Total Paid Pile Length (ft)	Total Cost of Piling	Average Pile Cost/Lft
2009	52	0	0	$ -	$ -	65,693	$ 3,443,240.00	65,693	$ 3,443,240.00	$ 52.41
2010	50	378	5	$ 14,607.54	$ 5,562.45	43,522	$ 1,896,544.63	43,900	$ 1,916,714.62	$ 43.66
2011	49	1958	44	$ 92,352.57	$ 53,586.22	38,785	$ 2,250,768.06	40,743	$ 2,396,706.85	$ 58.82
2012	29	888	20	$ 58,085.46	$ 41,062.67	27,580	$ 1,540,159.11	28,468	$ 1,639,307.24	$ 57.58
2013	15	697	10	$ 31,537.33	$ 13,847.50	12,040	$ 555,941.80	12,737	$ 601,326.63	$ 47.21
2014	24	1878	43	$ 104,031.02	$ 63,190.00	17,256	$ 1,174,436.62	19,134	$ 1,341,657.64	$ 70.12
Total	*219*	*5799*	*122*	*$ 300,613.92*	*$ 177,248.84*	*204,876*	*$ 10,861,090.22*	*210,675*	*$ 11,338,952.98*	*$ 53.82*
				2.7%	*1.6%*					

Piling Cost & PDA testing Cost Data for FY 2009 thru 2014 as of May 28, 2015

FY	Number of Contracts	Paid Production Pile (ft)	Paid Test Pile (ft)	Total Pile length Paid (ft)	Total Paid Pile Cost	Test Pile Dynamic Production (701-09557)	Total pile Cost	Test Pile Restrike Cost Paid to Contractor (701-09559)	PDA/DPLT cost paid to Contractor (701-06011)	Total Cost Paid to GRL for PDA/DLT	Total Cost of Piling	Average Pile Cost/Lft
2009	29	252,276	11,629	263,905	$ 13,036,549.33	$ 581,380.99	$ 13,617,930.32	$ 310,035.97	$ 373,437.18	$ 354,006.25	$ 14,655,409.72	$ 55.53
2010	27	172,495	5,988	178,483	$ 7,344,338.30	$ 253,152.06	$ 7,597,490.36	$ 152,785.74	$ 245,120.90	$ 498,946.78	$ 8,494,343.78	$ 47.59
2011	37	195,581	13,942	209,523	$ 9,730,184.48	$ 660,372.88	$ 10,390,557.36	$ 243,295.35	$ 350,339.42	$ 629,095.65	$ 11,613,287.78	$ 55.43
2012	36	113,254	8,236	121,490	$ 5,824,651.04	$ 430,689.41	$ 6,255,340.45	$ 195,159.70	$ 251,674.44	$ 940,002.50	$ 7,642,177.09	$ 62.90
2013	24	91,746	4,628	96,375	$ 4,481,481.97	$ 278,857.31	$ 4,760,339.28	$ 99,044.23	$ 110,710.28	$ 748,970.00	$ 5,719,063.79	$ 59.34
2014	31	107,809	8,697	116,506	$ 5,185,810.73	$ 450,866.60	$ 5,636,677.33	$ 213,677.10	$ 302,056.56	$ 485,237.59	$ 6,637,648.58	$ 56.97
										$ (397,175.00)	$ (397,175.00)	
	184	933,161	53,120	986,281	$ 45,603,015.85	$ 2,655,319.25	$ 48,258,335.10	$ 1,213,998.09	$ 1,633,338.78	$ 3,259,083.77	$ 54,364,755.74	$ 55.12
								2.23%	3.00%	5.99%		

$ Paid on DB Contracts

Quantity Volitility As a function of Driving Criteria Methodology

Pile Quanitities driven with Gates Formula criteria

FY	# of Contracts	Original Quantity	Current Quantity	Quantity Placed To-Date	Diff: Current Quantity and Quantity Placed	Average Total Quanity per Contract	Average Overrun/Underrun per Contract	% Overrun/Under Run
2008	47	52,817.69	51,677.31	45,125.88	(6,551.43)	960.13	(139.39)	-15%
2009	49	61,180.00	69,036.41	62,335.53	(6,700.87)	1,272.15	(136.75)	-11%
2010	52	47,142.46	44,902.66	40,255.18	(4,647.48)	774.14	(89.37)	-12%
2011	49	48,045.26	46,203.97	38,432.89	(7,771.08)	784.34	(158.59)	-20%
2012	29	30,598.00	27,219.60	25,733.29	(1,486.31)	887.35	(51.25)	-6%
2013	15	15,374.00	14,368.05	13,546.59	(821.47)	903.11	(54.76)	-6%
2014	25	18,218.20	19,118.20	14,765.65	(4,352.55)	590.63	(174.10)	-29%
Totals	266	273,375.60	272,526.20	240,195.00	(32,331.20)	902.99	(121.55)	-13%

Pile Quantities driven with PDA criteria

FY	# of Contracts	Original Quantity	Current Quantity	Quantity Placed To-Date	Diff: Current Quantity and Quantity Placed	Average Total Quanity per Contract	Average Overrun/Underrun per Contract	% Overrun/Under Run
2008	12	59,918.72	61,685.38	54,963.12	(6,722.26)	4,580.26	(560.19)	-12%
2009	30	255,927.02	244,553.14	245,706.15	1,153.01	8,190.21	38.43	0%
2010	25	184,338.02	179,282.77	168,991.07	(10,291.70)	6,759.64	(411.67)	-6%
2011	37	184,219.80	205,894.14	198,887.08	(7,007.06)	5,375.33	(189.38)	-4%
2012	36	132,856.11	127,122.21	111,670.00	(15,452.21)	3,101.94	(429.23)	-14%
2013	24	95,480.50	104,084.47	94,177.10	(9,907.37)	3,924.05	(412.81)	-11%
2014	30	138,679.10	151,321.60	140,400.98	(10,920.62)	4,680.03	(364.02)	-8%
Totals	194	1,051,419.27	1,073,943.71	1,014,795.50	(59,148.21)	5,230.90	(304.89)	-6%

Upcoming Changes

Assuring Quality in Geotechnical Reports

Ref. FHWA GEC 014

Geotechnical Consultants Role:

The role and responsibility of consultants if they are performing geotechnical investigations and developing Geotechnical Report's is to:

- Review and understand the scope of the project and the geotechnical needs.
- Perform the investigation and analyses consistent with owner requirements and/or industry standards (e.g., AASHTO, FHWA, GDM, etc.).
- Develop recommendations, including existing or new details and specifications necessary to implement recommendations.
- Verify that recommendations, including details and specifications, have been properly included in the plans and specifications.
- Perform and document **Quality Control and Quality Assurance** reviews of the GRs

QC & QA of Geotechnical Reports (DD Phase):

- Quality Control (QC):

  Checking of all subsurface information, analyses, specifications, details and special requirements for accuracy and their ability to meet the requirements provided by the owner or by standard of practice.

- Quality Assurance (QA):

  Is the process by which QC is verified for the Geotechnical Reports for accuracy and adequacy to meet or exceed project requirements and assist the design engineers in:

  - Reviewing both geotechnical reports and plan, specification and estimate (PS&E) packages.
  - Recognizing cost saving opportunities.
  - Identifying deficiencies or potential contract dispute issues due to inadequate geotechnical investigation, analysis or design.
  - Recognizing when to request additional technical assistance from geotechnical specialist

NextLevel INDIANA

QA/QC of Geotechnical Reports

Quality Assurance Checklist and Documentation:

- <u>General Information Form;</u>
  - Developed to document basic information for any Geotechnical Report (GR) review including:

  Project Title, Project Contracting Method (DBB, DB, PPP, other), QA Reviewer and Firm/Agency Affiliation, GR Title, GR Type (e.g., GR, GDR, Memorandum, Email), GR Author and Firm, GR Author/Firm Client (Owner, Contractor, Other), Project Component(s) Covered (Roadway, Structure, Other) Project Design Development Stage (Planning, Preliminary, Final) and QA Review Level (Discipline Level Review; Project Level Audit)
- <u>Checklists Attached</u> (Attach Specific Applicable checklists)
- <u>Quality Assurance Audits:</u>

  Performed by the Owner Agency (INDOT)

NextLevel INDIANA

Geotechnical Report (GR) QA Checklist Part 1

Geotechnical Report (GR) Quality Assurance Checklist

Part 1 – General Information Form

Project Name: ______________________________

Project Contracting Method: DBB ______ DB _______ PPP _________ Other ________

Note: If other, describe here: ______________________________

QA Reviewer __________________ Firm/Agency Affiliation: ____________________

GR Title: ______________________________

GR Type (e.g., GR, GDR, Tech Memo, Email) ______________________________

GR Author and Firm: ______________________________

GR Author/Firm Client: Owner Agency _______ Contractor _________ Other ____________

Note: If other, describe here: ______________________________

Project Component(s) Covered by GR: Roadway _____ Structure ______ Other ________

Note: If other, describe here: ______________________________

Project Development Stage

Planning/Conceptual: _______ Preliminary Design: _______

Final Design: __________

If other than above, describe here: ______________________________

Note: Use appropriate Checklist Form Based on Project Information.

Copy of Review Comments Attached: Yes _____ No _____

Copy of QC Checklists Attached: Yes _____ No _____

Accepted: Yes _____ No _____ (If No, return for modification and resubmission)

Signature of Reviewer ____________________________ Date: _______________

QA Review Level: Discipline Level Review _____ Project/Program Level Audit ______

Part 2 – Checklists Attached (Attach Specific Applicable Checklists)

_____A – Site Investigation Information

_____B – Centerline Cuts and Embankments

_____C – Embankment over Soft Ground

_____D – Landslide Corrections

_____E – Retaining Structures

_____F – Structure Foundations – Spread Footings

_____G – Structure Foundations – Driven Piles

_____H – Structure Foundations – Drilled Shafts

_____I – Structure Foundations – Micropiles/ACIP, etc.

_____J - Ground Improvement Techniques

_____K – Material Sites (Common or Borrow)

_____L – (add as needed)

_____M – (add as needed)

_____N – (add as needed)

Comments:

General:______________________________

NextLevel INDIANA

Geotechnical Report (GR) QA Checklist Part 2

GR REVIEW CHECKLIST FOR SITE INVESTIGATION

A. Site Investigation Information

Since the most important step in the Geotechnical Design process is to conduct an adequate site Investigation, presentation of the subsurface information in the geotechnical report and on the plans deserves careful attention.

Geotechnical Report Test	Yes	No	Unknown or N/A
1. Is the general location of the investigation described and/or a vicinity map included?	___	___	___
2. Is scope and purpose of the investigation summarized?	___	___	___
3. Is concise description given of geologic setting and topography of area?	___	___	___
4. Are the field explorations and laboratory tests on which the report is based listed?	___	___	___
5. Is the general description of subsurface soil, rock, and groundwater conditions given?	___	___	___
*6. Is the following information included with the geotechnical report (typically included in the report appendices):	___	___	___
A. Test hole logs?	___	___	___
B. Field test data?	___	___	___
C. Laboratory test date	___	___	___
D. Photographs (If Pertinent)?	___	___	___
Plan and Subsurface Profile			
*7. Is a plan and subsurface profile of the investigation site provided?	___	___	___
8. Are the field exploration located on the plan view?	___	___	___

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate Geotechnical Engineer for the clarification and/or to discuss the project.

GR REVIEW CHECKLIST FOR CENTERLINE CUTS AND ENBANKMENTS

B. Centerline Cuts and Embankments

In addition to the basic information listed in Section A, is the following information provided in the project geotechnical report.

Are station-to-station descriptions included for:	Yes	No	Unknown or N/A
1. Existing surface and subsurface drainage?	___	___	___
2. Evidence of springs and excessively wet areas?	___	___	___
3. Slides, slumps, and faults noted along the alignment?	___	___	___
Are station-to-station recommendations included for the following?			
General Soil Cut or Fill			
4. Specific surface/subsurface drainage recommendations?	___	___	___
5. Excavation limits of unsuitable materials?	___	___	___
*6. Erosion protection measures for back slopes, side slopes, and ditches, including riprap recommendations or special slope treatment.	___	___	___
Soil Cuts			
*7. Recommended cute slope design?	___	___	___
8. Are clay cut slopes designed for minimum F.S. = 1.50?	___	___	___
9. Special usage of excavated soils?	___	___	___
10. Estimated shrink-swell factors for excavated materials?	___	___	___
11. If answer to 3 is yes, are recommendations provided for design treatment?	___	___	___

B. Centerline Cuts and Embankments (Cont.)	Yes	No	Unknown or N/A
Fills			
12. Recommended fill slope design?	___	___	___
13. Will fill slope design provide minimum F.S. = 1.25?	___	___	___
Rock Slopes			
*14. Are recommended slope designs and blasting specifications provided?	___	___	___
*15. Is the need for special rock slope stabilization measures, e.g., rock fall catch ditch, wire mesh slope protection, shotcrete, rock bolts, addressed?	___	___	___
16. Has the use of "template" designs been avoided (such as designing all rock slopes on 0.25:1 rather than designing based on orientation of major rock jointing)?	___	___	___
*17. Have effects of blast induced vibrations on adjacent structures been evaluated?	___	___	___

*A response other than (yes) or (N/A) for any of these checklist questions is cause to contact the appropriate Geotechnical Engineer for a Clarification and /or to discuss the project.

NextLevel INDIANA