FINAL REPORT

OF

SUBSURFACE EXPLORATION AND

MSE WALL AND EMBANKMENT EVALUATIONS

FOR

PROPOSED US 23 / SR 823 INTERCHANGE

PROJECT SCI-823-10.13 PORTSMOUTH BYPASS (PID 79977)

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DLZ Job No. 0121-3070.03
Document No. 0088

November 16, 2007

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1.0 INTRODUCTION

This report presents the findings of the subsurface exploration and evaluations of mechanically stabilized earth (MSE) retaining walls and embankments for the proposed US 23 / SR 823 (Portsmouth Bypass) Interchange. The project is located in Scioto County, north of Lucasville, Ohio, near the area of the Scioto County Fairgrounds.

The purpose of this exploration was to 1) determine the subsurface conditions to the depths penetrated by the borings, 2) evaluate the engineering characteristics of the subsurface materials, and 3) provide information to assist in designing the proposed MSE walls and earthen embankments within the interchange.

The geotechnical engineer has planned and supervised the performance of the geotechnical engineering services, has considered the findings, and has prepared this report in accordance with generally accepted geotechnical engineering practices. No other warranties, either expressed or implied, are made as to the professional advice included in this report.

2.0 GENERAL PROJECT INFORMATION

The proposed US 23 / SR 823 Interchange will serve as the northern terminus of the proposed SR 823 roadway. Based upon the information provided, the proposed interchange will consist of four ramps and six bridges. It is understood that the ramps will be constructed using MSE retaining walls and earthen embankments. The US 23 / SR 823 Interchange, as defined by this report, will essentially begin at SR 823 station 883+39 and terminate upon merging with existing US 23.

The currently proposed interchange will include four ramps. For the purpose of this report, the ramps within the interchange area will be referred to as Ramp A through Ramp D. Ramp A will direct southbound US 23 traffic onto SR 823, and Ramp B will direct northbound US 23 traffic onto SR 823. Ramp C will direct SR 823 traffic onto US 23 northbound, and Ramp D will direct SR 823 traffic onto US 23 southbound. Approximately 1,034 and 1,332 linear feet of MSE walls will be used to construct Ramps B and C, respectively. MSE walls are also planned at the abutment locations for the SR 823 bridges over Fairground Road and the Norfolk Southern Railroad and US 23. It is understood that MSE walls are not planned for any portions of Ramps A and D. For additional information, refer to the site plan drawings in Appendix A.

Individual reports have been prepared for each bridge and the abutment MSE walls contained within the interchange. The analyses and recommendations for the MSE walls along the ramps

are presented in their associated bridge reports, and are reiterated in this report for convenience. For information regarding the bridges, please refer to the respective bridge and MSE wall reports, submitted under separate cover.

In addition to MSE walls, earthen embankments will be used to construct the ramps. It is understood that the interchange embankments and MSE walls will require fills of up to 43 feet. Although most of the interchange area will require embankment fills, rock cuts of up to 85 feet will be required at the eastern end of the interchange, near station 886+00. The transition from cut to fill sections will occur at approximate station 889+25. Information regarding the rock cut recommendations can be found in the Report of Rock Cut Slopes for Project SCI-823-10.13, dated November 16, 2007.

Culverts are proposed for various drainage features within the interchange. The findings and recommendations for the design of the proposed culverts are presented under separate cover.

The analysis and recommendations presented in this report have been made on the basis of the foregoing information. If the proposed location or the overall concept of the proposed interchange is changed or differs from that assumed, DLZ Ohio, Inc. (DLZ) should be informed of the changes so that the recommendations and conclusions presented in this report may be revised as necessary.

3.0 FIELD EXPLORATION

The field exploration consisted of drilling eighty-seven borings for various elements of the US 23 / SR 823 Interchange. Between March 14, 2005 and March 22, 2005, twenty-one borings were drilled for the proposed bridges in the interchange and identified as borings TR-46 through TR-61, TR-49A, TR50A, TR-53A, TR-55A, and TR-59A. These borings were drilled and sampled to the top of rock, and 10 feet of rock was cored in each boring. The depths of these borings ranged from 25 feet to 45 feet below the existing ground surface. Between July 13 and November 2, 2005, fifty-two borings, identified as borings B-1101 through B-1152 were drilled and sampled for the proposed ramps and embankments. The depths of these borings ranged from 10 feet to 49 feet below the existing ground surface.

A supplemental drilling program was performed based upon refined alignments. Seven borings (B-1105A, B-1109A, B-1117A, B-1122A, B-1133A, B-1136A, and B-1138A) were drilled for the proposed ramps, between July 11 and August 2, 2007. These borings were drilled to depths ranging from 16.3 to 31.7 feet below the existing ground surface. Four additional structure borings (B-45 through B-47, and B-54) were drilled for the currently proposed structures, between June 14 and July 31, 2007. These borings were drilled to depths ranging from 37.0 to 42.0 feet below the existing ground surface. Three culvert borings (C-120, C-121, and C-123) were drilled for the currently proposed culverts, between July 30 and August 1, 2007. These borings were drilled to depths ranging from 27.5 to 32.5 feet below the existing ground surface.

The boring locations were planned and staked in the field by representatives of DLZ and Lockwood, Lanier, Mathias & Noland, Inc. (2LMN). The surveyed locations and ground surface

elevations of the borings were determined by representatives of 2LMN. The surveyed locations of the borings are shown on the Boring Location Plan, presented in Appendix B. Information concerning the drilling procedures is also presented in Appendix B.

4.0 FINDINGS

4.1 Geology of the Site

Generalized geological references report that the site lies on the east side of the flood plain of the Teays Stage, Portsmouth River, which is currently the east side of the Scioto River valley. This area is unglaciated, however, the Scioto River valley is filled with Illinoian and Wisconsin glacial outwash to depths of up to 90 feet.

The area of this structure is characterized by gently to moderately sloping topography rising from of the floodplain of the Scioto River. The project area is located in the Shawnee-Mississippian Plateau of the unglaciated portion of the Appalachian Plateau Physiographic Region. The Shawnee-Mississippian Plateau is characterized by Devonian aged to Pennsylvanian aged rocks and contains residual, colluvial, alluvial, and lacustrine soils.

The genesis of the soils varies across the site. Soils in the floodplain consist primarily of alluvium and alluvial terraces, that are generally composed of silty clay, coarse sand, gravel, and cobbles. Some soils on the hillsides are comprised of lacustrine deposits. Lacustrine soils in this area are commonly known as "Minford Silts" or the Minford Complex. These deposits were formed during the early to middle Pleistocene age when the northward flowing Teays River system was blocked by the southward advance of the Kansan aged ice sheets. As the glaciers advanced, the course of the Teays River was blocked south of Chillicothe and a large lake was formed from the impoundment of the waterways. As a result of the impoundment, vast quantities of sediments were deposited. These deposits ranged from 10 to 80 feet in thickness, thinning towards the margins.

Generalized geologic references report that bedrock across the proposed interchange site consists of shale and sandstone of the Cuyahoga Formation, Sunbury shale, and Berea sandstone of Mississippian to Devonian age.

Shale and sandstone of the Cuyahoga Formation as well as Sunbury shale are evident in the borings drilled on the eastern end of the interchange. Borings drilled west of the Fairground Road site encounter progressively thinner layers of the shale bedrock. West of the Norfolk and Southern Railroad and immediately east of US 23, the shale is no longer encountered at the top of rock. West of the Norfolk and Southern railroad, Berea Sandstone is generally encountered at the top of rock.

4.2 Subsurface Conditions

The following sections present the generalized subsurface conditions encountered by the borings. For more detailed information, refer to the boring logs presented in Appendix B. The results of index tests (grain-size and plasticity) are shown on the boring logs and also in Appendix B. The results of shear strength and consolidation testing are presented in Appendix C.

4.2.1 Soil Conditions

Sixty-two of the eighty-seven borings encountered topsoil at the ground surface. The thickness of topsoil encountered ranged from 1 to 8 inches with an average of approximately 4 inches. Eighteen of the remaining borings encountered asphalt concrete pavement over aggregate base at the ground surface. The thickness of asphalt concrete pavement encountered ranged from 3 to 8 inches with an average of approximately 5.5 inches, while the thickness of the aggregate base ranged from 4 to 8 inches with an average of approximately 6 inches.

Underlying the topsoil or pavement layers, thirty-two of the eighty-seven borings encountered soil which was identified as fill and/or possible fill material to depths of up to 16.0 feet below the existing ground surface. The fill and/or possible fill material generally consisted of cohesive soils; some of which were confirmed by laboratory testing to contain organic soil. Five samples from borings B-1102, B-1103, B-1129, and B-1150 were tested to determine the organic content. The results indicate organic contents ranging from 3.74 to 6.12 percent, which are considered to be slightly to moderately organic.

Underlying the fill, possible fill, or surface materials, eighty of the eighty-seven borings generally encountered cohesive soils, consisting of silt (A-4b) to clay (A-7-6), to depths between 5.5 and 27.5 feet below the existing ground surface. Granular material was typically encountered beneath these cohesive soils to the top of bedrock. It should be noted that before encountering any cohesive soils seven of the eighty-seven borings first encountered very loose to dense, damp to moist, gravel with sand (A-1-b) or gravel with sand and silt (A-2-4) below the surface materials.

It should be noted that several of the borings encountered a water-bearing granular layer overlying bedrock. This granular layer was generally encountered beneath a fine-grained, cohesive layer. It appears that the water in the granular layer was confined under pressure by the cohesive layer. As a result, when sampling through the fine-grained cohesive layer into the granular layer, water pressure in the granular layer was released through and around the augers and split-spoon sampler. This situation developed a "quick" condition and resulted in the weight-of-hammer (WOH) SPT N-values in the upper portions of the granular layers.

4.2.2 Bedrock Conditions

Seventy-one of the eighty-seven borings encountered bedrock. The bedrock generally consisted of medium hard to hard sandstone. However shale, siltstone, and claystone were also encountered in borings drilled on the eastern portions of the interchange. The top of bedrock was encountered at depths between 13.0 and 34.5 feet below the existing ground surface, with an average depth to top of bedrock of 23.9 feet. It should be noted that some of the bedrock encountered at higher elevations were highly weathered to decomposed and exhibited a soil-like structure.

The recovery in each core run varied between 45 and 100 percent, with an average of 94 percent. The rock quality designation (RQD) of the bedrock ranged between 0 and 97 percent with an average of 60 percent, indicating "fair" quality rock.

4.2.3 Groundwater Conditions

Seepage was observed in sixty-eight of the eighty-seven borings. Where observed, seepage was first encountered at depths ranging from 6.0 to 28.0 feet below the ground surface. Prior to rock coring operations, measurable water levels were observed in forty-eight of the borings at depths ranging from 8.0 to 31.0 feet below the existing ground surface. Final water levels were present in sixty-six of the borings at depths ranging from 2.0 to 22.0 feet below the ground surface. The final water levels included water that was used for rock coring and consequently may not be representative of actual groundwater conditions.

It should be noted that groundwater levels may fluctuate with seasonal variations and following periods of heavy or prolonged precipitation. Therefore, the readings indicated on the boring logs may not be representative of the long-term groundwater level. Long-term monitoring would be necessary to obtain a more accurate estimate of the groundwater table elevation.

A piezometer was installed in boring B-54 to monitor the groundwater level in the area of Wall No. 3. This piezometer was screened in the granular layers overlying bedrock. The groundwater levels in the piezometer ranged from 20.2 to 23.5 feet below the existing ground surface (el 518.6 to 515.3). The average phreatic level was approximately 21.4 feet below the ground surface, corresponding to an elevation of 517.4.

A piezometer was installed in boring B-1109A to monitor the groundwater level in the area of Ramp B. This piezometer was screened in the granular layers overlying bedrock. Readings indicate that the phreatic level in the granular layers ranged from 0.2 to 1.8 feet below the existing ground surface (el 532.3 to 530.7). The average phreatic level is approximately 1.2 feet below the ground surface, corresponding to an elevation of 531.3.

A piezometer was installed in boring B-46 to monitor the groundwater level in the area of Fairground Road. This piezometer was screened in the granular layers overlying bedrock. Readings indicate that the phreatic level in the granular layers of boring B-46 ranged from 15.9 to 16.1 feet below the existing ground surface (el 549.5 to 549.7). The average phreatic level is approximately 16.0 feet below the ground surface, corresponding to an elevation of 549.6.

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Shear Strength Selection

Shear strength values used in stability analyses were based on laboratory shear strength testing, in-situ vane shear testing, in-situ moisture content, hand penetrometer values, typical correlations, and engineering judgment.

Unconsolidated undrained (UU) triaxial testing and unconfined compression (UC) testing was performed on selected samples to determine the initial undrained shear strength of the clay layers for the purposes of analyses. Also, consolidation testing was performed on selected samples to establish parameters for settlement analyses.

Due to the low in-situ undrained shear strength of the foundation soils, staged construction is anticipated. As a result, undisturbed, Shelby Tube samples were collected for laboratory testing to determine additional shear strength parameters for staged construction analyses. Consolidated undrained triaxial testing (CIU) was performed on selected samples ranging from silt (A-4b) to clay (A-7-6). Results of testing reported the angles of shearing resistance (from total stress curve, Φ_{cu}) ranging from 14.2 to 23.8 degrees. The results of these tests are included in Appendix C.

Shear strength testing was also performed on the granular soils that exhibited low SPT N-values. A direct shear test was performed on a sample of granular material from boring TR-61. The sample was remolded in a very loose condition and was saturated in the mold with free water. The sample was stirred prior to commencing the test to ensure a loose condition. The results of the tests indicate friction angles between 42.1 and 45.7 degrees. However, depending on the grain-size and in-situ relative density of the granular soil, values ranging from 28 to 32 degrees were conservatively selected for the analyses. The results of the test are presented here in graphic form, as well as in Appendix C.

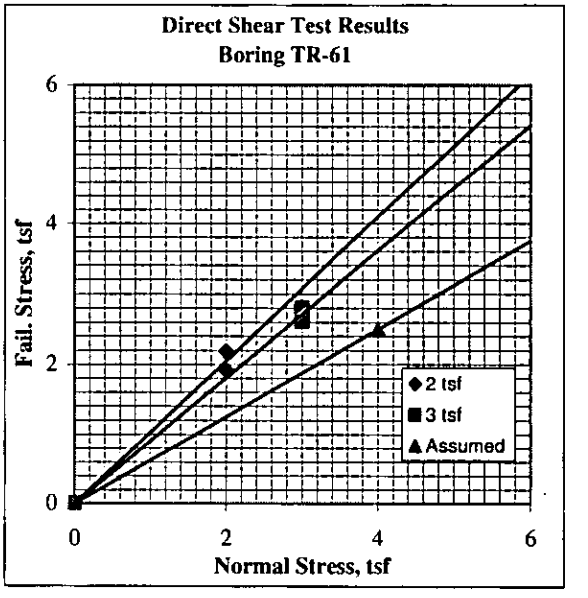


Table 1 below presents the shear strength parameters assumed in the analyses of the proposed MSE retaining walls. For more information, refer to the drawings illustrating the result of the stability analyses, presented in Appendix D.

Table 1 - Strength Parameters Used in MSE Wall Stability Analyses
Proposed SR 823 and US 23 Interchange

Zone	Soil Type	Unit Weight (pcf)	Strength Parameters			
			Undrained		Drained	
			c	ϕ	c'	ϕ'
Reinforced Fill - MSE	Compacted Granular Fill	120	0	34	0	34
Retained Soil - Embankment / MSE	Compacted Embankment Fill	120	0	30	0	30
Foundation Soil Fairground Road (Wall No. 1)	Very Stiff Silt & Clay	120	2350	0	0	29
	Silt	120	0	29	0	29
Foundation Soil Fairground Road (Wall No. 2)	Very Stiff Silty Clay	120	1500	0	0	29
	Sand and Gravel	120	0	30	0	30
Foundation Soil US 23 Ramp B (Wall No. 4)	Very Stiff Clay	120	2000	0	0	29
	Med. Stiff Clay	120	900	0	0	28
	Sand and Gravel	120	0	29	0	29
Foundation Soil US 23 Ramp C (Wall No. 5)	Very Stiff Clay	120	2000	0	0	29
	Med. Stiff Clay	120	900	0	0	28
	Sand and Gravel	120	0	29	0	29
Foundation Soil SR 823 over NS RR and US 23 (Wall No. 6)	Very Stiff Clay	120	2000	0	0	29
	Gravel, Sand, and Silt	120	0	28	0	28
Foundation Soil SR 823 over NS RR and US 23 (Wall No. 3)	Very Stiff Clay	120	2000	0	0	29
	Med. Stiff Clay	120	900	0	0	28
	Gravel and Sand	120	0	32	0	32

5.2 Mechanically Stabilized Earth (MSE) Retaining Walls General Information

An MSE retaining wall essentially consists of good quality backfill material with layers of metal or plastic reinforcing that are attached to concrete facing panels. The MSE wall and associated backfill should be constructed in accordance with the specifications of the manufacturer of the MSE wall.

Calculations for bearing capacity, sliding, and overturning as well as the results of the global stability analyses are attached. Other internal stability analyses are required for the design of an MSE wall, but are considered outside the scope of this report. The use of deep foundations is assumed for the purposes of MSE wall analyses. Therefore, the minimum required factor of safety against global stability was taken to be 1.3.

In accordance with the ODOT Bridge Design Manual (BDM) guidelines, a unit weight of 120 pcf and a friction angle of 34 degrees were selected for the backfill material in the reinforced zone. The fill material used to construct the roadway embankments is assumed to have a unit weight of 120 pcf and a friction angle of 30 degrees. If the embankment fill material or backfill material for the reinforcing zone has properties significantly different from these values, DLZ should be informed so that the analyses may be revised as necessary.

5.3 MSE Wall Recommendations

The recommendations for the abutment and ramp MSE retaining walls are presented in the following sections. It should be noted that the analyses and recommendations for these walls have also been included in the final reports for the interchange bridges and are presented under separate cover.

5.3.1 MSE Wall Evaluations and Recommendations
SR 823 over Fairground Road, East Abutment Location – Wall No. 1

The proposed wall is understood to be located at approximate station 891+70. This wall will extend 340 feet along Fairground Road, in front of the east abutments of the US 23 Ramp B, US 23 Ramp C, and SR 823 bridges over Fairground Road. For additional information, refer to the site plans, included in Appendix A.

As per ODOT's Supplemental Specification 840 (SS 840), section 840.04 A, the full height of an MSE retaining wall in front of an abutment should be measured to the profile grade elevation at the face of the wall. Assuming that the top of leveling pad for this wall will be placed at approximate elevation 563, the maximum wall height was assumed to be approximately 34.0 feet (including embedment).

For MSE Wall No. 1, the subsurface profile encountered by borings B-47 and B-1146 were assumed to be the most critical with respect to stability. A composite profile based upon these two borings was used in the stability analyses for this wall.

Borings B-47 and B-1146 generally encountered very stiff silt (A-4b) and silt and clay (A-6a) from the bottom of the leveling pad excavation (el. 561.5) to approximate elevation 557.2. Below these cohesive layers, borings generally encountered cohesionless silt (A-4b) to the top of weathered bedrock at approximate elevation 554.5

Analyses were performed to determine the global stability, bearing capacity and stability (overturning and sliding) of the proposed MSE wall bearing on the existing soils. The results of the analyses indicate that the factors of safety for

global stability, bearing capacity and stability (overturning and sliding) were above the minimum recommended values.

Calculations indicate that a minimum reinforcement length of 1.1 times the full height (H+D) or 37.4 feet is required for external stability of the proposed MSE wall at the Wall No.1 location.

Settlement was calculated using the computer program EMBANK, using the "end of fill" option to model the non-continuous embankment loading. The maximum settlement at the face of MSE Wall No.1 was estimated to be approximately 3 inches for the full height wall section. Differential settlement at this location was estimated to be approximately 0.4 percent, which is less than the typically cited maximum value. MSE retaining walls are able to withstand relatively large amounts of differential settlement, typically up to 100 millimeters per 10 meters of wall length (1.0 percent).

Time-rate of consolidation calculations indicate that ninety percent of the total primary consolidation should occur in approximately 7 days. Given the relatively small magnitude of consolidation, and the short estimated time to ninety percent consolidation, it should not be necessary to use prefabricated vertical drains (wick drains) or other means to accelerate the consolidation.

Table 2 presents the MSE retaining wall parameters and results of analyses for MSE Wall No. 1.

Table 2 - MSE Retaining Wall Parameters and Analyses Results
MSE Wall No. 1, East of Fairground Road

Retained Soil (New Embankment) Unit Weight = 120 pcf Coefficient of Active Earth Pressure (K_a) = 0.33 (Based on $\Phi' = 30°$)
Sliding along base of MSE wall Sliding Coefficient (μ)(0.67) = tan 29°(0.67) = 0.37
Allowable Bearing Capacity – Undrained Condition q_{all} = 4,901 psf
Allowable Bearing Capacity – Drained Condition q_{all} = 8,627 psf
Global Stability Factor of Safety – Undrained Condition = 2.6 Factor of Safety – Drained Condition = 2.1 Factor of Safety – Drained Seismic Condition = 1.9
Estimated Settlement of MSE Volume Maximum Total Settlement = 3 inches Differential Settlement = 0.4% (maximum allowable is 1.0% ODOT BDM 204.6.2.1)
Full Height of MSE Wall = 34.0 feet (including embedment depth) Minimum Embedment Depth = 3.0 feet* Minimum Length of Reinforcement for External Stability, 1.1(H+D) = 37.4 feet

* Assumed top of leveling pad elevation is 563. Embedment Depth may vary depending on actual top of leveling pad elevation. Minimum embedment depth of 3.0 feet.

5.3.2 MSE Wall Evaluations and Recommendations
SR 823 over Fairground Road, West Abutment Location – Wall No. 2

The proposed wall is understood to be located at approximate station 892+58. This wall will extend 390 feet along Fairground Road, in front of the west abutments of the US 23 Ramp B, US 23 Ramp C, and SR 823 bridges over Fairground Road. For additional information, refer to the site plans in Appendix A.

Assuming that the top of leveling pad for this wall will be placed at approximate elevation 562, the maximum wall height was measured to be approximately 32.0 feet (including embedment).

The subsurface profile encountered by borings B-45 and B-1113 were assumed to be the most critical with respect to stability. A composite profile based upon these two borings was used in the stability analyses for this wall.

Borings B-45 and B-1113 generally encountered stiff silty clay (A-6b) and gravel with sand, silt, and clay (A-2-6) from the bottom of the leveling pad excavation (el. 560.5) to approximate elevation 548.0. Below these soil layers, borings

generally encountered gravel with sand and silt (A-2-4) to the top of weathered bedrock, at approximate elevation 544.5

Analyses were performed to determine the global stability, bearing capacity and stability (overturning and sliding) of the proposed MSE walls bearing on the existing soils. The results of the analyses indicate that the factors of safety for global stability, drained bearing capacity, and stability (overturning and sliding) are above the required minimum recommended values. However, the factor of safety for undrained bearing capacity was found to be 1.7, which is below the minimum required value of 2.5.

In order to construct the wall while maintaining the minimum required factor of safety against undrained bearing capacity, the use of staged construction was investigated. Staged constructions analyses were performed which assume an increase in the undrained shear strength of the foundation soils via consolidation under the loading of each stage. These analyses indicate that MSE Wall No. 2 could be built in three staged with pore water pressure monitoring in the clay layers.

Based upon additional analyses, the first stage of 19.0 feet plus the embedment depth may be constructed while maintaining a factor of safety of 2.5 against undrained bearing capacity failure. MSE walls that are less than 19.0 feet tall plus embedment depth may be constructed in a single stage, without any waiting periods. However, at least ninety percent of excess pore pressures should be allowed to dissipate prior to placing the second stage. Correspondingly, excess pore water pressures measured in the foundation clay layers during the first staged of construction should be below 1.6 psi prior to placing the next stage. After excess pore pressures have sufficiently dissipated, the second stage of 8.0 feet may be constructed. At least ninety percent of excess pore pressures should be allowed to dissipate prior to placing the final stage. Correspondingly, excess pore water pressures measured in the foundation clay layers during the second stage of construction should be below 0.7 psi prior to placing the final stage. After excess pore pressures have sufficiently dissipated, the final stage may be constructed up to the proposed grade.

It is recommended that pore pressures and settlements in the clay layers of the foundation soils be monitored throughout the construction process. Recommendations and details concerning instrumentation placement, required waiting periods, pore pressure monitoring, and staged construction details can be found in the Instrumentation and Special Construction plans presented in Appendix A.

Time-rate of consolidation calculations indicate that an estimated consolidation period of 18 days is required to allow the excess pore water pressures to dissipate in the foundation soils after both the first stage and the second stage of

construction. The ODOT construction representative may modify the estimated waiting periods during construction based upon pore pressure measurements in the field. Given the relatively short estimated time to ninety percent consolidation, it should not be necessary to use prefabricated vertical drains (wick drains) or other means to accelerate dissipation of pore water pressures for staged construction.

Calculations indicate that a minimum reinforcement length of 1.1 times the full height (H+D) or 35.2 feet is required for stability of the proposed MSE wall at the Wall No. 2 location.

The maximum settlement at the face of MSE Wall No. 2 was estimated to be approximately 5 inches for the full height wall section. Differential settlement at this location was estimated to be approximately 0.6 percent, which is considered to be acceptable.

Table 3 presents the MSE retaining wall parameters and results of analyses for MSE Wall No. 2.

Table 3 - MSE Retaining Wall Parameters and Analyses Results
MSE Wall No. 2, West of Fairground Road

Retained Soil (New Embankment) Unit Weight = 120 pcf Coefficient of Active Earth Pressure (K_a) = 0.33 (Based on $\Phi' = 30°$)
Sliding along base of MSE wall Sliding Coefficient (μ)(0.67) = tan 29°(0.67) = 0.37
Allowable Bearing Capacity – Undrained Condition *(Staged Construction)** *q_{all} Stg.1=3,153 psf q_{all} Stg.2=4,284 psf q_{all} Stg.3=4,761 psf*
Allowable Bearing Capacity – Drained Condition q_{all} = 8,181 psf
Global Stability Factor of Safety – Undrained Condition = 2.0 Factor of Safety – Drained Condition = 2.2 Factor of Safety – Drained Seismic Condition = 2.0
Estimated Settlement of MSE Volume Maximum Total Settlement = 5 inches Differential Settlement = 0.6% (maximum allowable is 1.0% ODOT BDM 204.6.2.1)
Full Height of MSE Wall = 32.0 feet (including embedment depth) Minimum Embedment Depth = 3.0 feet* Minimum Length of Reinforcement for External Stability, 1.1(H+D) = 35.2 feet

* Assumed top of leveling pad elevation is 562. Embedment depth may vary depending on actual top of leveling pad. Minimum embedment depth of 3.0 feet.

5.3.3 MSE Wall Evaluations and Recommendations
US 23 Ramp B – Wall No. 4

It is understood that MSE walls will be placed along US 23 Ramp B from station 2598+23 to 2604+48 to contain the embankment fill material. As shown on the provided drawings, an MSE wall is planned only on the left side of Ramp B from station 2598+23 to 2600+75. The MSE walls will continue on both sides of Ramp B from station 2600+75 to 2604+48. Also, as part of this retaining wall system, an MSE wall is currently planned at station 2604+48 to contain the rear abutment of the proposed Ramp B bridge.

Near the rear abutment location (station 2604+48), the top of leveling pad for this wall was assumed to be elevation 532.2. The maximum wall height was estimated to be approximately 40.5 feet (including embedment). At shorter wall sections (station 2600+75) it is assumed that the top of leveling pad for this wall will be placed at approximate elevation 536.6.

The subsurface profile generally encountered by borings B-1109 and B-1108 were assumed to be the most critical with respect to stability for MSE Wall No. 4, which will contain the fill for Ramp B.

Borings B-1109 and B-1108 generally encountered very stiff sandy silt (A-4a) and silt and clay (A-6a) from the bottom of the leveling pad excavation (el. 532.2) to approximate elevation 527.6. Below the layers, borings generally encountered medium stiff silty clay (A-6b) to approximately elevation 522.6. Below this layer, borings generally encountered cohesionless silt (A-4b) to approximate elevation 517.1, the top of weathered bedrock.

Analyses were performed to determine the global stability, bearing capacity, and stability (overturning and sliding) of the proposed MSE walls bearing on the existing soils. The results of the analyses indicated that the factors of safety for global stability, drained bearing capacity, and stability (overturning and sliding) were above the minimum recommended values. However, the factor of safety for undrained bearing capacity of Wall No. 4 was found to be 1.0, which is below the minimum required value of 2.5.

In order to construct the MSE wall while maintaining the minimum required factor of safety against undrained bearing capacity, the use of staged construction was investigated. Additional analyses were performed, assuming that an increase in the undrained shear strength of the foundation soils will occur due to the consolidation from the loading of each stage. These analyses indicate that MSE Wall No. 4 could be built in four stages with pore water pressure monitoring in clay layers.

Based upon these additional analyses, the first stage of 13.0 feet plus the embedment depth may be constructed while maintaining a factor of safety of 2.5 against undrained bearing capacity failure. MSE walls that are less than 13 feet tall plus the embedment depth may be constructed in a single stage, without any waiting periods. However, at least ninety percent of excess pore pressures should be allowed to dissipate prior to placing the next stage. Correspondingly, excess pore water pressures measured in the foundation clay layers during construction should be below 1.08 psi prior to placing the next stage. After excess pore pressures have sufficiently dissipated, the second stage of 11.0 feet may be constructed. At least ninety percent of excess pore pressures should be allowed to dissipate prior to placing the next stage. Correspondingly, excess pore water pressures measured in the foundation clay layers during the second stage construction should be below 0.92 psi prior to placing the next stage. After excess pore pressures have sufficiently dissipated, the third stage of 8.0 feet may be constructed. At least ninety percent of excess pore pressures should be allowed to dissipate prior to placing the final stage. Correspondingly, excess pore water pressures measured in the foundation clay layers during the third stage of construction should be below 0.67 psi prior to placing the final stage. After excess pore pressures have sufficiently dissipated, the final stage may be constructed up to the proposed grade.

It is recommended that pore pressures and settlements in the clay layers of the foundation soils be monitored throughout the construction process. Recommendations and details concerning instrumentation placement, required waiting periods, pore pressure monitoring, and staged construction details can be found in the Instrumentation and Special Construction plans presented in Appendix A.

Time-rate of consolidation calculations indicate that a consolidation period will be required after the first, second, and third stages of construction to allow the excess pore water pressures to dissipate in the foundation soils. Time-rate of consolidation calculations indicate that a consolidation period of approximately 45 days will be required after each stage to achieve ninety percent (U=90%) of consolidation. The ODOT construction representative may modify the estimated waiting periods during construction based upon pore pressure measurements in the field.

The use of prefabricated vertical drains (wick drains) may be considered to accelerate the consolidation of foundation soils under the proposed ramp. The estimated times for ninety percent consolidation using various wick drain spacing options are presented in Table 4. The consolidation times (U=90%) in Table 4 are required after each stage to allow pore pressures to dissipate prior to the application of subsequent stages.

Table 4 - Wick Drain Spacing and Consolidation Periods

US 23 Ramp B, MSE Wall No. 4		
Spacing (ft)	**Time to U=90% (days)**	**Approximate Depth of Wick Drains (ft)**
5	20	25
7	30	25
9	35	25

++ U=90%, required consolidation after stages 1, 2, and3, prior to placing subsequent stages

The length of the reinforcing straps is limited by the width of the ramp for sections with higher walls. At the maximum wall height of 40.5 feet, a reinforcing strap length of approximately 0.85(H+D) is the maximum length that can be accommodated by the ramp dimensions. As the height of the ramp lessens, while the width remains constant (34 feet), it is recommended that a minimum reinforcing length of 1.0 times the full height (H+D) be used as allowed by the ramp dimensions. For higher, back-to-back wall sections, the reinforcement length may be reduced as long as the soil reinforcement overlap is 0.3 (H+D) or greater. It should be noted that longer soil reinforcement may be needed for internal stability.

The maximum estimated settlement at the centerline of the rear abutment retaining wall (station 2604+48) was estimated to be approximately 6 inches. Differential settlement at the wall face, between station 2604+48 and 2603+98 was calculated to be approximately 0.3 percent, which is considered to be acceptable.

The estimated settlement at the proposed wall face at station 2600+75 was estimated to be approximately 2 inches. Similarly, the estimated settlement at the centerline of the ramp was estimated to be approximately 3 inches.

Table 5 presents the MSE retaining wall parameters and results of analyses for MSE Wall No. 4.

Table 5 - MSE Retaining Wall Parameters and Analyses Results
MSE Wall No. 4, US 23 Ramp B MSE Wall

Retained Soil (New Embankment) Unit Weight = 120 pcf Coefficient of Active Earth Pressure (K_a) = 0.33 (Based on $\Phi' = 30°$)
Sliding along base of MSE wall Sliding Coefficient (μ)(0.67) = tan 29°(0.67) = 0.37
Allowable Bearing Capacity – Undrained Condition *(Staged Construction)* q_{all} *Stg.1=2,287 psf* q_{all} *Stg.2=3,508 psf* q_{all} *Stg.3=4,541 psf* q_{all} *Stg.4=5,293 psf*
Allowable Bearing Capacity – Drained Condition q_{all} = 7,206 psf
Global Stability Factor of Safety – Undrained Condition = 1.5 Factor of Safety – Drained Condition = 2.2 Factor of Safety – Drained Seismic Condition = 2.1
Estimated Settlement of MSE Volume δ_A = 4 inches (Corner, abutment wall, sta. 2604+48) δ_B = 6 inches (At abutment wall centerline, sta. 2604+48) δ_C = 6 inches (At wall face, sta. 2603+98) δ_D = 8 inches (At ramp centerline, sta. 2603+98) δ_E = 2 inches (At wall face, sta. 2600+75) δ_F = 3 inches (At ramp centerline, sta. 2600+75) Differential Settlement = 0.30% (maximum allowable is 1.0% ODOT BDM 204.6.2.1)
Maximum Full Height of MSE Wall = 40.5 feet (including embedment depth) Minimum Embedment Depth = 3.0 feet* Minimum Length of Reinforcement for External Stability, 1.0(H+D)**

* Assumed top of leveling pad elevation is 532.7. Embedment depth may vary depending on actual top of leveling pad. Minimum embedment depth of 3.0 feet.

** Use 1.0(H+D) where allowed by ramp width. For higher wall sections, reductions of reinforcement length due to limiting ramp width is permissible given that the reinforcement overlap is 0.3 (H+D) or greater.

5.3.4 MSE Wall Evaluations and Recommendations
US 23 Ramp C – Wall No. 5

It is understood that MSE walls will be placed along US 23 Ramp C from station 3900+32 to 3907+00 to contain the embankment fill material. As shown on the provided drawings, MSE walls are planned on both sides of Ramp C from station 3900+32 to 3906+50. However, an MSE wall is planned only on the left side of Ramp C from station 3906+50 to 3907+00. Also, as part of this retaining wall system, an MSE wall is currently planned at station 3900+32 to contain the forward abutment of the proposed Ramp C bridge.

Near the forward abutment location (station 2604+48), it is assumed that the top of leveling pad for this wall will be placed at approximate elevation 536.6. Consequently, the maximum wall height was measured to be approximately 37.3

feet (including embedment). Similarly, at shorter wall sections (station 3902+50) it is assumed that the top of leveling pad for this wall will be placed at approximate elevation 535.9.

In the analysis of MSE Wall No. 5, the subsurface profile encountered by borings B-1121 and B-1122 were considered to be the most critical with respect to stability.

Borings B-1121 and B-1122 generally encountered very stiff sandy silt (A-4a) and silt and clay (A-6a) between elevation 536.6 (the bottom of the leveling pad excavation) and approximate elevation 533.5. Below the cohesive layers, borings generally encountered medium stiff silty clay (A-6b) to approximately elevation 526.0. Following the silty clay layer, borings generally encountered granular soils consisting of gravel with sand, silt, and clay (A-2-6) to coarse and fine sand (A-3a) to the top of weathered bedrock at approximate elevation 517.5.

Analyses were performed to determine the global stability, bearing capacity and stability (overturning and sliding) of the proposed MSE walls bearing on the existing soils. The results of the analyses indicated that the factors of safety for global stability, drained bearing capacity and stability (overturning and sliding) were above the minimum recommended values. However, the factor of safety for undrained bearing capacity of Wall No. 5 was found to be 1.0, which is below the minimum required value of 2.5.

In order to construct the MSE wall while maintaining the minimum factor of safety against undrained bearing capacity, the use of staged construction was investigated. Additional analyses were performed, assuming that an increase in the undrained shear strength of the foundation soils will occur due to the consolidation from the loading of each stage. These analyses indicate that MSE Wall No. 5 could be built in four stages. However, monitoring the pore water pressures in the underlying clay layers is necessary throughout the construction process. Details of the staged construction are presented in the following paragraphs.

Based upon the additional analyses, the first stage of 13.0 feet plus the embedment depth may be constructed while maintaining a factor of safety of 2.5 against undrained bearing capacity failure. MSE walls that are less than 13.0 feet tall plus embedment depth may be constructed in a single stage without any waiting periods. At least ninety percent of excess pore pressures should be allowed to dissipate prior to placing the second stage. Correspondingly, the excess pore water pressures in the clay layers during the first construction stage should be below 1.08 psi prior to placing the second stage. After excess pore pressures have sufficiently dissipated, the second stage of 10.0 feet may be constructed. Similarly, at least ninety percent of excess pore pressures should be allowed to dissipate prior to placing the third stage. This corresponds to the excess pore

water pressures in the clay layers during the second stage of construction to be below 0.83 psi prior to placing the third stage. After excess pore pressures have sufficiently dissipated, the third stage of 8.0 feet may be constructed. A minimum of fifty percent of excess pore pressures should be allowed to dissipate prior to placing the final stage. Hence, excess pore water pressures measured in the foundation clay layers during the third construction stage should be below 3.4 psi prior to placing the final stage. After excess pore pressures have sufficiently dissipated, the final stage may be constructed up to the proposed grade.

It is recommended that pore pressures and settlements in the clay layers of the foundation soils be monitored throughout the construction process. Recommendations and details concerning instrumentation placement, required waiting periods, pore pressure monitoring, and staged construction details can be found in the Instrumentation and Special Construction plans presented in Appendix A.

A consolidation period will be required after each loading stage to allow the excess pore water pressures to dissipate. Time-rate of consolidation calculations (without wick drains) indicate that a consolidation period of approximately 56 days will be required for both the first and second stages to achieve ninety percent (U=90%) consolidation. However, a consolidation period of approximately 13 days will be required for the third stage to achieve fifty percent consolidation (U=50%), prior to placing the remaining fill to the proposed finished grade. Note that the consolidation periods are only estimates. The ODOT construction representative may modify the waiting periods during construction based upon pore pressure measurements in the field.

The use of prefabricated vertical drains (wick drains) may be considered to accelerate the consolidation of foundation soils. The estimated times for the required fifty percent and ninety percent consolidation using various wick drain spacing options are presented in Table 6.

Table 6 - Wick Drain Spacing and Consolidation Periods

US 23 Ramp C, MSE Wall No. 5			
Spacing (ft)	**+Time to U=50% (days)**	**++Time to U=90% (days)**	**Approximate Depth of Wick Drains (ft)**
5	5	20	22
7	10	30	22
9	10	40	22

+ U=50%, required consolidation after stage 3, prior to placing remaining fill

++ U=90%, required consolidation after stages 1 and 2, prior to placing subsequent stages

The length of the reinforcing straps is limited by the width of the ramp at the abutment location. For the Ramp C MSE walls, it is recommended that a reinforcement length of 1.0 times the full height (H+D) be used as allowed by ramp dimensions. For higher, back-to-back wall sections, the reinforcement

length may be reduced as long as the soil reinforcement overlap is 0.3 (H+D) or greater. It should be noted that longer soil reinforcement may be needed for internal stability.

The maximum settlement at the centerline of the forward abutment retaining wall (station 3900+32) was estimated to be approximately 4 inches. Differential settlement at the wall face, between station 3900+32 and 3900+82 was calculated to be approximately 0.3 percent, which is considered to be acceptable.

The estimated settlement at the proposed wall face at station 3902+50 was estimated to be approximately 2 inches. Similarly, the estimated settlement at the centerline of the ramp was estimated to be approximately 4 inches.

Table 7 presents the MSE retaining wall parameters and results of analyses for MSE Wall No. 5.

Table 7 - MSE Retaining Wall Parameters and Analyses Results
MSE Wall No. 5, US 23 Ramp C MSE Wall

Retained Soil (New Embankment) Unit Weight = 120 pcf Coefficient of Active Earth Pressure (K_a) = 0.33 (Based on $\Phi' = 30°$)
Sliding along base of MSE wall Sliding Coefficient (μ)(0.67) = tan 29°(0.67) = 0.37
Allowable Bearing Capacity – Undrained Condition *(Staged Construction)* q_{all} *Stg.1=2,226 psf* q_{all} *Stg.2=3,432 psf* q_{all} *Stg.3=4,359 psf* q_{all} *Stg.4=4,772 psf*
Allowable Bearing Capacity – Drained Condition q_{all} = 7,125 psf
Global Stability Factor of Safety – Undrained Condition = 1.7 *(Without Staged Construction)* Factor of Safety – Drained Condition = 2.5 Factor of Safety – Drained Seismic Condition = 2.4
Estimated Settlement of MSE Volume δ_A = 2 inches (Corner, abutment wall, sta. 3900+32) δ_B = 4 inches (At abutment wall centerline, sta. 3900+32) δ_C = 4 inches (At wall face, sta. 3900+82) δ_D = 8 inches (At ramp centerline, sta. 3900+82) δ_E = 2 inches (At wall face, sta. 3902+50) δ_D = 4 inches (At ramp centerline, sta. 3902+50) Differential Settlement = 0.30% (maximum allowable is 1.0% ODOT BDM 204.6.2.1)
Maximum Full Height of MSE Wall = 37.3 feet (Including Embedment Depth) Minimum Embedment Depth = 3.0 feet* Minimum Length of Reinforcement for External Stability, 1.0(H+D) **

* Assumed top of leveling pad elevation is 537.1. Embedment depth may vary depending on actual top of leveling pad. Minimum embedment depth of 3.0 feet.

** Use 1.0(H+D) where allowed by ramp width. For higher wall sections, reductions of reinforcement length due to limiting ramp width is permissible given that the reinforcement overlap is 0.3 (H+D) or greater.

5.3.5 MSE Wall Evaluations and Recommendations
SR 823 over NS Railroad and US 23, Rear Abutment – Wall No. 6

The proposed wall is understood to be located at approximate station 895+54. This wall will extend 229 feet along existing US 23, in front of the rear abutment of the SR 823 bridge over the Norfolk Southern Railroad and US 23. For additional information, refer to the site plans, included in Appendix A.

It is assumed that the top of leveling pad for this wall will be placed at approximate elevation 541.7. The maximum wall height was measured to be approximately 43.3 feet (including embedment).

In the analysis of MSE Wall No. 6, the subsurface profile encountered by borings B-1141 and TR-52 are considered to be the most critical with respect to stability.

Borings B-1141 and TR-52 generally encountered very stiff sandy silt (A-4a) and silt and clay (A-6a) between elevation 541.2 (the bottom of the leveling pad) and approximate elevation 539.9. Below these cohesive soil layers, borings generally encountered loose gravel with sand, silt and clay (A-2-6) to the top of bedrock at approximately elevation 523.0.

Analyses were performed to determine the global stability, bearing capacity and stability (overturning and sliding) of the proposed MSE walls bearing on the existing soils. The results of the analyses indicate that the factors of safety for global stability, bearing capacity and stability (overturning and sliding) are above the minimum recommended values.

The stability analyses indicate that a minimum reinforcement length of 0.85 times the full height (H+D) feet should be used for external stability. The reinforcement length may be increased to achieve the required internal stability.

The maximum settlement occurring at the centerline of Wall No. 6 is estimated to be approximately 1 inch. Differential settlement at the wall face, between the centerline and the toe of the proposed MSE wall was calculated to be approximately 0.1 percent, which is considered to be acceptable.

Table 8 presents the MSE retaining wall parameters and results of the analyses for MSE Wall No. 6.

Table 8 - MSE Retaining Wall Parameters and Analysis Results
Rear Abutment Location, MSE Wall No. 6

Retained Soil (New Embankment) Unit Weight = 120 pcf Coefficient of Active Earth Pressure (K_a) = 0.33 (Based on $\Phi' = 30°$)
Sliding along base of MSE wall Sliding Coefficient (μ)(0.67) = tan 28°(0.67) = 0.36
Allowable Bearing Capacity – Undrained Condition q_{all} = *NA (granular foundation soils below MSE wall leveling pad)*
Allowable Bearing Capacity – Drained Condition q_{all} = 6,933 psf
Global Stability Factor of Safety – Undrained Condition = 2.0 Factor of Safety – Drained Condition = 1.8 Factor of Safety – Drained Seismic Condition = 1.7
Estimated Settlement of MSE Volume δ_A = Negligible (toe of embankment / wall) δ_B = 1 inch (centerline of embankment / wall) Differential Settlement = 0.1% (maximum allowable is 1.0% ODOT BDM 204.6.2.1)
Maximum Full Height of MSE Wall = 43.3 feet (Including Embedment Depth) Minimum Embedment Depth = 3.0 feet* Minimum Length of Reinforcement for External Stability, 0.85(H+D)

* Assumed top of leveling pad elevation is 541.7. Embedment depth may vary depending on actual top of leveling pad., however, a minimum embedment depth of 3.0 feet is required.

5.3.6 MSE Wall Evaluations and Recommendations
SR 823 over NS Railroad and US 23, Forward Abutment – Wall No. 3

The proposed wall is understood to be located at approximate station 899+07. This wall will extend 187 feet along existing US 23, in front of the forward abutment of the SR 823 bridge over the Norfolk Southern Railroad and US 23. For additional information, refer to the site plans, included in Appendix A.

In the analysis of MSE Wall No. 3, the subsurface profile encountered by borings B-54 and TR-49 are considered to be the most critical with respect to stability.

The maximum wall height was measured to be approximately 39.4 feet (including embedment). It is assumed that the top of leveling pad for this wall will be placed at approximate elevation 535.0.

Borings B-54 and TR-49 generally encountered soils consisting of silt (A-4b) to silt and clay (A-6a) between elevation 534.5 (the bottom of the leveling pad) and approximate elevation 520.7. The consistency of these cohesive soils was very stiff between elevation 534.5 and elevation 533.7, but stiff to medium stiff below elevations 533.7. Below the cohesive soil layers, borings generally encountered

loose gravel with sand (A-1-b) and coarse and fine sand (A-3a) to the top of bedrock at approximate elevation 507.7.

Analyses were performed to determine the global stability, bearing capacity and stability (overturning and sliding) of the proposed MSE walls bearing on the existing soils. The results of the analyses indicate that the factors of safety for global stability, drained bearing capacity and overturning are all above the minimum recommended values. However, the factor of safety against undrained bearing capacity failure is found to be 0.81, which is well below the minimum required value of 2.5. The factor of safety against sliding under the undrained condition is found to be 0.89, which is well below the minimum required value of 1.5.

In order to construct the MSE wall while maintaining the minimum factor of safety against undrained bearing capacity and sliding, the possible use of staged construction was investigated. Additional analyses were performed, assuming that an increase in the undrained shear strength of the foundation soils would occur due to the consolidation after each stage of wall construction. Calculations using the maximum wall height of 39.4 feet, indicate that the required factor of safety of 2.5 against undrained bearing capacity failure will not be achieved with the estimated increase in shear strength in the foundation soils. As a result, the wall cannot be constructed using staged construction.

The use of preloading to surcharge the foundation soils prior to construction of the MSE wall was also investigated. The toe of this preloading embankment should be located approximately at station 898+82, or 25 feet east (down-station) of the face of Wall No. 3. Analyses indicate that an embankment using 1H:1V side slopes, which is approximately 36 feet tall would sufficiently surcharge the existing foundation soils. Flatter slopes could be used, but would require the toe of the slope to extend into the pavement surface of existing US 23, which may require lane closures. Therefore, options using flatter slopes were not explored.

A reinforced soil slope, using a geogrid or geotextile fabric, is required for the stability of the recommended 1H:1V side slopes. Global stability analyses were performed to determine the minimum required reinforcement length. The analyses indicate that a minimum reinforcement length of 20 feet should be required for external stability. Other analyses are required to determine the internal stability of the reinforced slopes and are not considered to be within the scope of work for this report. The geotextile supplier should determine the length and the spacing of the reinforcement required for internal stability. The minimum required reinforcement length may be increased if necessary.

As with the MSE walls, the analyses for the reinforced soil slopes assume a unit weight of 120 pounds per cubic foot (pcf) and an effective friction angle of 34 degrees for the backfill material in the reinforced zone. In accordance with

ODOT guidelines, the fill material used to construct the roadway embankments is assumed to have a unit weight of 120 pcf and an effective friction angle of 30 degrees.

The preloading embankment should be constructed up to elevation 574.1 (approximately 36 feet high) and allowed to consolidate to at least ninety percent of primary consolidation (U=90%). After the foundation soils have sufficiently consolidated under the surcharge load, the preloading embankment should be removed, and the proposed MSE wall constructed. Stability analyses indicate that a MSE soil reinforcement length of 0.85 times the full height (H+D) or 33.5 feet should be used for Wall No. 3. This value is a minimum and may be increased for internal stability.

It is recommended that pore pressures and settlements in the clay layers of the foundation soils be monitored throughout the construction process. Recommendations and details concerning instrumentation placement, required waiting periods, pore pressure monitoring, and preloading embankment construction details can be found in the Instrumentation and Special Construction plans presented in Appendix A.

Calculations indicate that approximately 9 inches of settlement will occur at the location of the proposed wall face during the preloading. When the surcharge embankment is removed, it is anticipated that the foundation soils will rebound slightly before they consolidate again under the weight of the MSE wall and fill. Calculations using the recompression index, for the fine-grained foundation soils indicate that the maximum settlement beneath the MSE wall will be approximately 2 inches with differential settlement of approximately 0.1 percent, which is considered to be acceptable.

Based on the results of time-rate of consolidation calculations, the time to 90 percent consolidation (U=90%) is estimated to be 81 days. This duration can be shortened through the use of prefabricated vertical drains (wick drains). The consolidation times using various wick drain spacing are presented in Table 9.

Table 9 - Wick Drain Spacing and Consolidation Periods (Preloading)

SR 823 over Norfolk Southern Railroad and US 23, MSE Wall No. 3		
Spacing (ft)	**+Time to U=90% (days)**	**Approximate Depth of Wick Drains (ft)**
5	20	20
7	30	20
9	40	20

+ U=90%, required minimum consolidation of foundation soils under preloading embankment.

Table 10 presents the MSE retaining wall parameters and results of analyses for MSE Wall No. 3.

Table 10 - MSE Retaining Wall Parameters and Analysis Results
Forward Abutment Location, MSE Wall No. 3

Retained Soil (New Embankment) Unit Weight = 120 pcf Coefficient of Active Earth Pressure (K_a) = 0.33 (Based on $\Phi' = 30°$)
Sliding along base of MSE wall Sliding Coefficient (μ)(0.67) = tan 28°(0.67) = 0.36
Allowable Bearing Capacity – Undrained Condition q_{all} = *NA (undrained condition not mobilized due to preloading)*
Allowable Bearing Capacity – Drained Condition q_{all} = 6,559 psf
Global Stability Factor of Safety – Undrained Condition = 1.3 *(Using Initial Shear Strengths)* Factor of Safety – Drained Condition = 1.9 Factor of Safety – Drained Seismic Condition = 1.8
Estimated Settlement of MSE Volume δ_C = Negligible (toe of embankment / wall) *(After Preloading)* δ_D = 2 inches (centerline of embankment / wall) *(After Preloading)* Differential Settlement = 0.1% (maximum allowable is 1.0% ODOT BDM 204.6.2.1)
Maximum Full Height of MSE Wall = 39.4 feet (Including Embedment Depth) Minimum Embedment Depth = 3.0 feet* Minimum Length of Reinforcement for External Stability, 0.85(H+D)

* Assumed top of leveling pad elevation is 535.0. Embedment depth may vary depending on actual top of leveling pad., however, a minimum embedment depth of 3.0 feet is required.

5.4 Embankment Recommendations

For construction of the interchange, several earthen embankments will be required. All embankment sections were analyzed for global stability and settlement. As per ODOT Office of Geotechnical Engineering, the following material properties were used for the stability analyses of the embankments; 1) a cohesion value of 2000 pounds per square foot (psf) and a friction angle of zero degrees were used for the undrained analysis and 2) a cohesion value of 300 psf and a friction angle of 28 degrees were used for the drained and seismic analyses.

Based on the results of the analyses, factors of safety greater than the minimum recommended values for undrained, drained, and seismic conditions can be achieved for the earthen embankments with side slopes of no steeper than 2H:1V. Table 11 summarized the results of the stability and settlement analyses. For more information, refer to the drawings, illustrating the results of the global stability analyses and settlement calculation, presented in Appendix D.

Table 11 – Summary of Analysis Results, Interchange Embankments

Station	Alignment	Embankment Height	Factor of Safety Against Global Stability			Maximum Settlement
			Undrained	Drained	Seismic	
892+95	SR 823	28.0 ft	2.3	1.8	1.7	5 in
895+17	SR 823	34.5 ft	2.9	1.7	1.6	1 in
899+44	SR 823	35.9 ft	2.0	1.7	1.6	9 in
4906+00 / 1906+50	Ramp D / Ramp A	25.3 ft	3.4	2.1	1.9	7 in
4911+00 / 1912+00	Ramp D / Ramp A	18.7 ft	3.2	2.0	1.9	6 in
1919+00	Ramp A	6.8 ft	4.0	3.1	2.8	2 in
4914+00	Ramp D	9.2 ft	5.1	2.3	2.3	3 in
2609+07	Ramp B	30.8 ft	2.6	1.8	1.6	8 in
3894+77	Ramp C	28.3 ft	2.1	1.8	1.7	13 in

5.5 Special Construction and Wick Drains – General Recommendations

Stability analyses indicate that staged construction techniques and preloading will be required to construct many of the proposed MSE retaining walls within the interchange. MSE Wall Nos. 2, 4, and 5 will require the use of staged construction to build the proposed walls, while Wall No. 3 will require the use of preloading to surcharge the existing foundation soils prior to the construction of the MSE wall.

Depending on the construction schedule, it may be beneficial to use wick drains to accelerate the consolidation of foundation soils. Potential treatment areas have been identified. Potential treatment areas and associated details are presented on drawing in Appendix A.

It is recommended that wick drains be installed within and to 15 feet beyond (where possible) the limits of the proposed ramp walls/embankments using a triangular spacing pattern. Wick drains should be installed to a depth which is sufficient to penetrate the upper, fine-grained layer. The recommended wick drain installation depths for various wall sections are indicated in their respective report sections, and also in the Wick Drain and Instrumentation Plan, presented in Appendix A. Three feet of sand (ODOT Item 703.02) should be placed over the treated area prior to construction of the embankment. This layer will provide a free draining layer beneath any embankment fill, allowing pore water to be expelled.

It is recommended that pore water pressures be monitored in the fine-grained layers of the foundation soils. Details and recommendations for the placement of piezometers and settlement platforms are presented in Appendix A. Information regarding staged construction, preloading, and wick drains is also included in Appendix A.

5.6 General Earthwork Recommendations

Approximately 1 to 8 inches of topsoil were encountered at the ground surface. All topsoil and vegetation within the footprint of the new embankment and roadway should be removed prior to any new fill placement. All pavement and organic soil within 3 feet of subgrade level should also be removed prior to placing fill or pavement materials. However, overexcavation may need to be deeper if organic soils are encountered at depths greater than three feet.

Five samples from four borings (B-1102, B-1103, B-1129, and B-1150) drilled for other features of the interchange were tested to determine the organic content. The results indicate organic contents ranging from 3.74 to 6.12 percent, which are considered to be slightly to moderately organic. Although the borings encountered only sporadic, thin, slightly to moderately organic soil layers, organic or very soft soils may be encountered at locations other than where the borings were drilled. Consequently, the Contractor should be prepared to perform overexcavation of any poor soils or organic soils at the proposed bridge and embankment areas, and to replace the overexcavated soil with compacted engineered fill as needed.

Fill and/or possible fill was encountered in several of the borings. The presence of these materials does not necessarily indicate poor subgrade conditions. However, because of the apparent uncontrolled nature of some of the fill, it should be anticipated that conditions at some locations along the proposed roadway alignments may vary considerably from those encountered by the borings, especially outside of the existing roadways.

The soils identified as possible fill did not necessarily contain deleterious material or other obvious evidence indicative of fill material. It is often difficult to distinguish between clean fill and natural material based solely on the appearance of the samples. The materials classified as possible fill were identified as such based on other additional information, including the topography of the site and depth below existing grade.

5.7 Excavation and Groundwater Considerations

Most of the proposed MSE walls are anticipated to require excavations of less than five feet. Based upon seepage and groundwater observations, it is anticipated that excavations of five feet or less will encounter little if any seepage.

Due to the existing slope geometry relative to proposed Wall No. 6 location, significant excavations will be required to accommodate the installation of the soil reinforcing straps. Based upon the provided drawings, the bottom of the MSE wall leveling pad is anticipated to be at elevation 541.2. Borings B-1141, B-1142, and TR-52, drilled in the area of the rear abutment encountered water-bearing granular soils at approximate elevation 539.9. Seepage was observed in these borings at approximate elevation 535.0. Although groundwater or seepage was not observed above the bottom of excavation, the

contractor should be prepared to deal with any seepage zones that may be present which were not observed in the borings.

Near the Ramp B retaining walls (Wall No. 4), seepage was first observed in the borings at depths between 10.0 and 26.0 feet below the ground surface. Measurable water levels were observed in some of the borings prior to rock coring at depths between 12.0 and 26.0 feet below the ground surface. However, excavations could encounter seepage based upon piezometer observations. The piezometer installed in boring B-1109A indicated that the phreatic level in the water-bearing granular layers is at approximate elevation 531.3, or 1.2 feet below the existing ground surface.

The bottom of the excavations should be kept essentially dry. Excavations extending below the water table into sand, silt, or gravel deposits can result in a "quick condition" when the confining effect of the overburden is removed. To prevent this occurrence, areas of proposed excavation may need to be dewatered. The water level should be maintained a minimum of 3 feet below the bottom of the proposed excavation during construction.

All excavations should be constructed in accordance with the current OSHA regulations governing excavation and trench safety standards (29 CFR Part 1926). It is recommended that earthwork be performed under continuous observation and testing by a soils technician with the general guidance of a geotechnical engineer.

Heavy equipment working close to excavations and stockpiles of construction materials close to the excavations act as a surcharge weight and may result in instability of the excavation sidewalls. In addition, vibrations from heavy equipment or trains could result in instability of the excavation sidewalls as well. A "competent person" having knowledge relative to slope stability should constantly observe side slopes of excavations for signs of yielding and potential failure or "cave'ins".

6.0 CLOSING REMARKS

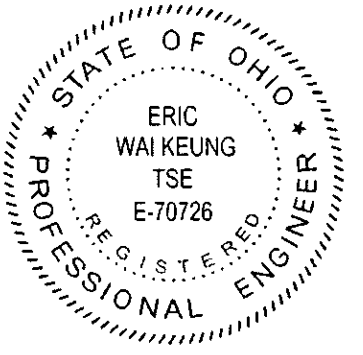
We encourage you to discuss with us any questions or concerns you have about the findings and conclusions presented in this report. Please do not hesitate to call if we can be of any further assistance.

Sincerely,

DLZ Ohio, Inc.

Steven J. Riedy
Geotechnical Engineer

Eric Tse, P.E.
Senior Geotechnical Engineer



Copies: CH2M Hill Corporation – 3
ODOT District 9 – 4
File – 3

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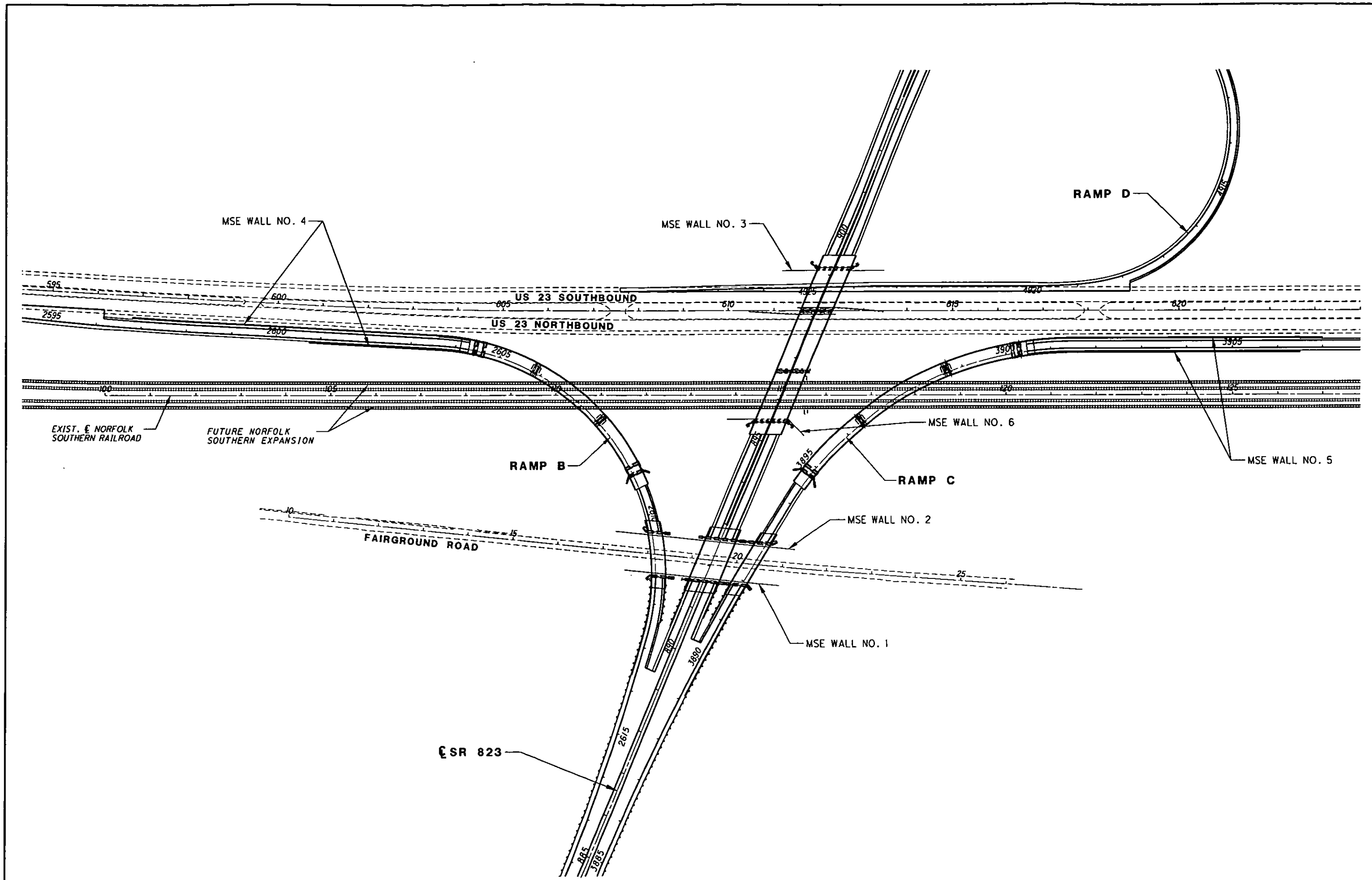
APPENDIX A

DLZ

APPENDIX A

Site Plan Drawings
Wick Drain and Instrumentation Plan

Site Plan Drawings



HORIZONTAL SCALE IN FEET
0 50 100 200

GENERAL SITE PLAN
US 23/SR 823 INTERCHANGE

PID NO. 79977

SCI-823-10.13

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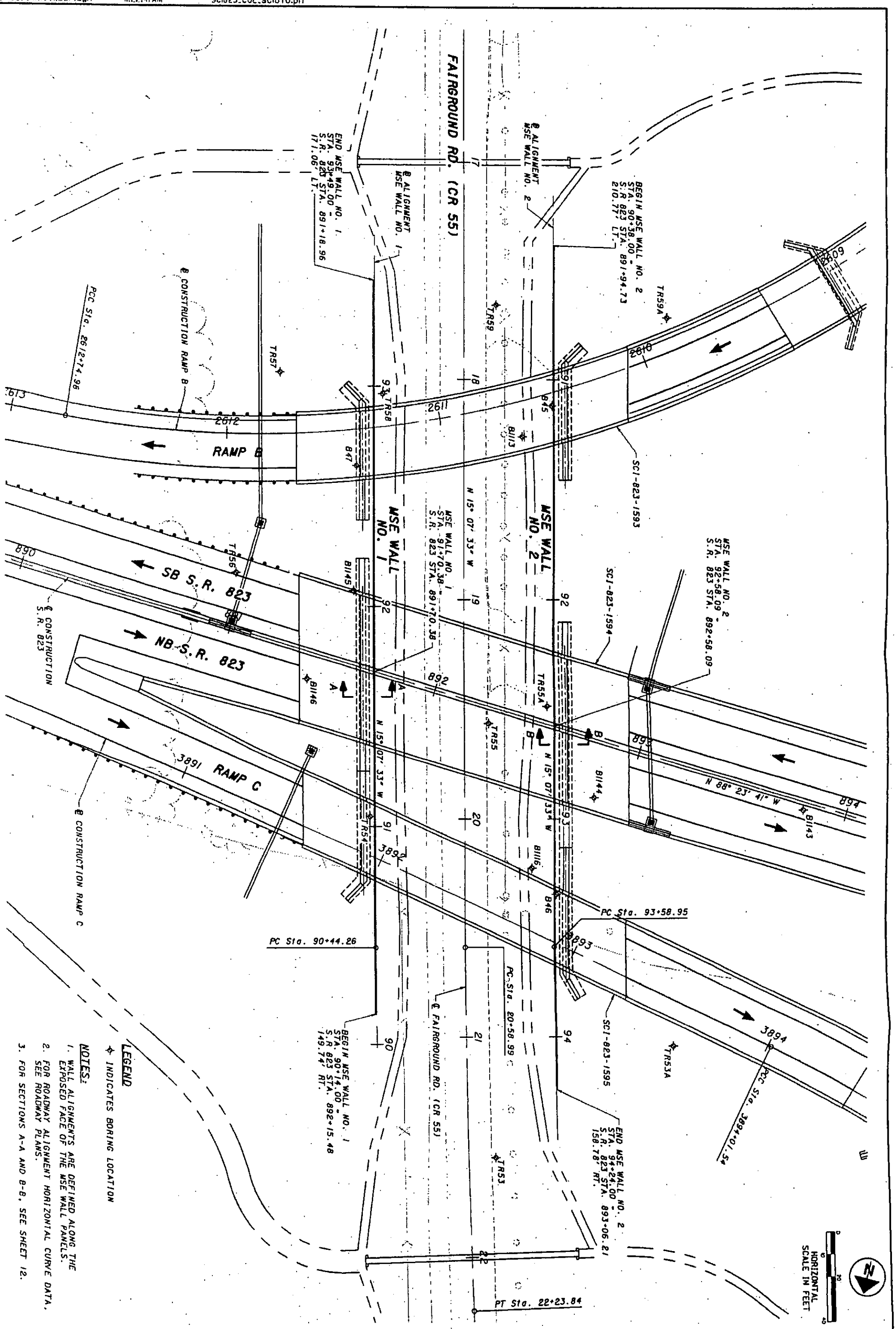


LEGEND

✧ INDICATES BORING LOCATION

NOTES:

1. WALL ALIGNMENTS ARE DEFINED ALONG THE EXPOSED FACE OF THE MSE WALL PANELS.
2. FOR ROADWAY ALIGNMENT HORIZONTAL CURVE DATA, SEE ROADWAY PLANS.
3. FOR SECTIONS A-A AND B-B, SEE SHEET 12.

DESIGNED JBA	DRAWN JBA	REVIEWED	DATE 08/07	DESIGN AGENCY: CH2MHILL 8775 Perimeter Drive, Suite 190 Dublin, Ohio 43017	
CHECKED	REVISED	STRUCTURE FILE NUMBER			

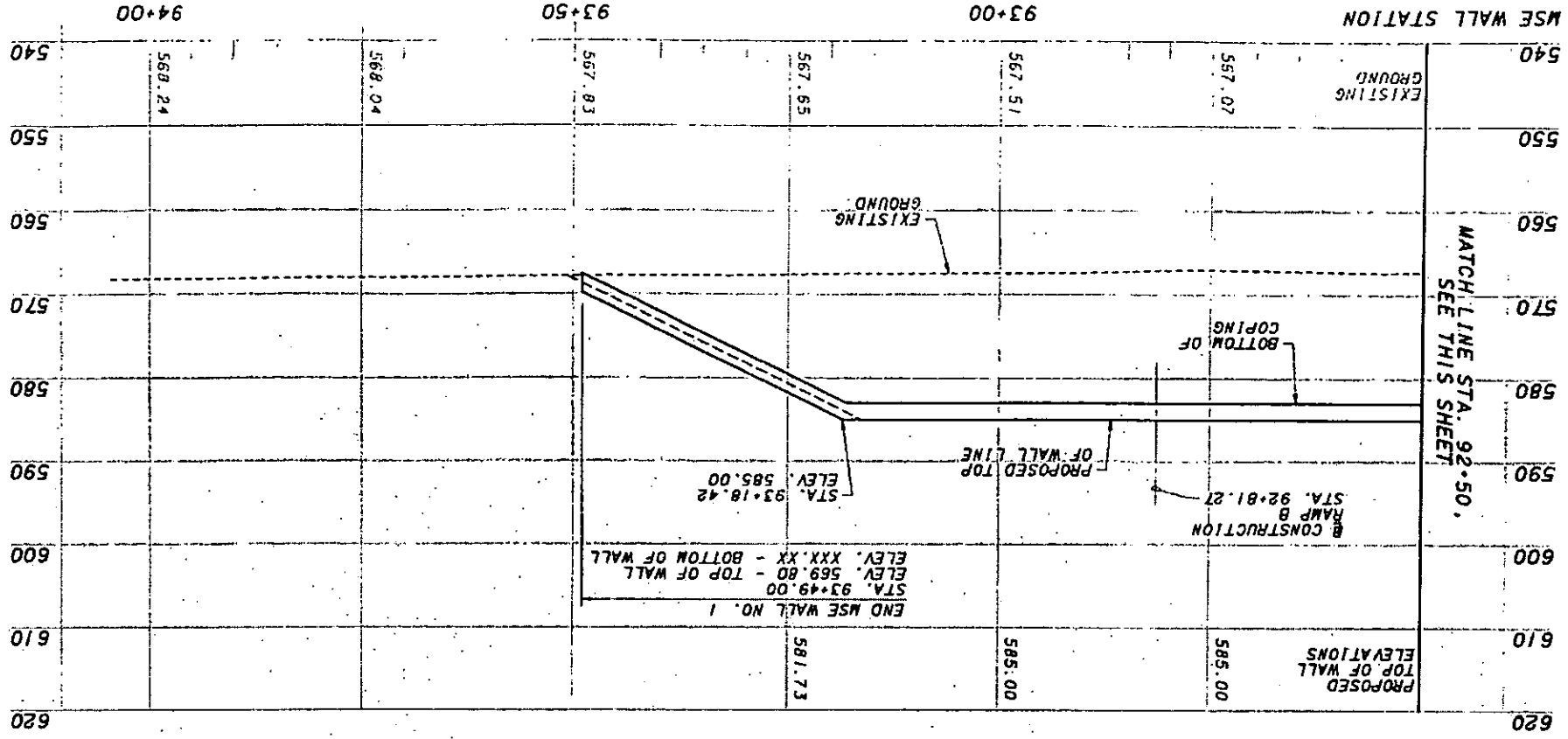
SCI-823-10.13
PID 79977

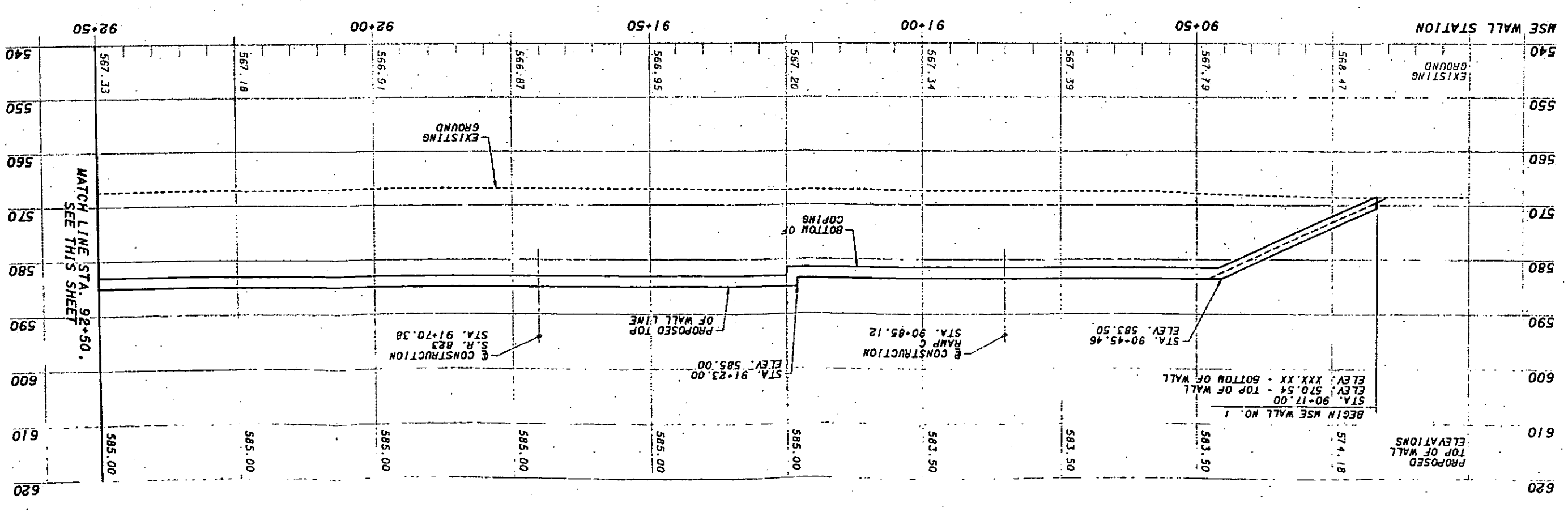
MSE WALLS 1 & 2 PLAN VIEW

SCI-823-10.13
PID 79977

WALL ELEVATION - MSE WALL NO. 1

NOTES:
1. MSE WALL ELEVATIONS ARE SHOWN VIEWED FROM THE EXPOSED FACE OF THE WALL.
2. FOR DEFINITION OF MSE WALL TOP AND BOTTOM ELEVATIONS, SEE WALL SECTION ON SHEET X.





DESIGNED	DRAWN	REVIEWED	DATE
JBA	JBA		08/07
CHECKED	REVISED	STRUCTURE FILE NUMBER	

DESIGN AGENCY
CH2MHILL
6775 Perimeter Drive, Suite 190
Dublin, Ohio 43017

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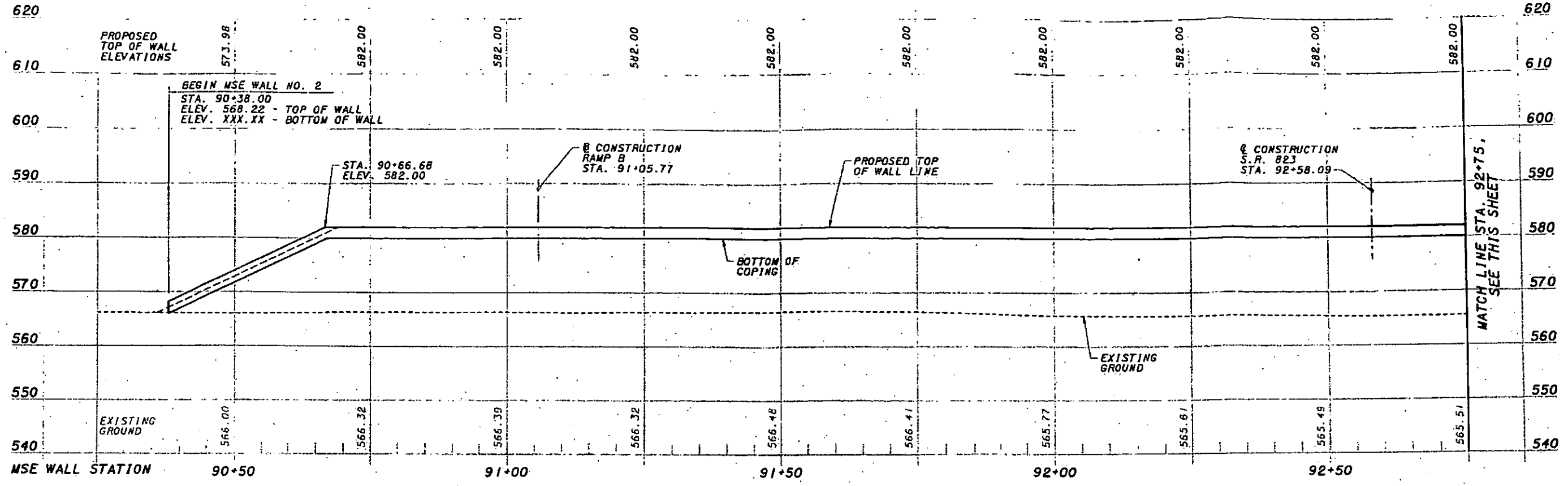

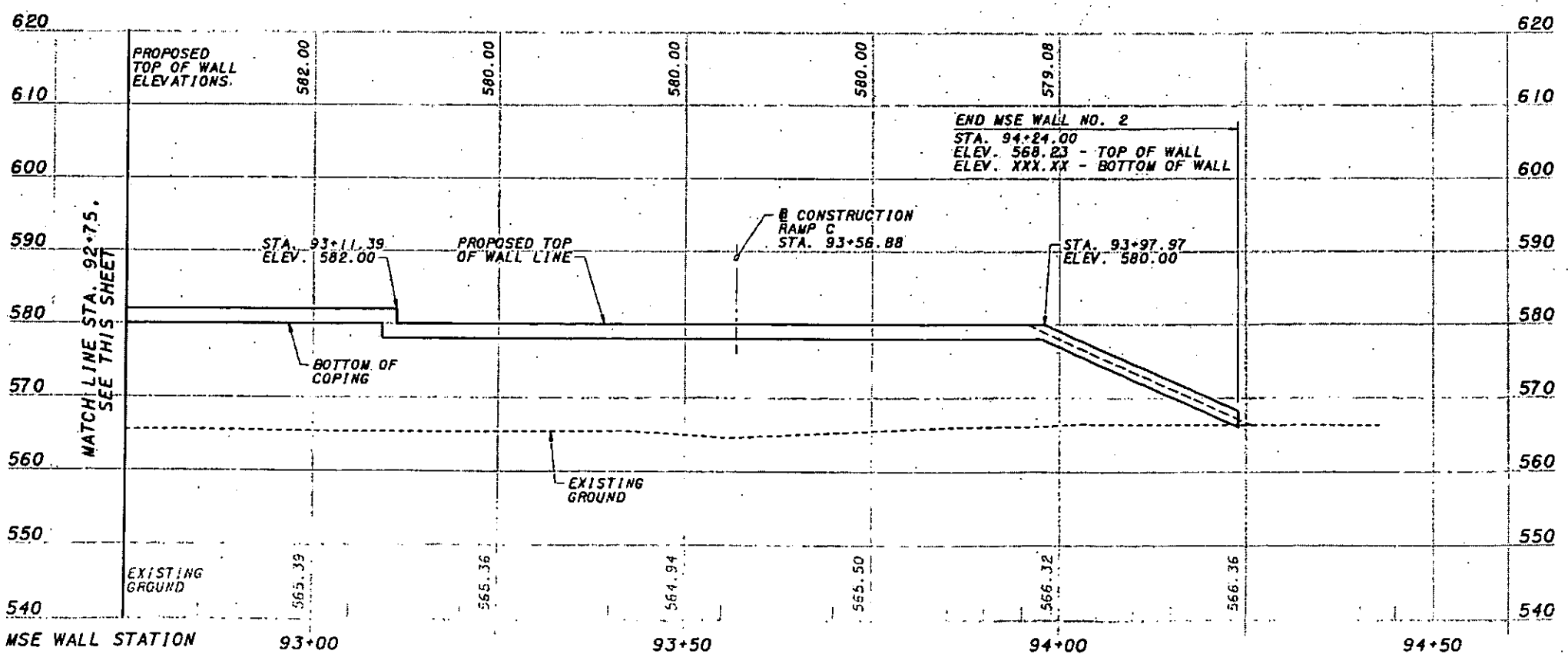

NOTES:

1. MSE WALL ELEVATIONS ARE SHOWN VIEWED FROM THE EXPOSED FACE OF THE WALL.
2. FOR DEFINITION OF MSE WALL TOP AND BOTTOM ELEVATIONS, SEE WALL SECTION ON SHEET X.

DESIGN AGENCY
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5775 Perimeter Drive, Suite 190
Dublin, Ohio 43017

DESIGNED	DRAWN	REVIEWED	DATE
JBA	JBA		08/07
CHECKED	REVISED	STRUCTURE FILE NUMBER	

WALL ELEVATION - MSE WALL NO. 2

SCI-823-10.13
PID 79977

X / X

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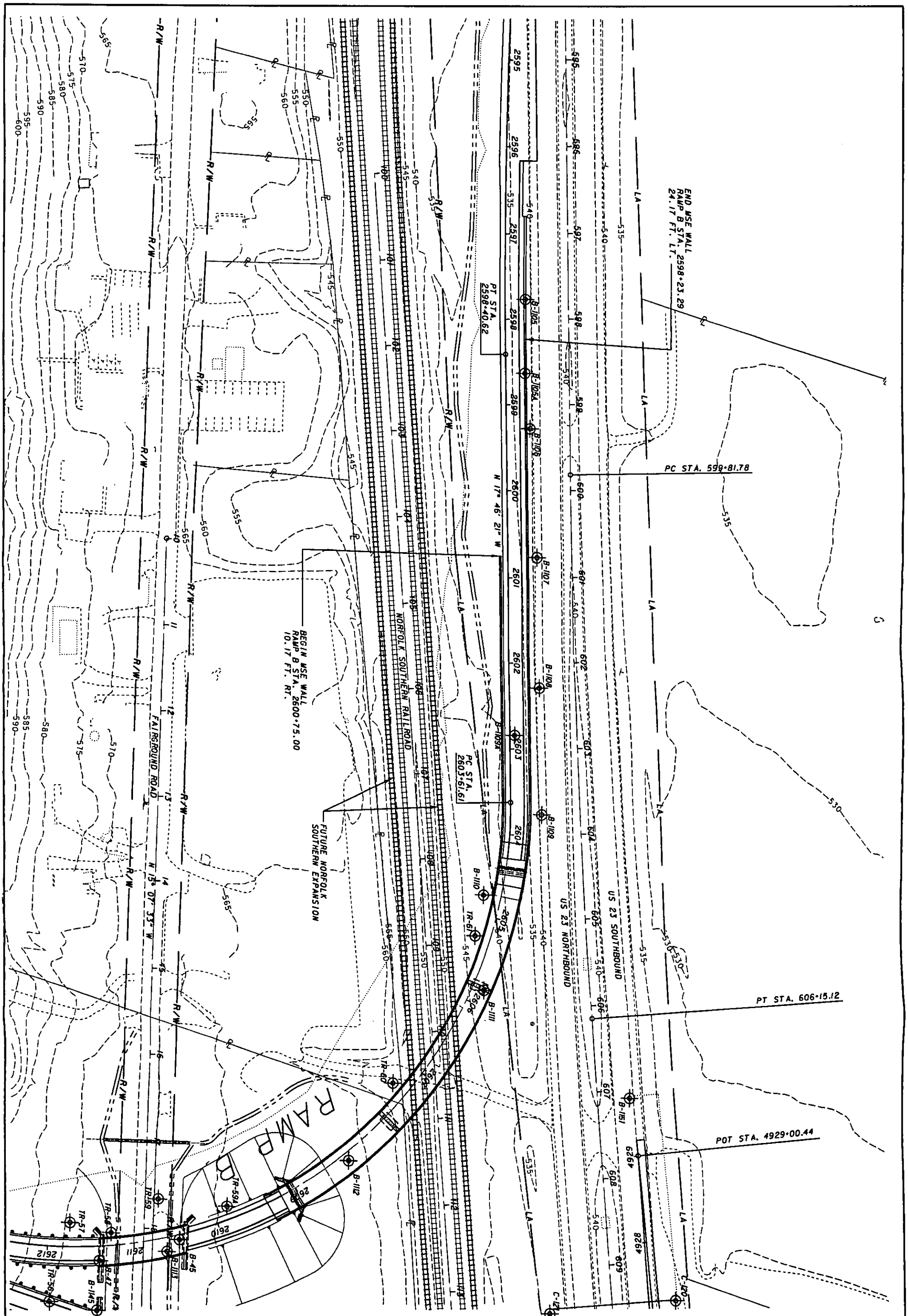

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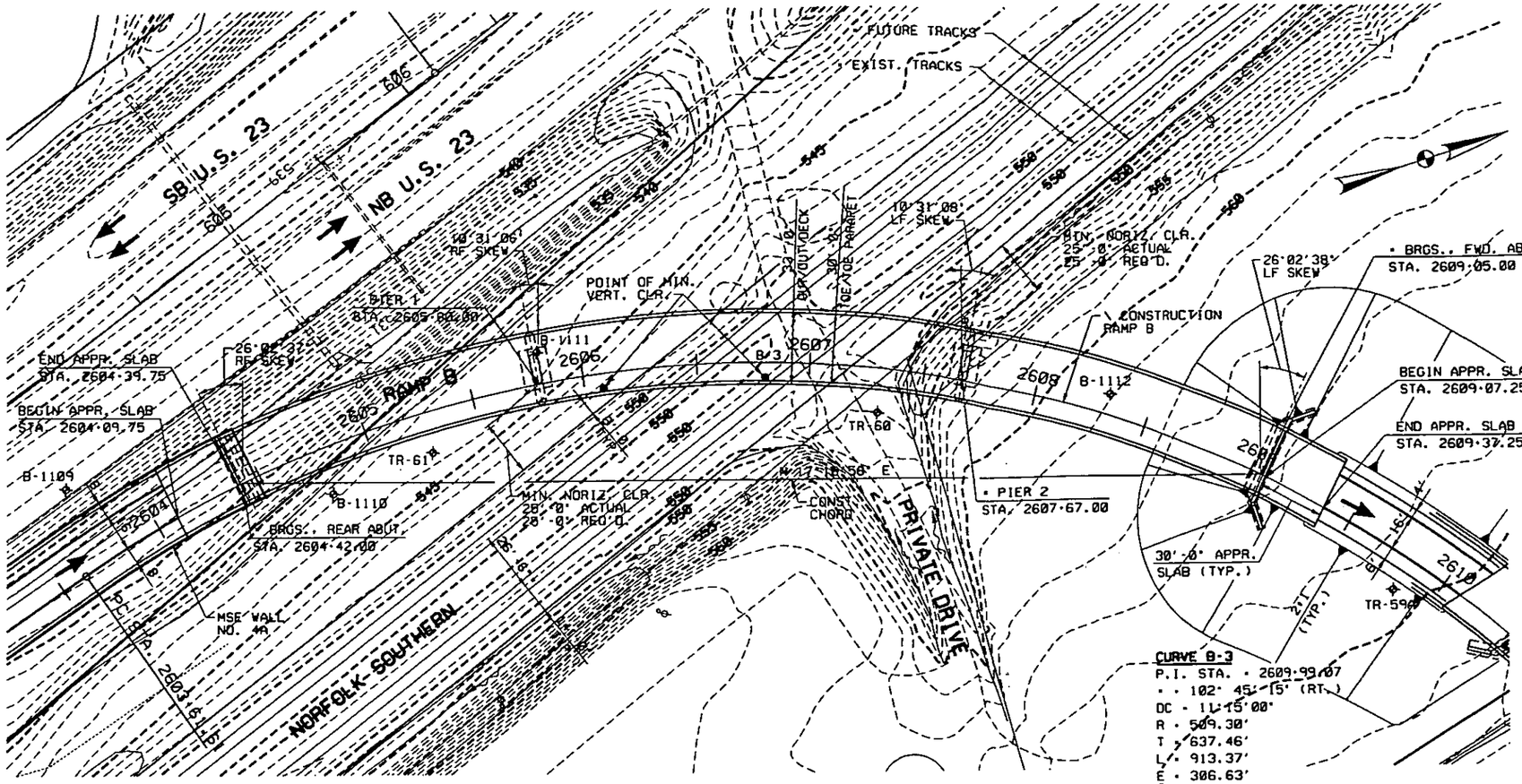
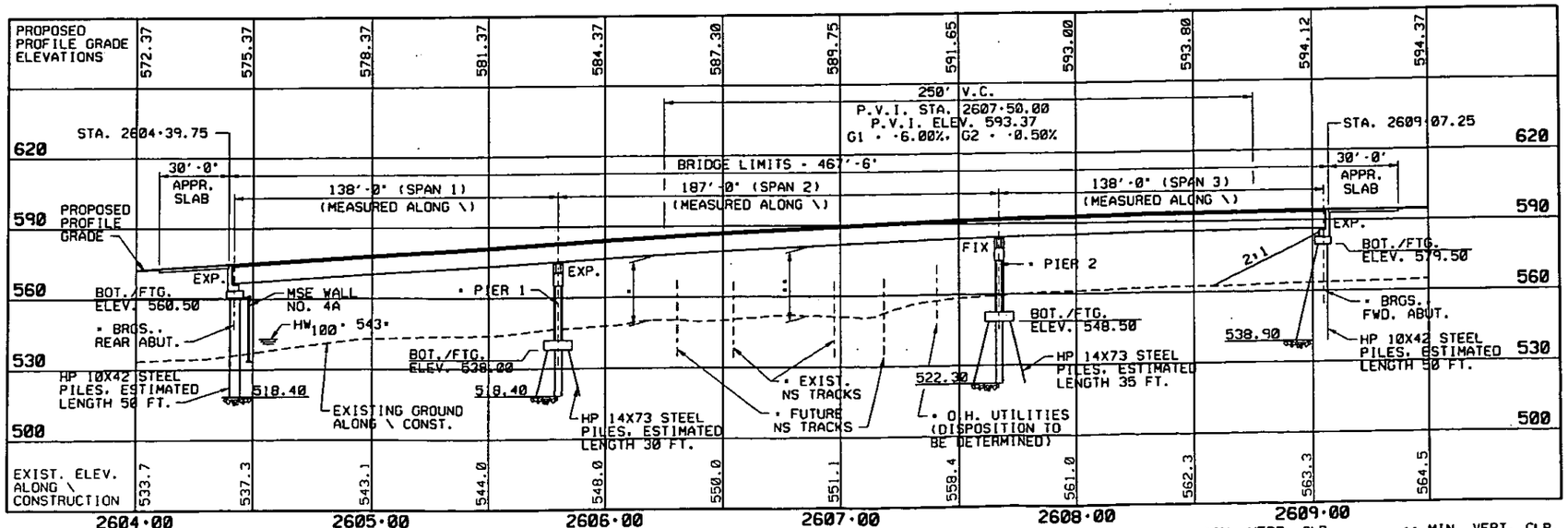


PLAN



PROFILE ALONG \ SURVEY AND CONSTRUCTION, RAMP B

• MIN. VERT. CLR. 25'-5" ACTUAL 23'-3" REQ'D.

•• MIN. VERT. CLR. 28'-5" ACTUAL 23'-2" REQ'D.

BENCHMARKS

TRAFFIC DATA

CURRENT ADT (2010) = 2700
DESIGN ADT (2030) = 3600
DESIGN ADTT = 500

LEGEND

⊕ DENOTES SOIL BORING LOCATION

NOTE

EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

PROPOSED STRUCTURE

TYPE: THREE SPAN COMPOSITE CURVED STEEL PLATE GIRDERS (WEATHERED ASTM A709, GR 50W) WITH REINFORCED CONCRETE DECK ON JOINTED STUB ABUTMENT ON MSE WALL (REAR) AND JOINTED STUB ABUTMENT BEHIND 2:1 EMBANKMENT (FWD.) WITH T-TYPE PIERS

LENGTH OF SPAN: 131'-0", 187'-0", 131'-0", C-C BEARINGS, MEASURED ALONG \ CONSTRUCTION

ROADWAY: 30'-0" TOE/TOE PARAPETS

SIDEWALK: NONE

DESIGN LOADING: HS25 (CASE II) AND THE ALTERNATE MILITARY LOADING, FWS = 60 LB/FT²

SKEW: 26°02'37" RF (REAR ABUTMENT), 10°31'06" RF (PIER 1), 10°31'08" LF (PIER 2), 26°02'38" LF (FORWARD ABUTMENT), MEASURED FROM THE NORMAL TO THE CONSTRUCTION CHORD

WEARING SURFACE: MONOLITHIC CONCRETE

APPROACH SLABS: AS-1-81 (30'-0" LONG)

ALIGNMENT: HORIZONTALLY CURVED (\ RADIUS= 509.30 FT.)

SUPERELEVATION: 0.071 FT/FT

LATITUDE: N 38°53'28"

LONGITUDE: W 82°59'54"

DESIGN AGENCY
CH2MHILL
8776 Perimeter Drive, Suite 180
Dublin, Ohio 43017

DESIGNED	DRAWN	REVIEWED	DATE
DGS	JBA	WRT	06/07
CHECKED	REVISED	STRUCTURE FILE NUMBER	
SCJ		7306717	

SCIOTO COUNTY
STA. 2604+39.75
TO STA. 2609+07.25

SITE PLAN
BRIDGE NO. SCI-823-1598
RAMP B OVER NORFOLK SOUTHERN - ALT. 1

SCI-823-10.13
PID 79977

1 / 3

$PLOTTER$
$DATE$
$TIME$
$USER$
$FILE$

10/18/2007
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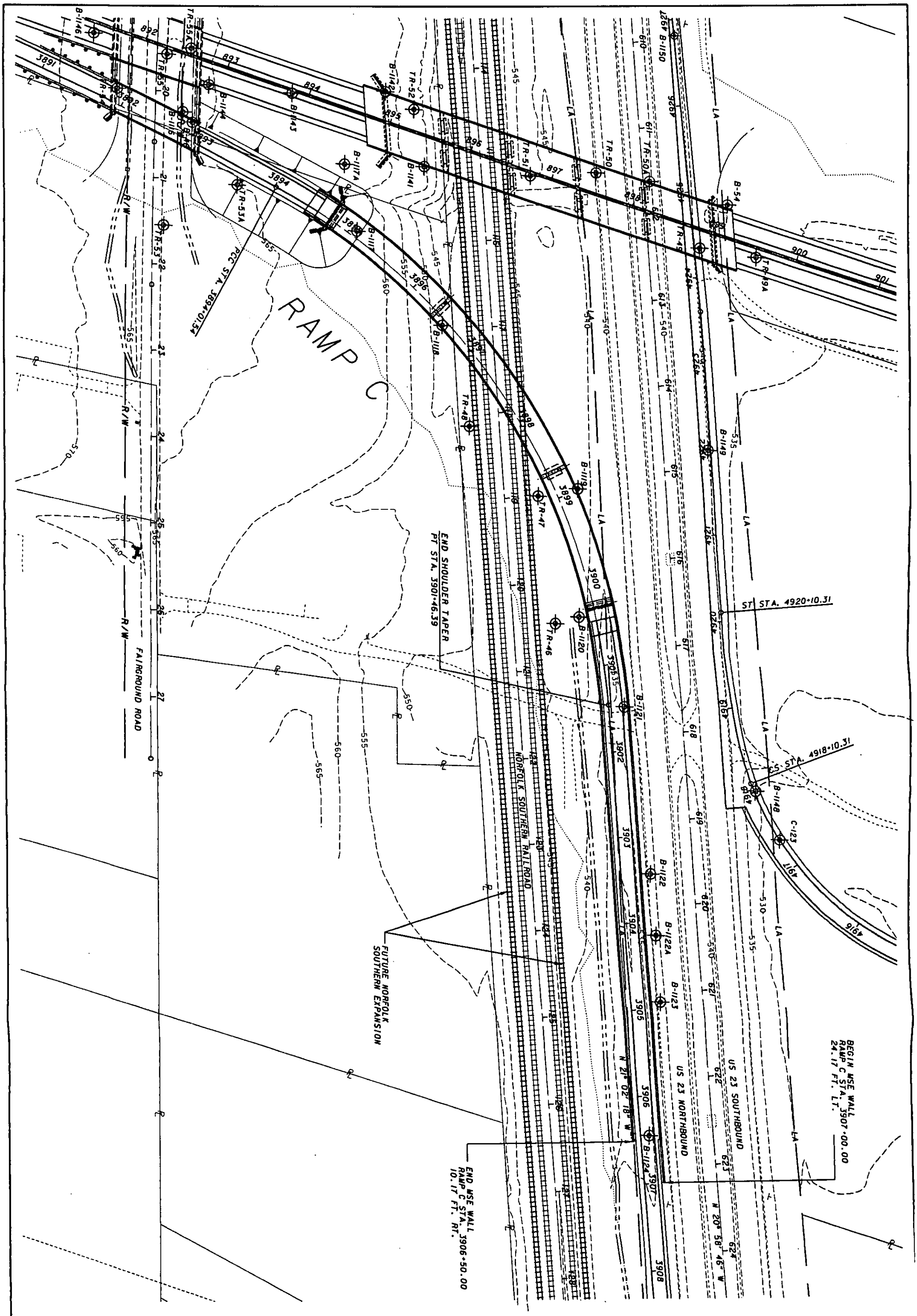
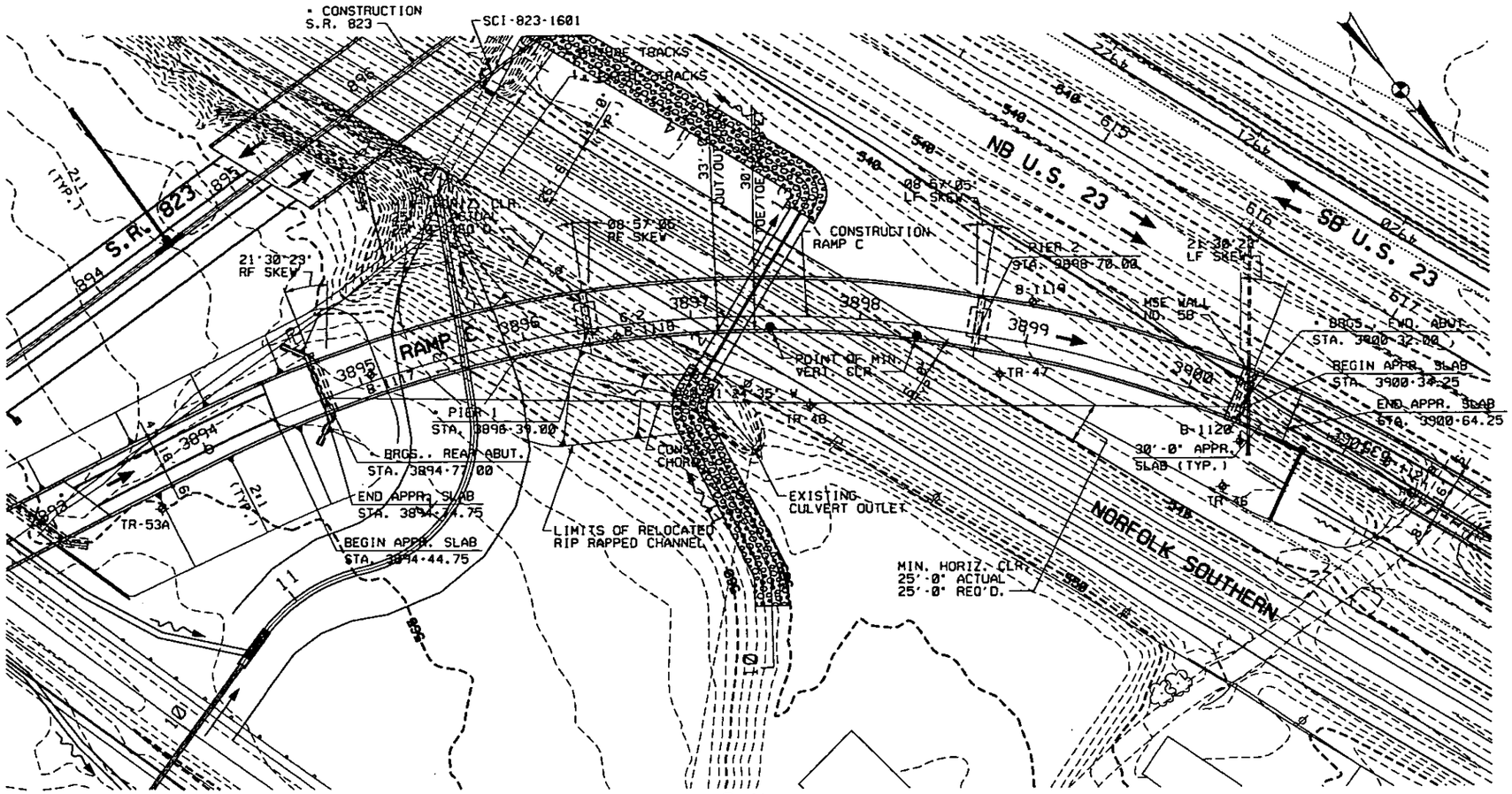
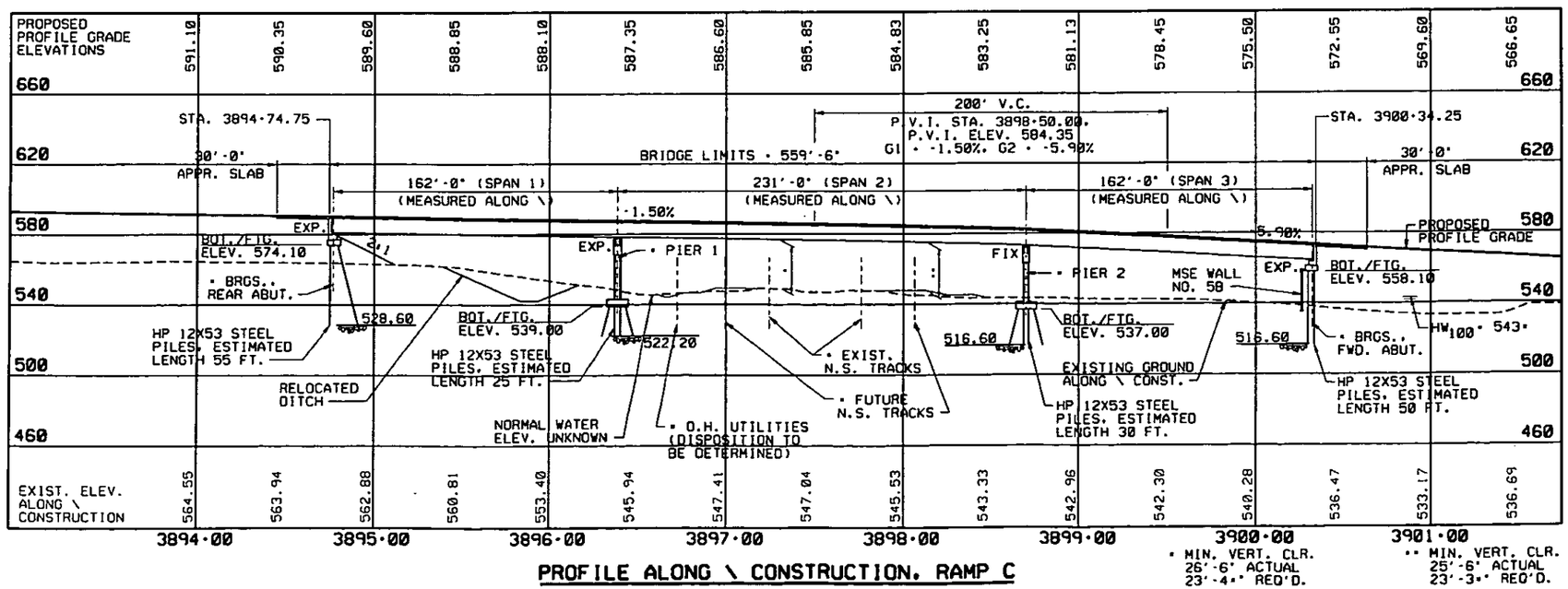


SCI-823	PID NO. 79977	US 23 RAMP C PLAN DRAWING	0 25 50 100 HORIZONTAL SCALE IN FEET



PLAN



PROFILE ALONG \ CONSTRUCTION, RAMP C

$PLOTTER$
$DATE$ $TIME$
$USER$ $FILE$

BENCHMARKS

CURVE C-2
P.I. STA. = 3898+09.03
Δ = 57°43'34" (RT.)
DC = 07°45'00"
R = 739.30'
T = 407.49'
L = 744.85'
E = 104.87'
E_{MAX} = 0.069

TRAFFIC DATA

CURRENT ADT (2010) = 6200
DESIGN ADT (2030) = 9400
DESIGN ADTT = 1320

LEGEND

⌖ DENOTES SOIL BORING LOCATION

NOTE

EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

PROPOSED STRUCTURE

TYPE: THREE-SPAN COMPOSITE CURVED STEEL PLATE GIRDERS (WEATHERED ASTM A709, GR 50W) WITH REINFORCED CONCRETE DECK ON JOINTED STUB ABUTMENT (REAR) AND JOINTED STUB ABUTMENT ON MSE WALL (FWD.) WITH T-TYPE PIERS

LENGTH OF SPAN: 162'-0", 231'-0", 162'-0" C-C BEARINGS, MEASURED ALONG \ CONSTRUCTION

ROADWAY: 30'-0" TOE/TOE PARAPETS

SIDEWALK: NONE

DESIGN LOADING: HS25 (CASE II) AND THE ALTERNATE MILITARY LOADING, FWS = 60 LB/FT²

SKEW: 21°30'23" RF (REAR ABUTMENT), 08°57'05" RF (PIER 1), 08°57'05" LF (PIER 2), 21°30'23" LF (FORWARD ABUTMENT), MEASURED FROM THE NORMAL TO THE CONSTRUCTION CHORD

WEARING SURFACE: MONOLITHIC CONCRETE

APPROACH SLABS: AS-1-81 (30'-0" LONG)

ALIGNMENT: HORIZONTALLY CURVED (\ RADIUS = 739.30 FT.)

SUPERELEVATION: 0.069 FT/FT

LATITUDE: N 38°53'34"

LONGITUDE: W 82°59'57"

DESIGN AGENCY
CH2MHILL
5775 Perimeter Drive, Suite 190
Dublin, Ohio 43017

DESIGNED	DRAWN	REVIEWED	DATE
SKT	JBA	SCJ	06/07

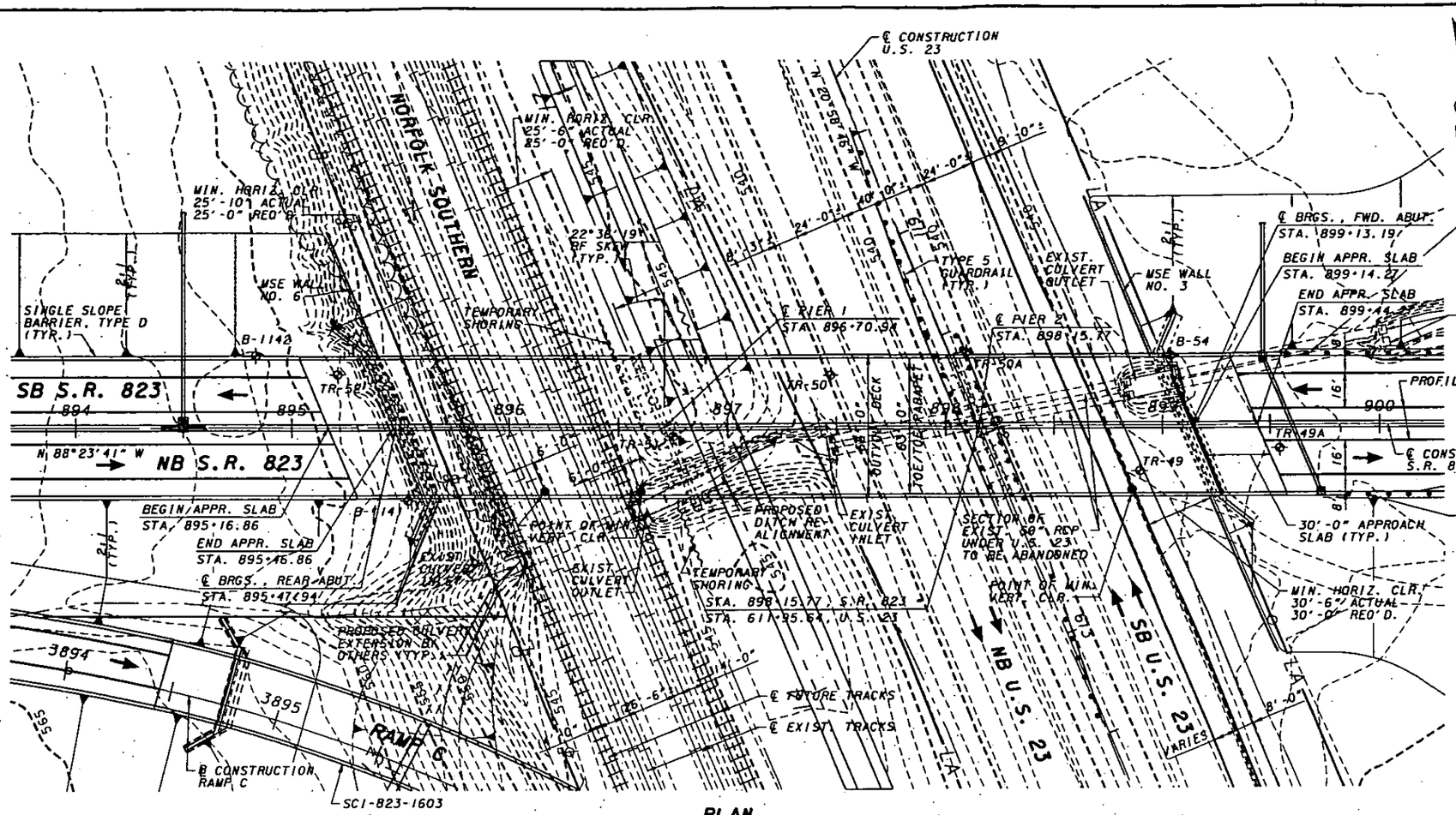
CHECKED	REVISED	STRUCTURE FILE NUMBER
DGS		7306814

SCIOTO COUNTY
STA. 3894+74.75
TO STA. 3900+34.25

SITE PLAN
BRIDGE NO. SCI-823-1603
RAMP C OVER NORFOLK SOUTHERN - ALT. 4

SCI-823-10.13
PID 79977

1 / 3



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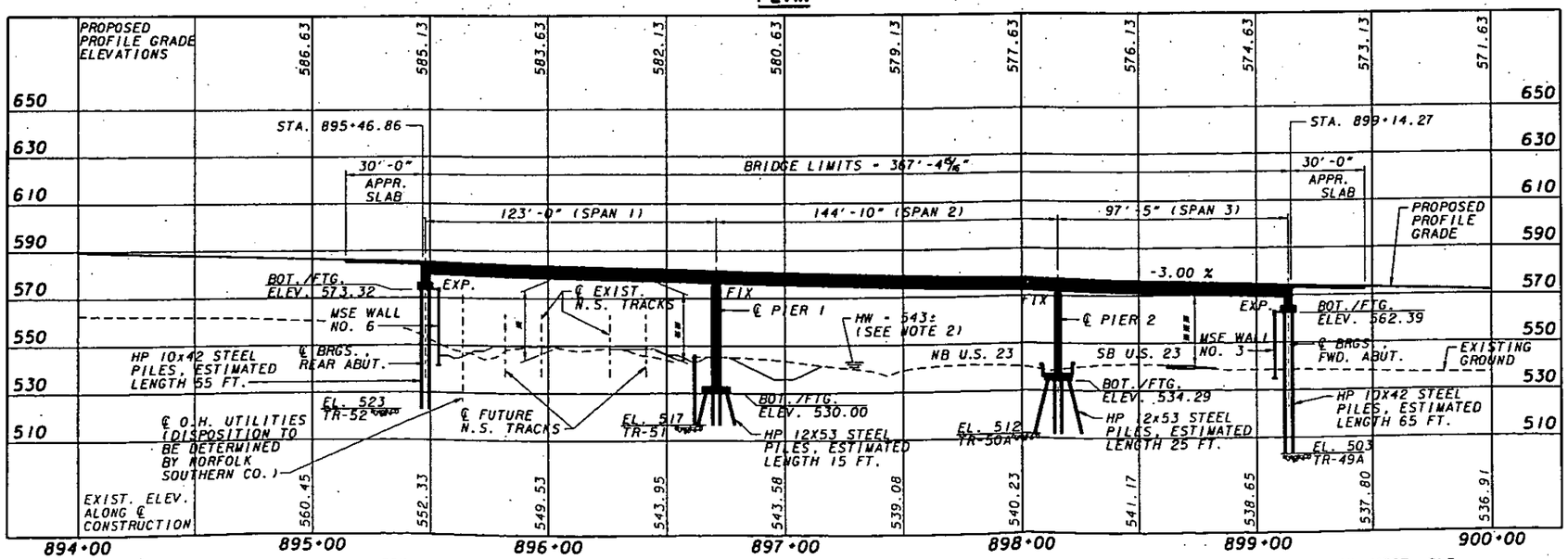

* MIN. VERT. CLR. 27'-1" ACTUAL 23'-5⅛" REQ'D.

** MIN. VERT. CLR. 27'-1" ACTUAL 23'-6½" REQ'D.

*** MIN. VERT. CLR. 28'-8" ACTUAL 17'-0" REQ'D.

PROFILE ALONG PROFILE GRADE LINE, S.R. 823

BENCHMARKS

TRAFFIC DATA

CURRENT ADT (2010) - 8900
DESIGN ADT (2030) - 13000
DESIGN ADTT (2030) - 1820

LEGEND

INDICATES BORING LOCATION

NOTES:

1. EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.
2. HIGHWATER (HW) ELEV. 543± IS THE 100 YEAR SCIOTO RIVER BACKWATER ELEVATION AS DETERMINED BY FEMA.
3. MEDIAN GUARDRAIL AT PIER 2 TO BE IN ACCORDANCE WITH STANDARD DRAWING GR-6.2, DESIGN A.

PROPOSED STRUCTURE

TYPE: THREE-SPAN COMPOSITE STEEL PLATE GIRDERS (WEATHERING ASTM A709, GR 50W) WITH REINFORCED CONCRETE DECK ON SEMI-INTEGRAL ABUTMENTS BEHIND MSE WALLS WITH CAP AND COLUMN PIERS

LENGTH OF SPAN: 123'-0", 144'-10", 97'-5" C-C BEARINGS, MEASURED ALONG ℄ CONSTRUCTION

ROADWAY: 30'-1⅛" TOE/TOE BARRIERS (RB)
30'-1⅛" TOE/TOE BARRIERS (LB)

SIDEWALK: NONE

DESIGN LOADING: HS25 (CASE II) AND THE ALTERNATE MILITARY LOADING, FWS = 60 LB/FT²

SKEW: 22°36'19" RIGHT FORWARD

WEARING SURFACE: MONOLITHIC CONCRETE

APPROACH SLABS: AS-1-81 (30'-0" LONG)

ALIGNMENT: TANGENT

CROWN: 0.016 FT/FT

LATITUDE: N 38°53'32"

LONGITUDE: W 82°59'58"

DESIGN AGENCY
CH2MHILL
6775 Perimeter Drive, Suite 190
Dublin, Ohio 43017

DESIGNED DGS | DRAWN JBA | CHECKED SKT | REVIEWED SCJ | DATE 09/07
STRUCTURE FILE NUMBER 7306792

SCIOTO COUNTY
STA. 895+46.86
TO STA. 899+14.27

SITE PLAN
BRIDGE NO. SCI-823-1601
S.R. 823 OVER NORFOLK SOUTHERN & U.S. 23

SCI-823-10.13
PID 79977

1 / 5

1/2007
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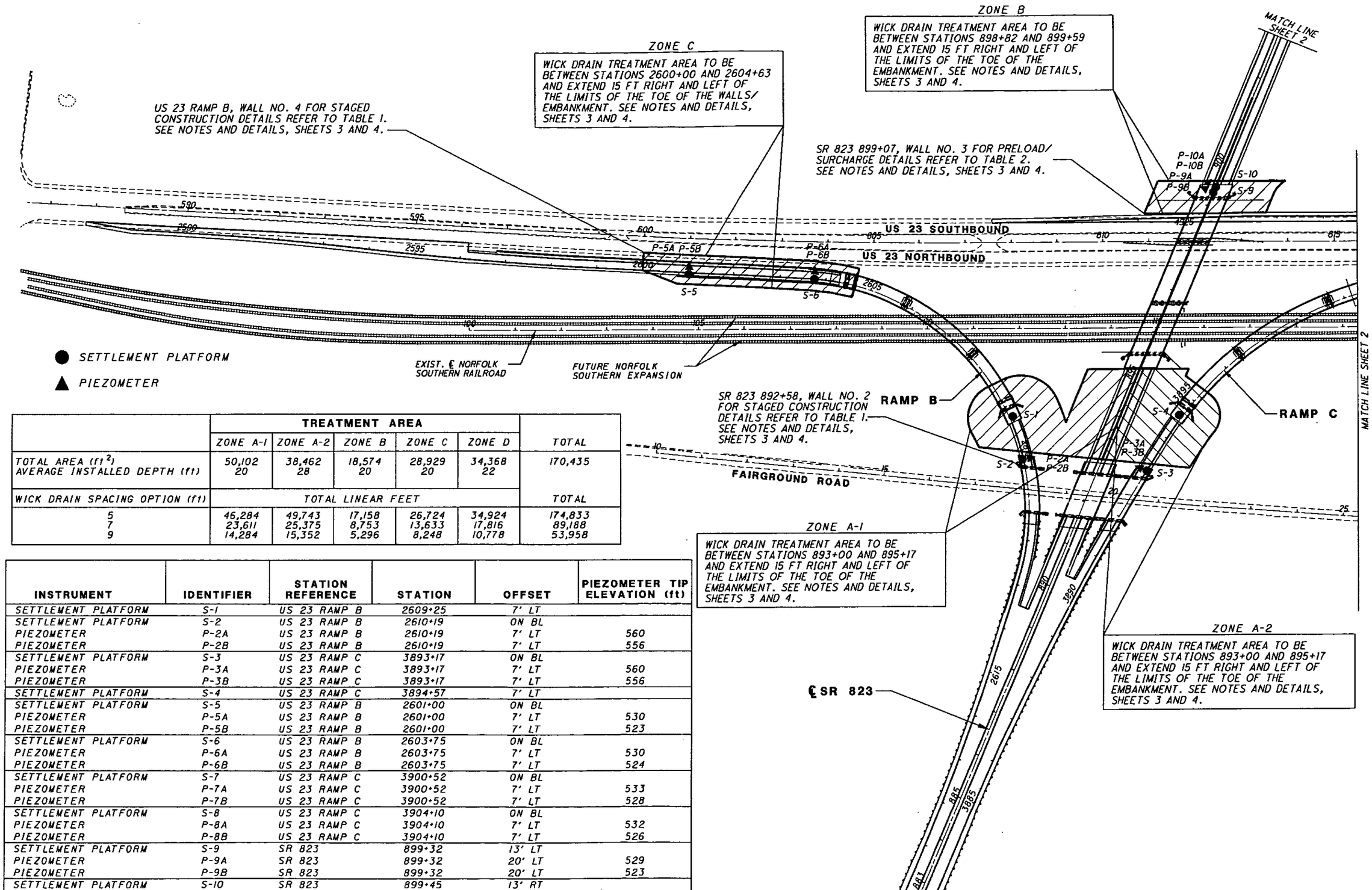
Wick Drain and Instrumentation Plan



	TREATMENT AREA					
	ZONE A-1	ZONE A-2	ZONE B	ZONE C	ZONE D	TOTAL
TOTAL AREA (ft^2) AVERAGE INSTALLED DEPTH (ft)	50,102 20	38,462 28	18,574 20	28,929 20	34,368 22	170,435
WICK DRAIN SPACING OPTION (ft)	TOTAL LINEAR FEET					TOTAL
5	46,284	49,743	17,158	26,724	34,924	174,833
7	23,611	25,375	8,753	13,633	17,816	89,188
9	14,284	15,352	5,296	8,248	10,778	53,958

INSTRUMENT	IDENTIFIER	STATION REFERENCE	STATION	OFFSET	PIEZOMETER TIP ELEVATION (ft)
SETTLEMENT PLATFORM	S-1	US 23 RAMP B	2609+25	7' LT	
SETTLEMENT PLATFORM	S-2	US 23 RAMP B	2610+19	ON BL	
PIEZOMETER	P-2A	US 23 RAMP B	2610+19	7' LT	560
PIEZOMETER	P-2B	US 23 RAMP B	2610+19	7' LT	556
SETTLEMENT PLATFORM	S-3	US 23 RAMP C	3893+17	ON BL	
PIEZOMETER	P-3A	US 23 RAMP C	3893+17	7' LT	560
PIEZOMETER	P-3B	US 23 RAMP C	3893+17	7' LT	556
SETTLEMENT PLATFORM	S-4	US 23 RAMP C	3894+57	7' LT	
SETTLEMENT PLATFORM	S-5	US 23 RAMP B	2601+00	ON BL	
PIEZOMETER	P-5A	US 23 RAMP B	2601+00	7' LT	530
PIEZOMETER	P-5B	US 23 RAMP B	2601+00	7' LT	523
SETTLEMENT PLATFORM	S-6	US 23 RAMP B	2603+75	ON BL	
PIEZOMETER	P-6A	US 23 RAMP B	2603+75	7' LT	530
PIEZOMETER	P-6B	US 23 RAMP B	2603+75	7' LT	524
SETTLEMENT PLATFORM	S-7	US 23 RAMP C	3900+52	ON BL	
PIEZOMETER	P-7A	US 23 RAMP C	3900+52	7' LT	533
PIEZOMETER	P-7B	US 23 RAMP C	3900+52	7' LT	528
SETTLEMENT PLATFORM	S-8	US 23 RAMP C	3904+10	ON BL	
PIEZOMETER	P-8A	US 23 RAMP C	3904+10	7' LT	532
PIEZOMETER	P-8B	US 23 RAMP C	3904+10	7' LT	526
SETTLEMENT PLATFORM	S-9	SR 823	899+32	13' LT	
PIEZOMETER	P-9A	SR 823	899+32	20' LT	529
PIEZOMETER	P-9B	SR 823	899+32	20' LT	523
SETTLEMENT PLATFORM	S-10	SR 823	899+45	13' RT	
PIEZOMETER	P-10A	SR 823	899+45	20' RT	529
PIEZOMETER	P-10B	SR 823	899+45	20' RT	523

WICK DRAIN AND INSTRUMENTATION PLAN
US 23/ SR 823 INTERCHANGE

PID NO. 79977

SCI-823-10.13

4

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MATCH LINE SHEET 1

MATCH LINE SHEET 1

US 23 RAMP C, WALL NO. 5
FOR STAGED CONSTRUCTION
DETAILS REFER TO TABLE 1.
SEE NOTES AND DETAILS,
SHEETS 3 AND 4.

WICK DRAIN TREATMENT AREA TO BE
BETWEEN STATIONS 3900+17 AND 3905+50
AND EXTEND 15 FT RIGHT AND LEFT OF
THE LIMITS OF THE TOE OF THE WALLS/
EMBANKMENT. SEE NOTES AND DETAILS,
SHEETS 3 AND 4.

ZONE D, US 23 RAMP C

RAMP D

RAMP C

RAMP A

EXIST. & NORFOLK
SOUTHERN RAILROAD

FUTURE NORFOLK
SOUTHERN EXPANSION

US 23 SOUTHBOUND

US 23 NORTHBOUND

S-7

S-8

P-14

P-13

P-84

P-85

3900

3905

3910

3915

3920

3925

3930

3935

3940

3945

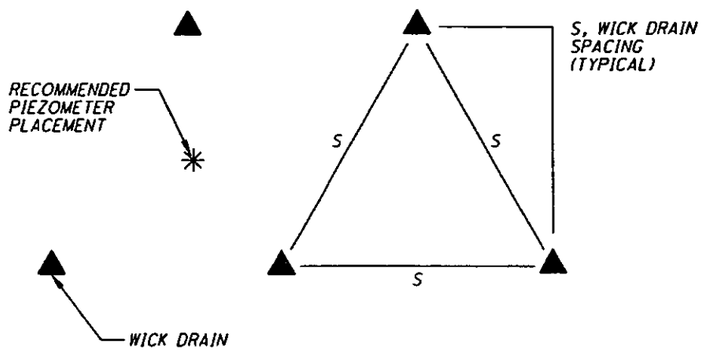
2 of 4	SCI-823-10.13	PID NO. 79977	WICK DRAIN AND INSTRUMENTATION PLAN US 23/SR 823 INTERCHANGE

0 100
50 200
HORIZONTAL SCALE IN FEET

N

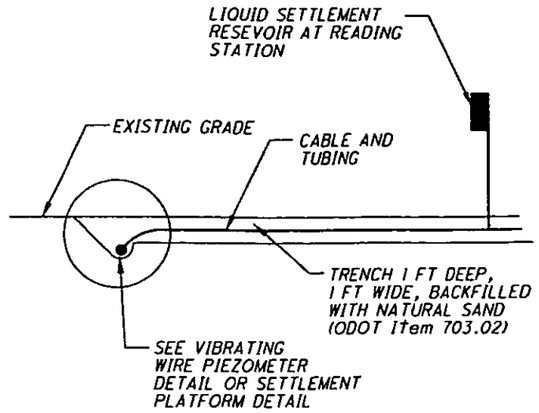
DETAIL "A"

WICK DRAIN TYPICAL LAYOUT-PLAN VIEW
(NOT TO SCALE)



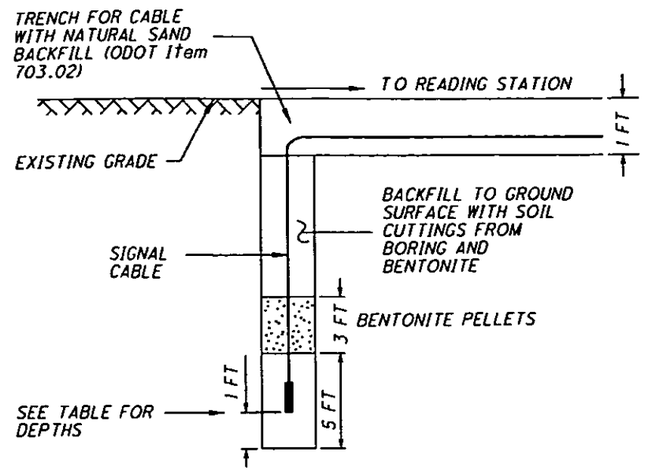
DETAIL "B"

INSTRUMENTATION DETAILS
(NOT TO SCALE)



VIBRATING WIRE PIEZOMETER DETAIL

(NOT TO SCALE)



SETTLEMENT PLATFORM DETAIL

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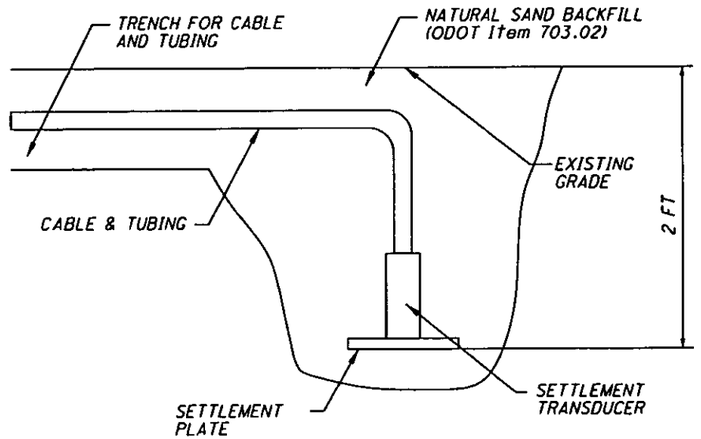


TABLE 1 -STAGED CONSTRUCTION DETAILS

EMBANKMENT SECTIONS, APPROXIMATE STATIONS	EMBANKMENT/WALL STAGE HEIGHT (ft)		MAXIMUM EXCESS PORE PRESSURE, PRIOR TO PLACING SUBSEQUENT STAGES (psi)++	REQUIRED WAITING PERIOD**			
				WICK DRAIN SPACING			
				NO WICK DRAINS	5 FT	7 FT	9 FT
SR 823 892+58 TO 892+93, WALL NO. 2	STAGE 1	19*	1.6	18 DAYS	NA	NA	NA
	STAGE 2	8	0.7	18 DAYS	NA	NA	NA
	STAGE 3	2+	NA	NA	NA	NA	NA
US 23 RAMP B STA. 2600+00 TO 2604+48, WALL NO. 4	STAGE 1	13*	1.6	45 DAYS	20 DAYS	30 DAYS	35 DAYS
	STAGE 2	11	0.7	45 DAYS	20 DAYS	30 DAYS	35 DAYS
	STAGE 3	8	0.7	45 DAYS	20 DAYS	30 DAYS	35 DAYS
	STAGE 4	5.5+	NA	NA	NA	NA	NA
US 23 RAMP C STA. 3900+32 TO 3905+50, WALL NO. 5	STAGE 1	13*	1.0	56 DAYS	20 DAYS	30 DAYS	40 DAYS
	STAGE 2	10	1.1	56 DAYS	20 DAYS	30 DAYS	40 DAYS
	STAGE 3	8	0.8	13 DAYS	5 DAYS	10 DAYS	10 DAYS
	STAGE 4	3.3+	3.4	NA	NA	NA	NA

* STAGE 1 HEIGHT, NOT INCLUDING MSE WALL EMBEDMENT DEPTH. EMBEDMENT DEPTH (MEASURED BELOW EXISTING GROUND SURFACE) MAY BE ADDED TO STAGE 1 HEIGHT.
** PROVIDED WAITING PERIODS ARE ESTIMATES ONLY. PIEZOMETER READINGS SHOULD VERIFY THAT PORE PRESSURE REQUIREMENTS ARE MET.
+ THE MSE WALL MAY BE CONSTRUCTED UPTO THE PROPOSED GRADE.
++ EXCESS PORE PRESSURES SHOULD FALL TO OR BELOW THE CITED LEVELS PRIOR TO PLACING THE SUBSEQUENT STAGES.

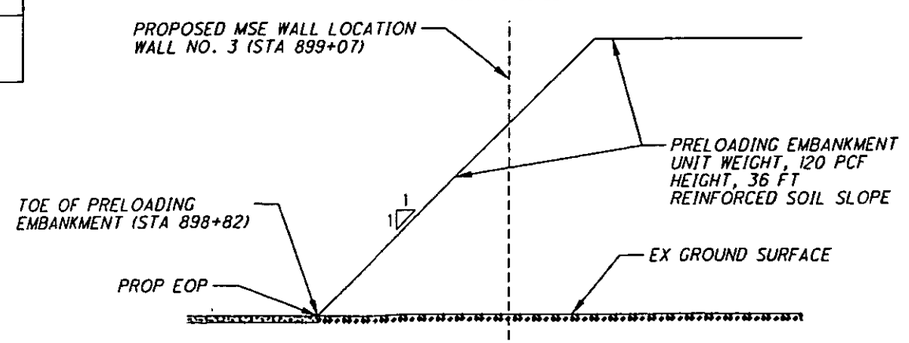
TABLE 2 -PRELOADING EMBANKMENT CONSTRUCTION DETAILS

PRELOAD / SURCHARGE EMBANKMENT	PRELOADING EMBANKMENT HEIGHT (ft)	MAXIMUM EXCESS PORE PRESSURE PRIOR TO REMOVING SURCHARGE AND CONSTRUCTING MSE WALL (psi)*	REQUIRED CONSOLIDATION PERIOD* (under surcharge load)			
			WICK DRAIN SPACING			
			NO WICK DRAINS	5 FT	7 FT	9 FT
SR 823 899+07 TO 899+41, WALL NO. 3	36	3.0	45 DAYS	20 DAYS	30 DAYS	40 DAYS

* Provided waiting periods are estimates only. Piezometer readings should verify that pore pressure requirements are met.
+ Excess pore pressures should fall to or below the cited levels prior to placing the subsequent stages.

DETAIL "C"

PRELOADING EMBANKMENT
VIEW LOOKING SOUTH
(NOT TO SCALE)



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INSTRUMENTATION AND SPECIAL CONSTRUCTION NOTES AND DETAILS

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NOTES:

1. PLACE 3 FEET OF ODOT ITEM 703.02 BEFORE THE INSTALLATION OF THE WICK DRAINS. WICK DRAINS TO BE INSTALLED PRIOR TO EMBANKMENT CONSTRUCTION.

2. THE SAND SHALL CONSIST OF CLEAN, FREE-DRAINING, COARSE NATURAL SAND, OR SAND AND PEA GRAVEL, SHALL BE GRADED UNIFORMLY FROM COARSE TO FINE, AND SHALL BE OF SUCH SIZE THAT, WHEN TESTING ON U.S. STANDARD SIEVES IN ACCORDANCE WITH AASHTO T27 AND WASHING THE SAMPLE IN ACCORDANCE WITH AASHTO T11, SHALL CONFORM TO THE GRADING REQUIREMENTS OF ODOT CMS 703.02.

3. THE SAND SHALL NOT CONTAIN ANY ORGANIC OR OTHER DELETERIOUS MATERIALS AND SHALL NOT BE FROZEN WHEN PLACED.

4. IF DENSE SAND, GRAVEL OR HARD SOIL LAYERS ARE ENCOUNTERED BELOW THE GROUND SURFACE AND CANNOT BE PENETRATED WITH REASONABLE EFFORT, THE CONTRACTOR SHALL BE REQUIRED TO PRE-DRILL THE WICK DRAIN LOCATIONS.

5. WICK DRAINS SHALL BE INSTALLED FROM THE WORKING SURFACE TO THE DEPTH SHOWN IN THE PLANS, OR TO COMPLETELY PENETRATE THE COMPRESSIBLE FOUNDATION SOILS AT SUCH A DEPTH EITHER SHALLOWER OR DEEPER THAN PLAN DEPTH WHERE THE SOIL RESISTS A REASONABLE EFFORT AT FURTHER PENETRATION.

6. SETTLEMENT PLATES SHALL BE GEOKON MODEL 4600 OR EQUIVALENT.

7. VIBRATING WIRE PIEZOMETERS SHALL BE SLOPE INDICATOR MODEL 52611099 OR EQUIVALENT.

8. MSE WALLS ALONG US 23 RAMP B, RAMP C, AND WALL NO 2 (WEST OF FAIRGROUND ROAD) MUST BE BUILT USING STAGED CONSTRUCTION. THE FOUNDAITON PORE WATER PRESSURES AND SETTLEMENTS SHALL BE MONITORED. THE STAGED CONSTRUCTION STATION LIMITS, STAGED HEIGHTS, PORE PRESSURE DETAILS ARE PRESENTED IN TABLE 1 1. A WAITING PERIOD WILL BE REQUIRED BETWEEN STAGES TO ALLOW PORE PRESSURES TO DISSIPATE PRIOR TO PLACING SUBSEQUENT STAGES. THE MAXIMUM REQUIRED PORE PRESSURE AS WELL AS THE REQUIRED WAITING PERIOD FOR SELECTED WICK DRAIN SPACING OPTIONS IS OUTLINED IN TABLE 1.

9. A PRELOADING EMBANKMENT IS REQUIRED AT THE WALL NO 3 LOCATION (STA.899+07) PRIOR TO CONSTRUCTING THE MSE WALL. THE PRELOADING EMBANKMENT SHALL USE 1H:1V SLOPES ALONG EXISTING US 23 (IN THE TRANSVERSE DIRECTION). SEE DETAIL "C". THE PRELOADING EMBANKMENT SHOULD EXTEND IN THE TRANSVERSE DIRECTION TO THE LIMITS OF THE PROPOSED WALL, AN BE CONSTRUCTED UP TO THE PROPOSED ELEVATION. A WAITING PERIOD WILL BE REQUIRED PRIOR TO REMOVING THE PRELOADING EMBANKMENT AND CONSTRUCTING THE MSE WALL. DETAILS FOR THIS PRELOADING EMBANKMENT CAN BE FOUND IN TABLE 2.

10. THE ACTUAL WICK DRAIN TREATMENT AREA AND DEPTH MIGHT DIFFER FROM THE PROPOSED LIMITS DUE TO SOIL VARIATIONS AT THE SITE AND THEREFORE SHOULD BE CONFIRMED IN THE FIELD BY THE ODOT CONSTRUCTION REPRESENTATIVE.

11. IT IS RECOMMENDED THAT WICK DRAINS BE INSTALLED PRIOR TO THE INSTALLATION OF SETTLEMENT PLATFORMS OR PIEZOMETERS. PIEZOMETERS SHOULD BE PLACED EQUAL DISTANCES FROM ADJACENT WICK DRAINS TO PREVENT PORE PRESSURE DISSIPATION NEAR THE DRAINS FROM SKEWING MEASUREMENTS, SEE DETAIL "A". THE ODOT CONSTRUCTION REPRESENTATIVE MAY MODIFY THE INSTRUMENTATION PLAN BASED UPON FIELD CONDITIONS.

CALCULATED SJR
CHECKED DAA

INSTRUMENTATION AND SPECIAL CONSTRUCTION NOTES AND DETAILS

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APPENDIX B

DLZ

APPENDIX B

Boring Location Plan
Table of Boring Locations
General Information – Drilling Procedures and Logs of Borings
Legend – Boring Log Terminology
Boring Logs – Eighty-seven (87) Boring Logs

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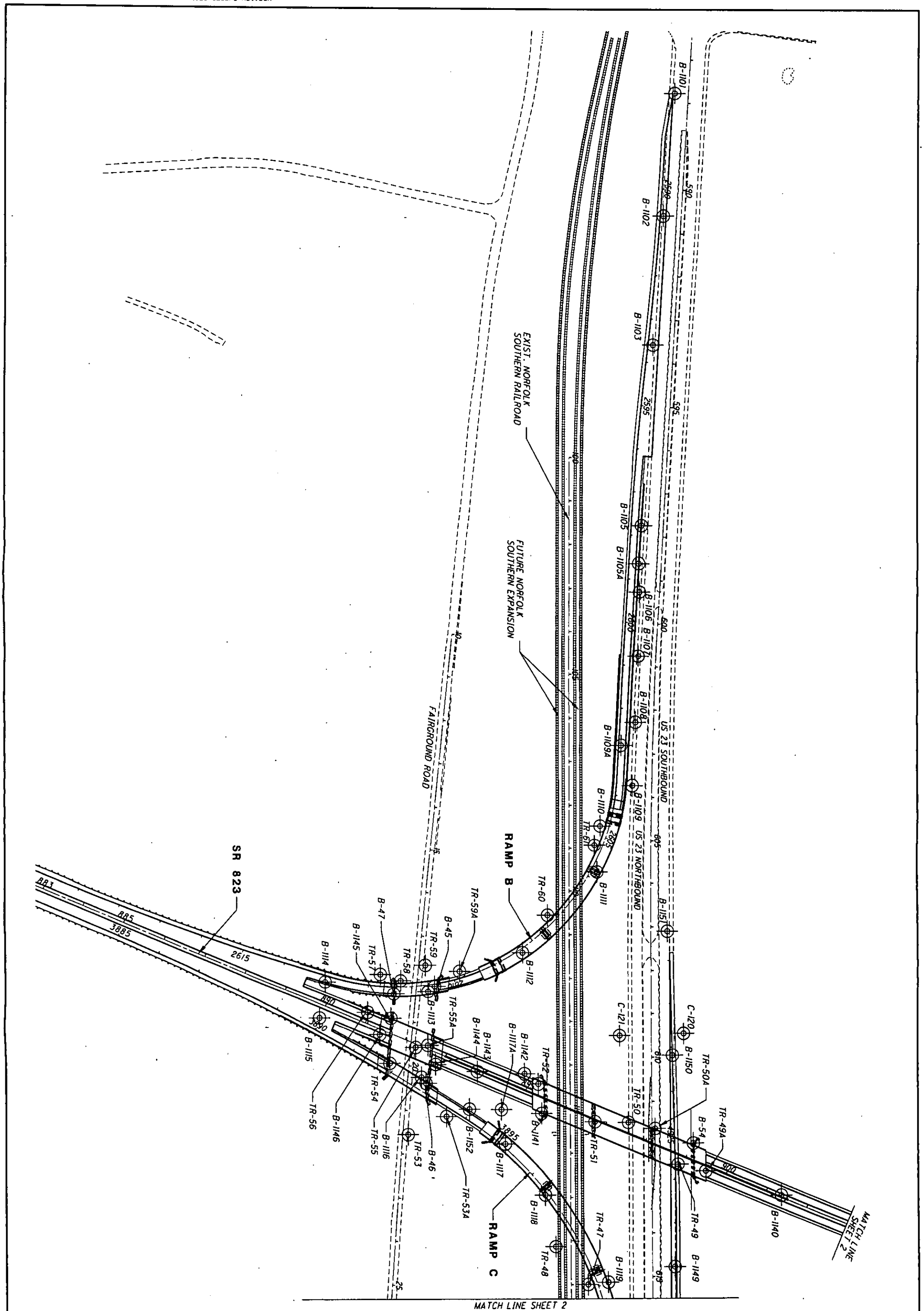
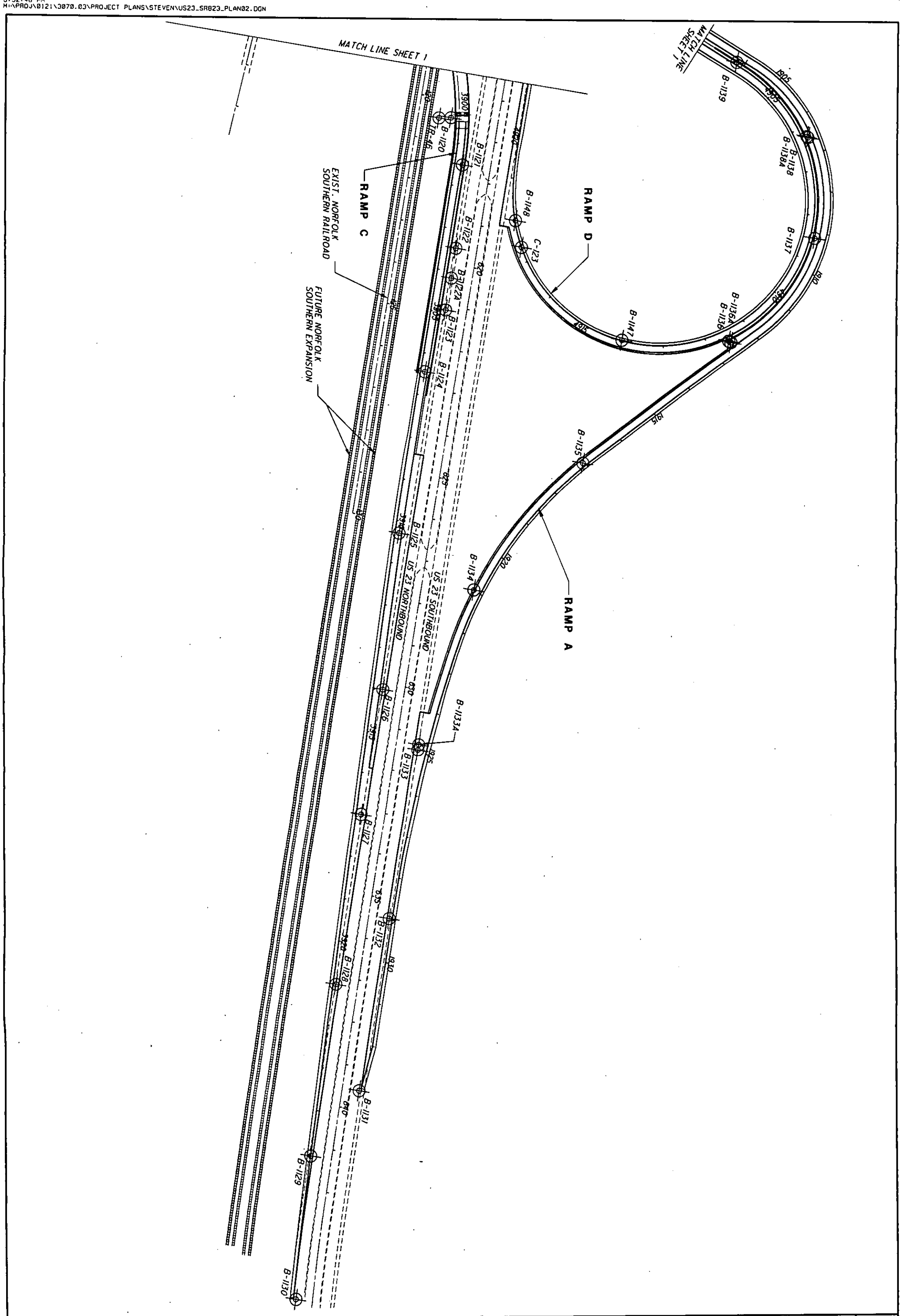


1/2	SCI-823-10.13	PID NO. 79977	**BORING LOCATION PLAN** **US 23/ SR 823 INTERCHANGE**

0 50 100 200
HORIZONTAL SCALE IN FEET

N



2/2	SCI-823-10.13	PID NO. 79977	**BORING LOCATION PLAN** **US 23/ SR 823 INTERCHANGE**

0 100
50 200
HORIZONTAL SCALE IN FEET

N

US 23 / SR 823 Interchange Borings

Boring	Alignment	Station	Offset	Elev
B-1139	SR 823 ML	903+92.6	1.5 R	529.7
B-1140	SR 823 ML	901+35.7	4.3 L	535.8
B-1141	SR 823 ML	895+53.5	34.0 R	556.2
B-1142	SR 823 ML	894+83.0	33.3 L	560.4
B-1143	SR 823 ML	893+80.3	3.7 R	563.2
B-1144	SR 823 ML	892+85.3	25.8 L	565.2
B-1145	SR 823 ML	891+50.3	32.7 L	567.3
B-1146	SR 823 ML	891+40.7	12.2 R	567.7
B-54	SR 823 ML	899+03.3	36.8 L	538.7
TR-49	SR 823 ML	898+89.3	21.2 R	539.8
TR-49A	SR 823 ML	899+54.2	10.9 R	538.1
TR-50	SR 823 ML	897+47.1	23.7 L	540.5
TR-50A	SR 823 ML	898+09.3	34.1 L	539.3
TR-51	SR 823 ML	896+74.9	4.3 R	544.5
TR-52	SR 823 ML	895+21.1	24.6 L	558.0
TR-55	SR 823 ML	892+28.2	7.5 R	567.1
TR-55A	SR 823 ML	892+52.3	7.8 L	565.4
TR-56	SR 823 ML	890+95.4	24.6 L	570.0
B-1131	US 23 RAMP A	1933+06.8	15.9 R	541.0
B-1132	US 23 RAMP A	1928+97.1	7.4 R	540.7
B-1133	US 23 RAMP A	1924+94.0	20.4 R	540.2
B-1133A	US 23 RAMP A	1924+81.1	21.8 R	540.2
B-1134	US 23 RAMP A	1920+97.5	18.1 R	534.0
B-1135	US 23 RAMP A	1917+04.6	8.4 R	533.1
B-1136	US 23 RAMP A	1912+58.4	33.2 R	524.9
B-1136A	US 23 RAMP A	1912+56.3	27.4 R	524.7
B-1137	US 23 RAMP A	1909+15.9	25.8 R	525.0
B-1138	US 23 RAMP A	1906+57.1	23.6 R	525.3
B-1138A	US 23 RAMP A	1906+53.4	25.3 R	525.0
B-1101	US 23 RAMP B	2587+78.9	15.8 L	541.6
B-1102	US 23 RAMP B	2590+60.8	7.0 L	540.8
B-1103	US 23 RAMP B	2593+58.6	11.4 L	539.5
B-1104*	US 23 RAMP B	2596+29.8	8.3 L	538.8
B-1105	US 23 RAMP B	2597+77.5	24.0 L	539.0
B-1105A	US 23 RAMP B	2598+63.3	22.4 L	538.0
B-1106	US 23 RAMP B	2599+28.3	27.8 L	540.2
B-1107	US 23 RAMP B	2600+77.4	34.2 L	540.5
B-1108	US 23 RAMP B	2602+29.5	35.3 L	540.7
B-1109	US 23 RAMP B	2603+75.4	36.5 L	540.6
B-1109A	US 23 RAMP B	2602+83.8	5.6 L	532.5
B-1110	US 23 RAMP B	2604+76.5	20.7 R	542.3
B-1111	US 23 RAMP B	2605+81.7	14.0 L	543.8
B-1112	US 23 RAMP B	2608+31.5	9.0 L	560.9
B-1113	US 23 RAMP B	2610+64.3	16.0 L	566.8
B-1114	US 23 RAMP B	2612+98.5	14.8 L	584.1
B-45	US 23 RAMP B	2610+47.6	5.8 L	566.0
B-47	US 23 RAMP B	2611+41.0	16.7 L	567.5
TR-57	US 23 RAMP B	2611+74.6	27.9 R	569.5
TR-58	US 23 RAMP B	2611+25.3	14.7 R	567.1

* Denotes As Per Plan Boring Location

US 23 / SR 823 Interchange Borings

Boring	Alignment	Station	Offset	Elev
TR-59	US 23 RAMP B	2610+61.7	45.7 R	567.3
TR-59A	US 23 RAMP B	2609+82.8	15.0 R	563.9
TR-60	US 23 RAMP B	2607+31.2	19.6 R	552.3
TR-61	US 23 RAMP B	2605+26.3	18.1 R	543.4
B-1115	US 23 RAMP C	3889+95.6	28.7 L	582.4
B-1116	US 23 RAMP C	3892+65.9	26.2 L	565.8
B-1117	US 23 RAMP C	3895+08.1	7.3 L	562.6
B-1117A	US 23 RAMP C	3894+54.8	63.4 L	561.7
B-1118	US 23 RAMP C	3896+55.5	6.3 R	546.2
B-1119	US 23 RAMP C	3898+99.1	24.8 L	542.0
B-1120	US 23 RAMP C	3900+39.5	19.1 R	542.7
B-1121	US 23 RAMP C	3901+49.8	18.1 L	539.0
B-1122	US 23 RAMP C	3903+45.0	34.5 L	540.7
B-1122A	US 23 RAMP C	3904+16.1	35.8 L	540.7
B-1123	US 23 RAMP C	3904+93.1	34.5 L	540.9
B-1124	US 23 RAMP C	3906+44.7	10.0 L	533.5
B-1125	US 23 RAMP C	3910+29.2	9.3 L	538.9
B-1126	US 23 RAMP C	3913+97.9	22.7 L	540.7
B-1127	US 23 RAMP C	3916+94.6	11.7 L	540.0
B-1128	US 23 RAMP C	3921+02.4	6.9 L	540.6
B-1129	US 23 RAMP C	3925+05.5	0.2 L	540.9
B-1130	US 23 RAMP C	3928+41.7	5.9 L	541.4
B-1152*	US 23 RAMP C	3893+96.5	23.1 L	563.0
B-46	US 23 RAMP C	3892+81.3	20.3 L	565.6
TR-46	US 23 RAMP C	3900+40.8	47.7 R	543.1
TR-47	US 23 RAMP C	3898+88.1	20.9 R	543.1
TR-48	US 23 RAMP C	3897+72.5	52.7 R	546.3
TR-53	US 23 RAMP C	3893+05.9	100.7 R	566.7
TR-53A	US 23 RAMP C	3893+60.3	19.3 R	565.3
TR-54	US 23 RAMP C	3891+87.0	16.7 L	566.9
B-1147	US 23 RAMP D	4913+98.9	1.2 R	529.7
B-1148	US 23 RAMP D	4918+00.2	1.5 R	530.2
B-1149	US 23 RAMP D	4921+98.8	3.0 L	540.4
B-1150	US 23 RAMP D	4926+81.3	0.6 R	540.8
B-1151	US 23 RAMP D	4929+67.2	3.5 L	541.1
C-120	US 23 RAMP D	4927+30.5	27.6 R	536.1
C-123	US 23 RAMP D	4917+35.8	0.0 L	529.7
C-121	SR 23 EX	609+50.3	73.7 R	537.7

* Denotes As Per Plan Boring Location

GENERAL INFORMATION
DRILLING PROCEDURES AND LOGS OF BORINGS

Drilling and sampling were conducted in accordance with procedures generally recognized and accepted as standardized methods of investigation of subsurface conditions concerning geotechnical engineering considerations. Borings were drilled with either a truck-mounted or ATV-mounted drill rig.

Drive split-barrel sampling was performed in 1.5 foot increments at intervals not exceeding 5 feet. In the event the sampler encountered resistance to penetration of 6 inches or less after 50 blows of the drop hammer, the sampling increment was discontinued. Standard penetration data were recorded and one or more representative samples were preserved from each sampling increment.

In borings where rock was cored, NXM or NQ size diamond coring tools were used.

In the laboratory all samples were visually classified by a geotechnical engineer. Moisture contents of representative fine-grained soil samples were determined. A limited number of samples, considered representative of foundation materials present, were selected for performance of grain-size analyses and plasticity characteristics tests. The results of these tests are shown on the boring logs.

The boring logs included in the Appendix have been prepared on the basis of the field record of drilling and sampling, and the results of the laboratory examination and testing of samples. Stratification lines on the boring logs indicating changes in soil stratigraphy represent depths of changes approximated by the driller, by sampling effort and recovery, and by laboratory test results. Actual depths to changes may differ somewhat from the estimated depths, or transitions may occur gradually and not be sharply defined. The boring logs presented in this report therefore contain both factual and interpretative information and are not an exact copy of the field log.

Although it is considered that the borings have disclosed information generally representative of site conditions, it should be expected that between borings conditions may occur which are not precisely represented by any one of the borings. Soil deposition processes and natural geologic forces are such that soil and rock types and conditions may change in short vertical intervals and horizontal distances.

Soil/rock samples will be stored at our laboratory for a period of six months. After this period of time, they will be discarded, unless notified to the contrary by the client.

LEGEND – BORING LOG TERMINOLOGY

Explanation of each column, progressing from left to right

1. Depth (in feet) – refers to distance below the ground surface.

2. Elevation (in feet) – is referenced to mean sea level, unless otherwise noted.

3. Standard Penetration (N) – the number of blows required to drive a 2-inch O.D., 1-3/8 inch I.D., split-barrel sampler, using a 140-pound hammer with a 30-inch free fall. The blows are recorded in 6-inch drive increments. Standard penetration resistance is determined from the total number of blows required for one foot of penetration by summing the second and third 6-inch increments of an 18-inch drive.

   50/n – indicates number of blows (50) to drive a split-barrel sampler a certain number of inches (n) other than the normal 6-inch increment.

4. The length of the sampler drive is indicated graphically by horizontal lines across the "Standard Penetration" and "Recovery" columns.

5. Sample recovery from each drive is indicated numerically in the column headed "Recovery".

6. The drive sample location is designated by the heavy vertical bar in the "Sample No., Drive" column.

7. The length of hydraulically pressed "Undisturbed" samples is indicated graphically by horizontal lines across the "Press" column.

8. Sample numbers are designated consecutively, increasing in depth.

9. Soil Description

   a. The following terms are used to describe the relative compactness and consistency of soils:

   Granular Soils – Compactness

Term	Blows/Foot Standard Penetration
Very Loose	0 – 4
Loose	4 – 10
Medium Dense	10 – 30
Dense	30 – 50
Very Dense	over 50

   Cohesive Soils – Consistency

Term	Unconfined Compression tons/sq.ft.	Blows/Foot Standard Penetration	Hand Manipulation
Very Soft	less than 0.25	below 2	Easily penetrated by fist
Soft	0.25 – 0.50	2 – 4	Easily penetrated by thumb
Medium Stiff	0.50 – 1.0	4 – 8	Penetrated by thumb with moderate pressure
Stiff	1.0 – 2.0	8 – 15	Readily indented by thumb but not penetrated
Very Stiff	2.0 – 4.0	15 – 30	Readily indented by thumb nail
Hard	over 4.0	over 30	Indented with difficulty by thumb nail

   b. Color – If a soil is a uniform color throughout, the term is single, modified by such adjective as light and dark. If the predominant color is shaded by a secondary color, the secondary color precedes the primary color. If two major and distinct colors are swirled throughout the soil, the colors are modified by the term "mottled".

   c. Texture is based on the Ohio Department of Transportation Classification System. Soil particle size definitions are as follows:

Description		Size	Description		Size
Boulders		Larger than 8"	Sand	– Coarse	2.0 mm to 0.42 mm
Cobbles		8" to 3"		– Fine	0.42 mm to 0.074 mm
Gravel	– Coarse	3" to ¾"	Silt		0.074 mm to 0.005 mm
	– Fine	¾" to 2.0 mm	Clay		smaller than 0.005 mm

d. The main soil component is listed first. The minor components are listed in order of decreasing percentage of particle size.

e. Modifiers to main soil descriptions are indicated as a percentage by weight of particle sizes.

trace	0 to 10%
little	10 to 20%
some	20 to 35%
"and"	35 to 50%

f. Moisture content of **cohesionless soils** (sands and gravels) is described as follows:

Term	Relative Moisture or Appearance
Dry	No moisture present
Damp	Internal moisture, but none to little surface moisture
Moist	Free water on surface
Wet	Voids filled with free water

g. The moisture content of **cohesive soils** (silts and clays) is expressed relative to plastic properties.

Term	Relative Moisture or Appearance
Dry	Powdery
Damp	Moisture content slightly below plastic limit
Moist	Moisture content above plastic limit but below liquid limit
Wet	Moisture content above liquid limit

10. Rock Hardness and Rock Quality Designation

a. The following terms are used to describe the relative hardness of the **bedrock**.

Term	Description
Very Soft	Permits denting by moderate pressure of the fingers. Resembles hard soil but has rock structure. (Crushes under pressure of fingers and/or thumb)
Soft	Resists denting by fingers, but can be abraded and pierced to shallow depth by a pencil point. (Crushes under pressure of pressed hammer)
Medium Hard	Resists pencil point, but can be scratched with a knife blade. (Breaks easily under single hammer blow, but with crumbly edges.)
Hard	Can be deformed or broken by light to moderate hammer blows. (Breaks under one or two strong hammer blow, but with resistant sharp edges.)
Very Hard	Can be broken only by heavy and in some rocks repeated hammer blows.

b. Rock Quality Designation, RQD – This value is expressed in percent and is an indirect measure of rock soundness. It is obtained by summing the total length of all core pieces which are at least four inches long, and then dividing this sum by the total length of the core run.

11. Gradation – when tests are performed, the percentage of each particle size is listed in the appropriate column (defined in Item 9c).

12. When a test is performed to determine the natural moisture content, liquid limit moisture content, or plastic limit moisture content, the moisture content is indicated graphically.

13. The standard penetration (N) value in blows per foot is indicated graphically.

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-45 | Location: Sta. 2610+47.6, 5.8 ft. LT of US 23 Ramp B BL | Date Drilled: 6/14/07

WATER OBSERVATIONS: Water seepage at: 18.5'
Water level at completion: 8.3' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	566.0												
0.3	565.7						Topsoil with gravel fill - 4"						
		5 7 7	18	1			Stiff dark brown SILT (A-4b), little fine sand, trace coarse sand, some clay; damp to moist. @ 3.0', brown, trace gravel.						
		3 2 2	15	2		1.0		0	5	--	18	51	26
5.0	561.0							0	3	--	20	49	28
					P-1	1.25	Stiff brown SILTY CLAY (A-6b), little to some fine sand, trace coarse sand; moist.	0	3	--	21	77	
8.5	557.5				P-2		Loose to medium dense brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6), some silty clay; damp to moist.	30	21	--	18	17	14
10					P-3								
		3 2 2	18	3				13	43	--	23	8	13
		1 2 2	17	4			@ 16.0', moist to wet.	30	26	--	17	13	14
18.0	548.0												
		WOH 1 2	8	5			Loose brown GRAVEL WITH SAND AND SILT (A-2-4), some silty clay; moist to wet.	46	20	--	7	17	10
20													
21.0	545.0	31 50/3	8	6			Severely weathered to decomposed gray SHALE.						
22.0	544.0	Core 18"	Rec 18"	RQD 33%	R-1		Soft to medium hard gray SHALE; highly weathered, thinly laminated, moderately fractured, with typical low angle clay-filled fractures; contains sandstone beds.						
25		Core 60"	Rec 60"	RQD 92%	R-2		@ 23.8'-24.0', high angle iron stained fracture. @ 27.2', qu=2,651 psi.						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

50+

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-45 | Location: Sta. 2610+47.6, 5.8 ft. LT of US 23 Ramp B BL | Date Drilled: 6/14/07

WATER OBSERVATIONS: Water seepage at: 18.5'
Water level at completion: 8.3' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
30	536.0													
		Core 120"	Rec 120"	RQD 79%	R-3		Soft to medium hard gray SHALE; moderately weathered, argillaceous, micaceous, thinly laminated, moderately fractured, with typical low angle clay-filled fractures. @ 31.9'-33.0', 33.5'-34.9', decomposed.							
34.9	531.1						Medium hard blue SHALE; moderately weathered, carbonaceous, thinly laminated, slightly fractured. @ 37.5', qu=3,757 psi.							
40		Core 42"	Rec 42"	RQD 100%	R-4		@ 36.2'-36.8', high angle fracture.							
42.0	524.0						Bottom of Boring - 42.0'							
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-46 | Location: Sta. 3892+81.3, 20.3 ft. LT of US 23 Ramp C BL | Date Drilled: 6/15/07

WATER OBSERVATIONS: Water seepage at: 15.5'
Water level at completion: 4:3' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	565.6												
0.3	565.3						Topsoil-3"						
		6 20 14	11	1		4.5+	Hard brown SILT AND CLAY (A-6a), trace fine to coarse sand; damp to moist.						
							@ 3.5'-5.0', stiff.						
		3 3 5	17	2		1.75		0	1	--	3	62	34
5.0	560.6				P-1	1.5	Stiff brown SILTY CLAY (A-6b), trace fine to coarse sand; moist.	0	2	--	4	53	41
8.0	557.6				P-2	1.5	Stiff brown SILT AND CLAY (A 6a), some fine to coarse sand, some gravel, damp to moist.	23	19	--	12	28	18
10													
10.5	555.1	2 3 2	18	3			Loose brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6), little to some silty clay; moist.	17	36	--	27	7	13
		2 2 2	18	4									
15							@ 15.5', very loose, wet.						
		W.O.H	18	5				28	47	--	5	4	16
18.0	547.6						Severely weathered to decomposed gray shale.						
		19 42 50/4	16	6									
20.0	545.6						Soft to medium hard gray SHALE; highly weathered, thinly laminated, moderately fractured, contains occasional thin sandstone beds.						
		Core 60"	Rec 57"	RQD 80%	R-1								
25							@ 25.2', qu=4,011 psi.						
		Core	Rec	RQD	R-2								
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

50+

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-46 | Location: Sta. 3892+81.3, 20.3 ft. LT of US 23 Ramp C BL | Date Drilled: 6/15/07

WATER OBSERVATIONS: Water seepage at: 15.5'
Water level at completion: 4.3' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION
30	535.6	108"	108"	79%			Soft to medium hard gray SHALE; moderately to highly weathered, thinly laminated, moderately fractured; contains calcareous, thin sandstone beds. @ 31.2', highly weathered. @ 33.3', decomposed.
33.8	531.8						Medium hard black SHALE; slightly weathered, carbonaceous, thinly laminated, slightly fractured to unfractured.
35		Core 72"	Rec 72"	RQD 97%	R-3		@ 35.7', qu=3,030 psi. @ 33.8'-34.0', high angle fracture.
40.0	525.6						Bottom of Boring - 40.0'
45							
50							
55							
60							

GRADATION: % Aggregate | % C. Sand | % M. Sand | % F. Sand | % Silt | % Clay

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-47 | Location: Sta. 2611+41.0, 16.7 ft. LT of US 23 Ramp B BL | Date Drilled: 06/18/07 to 06/19/07

WATER OBSERVATIONS: Water seepage at: None
Water level at completion: 8.3' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	567.5												
0.4	567.1						Topsoil - 5"						
		4 6 5	16	1		4.5+	Hard brown SILT AND CLAY (A-6a), trace fine to coarse sand, dry to damp.	0	1	--	3	56	40
3.5	564.0												
5					P-1	4.5+	Medium stiff brown SILT (A-4b), some clay, trace fine sand; moist.	0	0	--	4	69	27
					P-2	1.25		0	1	--	14	63	22
8.5	559.0	4 6 7	18	2			Medium dense brown SILT (A-4b), trace to little fine to coarse sand; moist.	0	6	--	4	90	
10													
11.0	556.5	3 2 3	18	3			Loose brown SANDY SILT (A-4a), little to some fine to coarse sand, some gravel; moist.	33	9	--	11	47	
13.0	554.5	19 50/5	11	4			Severely weathered light gray SHALE.						
15													
		50/6	6	5									
17.0	550.5						Soft to medium hard gray SHALE; highly weathered to decomposed, thinly laminated, highly fractured, contains occasional thin sandstone beds; sphalerite.						
20		Core 60"	Rec 60"	RQD 95%	R-1		@ 20.4', qu=1,971 psi.						
		Core 24"	Rec 24"	RQD 93%	R-2								
25							@ 26.8', qu=3,110 psi.						
		Core 120"	Rec 120"	RQD 71%	R-3								
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic
Non-Plastic
50+
50+

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-47 | Location: Sta. 2611+41.0, 16.7 ft. LT of US 23 Ramp B BL | Date Drilled: 06/18/07 to 06/19/07

WATER OBSERVATIONS: Water seepage at: None
Water level at completion: 8.3' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
30	537.5						Soft to medium hard gray SHALE; highly weathered to decomposed, thinly laminated, highly fractured; contains occasional sandstone beds.						
35		Core 36"	Rec 36"	RQD 51%	R-4		@ 36.7'-36.9', slickenside fracture.						
37.0	530.5						Bottom of Boring - 37.0'						
40													
45													
50													
55													
60													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-54 | Location: Sta. 899+03.6, 36.8 ft. LT of SR 823 CL | Date Drilled: 07/31/07

WATER OBSERVATIONS: Water seepage at: 11.0', 14.5', 16.5', 18.5'
Water level at completion: 20.2' (prior to coring)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	538.7												
0.4	538.3						Topsoil - 5"						
		3 3 5	15	1		4.0	Very stiff to hard brown SANDY SILT (A-4a), little clay; damp.						
3.5	535.2	2 2 4	17	2		3.0	Very stiff brown SILT (A-4b), some clay; moist.	0	1	--	3	65	31
5.0	533.7						Medium stiff to stiff brown SILT AND CLAY (A-6a), trace to little fine to coarse sand; damp to moist.						
		2 3 3	14	3	ST1	1.0		0	1	--	9	60	30
8.5	530.2												
		2 3 3	16	4		1.5	Stiff brown SANDY SILT (A-4a), some clay, little to some fine to coarse sand; trace gravel; moist.	7	10	--	11	48	24
10								9	10	--	9	45	27
		2 2 2	18	5	ST2	1.25							
13.0	525.7												
		1 2 2	18	6A		1.25	Stiff brown SILT AND CLAY (A-6a), trace fine to coarse sand; moist.	0	1	--	4	61	34
15.0	523.7						Medium stiff to stiff brown SILT (A-4b), little fine to coarse sand, trace gravel; wet.						
		WOH 1 2	18	7	ST3	1.0		4	5	--	7	58	26
18.0	520.7												
		6 6 6	14	8			Medium dense brown GRAVEL WITH SAND (A-1-b), trace to little silty clay; moist to wet.	42	36	--	9	13	
20		10 18 12	13	9									
		3 7 7	16	10				41	41	--	10	8	
25													
25.5	513.2						Medium dense brown COARSE AND FINE SAND (A-3a); wet.						
		3 4 8	12	11			@ 27.5', water added to prevent sand heave.						
		8 9 9	12	12									
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic
Non-Plastic

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-54 | Location: Sta. 899+03.6, 36.8 ft. LT of SR 823 CL | Date Drilled: 07/31/07

WATER OBSERVATIONS: Water seepage at: 11.0', 14.5', 16.5', 18.5'
Water level at completion: 20.2' (prior to coring)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION
30	508.7						
31.0	507.7	50/2	2	13			Severely weathered brown SANDSTONE.
32.0	506.7						Medium hard gray SANDSTONE; very fine to fine grained, moderately weathered, argillaceous, micaceous, thinly bedded, moderately fractured, with typical low angle clay-filled fractures.
35		Core 60"	Rec 57"	RQD 71%	R-1		@ 36.8'-37.0', lost recovery, washed out clay.
							@ 32.0'-33.7', iron stained zone.
40		Core 60"	Rec 60"	RQD 70%	R-2		@ 34.8'-34.9',37.9'-38.1', clay-filled broken zones.
42.0	496.7						Bottom of Boring - 42.0'
45							
50							
55							
60							

GRADATION: % Aggregate | % C. Sand | % M. Sand | % F. Sand | % Silt | % Clay

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40 50+

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1101 | Location: Sta. 2587+78.9, 15.8 ft. LT of US 23 Ramp B BL | Date Drilled: 07/27/05

WATER OBSERVATIONS: Water seepage at: Not Reported
Water level at completion: Not Reported

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	541.6												
1.0	540.6	24 20 10 7	13	1			Asphalt - 5" Aggregate Base - 7"						
							Medium dense to dense brown GRAVEL WITH SAND AND SILT (A-2-4), trace clay; damp to moist.	32	26	--	12	20	10
		7 8 8 23	10	2				32	35	--	13	12	9
5		28 12 7 7	16	3									
7.5	534.1												
		5 6 6 5	16	4		1.75	Stiff brown SILT AND CLAY (A-6a), little fine to coarse sand, trace gravel; moist.						
10.0	531.6						Bottom of Boring - 10.0'						
15													
20													
25													
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

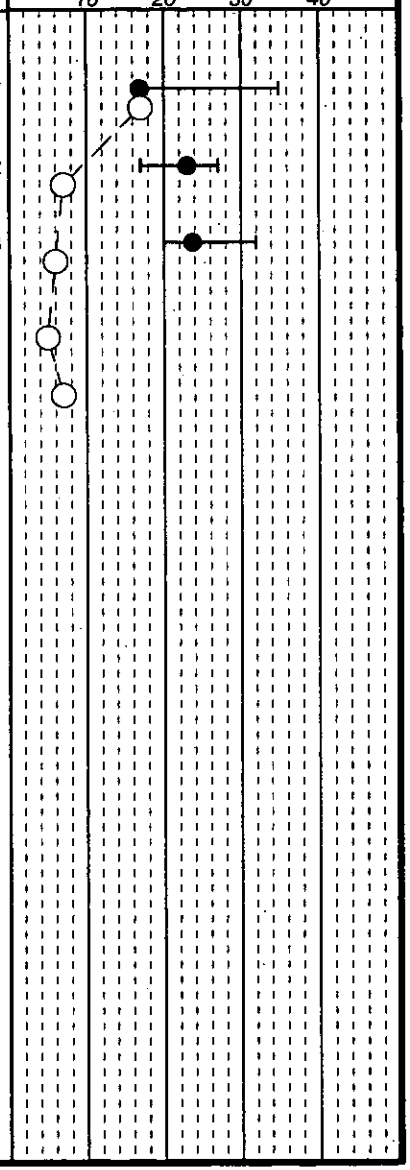
LOG OF: Boring B-1102 | Location: Sta. 2590+60.9, 7.0 ft. LT of US 23 Ramp B BL | Date Drilled: 07/14/05

WATER OBSERVATIONS: Water seepage at: None; Water level at completion: None

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	540.8												
0.8	540.0						Asphalt - 5" Aggregate Base - 4"						
		7 10 7 10	21	1		4.5+	Hard brown and gray SILTY CLAY (A-6b), little fine to coarse sand, trace gravel; slightly organic; damp.	2	2	--	10	49	37
3.0	537.8	3 3 4 4	24	2		2.5	Very stiff gray SILT (A-4b), some clay, trace fine sand; slightly organic; moist.	0	0	--	3	65	32
5.0	535.8	3 3 3 5	20	3		2.0	Stiff to very stiff brown SILT AND CLAY (A-6a), trace fine to coarse sand; damp to moist.	0	1	--	2	64	33
		2 2 3	16	4		1.0							
		3 4 3	18	5		3.5							
10.0	530.8						Bottom of Boring - 10.0'						
15													
20													
25													
30													

GRADATION

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

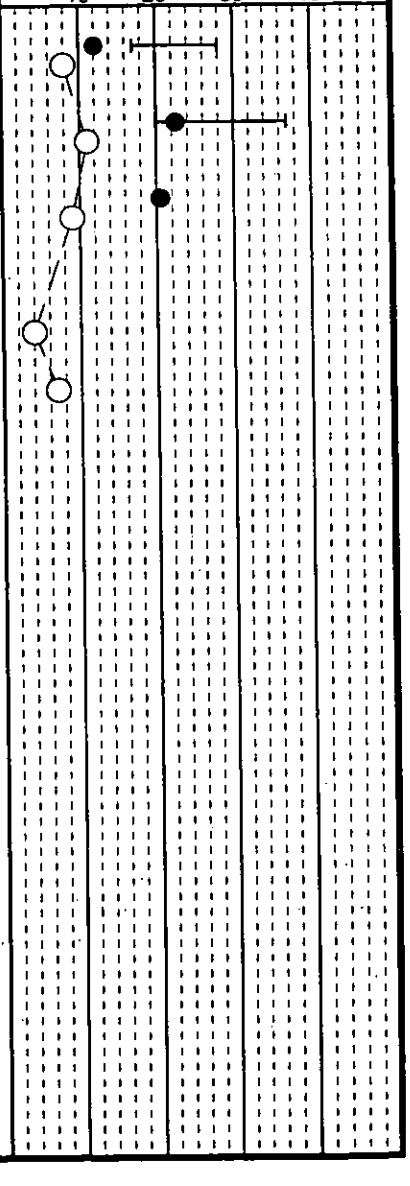
LOG OF: Boring B-1103 | Location: Sta. 2593+58.6, 11.4 ft. LT of US 23 Ramp B BL | Date Drilled: 07/14/05

WATER OBSERVATIONS: Water seepage at: None; Water level at completion: None

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	539.5												
0.4	539.1	2 3 5 5	24	1		4.5+	Topsoil - 5" Hard brown SILT AND CLAY (A-6a), some fine to coarse sand, little gravel; slightly organic; damp.	18	17	--	15	31	19
2.0	537.5	6 7 4 5	22	2		3.0	Very stiff to hard gray SILTY CLAY (A-6b), trace fine to coarse sand; moist. @ 2.0', 4.0', slightly organic. @ 4.0'-6.0', damp.	0	2	--	4	50	44
5		4 5 4 4	20	3		4.5+							
		2 2 2	18	4		1.5	@ 7.0', stiff.						
		4 4 3	18	5		1.0							
10.0	529.5						Bottom of Boring - 10.0'						
15													
20													
25													
30													

GRADATION

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 [11/6/2007 3:22 PM]

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Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1104 | Location: Sta. 2596+29.8, 8.3 ft. LT of US 23 Ramp B BL | Date Drilled: 07/14/05

WATER OBSERVATIONS: Water seepage at: 21.0'-35.0'
Water level at completion: 21.7' (prior to coring)
2.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	538.8												
0.8	538.0						Asphalt - 6" Aggregate Base - 4"						
		7 6 8 7	24	1		4.5+	Very stiff to hard brown SILT AND CLAY (A-6a), trace to little fine to coarse sand, trace gravel; damp.	4	4	--	8	51	33
		3 5 5 7	24	2		4.0		0	2	--	17	45	36
5		4 5 4 6	22	3		3.5		0	2	--	4	62	32
		3 5 3	18	4		1.0	@ 7.0', stiff, grayish brown, moist.						
		1 2 1	15	5		1.5							
10													
10.5	528.3												
		1 1 4	17	6		3.5	Very stiff brown SILTY CLAY (A-6b), trace fine to coarse sand, trace gravel; moist.						
		3 3 4	18	7		2.0							
15													
15.5	523.3												
		2 4 6	18	8		4.5+	Hard brown CLAY (A-7-6), trace fine to coarse sand, trace gravel; damp.						
		2 5 6	16	9		4.25							
20													
20.5	518.3												
		1 2 3	18	10			Loose to medium dense brown GRAVEL WITH SAND (A-1-b), little clay, trace silt; wet.						
		3 4 9	17	11									
25													
		10 18 17	15	12									
		5 12 17	16	13									
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1104 | Location: Sta. 2596+29.8, 8.3 ft. LT of US 23 Ramp B BL | Date Drilled: 07/14/05

WATER OBSERVATIONS: Water seepage at: 21.0'-35.0'
Water level at completion: 21.7' (prior to coring)
2.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○
30	508.8													
31.5	507.3	4 50/4	10	14			Loose to medium dense brown GRAVEL WITH SAND (A-1-b), little clay, trace silt; wet.							50+
							Severely weathered gray SANDSTONE, argillaceous, micaceous.							
		50/4	3	15										50+
35														
36.5	502.3	50/2	2	16										50+
		Core 60"	Rec 57"	RQD 57%	R1		Very hard gray SANDSTONE; very fine to fine grained, highly weathered, argillaceous, micaceous, massive, slightly fractured. @ 36.5'-37.3', decomposed. @ 37.3'-38.2', broken, highly weathered to decomposed.							
40														
41.5	497.3						Bottom of Boring - 41.5'							
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1105 | Location: Sta. 2597+77.5, 24.0 ft. LT of US 23 Ramp B BL | Date Drilled: 07/14/05

WATER OBSERVATIONS: Water seepage at: 22.0'-30.0'
Water level at completion: 22.0' (prior to coring)
6.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	539.0												
0.4	538.6						Topsoil - 5"						
		8 8 5	18	1		4.5+	Hard brown SILTY CLAY (A-6b), little fine to coarse sand, trace gravel; damp.	3	3	--	8	56	30
3.0	536.0												
		2 5 7	13	2		4.0	Stiff to very stiff brown and gray SILT AND CLAY (A-6a), trace to little fine to coarse sand, trace gravel; damp to moist.	1	3	--	12	46	38
5													
		2 2 3	18	3		1.5	@ 6.0', stiff; moist.	0	2	--	6	61	31
		1 1 1	13	4		1.75							
10													
		1 1 1	15	5		1.0							
		1 1 3	16	6		1.25							
15													
15.5	523.5						Very stiff to hard brown and gray CLAY (A-7-6), trace gravel, trace fine to coarse sand; damp.						
		4 5 7	18	7		4.25							
		2 3 5	17	8		3.5							
20													
20.5	518.5						Very loose to loose brown GRAVEL WITH SAND (A-1-b), little clay; wet.						
		2 3 4	18	9									
		W O H	4	10									
25													
		5 6 15	18	11			@ 26.0'-30.0', medium dense to dense.						
		6 21 28	16	12									
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1105 | Location: Sta. 2597+77.5, 24.0 ft. LT of US 23 Ramp B BL | Date Drilled: 07/14/05

WATER OBSERVATIONS: Water seepage at: 22.0'-30.0'
Water level at completion: 22.0' (prior to coring)
6.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N)
30.0	509.0													
	509.0	50/4	4	13			Severely weathered gray SANDSTONE, argillaceous, micaceous.							50+
32.0	507.0	Core 60"	Rec 60"	RQD 70%	R1		Hard gray SANDSTONE; very fine to fine grained, slightly weathered, argillaceous, micaceous, massively bedded, moderately fractured, iron-staining on high angle fractures. @ 32.3'-32.6', high angle fracture. @ 34.2'-34.5', decomposed, clay filled fractures.							
37.0	502.0						Bottom of Boring - 37.0'							

Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1105A | Location: Sta. 2598+63.3, 22.4 ft. LT of US 23 Ramp B BL | Date Drilled: 07/12/07

WATER OBSERVATIONS: Water seepage at: 22.3'-29.7'
Water level at completion: 21.0'

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	538.0												
0.3	537.7						Topsoil - 4"						
		3 5 8	13	1		4.5+	Very stiff to hard brown SILT AND CLAY (A-6a), some fine sand, trace coarse sand, trace gravel; damp to moist.						
5					ST1	2.5		1	3	--	22	43	31
							@ 5.5', stiff to very stiff, brownish gray, trace fine sand, moist.						
		4 6 7	18	2		2.0		1	1	--	3	61	34
7.8	530.2												
					ST2	1.0	Medium stiff to stiff mottled brown and gray SILT (A-4b), some clay, trace fine to coarse sand; trace gravel; moist to wet.	2	3	--	6	57	32
10.0	528.0	WOH 2 3	18	3		0.25	Very soft to soft mottled brown and gray SILT AND CLAY (A-6a), trace fine to coarse sand; moist.	0	4	--	5	51	40
					ST3	2.0	@ 12.9', stiff to very stiff, gray.	0	2	--	5	58	35
14.0	524.0												
15		4 5 8	18	4		3.0	Very stiff mottled brown and gray SANDY SILT (A-4a), trace fine sand; damp.	0	0	--	2	47	51
16.0	522.0												
					ST4	2.25	Very stiff mottled brown and gray SILTY CLAY (A-6b), trace fine to coarse sand; damp to moist.	0	1	--	2	42	55
		3 4 6	12	5		2.5	@ 18.5', little to some gravel.						
20							@ 20.5', medium stiff, little fine to coarse sand, moist.						
22.0	516.0	2 3 4	18	6A 6B		0.75	Loose to medium dense brown GRAVEL WITH SAND (A-1-b), trace to little silty clay; wet.						
		3 5 14	14	7				39	40	--	10	11	
25													
		2 2 3	18	8									
		4 16 17	12	9A			@ 29.5', contains sandstone fragments.						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢ LL
Blows per foot - ○
10 20 30 40

Non-Plastic

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1105A | Location: Sta. 2598+63.3, 22.4 ft. LT of US 23 Ramp B BL | Date Drilled: 07/12/07

WATER OBSERVATIONS: Water seepage at: 22.3'-29.7'
Water level at completion: 21.0'

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
	508.0													
30.0	508.0			9B			Severely weathered gray SANDSTONE.							
31.3	506.7	50/3	3	10			Bottom of Boring - 31.3'							50+
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1106 | Location: Sta. 2599+28.3, 27.8 ft. LT of US 23 Ramp B BL | Date Drilled: 07/14/05

WATER OBSERVATIONS: Water seepage at: 22.5'-31.0'
Water level at completion: 23.0' (prior to coring)
8.5' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	540.2												
0.3	539.9						Topsoil - 4"						
		6 7 6	14	1		4.5+	Hard brown SILT AND CLAY (A-6a), trace fine to coarse sand, trace gravel; damp to moist.	0	0	--	2	61	37
		4 6 5	18	2		4.5+		1	2	--	6	60	31
5													
5.5	534.7						Stiff to very stiff gray SILTY CLAY (A-6b), trace fine to coarse sand, trace gravel; moist.						
		2 5 4	16	3		3.75		0	1	--	4	59	36
		4 4 5	17	4		3.5							
10													
		2 2 2	13	5		2.0	@ 11.0', little gravel.						
		1 2 3	16	6		1.0							
15													
15.5	524.7						Very stiff to hard brown CLAY (A-7-6), some silt, trace fine to coarse sand; damp.						
		3 4 5	18	7		4.5+		0	1	--	2	34	63
		4 6 6	18	8		3.5							
20													
		2 3 5	17	9		2.5							
23.0	517.2						Loose brown GRAVEL WITH SAND (A-1-b), trace clay; wet.						
		1 1 1	13	10				13	57	--	23	7	Non-Plastic
25													
		4 3 3	16	11			@ 26.0'-27.5', little clay.						
		2 2 8	18	12									
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1106 | Location: Sta. 2599+28.3, 27.8 ft. LT of US 23 Ramp B BL | Date Drilled: 07/14/05

WATER OBSERVATIONS: Water seepage at: 22.5'-31.0'
Water level at completion: 23.0' (prior to coring)
8.5' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N)
30.0	510.2	50/4	4	13			Severely weathered gray SANDSTONE, argillaceous, micaceous.							50+1"
32.5	507.7	Core 60"	Rec 58"	RQD 65%	R1		Hard gray SANDSTONE; very fine to fine grained, moderately weathered, argillaceous, micaceous, thickly bedded, moderately fractured. @ 32.5'-33.2', broken zone. @ 33.6', 34.5', 34.7', 35.6', 35.9', shale laminations with fractures.							
37.5	502.7						Bottom of Boring - 37.5'							

Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

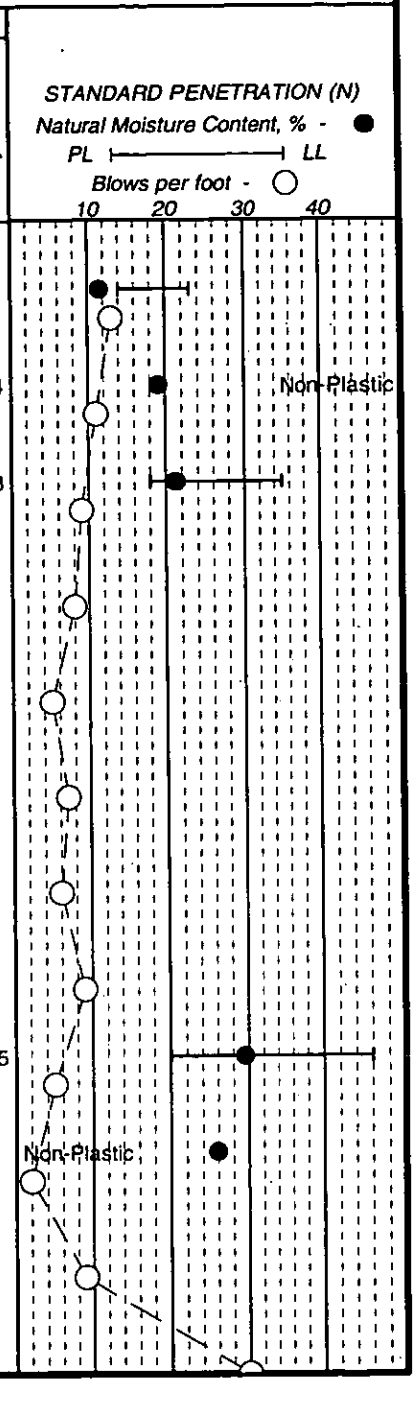
DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1107 | Location: Sta. 2600+77.4, 34.2 ft. LT of US 23 Ramp B BL | Date Drilled: 07/20/05

WATER OBSERVATIONS: Water seepage at: 25.0'-29.0'
Water level at completion: 25.0' (prior to coring)
6.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	540.5						Asphalt - 4" Aggregate Base - 8"						
1.0	539.5	5 7 6	10	1		3.5	Medium dense dark brown GRAVEL WITH SAND AND SILT (A-2-4), little clay; damp.	27	24	--	20	18	11
3.0	537.5	4 5 6	11	2			Medium dense brown SILT (A-4b), some clay, trace fine to coarse sand, trace gravel; damp to moist.	3	1	--	5	57	34
5.5	535.0	4 5 4	14	3		3.0	Very stiff gray SILTY CLAY (A-6b), little fine to coarse sand, trace gravel; damp to moist.	8	5	--	12	42	33
		3 4 4	12	4		2.5							
10.5	530.0	2 2 3	14	5		1.5	Stiff to very stiff brown and gray CLAY (A-7-6), "and" silt, trace fine to coarse sand; moist.						
		1 3 4	14	6		3.0							
		1 3 3	16	7		2.5							
		3 4 5	13	8		2.5							
		2 2 3	17	9		1.25		0	2	--	5	38	55
23.0	517.5	WOH 1 1	15	10			Loose brown GRAVEL WITH SAND (A-1-b), trace clay; wet.	9	70	--	14	7	
		2 4 5	10	11									
28.0	512.5	10 11 19	18	12			Medium dense brown GRAVEL WITH SAND AND SILT (A-2-4), trace clay; moist.						



FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1107 Location: Sta. 2600+77.4, 34.2 ft. LT of US 23 Ramp B BL Date Drilled: 07/20/05

WATER OBSERVATIONS: Water seepage at: 25.0'-29.0'
Water level at completion: 25.0' (prior to coring)
6.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
30.0	510.5												
	510.5	Core 60"	Rec 50"	RQD 20%	R1		Hard gray SANDSTONE; very fine to fine grained, slightly to moderately weathered, argillaceous, micaceous, massive, slightly fractured. @ 30.0'-30.7', lost recovery. @ 30.7'-31.6', calcareous, sulfur odor. @ 30.7'-31.6', 32.7'-32.9', 33.8'-33.9', high angle fractures.						
35.0	505.5						Bottom of Boring - 35.0'						

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

40 45 50 55 60

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

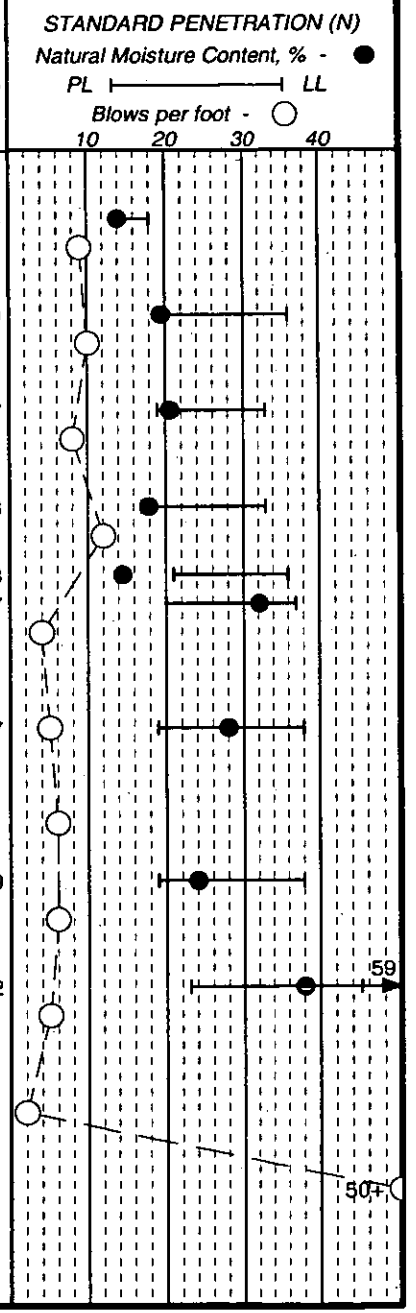
DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1108 | Location: Sta. 2602+29.5, 35.3 ft. LT of US 23 Ramp B BL | Date Drilled: 07/21/05

WATER OBSERVATIONS: Water seepage at: 25.0'
Water level at completion: 25.0' (prior to coring)
8.5' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	540.7						Asphalt - 4" Aggregate Base - 8"						
1.0	539.7	3 5 4	12	1		1.5	FILL: Stiff dark brown SANDY SILT (A-4a), little clay, little gravel; damp to moist.	10	18	--	28	31	13
3.0	537.7	3 4 6	10	2		3.0	FILL: Very stiff dark brown SILTY CLAY (A-6b), little fine to coarse sand, trace gravel; damp to moist.	6	4	--	8	43	39
5.5	535.2	2 3 5	16	3		--	FILL: Stiff to very stiff gray SILT AND CLAY (A-6a), little fine to coarse sand, little gravel; slightly organic; moist.	10	4	--	8	51	27
8.0	532.7	3 5 7	13	4		4.5+	Hard brown and gray SILTY CLAY (A-6b), trace to little fine to coarse sand, trace gravel; moist.	7	6	--	10	44	33
10.0	530.7	2 2 2	14	5	P1	3.75	Very stiff brown SILT AND CLAY (A-6a), trace fine to coarse sand; damp.	0	1	--	3	58	38
						1.0		3	0	--	1	59	37
12.0	528.7	2 2 3	16	6	P2	1.5	Stiff brown SILTY CLAY (A-6b), trace to little fine to coarse sand, trace gravel; moist.	2	4	--	9	48	37
		1 3 3	15	7		1.75							
		2 2 4	15	8	P3	1.0		1	4	--	5	51	39
21.5	519.2	1 2 3	18	9		1.5	Stiff brown CLAY (A-7-6), trace gravel, trace fine sand; moist.	2	0	--	1	25	72
23.0	517.7	WOH 1 1	15	10			Very loose to loose gray COARSE AND FINE SAND (A-3a), little gravel, trace clay; wet.						
26.5	514.2	6 50/4	9	11			Severely weathered black SILTSTONE, carbonaceous.						
28.9	511.8						Hard gray SANDSTONE interbedded with SILTSTONE.						



FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1108 | Location: Sta. 2602+29.5, 35.3 ft. LT of US 23 Ramp B BL | Date Drilled: 07/21/05

WATER OBSERVATIONS: Water seepage at: 25.0'
Water level at completion: 25.0' (prior to coring)
8.5' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
30	510.7	Core 60"	Rec 53"	RQD 78%	R1		Hard gray SANDSTONE interbedded with SILTSTONE; very fine to fine grained, moderately weathered, argillaceous, micaceous, medium bedded, slightly fractured. @ 28.9'-29.1', 31.4'-31.7', 32.2'-33.2', high angle fractures.						
33.5	507.2						Bottom of Boring - 33.5'						
35													
40													
45													
50													
55													
60													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

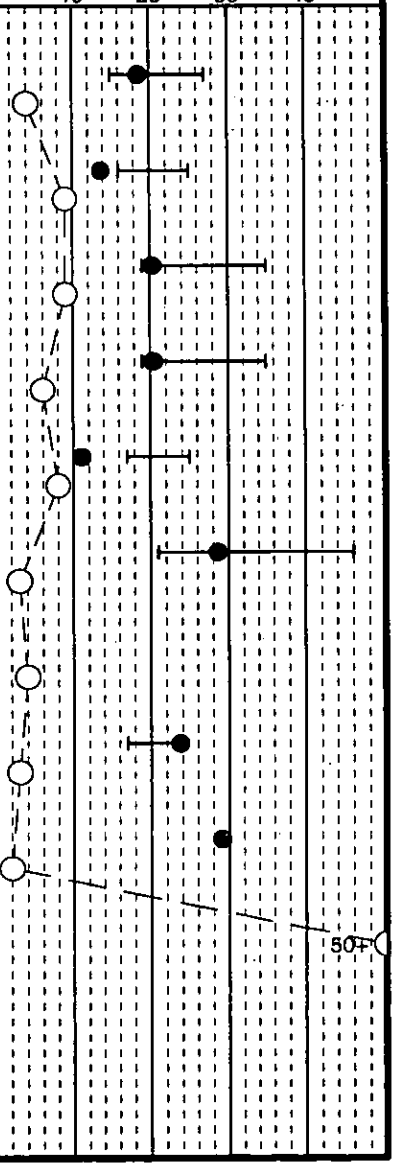
Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1109 | Location: Sta. 2603+75.4, 36.5 ft. LT of US 23 Ramp B BL | Date Drilled: 07/22/05

WATER OBSERVATIONS: Water seepage at: 19.0'-22.0'
Water level at completion: 19.0' (prior to coring)
8.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	540.6						Asphalt - 4" Aggregate Base - 8"						
1.0	539.6	3 2 2	12	1		1.5	FILL: Stiff dark brown SILT AND CLAY (A-6a), some fine to coarse sand, trace gravel; moist.	7	10	--	11	48	24
3.0	537.6	2 4 5	14	2		2.0	FILL: Stiff to very stiff dark brown SANDY SILT (A-4a), some gravel, little clay; contains wood fragments; damp.	22	15	--	12	32	19
5.5	535.1	3 4 5	15	3		3.5	POSSIBLE FILL: Very stiff to hard grayish brown SILTY CLAY (A-6b), trace fine to coarse sand, trace gravel; slightly organic; moist.	1	3	--	7	51	38
10		2 3 3	13	4		4.25		1	4	--	11	47	37
10.5	530.1	1 4 4	10	5			Medium stiff brown SANDY SILT (A-4a), some gravel, little clay; moist.	33	17	--	14	24	12
13.0	527.6	1 1 2	15	6		1.5	Stiff gray CLAY (A-7-6), some silt, trace fine to coarse sand, trace gravel; moist to wet.	1	3	--	7	35	54
15		1 1 3	12	7		2.0							
18.0	522.6	1 1 2	18	8		--	Soft brown SANDY SILT (A-4a), little clay, trace gravel; wet.	3	12	--	32	39	14
20		WOH 1 1	16	9		--		0	1	--	52	47	
23.5	517.1	10 50/5	9	10			Severely weathered black SHALE, carbonaceous.						
25.0	515.6	Core 60"	Rec 60"	RQD 77%	R1		Soft to medium hard black SHALE; very fine grained, moderately weathered to decomposed, carbonaceous, thinly laminated, highly fractured. @ 28.0'-28.1', 28.3'-28.6', high angle fracture.						
28.3	512.3						Medium hard to hard gray SANDSTONE; fine grained, highly weathered, micaceous, argillaceous, massive, slightly						
30.0	510.6												

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 (11/6/2007 3:22 PM)

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1109 | Location: Sta. 2603+75.4, 36.5 ft. LT of US 23 Ramp B BL | Date Drilled: 07/22/05

WATER OBSERVATIONS: Water seepage at: 19.0'-22.0'
Water level at completion: 19.0' (prior to coring)
8.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL — LL Blows per foot - ○ 10 20 30 40
30	510.6						fractured.							
							Bottom of Boring - 30.0'							
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1109A | Location: Sta. 2602+83.8, 5.6 ft. LT of US 23 Ramp B BL | Date Drilled: 07/12/07

WATER OBSERVATIONS: Water seepage at: 13.5'-15.0'
Water level at completion: 1.8' (includes surface water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	532.5												
0.5	532.0	WOH 2 4	12	1		1.75	Topsoil - 6" POSSIBLE FILL: Stiff brownish gray SANDY SILT (A-4a), little clay, little gravel; contains roots, coal fragments, and plant debris; moist. @ 3.0', wet.						
5		WOH 2 1	8	2		-		13	22	--	21	28	16
5.5	527.0	1 2 3	18	3	ST1	1.5	Stiff mottled brown and gray SILTY CLAY (A-6b), little fine to coarse sand, trace gravel; moist.	3	6	--	10	33	48
8.0	524.5	1 2 3	18	4	ST2	1.25 1.0	Medium stiff to stiff mottled brown and gray CLAY (A-7-6), little to some silt, trace fine to coarse sand; moist.	0	1	--	3	20	76
10													
11.3	521.2	W O H	3	5	ST3	0.5	Very loose to loose brown SANDY SILT (A-4a), little clay, trace gravel; wet. Note: No recovery in ST1 and ST3.						
15		WOH 2 6	10	6				9	8	--	38	32	13
16.0	516.5	50/3	3	7			Severely weathered black carbonaceous SHALE.						
16.3	516.2						Bottom of Boring - 16.3'						
20													
25													
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

57
50+
Non-Plastic

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

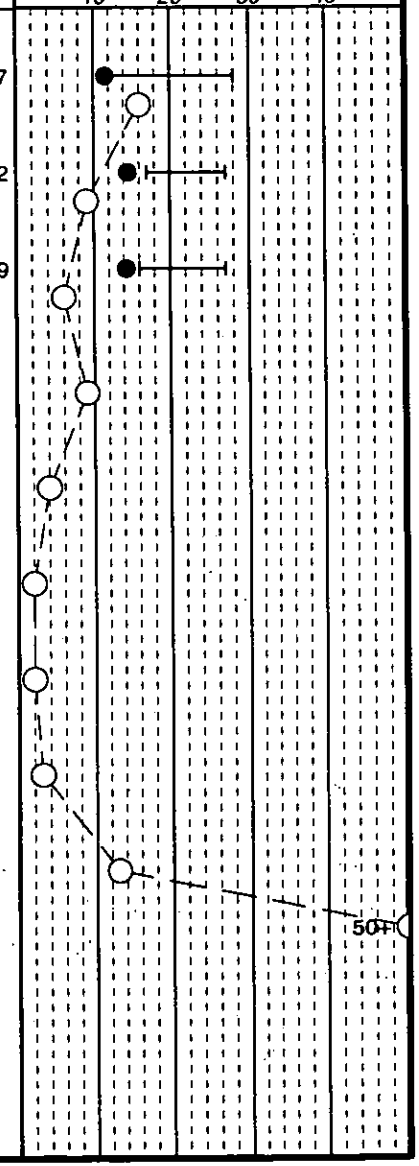
Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1110 | Location: Sta. 2604+76.5, 20.7 ft. RT of US 23 Ramp B BL | Date Drilled: 07/14/05

WATER OBSERVATIONS: Water seepage at: 12.0'-25.0'
Water level at completion: 12.0' (prior to coring)
5.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	542.3												
0.5	541.8						Topsoil - 6"						
		6 8 8	18	1		4.5+	Hard brown SILTY CLAY (A-6b), little fine to coarse sand, trace gravel; damp.	1	4	--	11	57	27
3.0	539.3												
		6 5 4	18	2		3.5	Very stiff brown SILT (A-4b), some clay, little fine to coarse sand; damp.	0	7	--	11	60	22
5													
5.5	536.8												
		2 3 3	15	3		4.0	Very stiff brown SILT AND CLAY (A-6a), "and" fine to coarse sand, trace gravel; moist.	3	15	--	25	28	29
		1 4 5	16	4		2.5							
10													
		2 2 2	18	5		2.0							
13.0	529.3												
		1 1 1	6	6			Very loose brown COARSE AND FINE SAND (A-3a), little clay, little gravel; wet.						
15													
		1 1 1	10	7									
18.0	524.3												
		2 1 2	16	8			Loose to medium dense brown GRAVEL WITH SAND (A-1-b), little clay, little silt; wet.						
20													
		9 6 7	9	9									
23.0	519.3												
		50/5	7	10			Severely weathered black SHALE, carbonaceous.						
25.0	517.3												
25.6	516.7						Soft black SHALE; decomposed, carbonaceous, thinly laminated, moderately fractured.						
		Core 60"	Rec 52"	RQD 32%	R1		Medium hard black SHALE; unweathered, carbonaceous, thinly laminated, slightly fractured. @ 27.8'-28.0', 29.3'-29.5', high angle fractures.						
30.0	512.3						Bottom of Boring - 30.0'						

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1110 | Location: Sta. 2604+76.5, 20.7 ft. RT of US 23 Ramp B BL | Date Drilled: 07/14/05

WATER OBSERVATIONS: Water seepage at: 12.0'-25.0'
Water level at completion: 12.0' (prior to coring)
5.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
30	512.3													
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 (11/6/2007 3:22 PM)

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

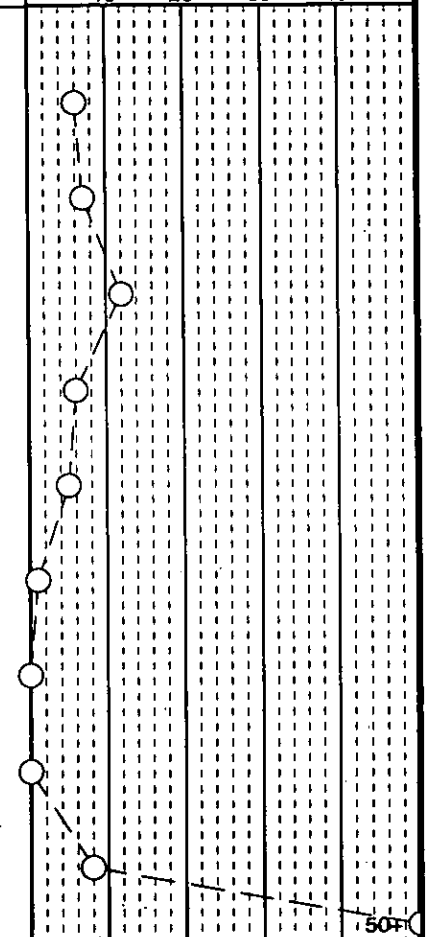
Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1111 | Location: Sta. 2605+81.7, 14.0 ft. LT of US 23 Ramp B BL | Date Drilled: 11/2/05

WATER OBSERVATIONS: Water seepage at: 10.0'-22.5'
Water level at completion: 8.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	543.8												
0.3	543.5						Topsoil - 3"						
		3 3 3	13	1		2.5	FILL: Very stiff to hard brown SANDY SILT (A-4a), little clay, trace gravel; damp.						
		4 3 4	10	2		4.5+							
5													
5.5	538.3						Very stiff to hard brown SILT AND CLAY (A-6a), trace fine to coarse sand, trace gravel; moist.						
		4 5 7	15	3		4.25							
		2 3 3	12	4		2.0	@ 8.5', some gravel, some fine to coarse sand.						
10													
10.5	533.3						Loose brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); wet.						
		2 2 3	12	5									
13.0	530.8						Very loose brown COARSE AND FINE SAND (A-3a), little clay, little gravel; wet.						
		WOH WOH 1	16	6									
15													
		W O H	18	7									
		W O H	11	8									
20													
20.5	523.3						Loose brown GRAVEL WITH SAND AND SILT (A-2-4), little clay; wet.						
		WOH 2 6	12	9									
23.5	520.3	50/4	2	10			Severely weathered black SHALE, carbonaceous.						
25.0	518.8						@ 25.0'-25.4', broken zone.						
							Medium hard to hard black SHALE; slightly to moderately weathered, argillaceous, carbonaceous, thinly laminated, moderately fractured, contains turbidity. @ 26.4'-26.5', 27.2', low angle fractures.						
30		Core 120"	Rec 120"	RQD 57%	R1								

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1111 | Location: Sta. 2605+81.7, 14.0 ft. LT of US 23 Ramp B BL | Date Drilled: 11/2/05

WATER OBSERVATIONS: Water seepage at: 10.0'-22.5'
Water level at completion: 8.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
30.0	513.8						Hard gray SANDSTONE; very fine to fine grained, moderately weathered, argillaceous, micaceous, medium bedded to thickly bedded, moderately to highly fractured. @ 31.5'-31.7', 32.1', low angle fractures. @ 32.7', 32.9', 33.6'-34.2', fractures with decomposed zones.							
35.0	508.8						Bottom of Boring - 35.0'							
40														
45														
50														
55														
60														

FILE: 0121-3070-03 (11/6/2007 3:22 PM)

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1112 | Location: Sta. 2608+31.5, 9.0 ft. LT of US 23 Ramp B BL | Date Drilled: 10-12-05

WATER OBSERVATIONS: Water seepage at: 26.0'-30.0'
Water level at completion: None (prior to coring)
6.6' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION
0	560.9						
0.3	560.6						Topsoil - 3"
		3 3 4	9	1		4.0	FILL: Very stiff to hard brown SILT AND CLAY (A-6a), little gravel, trace fine to coarse sand; moist.
3.0	557.9						
		5 5 6	18	2			FILL: Medium dense brown and dark gray SANDY SILT (A-4a), trace clay, trace gravel; damp.
5							
5.5	555.4						POSSIBLE FILL: Medium dense brown COARSE AND FINE SAND (A-3a), trace to little gravel; dry.
		5 7 7	15	3			
		13 14 14	10	4			
10							
		4 10 11	11	5			
		8 8 6	9	6			
15							
		3 3 4	17	7			@ 16.0', little silt, little clay; damp to moist.
		5 8 8	6	8			
20							
		5 6 6	13	9			
23.0	537.9						
		9 11 15	1	10			POSSIBLE FILL: Medium dense to dense brown GRAVEL WITH SAND (A-1-b), little silt, trace clay; wet.
25							
		3 5 6	14	11			
		6 25 15	11	12			
30							

GRADATION

% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
26	39	--	19	13	3

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1112 | Location: Sta. 2608+31.5, 9.0 ft. LT of US 23 Ramp B BL | Date Drilled: 10-12-05

WATER OBSERVATIONS: Water seepage at: 26.0'-30.0'
Water level at completion: None (prior to coring)
6.6' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
30	530.9						POSSIBLE FILL: Medium dense to dense brown GRAVEL WITH SAND (A-1-b), little silt, trace clay; wet.						
33.0	527.9						Medium hard black SHALE; moderately to highly weathered, carbonaceous, thinly bedded, moderately fractured. @ 33.9'-34.0', broken zone.						
35		Core 120"	Rec 120"	RQD 83%	R1								
40													
43.0	517.9						Bottom of Boring - 43.0'						
45													
50													
55													
60													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1113 | Location: Sta. 2610+64.3, 16.0 ft. LT of US 23 Ramp B BL | Date Drilled: 9/28/05

WATER OBSERVATIONS: Water seepage at: 15'
Water level at completion: 29.8' (prior to coring)
18.0' (15 hours after completion)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	566.8												
0.4	566.4	8 8 8	13	1		3.5	Topsoil - 5" Very stiff dark brown SILT AND CLAY (A-6a), little fine to coarse sand, trace gravel; contains roots; damp.						
5		4 3 4	15	2		4.0		1	3	--	11	52	33
5.5	561.3	3 4 6	16	3		4.0	Very stiff to hard brown and gray CLAY (A-7-6), "and" silt, little fine to coarse sand; moist.	0	1	--	12	47	40
8.0	558.8	5 4 7	18	4		1.5	Stiff brown and gray SILTY CLAY (A-6b), "and" fine to coarse sand, little gravel; moist.	15	15	--	28	23	19
10		2 3 2	17	5		1.5							
15		2 1 2	16	6		1.0							
15.5	551.3	2 1 1	18	7			Very loose brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); wet.	18	37	--	25	8	12
18.0	548.8	34 50/5	11	8			Severely weathered gray SHALE, micaceous.						
20		50/5	5	9									
		50/4	4	10									
25		50/4	4	11									
		50/4	4	12									
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40
50+ 50+ 50+ 50+ 50+

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1113 | Location: Sta. 2610+64.3, 16.0 ft. LT of US 23 Ramp B BL | Date Drilled: 9/28/05

WATER OBSERVATIONS: Water seepage at: 15'
Water level at completion: 29.8' (prior to coring)
18.0' (15 hours after completion)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL — LL Blows per foot - ○ 10 20 30 40
30	536.8	Core 48"	Rec 33"	RQD 0%	R1		Severely weathered gray SHALE, micaceous.							
		50/5	5	13										50+
35														
		50/4	4	14										50+
40														
44.0	522.8	50/2	2	15										50+
45		Core 60"	Rec 56"	RQD 58%	R2		Medium hard black SHALE; slightly to moderately weathered, carbonaceous, thinly laminated, slightly fractured. @ 45.1', 47.2', 48.9', decomposed fractures.							
49.0	517.8						Bottom of Boring - 49.0'							
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1114 | Location: Sta. 2612+98.5, 14.8 ft. LT of US 23 Ramp B BL | Date Drilled: 10/17/05

WATER OBSERVATIONS: Water seepage at: None
Water level at completion: None (prior to coring)
4.1' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	581.1						Topsoil - 3"/7" soil removed before drilling						
1.0	580.1	7 14 16	18	1		4.5+	Hard brown SILTY CLAY (A-6b), little fine to coarse sand, trace gravel; contains sandstone fragments; damp.	0	1	--	4	44	51
5		14 26 35	14	2		4.5+		3	4	--	9	46	38
		10 15 21	18	3		4.5+							
10		10 22 33	18	4		4.5+							
		11 17 26	18	5		4.5+							
14.7	566.4	17 21 40	18	6A 6B		4.5+	Severely weathered brownish gray SHALE.						
		21 35 50/5	17	7									
		50/5	5	8			@ 21.0', gray.						
21.5	559.6	50/3	3	9			Soft to medium hard gray SHALE interbedded with SANDSTONE; very fine grained, moderately to highly weathered, micaceous, argillaceous, medium bedded, moderately fractured. @ 21.6'-22.2', lost recovery from clay wash out.						
25		Core 120"	Rec 113"	RQD 70%	R1								
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢⊣ LL
Blows per foot - ○
10 20 30 40
61
55
61
50+
50+
50+

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1114 | Location: Sta. 2612+98.5, 14.8 ft. LT of US 23 Ramp B BL | Date Drilled: 10/17/05

WATER OBSERVATIONS: Water seepage at: None
Water level at completion: None (prior to coring)
4.1' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL — LL Blows per foot - ○ 10 20 30 40
30	551.1						Soft to medium hard gray SHALE interbedded with SANDSTONE; very fine grained, moderately to highly weathered, micaceous, argillaceous, medium bedded, moderately fractured.							
31.5	549.6						Bottom of Boring - 31.5'							
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

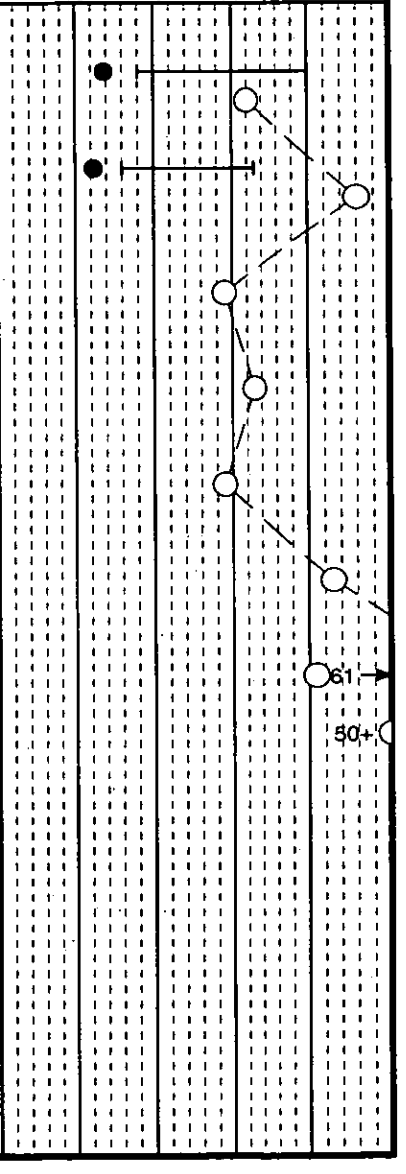
Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1115 | Location: Sta. 889+97.4, 30.0 ft. RT of SR 823 CL | Date Drilled: 10/14/05

WATER OBSERVATIONS: Water seepage at: None
Water level at completion: None (prior to coring)
8.1' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	582.4						Topsoil - 3"/6" soil removed before drilling						
1.0	581.4	11 15 17	18	1		4.5+	Hard brown SILTY CLAY (A-6b), little fine to coarse sand, trace gravel; contains sandstone fragments; damp to moist.	4	3	--	8	43	42
		11 20 26	18	2		4.5+		1	4	--	12	47	36
5		6 11 18	18	3		4.5+							
		10 14 19	18	4		4.5+							
10		7 10 19	18	5		4.5+							
		9 19 24	18	6		4.5+							
15.0	567.4						Severely weathered gray SHALE.						
		18 26 35	18	7									
19.0	563.4	50/5	5	8			Very soft to soft gray SANDSTONE; very fine grained, highly weathered, micaceous, laminated to thinly bedded, moderately fractured to broken, contains ferric band of very fine sandstone; contains moderate to abundant argillaceous laminations. @ 20.5'-20.7', decomposed zone, lost recovery.						
20													
		Core 120"	Rec 118"	RQD 71%	R1								
25													
29.0	553.4						Bottom of Boring - 29.0'						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1116 | Location: Sta. 3892+65.9, 26.2 ft. LT of US 23 Ramp C BL | Date Drilled: 9/27/05

WATER OBSERVATIONS: Water seepage at: 16.0'
Water level at completion: 17.5' (prior to coring)
17.5' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	565.8												
0.3	565.5						Topsoil - 4"						
		18 21 26	9	1			Dense grayish brown SANDY SILT (A-4a), trace clay; possible boulder; dry.						
3.0	562.8												
		8 9 10	8	2			Medium dense brown SILT (A-4b), some clay, trace fine to coarse sand; damp.	0	2	--	7	66	25
5													
		6 8 13	13	3									
8.0	557.8												
		4 4 6	13	4			Loose to medium dense reddish brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); damp to moist.	11	37	--	24	12	16
10													
		3 2 2	13	5			@ 11.0', moist to wet.						
		2 1 1	13	6			@ 13.5'-17.5', very loose, wet.						
15													
		1 WOH WOH	0	7									
18.0	547.8												
		12 50/3	9	8		--	Hard gray SILTY CLAY (A-6b), trace fine to coarse sand, trace gravel; dry to damp.	1	5	--	3	53	38
20.0	545.8						Severely weathered gray and black SHALE.						
		50/4	4	9									
		50/4	4	10									
25													
		50/4	4	11									
		50/4	4	12									
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40
50+ 50+ 50+ 50+

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1116 | Location: Sta. 3892+65.9, 26.2 ft. LT of US 23 Ramp C BL | Date Drilled: 9/27/05

WATER OBSERVATIONS: Water seepage at: 16.0'
Water level at completion: 17.5' (prior to coring)
17.5' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N)
30	535.8						Severely weathered gray and black SHALE.							
		50/5	5	13										50+
35														
38.0	527.8						Medium hard black SHALE; slightly to moderately weathered, laminated, slightly fractured.							
40		Core 120"	Rec 104"	RQD 21%	R1									
45														
48.0	517.8						Bottom of Boring - 48.0'							
50														
55														
60														

STANDARD PENETRATION (N): Natural Moisture Content, % - ●; PL ⊢—⊣ LL; Blows per foot - ○; 10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

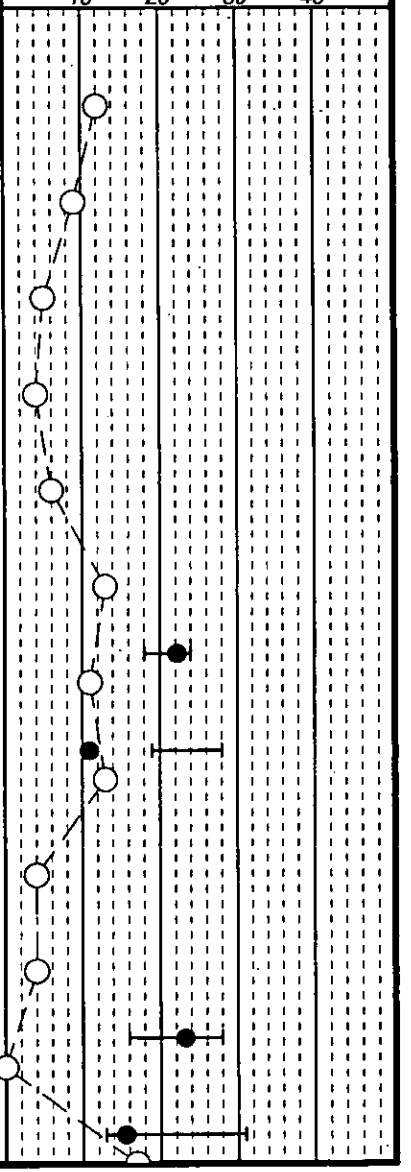
Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1117 | Location: Sta. 3895+08.1, 7.3 ft. LT of US 23 Ramp C BL | Date Drilled: 9/19/05 to 9/20/05

WATER OBSERVATIONS: Water seepage at: 26.0'
Water level at completion: 23.0' (prior to coring)
20.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	562.6												
0.7	561.9	3 6 6	6	1			Topsoil = 8" POSSIBLE FILL: Loose to medium dense brown and gray SANDY SILT (A-4a), little coarse gravel, trace clay; damp. @ 0.7'-2.5', contains roots.						
5		3 4 5	6	2									
5.5	557.1	4 2 3	3	3			POSSIBLE FILL: Medium stiff gray SILTY CLAY (A-6b), little gravel; contains organic material and sandstone fragments; moist.						
		2 2 2	2	4									
10		2 2 4	4	5									
		2 4 9	5	6									
15													
15.5	547.1	5 6 5	12	7		3.0	Very stiff brown SILT (A-4b), little clay, little fine to coarse sand; contains coarse sand seams; wet.	0	2	--	13	70	15
18.0	544.6	5 6 7	12	8			Loose to medium dense brown GRAVEL WITH SAND AND SILT (A-2-4), trace clay; moist to wet.	53	13	--	9	15	10
20		3 2 2	8	9									
		2 2 2	12	10									
25													
25.5	537.1	1 WOH WOH	12	11			Very loose brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); wet.	32	33	--	9	17	9
30		6 8 9	6	12			@ 28.5'-30.0', medium dense.	53	12	--	9	15	11

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1117 | Location: Sta. 3895+08.1, 7.3 ft. LT of US 23 Ramp C BL | Date Drilled: 9/19/05 to 9/20/05

WATER OBSERVATIONS: Water seepage at: 26.0'
Water level at completion: 23.0' (prior to coring)
20.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N)
30.0	532.6	4 5 7	6	13		0.5	Medium stiff gray SILT (A-4b), little fine to coarse sand, trace to little clay; wet.							
33.0	529.6	50/4	4	14			Severely weathered black SHALE, carbonaceous.							50+
35		50/3	3	15										50+
		50/3	2	16										50+
40														
43.0	519.6	Core 60"	Rec 60"	RQD 28%	R1		Soft black SHALE; moderately weathered, carbonaceous, laminated, moderately fractured. @ 43.0'-44.0', broken zone. @ 44.9'-45.0', decomposed.							
45														
48.0	514.6						Bottom of Boring - 48.0'							
50														
55														
60														

STANDARD PENETRATION (N): Natural Moisture Content, % - ●; PL ⊢—⊣ LL; Blows per foot - ○; 10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1117A | Location: Sta. 3894+54.8, 63.4 ft. LT of US 23 Ramp C BL | Date Drilled: 08/02/07

WATER OBSERVATIONS: Water seepage at: 20.5'-30.5'
Water level at completion: 28.1' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	561.7	9 13 12	13	1		4.5+	POSSIBLE FILL: Hard brown and gray SILT AND CLAY (A-6a), little fine to coarse sand, trace to little gravel; damp.						
		3 4 5	11	2		4.0		10	9	--	5	42	34
5		3 3 5	8	3		4.0							
		1 2 2	2	4	ST1	1.0	@ 8.0', medium stiff to stiff, some gravel.	23	11	--	6	30	30
10					ST2								
10.5	551.2	WOH WOH 2	14	5		1.0	POSSIBLE FILL: Medium stiff to stiff brownish gray SILT (A-4b), some clay, little fine to coarse sand, trace gravel; trace organic material; moist.	1	5	--	6	57	31
		3 2 2	10	6	ST3	1.0	@ 13.0', dark gray.						
15													
16.0	545.7	3 2 4	16	7		1.75	Stiff brown SILTY CLAY (A-6b), trace fine to coarse sand; moist.	0	1	--	3	63	33
		1 5 4	16	8		1.50	@ 19.0', trace to little gravel.						
20													
20.5	541.2	WOH WOH 2	14	9			Very loose brown GRAVEL WITH SAND AND SILT (A-2-4), some silty clay; wet.	32	28	--	8	18	14
		WOH 1 1	0	10									
25													
26.5	535.2	1 9 26	18	11A 11B			Dense to very dense brown and gray GRAVEL WITH SAND (A-1-b), little silty clay; wet.	51	16	--	14	19	
		7 21 42	14	12									
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic
Non-Plastic

FILE: 0121-3070-03 | 11/6/2007 3:22 PM |

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1117A | Location: Sta. 3894+54.8, 63.4 ft. LT of US 23 Ramp C BL | Date Drilled: 08/02/07

WATER OBSERVATIONS: Water seepage at: 20.5'-30.5'
Water level at completion: 28.1' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
	531.7													
30.0	531.7	7					Severely weathered black SHALE.							63
		16		13										
31.7	530.0	50/2	12				Bottom of Boring - 31.7'							50+
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

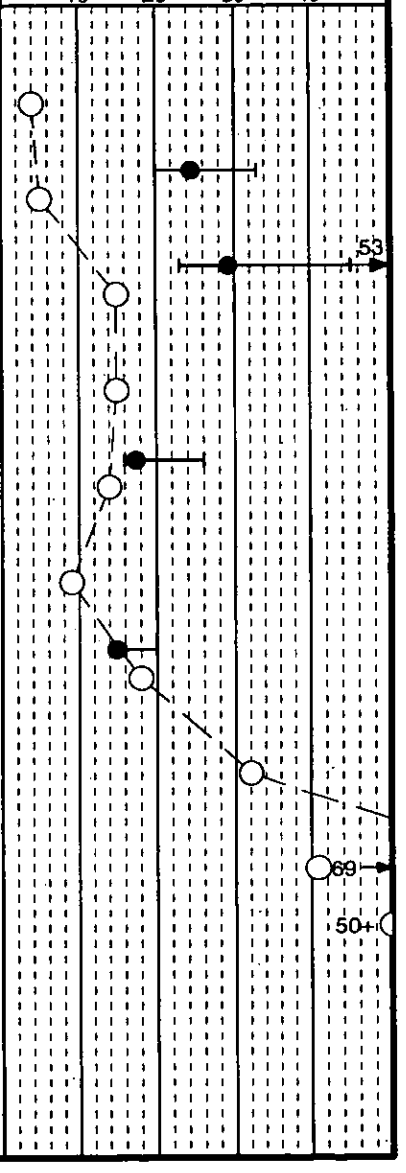
Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1118 | Location: Sta. 3896+55.5, 6.3 ft. RT of US 23 Ramp C BL | Date Drilled: 10/18/05

WATER OBSERVATIONS: Water seepage at: 11.8'-20.5'
Water level at completion: 12.7' (prior to coring)
15.6' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	546.2	1 2 2	18	1		0.75	No topsoil Medium stiff to stiff brown SILT AND CLAY (A-6a), trace fine to coarse sand, trace gravel; moist.						
5		1 2 3	18	2		1.5		1	2	--	5	62	30
5.5	540.7	5 6 9	18	3		2.5	Very stiff brown CLAY (A-7-6), some silt, trace fine sand; moist.	0	0	--	2	31	67
10		6 7 8	18	4		2.0	@ 11.0'-11.8', very soft to soft.						
11.8	534.4	4 5 9	18	5A 5B		0.25	Loose to medium dense brown GRAVEL WITH SAND AND SILT (A-2-4), trace clay; wet.	41	16	--	9	24	10
15		4 5 4	3	6									
15.5	530.7	4 7 11	13	7			Medium dense to dense brown GRAVEL WITH SAND (A-1-b), little silt, trace clay; wet.	55	12	--	10	18	5
20		7 14 18	13	8									
20.5	525.7	17 41 28	10	9			Severely weathered black SHALE.						
		50/3	3	10									
25.0	521.2						Medium hard black SHALE; moderately weathered, carbonaceous, laminated, slightly to moderately fractured.						
30		Core 120"	Rec 120"	RQD 78%	R1		@ 28.9'-29.1', broken zone.						

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1118 | Location: Sta. 3896+55.5, 6.3 ft. RT of US 23 Ramp C BL | Date Drilled: 10/18/05

WATER OBSERVATIONS: Water seepage at: 11.8'-20.5'
Water level at completion: 12.7' (prior to coring)
15.6' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION
30	516.2						
30.6	515.6						Medium hard black SHALE; moderately weathered, carbonaceous, laminated, slightly to moderately fractured.
							Hard gray SANDSTONE; very fine to fine grained, slightly to moderately weathered, micaceous, thickly bedded, slightly fractured. @ 30.8', 33.6', 33.7', 34.8', low angle clay filled fractures. @ 30.8'-33.8', calcareous.
35.0	511.2						Bottom of Boring - 35.0'
40							
45							
50							
55							
60							

GRADATION: % Aggregate | % C. Sand | % M. Sand | % F. Sand | % Silt | % Clay

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1119 | Location: Sta. 3898+99.1, 24.8 ft. LT of US 23 Ramp C BL | Date Drilled: 7/18/05

WATER OBSERVATIONS: Water seepage at: 10.0'-25.0'
Water level at completion: 12.0' (prior to coring)
5.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) / Natural Moisture Content, % / Blows per foot
0	542.0													
0.3	541.7						Topsoil - 4"							
		6 6 5	7	1		3.0	Very stiff brown SANDY SILT (A-4a), little clay, trace gravel; possible organic; damp.							
3.0	539.0													
		4 5 7	12	2		4.5+	Hard brown CLAY (A-7-6), trace fine to coarse sand, trace gravel; damp.							
5														
5.5	536.5						Stiff to very stiff brown SILTY CLAY (A-6b), "and" fine to coarse sand, trace gravel; moist.	9	11	--	32	22	26	
		4 4 5	12	3		2.0								
8.0	534.0													
		3 3 3	10	4			Very loose to loose brown GRAVEL WITH SAND AND SILT (A-2-4), trace clay; wet.	46	18	--	9	18	9	
10														
		1 1 1	8	5										
13.0	529.0													
		1 1 2	14	6			Very loose to loose brown COARSE AND FINE SAND (A-3a), little gravel, trace clay; trace silt; wet.							
15														
		2 4 3	12	7				12	47	--	22	19		Non-Plastic
18.0	524.0													
		5 8 9	13	8			Medium dense brown GRAVEL WITH SAND AND SILT (A-2-4), little clay; contains sandstone fragments; wet.	36	22	--	11	18	13	Non-Plastic
20														
20.5	521.5													
		4 5 17	12	9			Medium dense to dense brown COARSE AND FINE SAND (A-3a), little silt, little clay; contains sandstone fragments; moist.	14	6	--	48	20	12	Non-Plastic
		7 17 19	14	10										
25.0	517.0													
		Core 60"	Rec 59"	RQD 30%	R-1		Very hard gray SANDSTONE; very fine to fine grained, moderately to highly weathered, argillaceous, micaceous, thinly bedded to medium bedded, highly fractured, iron-staining @ 28.7'-28.9', high angle fractures.							
30.0	512.0						Bottom of Boring - 30.0'							

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1119 | Location: Sta. 3898+99.1, 24.8 ft. LT of US 23 Ramp C BL | Date Drilled: 7/18/05

WATER OBSERVATIONS: Water seepage at: 10.0'-25.0'
Water level at completion: 12.0' (prior to coring)
5.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
30	512.0													
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1120 | Location: Sta. 3900+39.5, 19.1 ft. RT of US 23 Ramp C BL | Date Drilled: 7/18/05

WATER OBSERVATIONS: Water seepage at: 11.0'-19.0'
Water level at completion: 11.0' (prior to coring)
5.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	542.7												
0.4	542.3						Topsoil - 5"						
		3 5 7	9	1		4.5+	Very stiff to hard brown CLAY (A-7-6), "and" silt, trace fine to coarse sand; damp.	0	1	--	2	44	53
		3 6 7	15	2		3.25		0	0	--	2	49	49
5													
5.5	537.2						Loose brown GRAVEL WITH SAND, SILT AND CLAY (A-2-6); moist to wet.						
		2 5 4	12	3				16	30	--	20	14	20
		1 2 4	8	4									
10													
10.5	532.2						Loose brown GRAVEL WITH SAND (A-1-b), some clay; wet.						
		3 3 2	6	5									
		1 1 1	8	6									
15													
		8 7 6	7	7									
		7 29 10	6	8			@ 18.5'-22.5', dense.						
20													
		14 22 18	6	9									
23.0	519.7						Medium dense brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); contains sandstone fragments; moist.						
		10 12 9	14	10									
25													
26.0	516.7	50/5	6	11			Severely weathered brown SANDSTONE.						
28.5	514.2						Hard gray SANDSTONE; very fine to fine grained.						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40
50+

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1120 | Location: Sta. 3900+39.5, 19.1 ft. RT of US 23 Ramp C BL | Date Drilled: 7/18/05

WATER OBSERVATIONS: Water seepage at: 11.0'-19.0'
Water level at completion: 11.0' (prior to coring)
5.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
30	512.7	Core 60"	Rec 54"	RQD 17%	R-1		Hard gray SANDSTONE; very fine to fine grained, moderately weathered, micaceous, argillaceous, laminated to medium bedded, moderately to highly fractured. @ 32.8'-33.1', broken.						
33.5	509.2						Bottom of Boring - 33.5'						
35													
40													
45													
50													
55													
60													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1121 | Location: Sta. 3901+49.8, 18.1 ft. LT of US 23 Ramp C BL | Date Drilled: 7/19/05

WATER OBSERVATIONS: Water seepage at: 16.0'-21.0'
Water level at completion: 16.0' (prior to coring)
9.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	539.0												
0.3	538.7						Topsoil - 4"						
		3 4 5	13	1		4.5+	FILL: Hard dark brown SILT AND CLAY (A-6a), little fine to coarse sand, little gravel; damp.	16	9	--	7	38	30
3.5	535.5	3 4 5	8	2		--	FILL: Medium stiff brown SANDY SILT (A-4a), some clay, trace gravel; wet.	7	16	--	24	31	22
5.5	533.5	3 4 3	13	3		1.0	Stiff gray SILT AND CLAY (A-6a), trace to little fine to coarse sand, trace gravel; moist.	2	4	--	6	57	31
10		2 2 2	16	4		1.25							
		W O H	17	5		1.0	@ 11.0', some fine to coarse sand.						
13.0	526.0						Very loose brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); moist to wet.						
15		2 1 1	10	6									
		4 9 9	9	7			@ 16.0'-17.5', medium dense.						
18.0	521.0						Medium dense brown COARSE AND FINE SAND (A-3a), some clay, trace gravel; wet.						
20		9 9 13	12	8									
21.5	517.5	12 11 11	13	9			Severely weathered gray SANDSTONE.						
		33 50/4	8	10									
25.0	514.0	Core 60"	Rec 57"	RQD 65%	R1		Very hard gray SANDSTONE; very fine to fine grained, slightly weathered, micaceous, argillaceous, medium bedded, moderately fractured. @ 25.3'-25.4', 26.3'-26.4', 29.1'-29.5', filled fractures. @ 29.7'-30.0', calcareous.						
30.0	509.0						Bottom of Boring - 30.0'						

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢—⊣ LL
Blows per foot - ○
10 20 30 40
50+

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1121 | Location: Sta. 3901+49.8, 18.1 ft. LT of US 23 Ramp C BL | Date Drilled: 7/19/05

WATER OBSERVATIONS: Water seepage at: 16.0'-21.0'
Water level at completion: 16.0' (prior to coring)
9.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
30	509.0													
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1122 | Location: Sta. 3903+45.0, 34.5 ft. LT of US 23 Ramp C BL | Date Drilled: 7/19/05

WATER OBSERVATIONS: Water seepage at: 16.0'-22.0'
Water level at completion: 16.0' (prior to coring)
10.5' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	540.7						Asphalt - 8" Aggregate Base - 4"						
1.0	539.7	5 5 6	9	1		2.0	FILL: Stiff to very stiff brown SANDY SILT (A-4a), little clay, little gravel; damp to moist.	16	19	--	22	28	15
3.0	537.7	5 5 9	14	2		4.5+	Hard brown and gray SILTY CLAY (A-6b), trace fine to coarse sand; moist.	0	1	--	4	56	39
5													
6.0	534.7	5 5 7	12	3		4.0	Very stiff to hard brown SILT AND CLAY (A-6a), little fine to coarse sand, little gravel; contains sand seams; moist.	13	11	--	8	44	24
8.0	532.7	10 5 4	9	4			Loose brown COARSE AND FINE SAND (A-3a), little gravel, trace clay; damp to moist.						
10													
10.5	530.2	3 5 4	2	5		3.0	Stiff to very stiff brown SILTY CLAY (A-6b), trace fine to coarse sand, trace gravel; moist.						
		2 2 3	12	6		1.0							
15		1 1 1	8	7		--	@ 16.0'-20.0', soft to medium stiff; wet.						
		WOH 3 3	6	8		0.5							
20													
20.5	520.2	13 16 15	12	9			Dense to very dense brown and gray GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); contains sandstone fragments; moist.						
		18 24 18	10	10									
25		22 50/3	4	11									
27.5	513.2	Core 60"	Rec 54"	RQD 65%	R1		Medium hard to hard gray SANDSTONE; very fine to fine grained, moderately to highly weathered, micaceous, argillaceous, thinly bedded to massive, slightly fractured.						
30													

GRADATION

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40
50+

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1122 | Location: Sta. 3903+45.0, 34.5 ft. LT of US 23 Ramp C BL | Date Drilled: 7/19/05

WATER OBSERVATIONS: Water seepage at: 16.0'-22.0'
Water level at completion: 16.0' (prior to coring)
10.5' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION
30	510.7						Medium hard to hard gray SANDSTONE; very fine to fine grained, moderately to highly weathered, micaceous, argillaceous, thinly bedded to massive, slightly fractured, iron-staining.
32.5	508.2						@ 28.2' to 28.3', broken.
35							@ 28.5' to 28.9', broken and decomposed.
							@ 30.4' to 30.7', broken with decomposed zones.
							Bottom of Boring - 32.5'
40							
45							
50							
55							
60							

GRADATION: % Aggregate | % C. Sand | % M. Sand | % F. Sand | % Silt | % Clay

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1122A | Location: Sta. 3904+16.1, 35.8 ft. LT of US 23 Ramp C BL | Date Drilled: 07/31/07

WATER OBSERVATIONS: Water seepage at: 18.5'-20.0'
Water level at completion: 17.4' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	540.7						Asphalt Concrete Pavement- 7" Aggregate base - 9"						
1.3	539.4	6 4 7	16	1		3.5	POSSIBLE FILL: Very stiff to hard brownish gray SILTY CLAY (A-6b), trace gravel, trace fine to coarse sand; damp to moist.						
		8 9 10	14	2		4.5+							
5		6 7 9	18	3		4.0		1	1	--	3	46	49
6.5	534.2	3 6 10	12	4		4.5+							
8.0	532.7						POSSIBLE FILL: Medium dense brown FINE SAND (A-3), trace to little gravel, trace silty clay; damp.						
		10 16 14	15	5		4.5+	Very stiff to hard brown SILT AND CLAY (A-6a), little to some fine to coarse sand, trace gravel; damp.						
10													
		5 5 5	18	6		2.0	@ 11.0', trace fine to coarse sand, moist.	9	20	--	11	28	32
								0	1	--	4	57	38
13.0	527.7				ST1	1.5	Stiff to very stiff mottled brown and gray CLAY (A-7-6), some to "and" silt, trace fine sand; moist.						
		2 3 4	13	7		2.0	@ 13.8', encountered red clay tile fragment.	0	0	--	2	35	63
15													
15.5	525.2				ST2	1.0	Medium stiff brown SILT AND CLAY (A-6a), trace to little fine sand, trace coarse sand; moist to wet.	0	1	--	4	56	40
		WOH 2 2	18	8		0.75		0	1	--	10	57	32
17.0	523.7						Medium stiff brown SILTY CLAY (A-6b), trace fine sand; moist.						
18.0	522.7				ST3	1.0	Soft to medium stiff brown SILT (A-4b), some clay, little to some fine to coarse sand; wet.	0	0	--	3	46	51
		WOH WOH 1	18	9		--		0	1	--	18	58	23
20								0	0	--	25	54	21
22.0	518.7	8 9 20	10	10		--	Severely weathered reddish brown SANDSTONE fragments.						
		28 31 26	16	11									
25													
		7 18 50/5	14	12			@ 26.5', gray.						
27.4	513.3						Bottom of Boring - 27.4'						
30													

GRADATION

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

57
50+

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1123 | Location: Sta. 3904+93.1, 34.5 ft. LT of US 23 Ramp C BL | Date Drilled: 7/19/05

WATER OBSERVATIONS: Water seepage at: 19.0'-20.0'
Water level at completion: 19.0' (prior to coring)
12.5' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	540.9						Asphalt - 6" Aggregate Base - 6"						
1.0	539.9	4 5 6	9	1		2.5	FILL: Very stiff gray SANDY SILT (A-4a), some gravel, little clay; damp.	25	12	--	13	34	16
3.0	537.9	2 5 4	10	2		4.5+	FILL: Very stiff to hard brown SILT AND CLAY (A-6a), little fine to coarse sand, trace gravel; damp.	7	6	--	4	45	38
5		5 6 5	15	3		3.0	@ 6.0', gray, organic staining and odor, contains sand seams.	4	8	--	8	47	33
		3 4 3	9	4		3.5							
10		3 3 4	13	5		2.5							
13.0	527.9												
		2 4 4	9	6		2.0	Stiff brown and gray SILTY CLAY (A-6b), trace fine to coarse sand, trace gravel; moist to wet.						
15		1 2 2	14	7		1.0							
		2 2 2	10	8		1.0							
20													
20.5	520.4	5 14 14	6	9		4.5+	Hard brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); damp.						
25		10 25 18	13	10		4.5+							
		8 46 50/3	8	11		4.5+							
27.5	513.4						Hard gray SANDSTONE; fine grained, moderately to highly weathered, micaceous, argillaceous, medium bedded, highly fractured to broken, iron-staining.						
30		Core 60"	Rec 50"	RQD 42%	R1								

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40
50+

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1123 | Location: Sta. 3904+93.1, 34.5 ft. LT of US 23 Ramp C BL | Date Drilled: 7/19/05

WATER OBSERVATIONS: Water seepage at: 19.0'-20.0'
Water level at completion: 19.0' (prior to coring)
12.5' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL — LL Blows per foot - ○ 10 20 30 40
30	510.9						Hard gray SANDSTONE; fine grained, moderately to highly weathered, micaceous, argillaceous, medium bedded, highly fractured to broken, iron-staining.							
32.5	508.4						Bottom of Boring - 32.5'							
35														
40														
45														
50														
55														
60														

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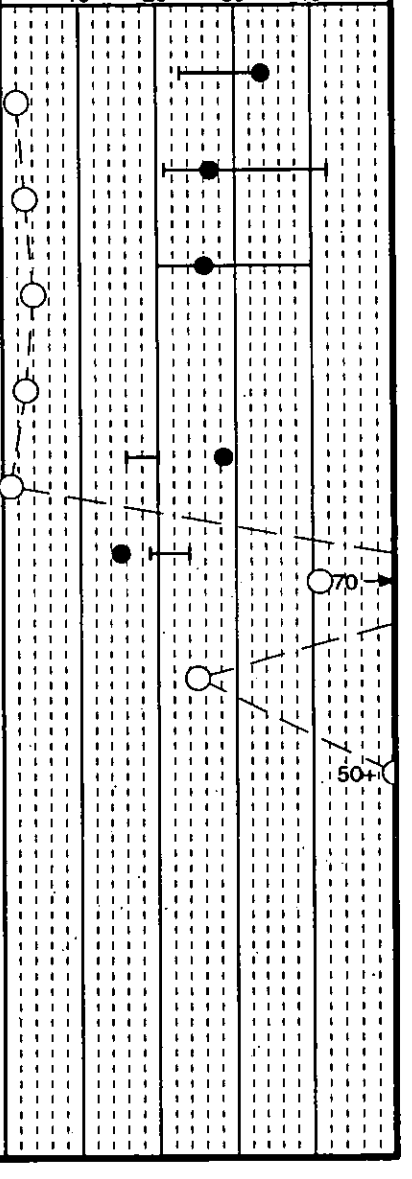
Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1124 | Location: Sta. 3906+44.7, 10.0 ft. LT of US 23 Ramp C BL | Date Drilled: 7/19/05

WATER OBSERVATIONS: Water seepage at: 11.0'-16.0'
Water level at completion: 11.0' (prior to coring)
14.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	533.5												
0.3	533.2						Topsoil - 4"						
		WOH 1 1	16	1		1.0	FILL: Stiff gray SILT AND CLAY (A-6a), little fine to coarse sand, trace gravel; contains roots; organic odor; moist to wet.	1	5	--	11	59	24
3.0	530.5												
		1 1 2	12	2		1.75	FILL: Stiff gray CLAY (A-7-6), trace fine to coarse sand; moist.	0	1	--	8	48	43
5													
5.5	528.0												
		2 2 2	12	3		1.5	Stiff brown SILTY CLAY (A-6b), trace fine to coarse sand; moist to wet.	0	0	--	7	52	41
		2 1 2	12	4		0.25	@ 8.5'-10.0', very soft to soft, some sand seams.						
10													
10.5	523.0												
		WOH WOH 1	8	5		<0.25	Very stiff to hard brown SANDY SILT (A-4a), little clay, trace gravel; damp to moist. @ 11.0'-12.5', very soft, wet.	1	1	--	36	44	18
		8 40 30	8	6		--	@ 13.5', some gravel.	27	14	--	18	30	11
15													
		8 10 15	8	7		--							
		46 18 50/4	8	8		--	@ 18.5'-20.0', gray, wet.						
20.0	513.5												
		Core 60"	Rec 48"	RQD 70%	R1		Hard gray SANDSTONE; very fine to fine grained, moderately weathered, micaceous, medium bedded, slightly fractured, iron-staining. @ 22.1'-22.5', 23.1'-23.2', high angle fractures.						
25.0	508.5						Bottom of Boring - 25.0'						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

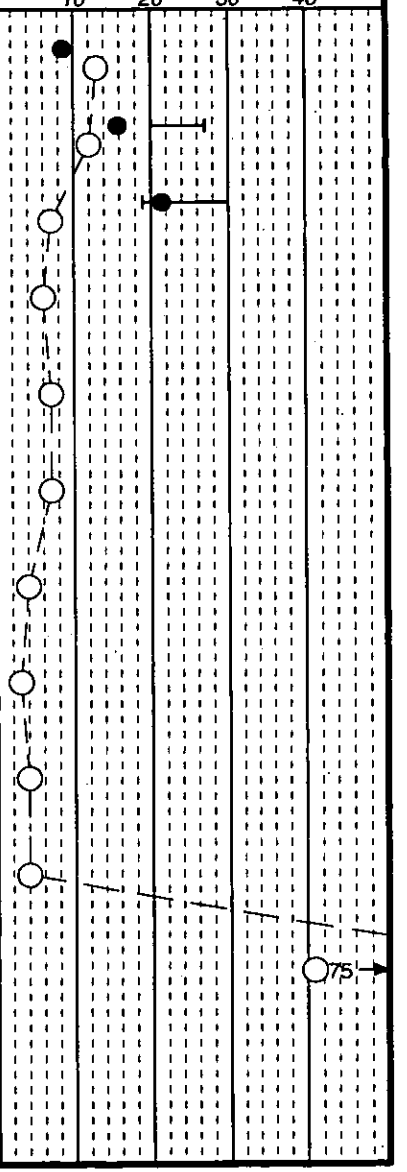
Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1125 | Location: Sta. 3910+29.2, 9.3 ft. LT of US 23 Ramp C BL | Date Drilled: 7/19/05 to 07/20/05

WATER OBSERVATIONS: Water seepage at: 14.0'-19.0'
Water level at completion: 14.0' (prior to coring)
11.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	538.9												
0.3	538.6	2 5 8 6	18	1		4.5+	Topsoil - 4" FILL: Hard brown SANDY SILT (A-4a), trace gravel, little clay; damp.						
		5 7 5 5	17	2		4.5+		8	14	--	11	49	18
4.0	534.9	4 3 4 4	19	3		2.0	Stiff brown SILT AND CLAY (A-6a), little fine to coarse sand, trace gravel; moist.	1	8	--	9	53	29
5		2 3 3	16	4		1.5							
8.0	530.9												
		2 3 4	18	5		2.5	Very stiff brown SILTY CLAY (A-6b), trace fine to coarse sand, trace gravel; moist.						
10													
		3 3 4	16	6		2.25							
							@ 13.5', "and" sand, wet.						
		2 2 2	16	7		--							
15													
15.5	523.4												
		1 1 2	12	8			Very loose brown GRAVEL WITH SAND (A-1-b), some silt, little clay; wet.						
		WOH 2 2	10	9									
20													
		WOH 2 2	3	10									
23.0	515.9												
		8 25 50	18	11			Very dense brown SANDY SILT (A-4a), trace gravel, trace clay; moist.						
25.0	513.9												
		Core 60"	Rec 52"	RQD 48%	R1		Hard gray SANDSTONE; very fine to fine grained, moderately to highly weathered, micaceous, argillaceous, medium bedded, moderately fractured, iron-staining. @ 25.2'-25.7', 26.2'-26.6', 27.5'-27.8', broken. @ 26.6'-26.7', 28.5'-28.6', high angle fractures.						
30.0	508.9						Bottom of Boring - 30.0'						

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1125 | Location: Sta. 3910+29.2, 9.3 ft. LT of US 23 Ramp C BL | Date Drilled: 7/19/05 to 07/20/05

WATER OBSERVATIONS: Water seepage at: 14.0'-19.0'
Water level at completion: 14.0' (prior to coring)
11.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL — LL Blows per foot - ○ 10 20 30 40
30	508.9													
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1126 | Location: Sta. 3913+97.9, 22.7 ft. LT of US 23 Ramp C BL | Date Drilled: 7/20/05

WATER OBSERVATIONS: Water seepage at: 11.0'-14.0', 21.0'-25.0'
Water level at completion: 11.0' (prior to coring)
7.5' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	540.7												
0.9	539.8	5 6 7 7	16	1		4.5+	Asphalt - 3" Aggregate Base - 8" Hard brown SILTY CLAY (A-6b), trace fine to coarse sand; damp.	0	1	--	2	62	35
3.0	537.7	1 6 5 5	17	2		4.5+	Very stiff to hard brown SILT AND CLAY (A-6a), some fine to coarse sand, trace gravel; damp to moist.	8	13	--	10	37	32
5		7 8 9 5	14	3		3.0	@ 5.0'-7.0', contains sand seams. @ 5.0', gray and brown.						
		3 4 5	15	4		2.5							
		2 2 3	13	5		3.5	@ 8.5', little fine to coarse sand.	0	1	--	11	42	46
10													
10.5	530.2	2 2 2	15	6		0.25	Soft brown SILT (A-4b), some clay, little fine to coarse sand; wet.	0	1	--	15	58	26
		1 1 2	13	7		0.5							
15													
15.5	525.2	WOH 2 2	18	8		0.75	Medium stiff brown SILT AND CLAY (A-6a), trace fine to coarse sand, trace gravel; moist to wet.	1	2	--	4	64	29
		1 2 2	16	9		1.0							
20													
20.5	520.2	WOH WOH 2	17	10			Very loose brown SANDY SILT (A-4a), little clay; wet.	0	12	--	48	29	11
23.0	517.7	8 14 21	18	11			Dense to very dense brown and gray GRAVEL WITH SAND (A-1-b), trace clay; wet.	5	69	--	20	6	
25		10 50/5	11	12									
27.5	513.2	Core 60"	Rec 53"	RQD 33%	R1		Hard to very hard gray SANDSTONE; very fine to fine grained, highly weathered to decomposed, micaceous, argillaceous, thinly bedded to medium bedded, highly fractured to broken.						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic
Non-Plastic

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1126 | Location: Sta. 3913+97.9, 22.7 ft. LT of US 23 Ramp C BL | Date Drilled: 7/20/05

WATER OBSERVATIONS: Water seepage at: 11.0'-14.0', 21.0'-25.0'
Water level at completion: 11.0' (prior to coring)
7.5' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
30	510.7												
32.5	508.2						Hard to very hard gray SANDSTONE; very fine to fine grained, highly weathered to decomposed, micaceous, argillaceous, thinly bedded to medium bedded, highly fractured to broken, iron-staining. @ 28.6'-30.5', decomposed.						
							Bottom of Boring - 32.5'						
35													
40													
45													
50													
55													
60													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

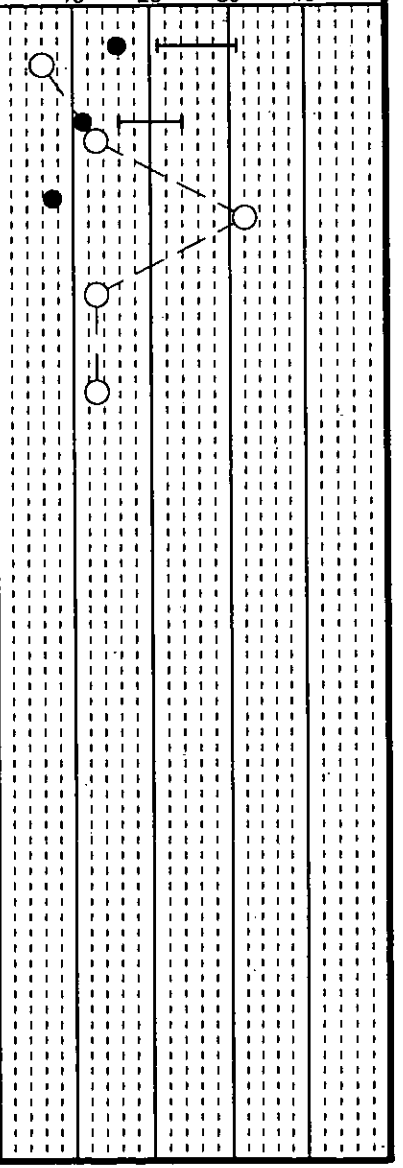
Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1127 | Location: Sta. 3916+94.6, 11.7 ft. LT of US 23 Ramp C BL | Date Drilled: 7/13/05

WATER OBSERVATIONS: Water seepage at: Not Reported; Water level at completion: Not Reported

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	540.0												
0.3	539.7	2 3 3 7	20	1		3.75	Topsoil - 4" Very stiff to hard brown SANDY SILT (A-4a), some clay, trace gravel; damp.	8	9	--	9	45	29
		6 5 8 7	22	2		4.5+		6	19	--	20	33	22
5		5 16 16 16	21	3		4.5+							
6.0	534.0	2 5 8	17	4		4.5+	Hard dark brown SILT AND CLAY (A-6a), little fine to coarse sand, trace gravel; damp.						
8.0	532.0						Very stiff brown SILTY CLAY (A-6b), trace fine to coarse sand; moist.						
		5 6 7	18	5		3.0							
10.0	530.0						Bottom of Boring - 10.0'						
15													
20													
25													
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1128 | Location: Sta. 3921+02.4, 6.9 ft. LT of US 23 Ramp C BL | Date Drilled: 7/13/05

WATER OBSERVATIONS: Water seepage at: None; Water level at completion: None

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	540.6												
1.0	539.6	8 11 7 6	19	1		4.5+	Asphalt - 8" Aggregate Base - 4" Hard brown SILT AND CLAY (A-6a), trace gravel, trace fine to coarse sand; damp.	8	2	--	2	55	33
3.0	537.6	3 9 17 10	22	2			Medium dense brown GRAVEL WITH SAND (A-1-b), little silt, trace clay; damp.	41	23	--	14	17	5
5.0	535.6	8 5 13 10	20	3		4.5+	Hard brown SILT AND CLAY (A-6a), trace gravel, trace fine to coarse sand; damp.	2	5	--	10	48	35
7.0	533.6	2 4 4	16	4		4.5+	Hard gray SILTY CLAY (A-6b), trace fine to coarse sand; damp. @ 8.5', brown.						
		4 4 4	18	5		4.25							
10.0	530.6						Bottom of Boring - 10.0'						
15													
20													
25													
30													

GRADATION

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1129 | Location: Sta. 3925+05.5, 0.2 ft. LT of US 23 Ramp C BL | Date Drilled: 7/13/05

WATER OBSERVATIONS: Water seepage at: None; Water level at completion: None

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	540.9												
0.8	540.1						Asphalt - 6" Aggregate Base - 4"						
		6 6 20 21	22	1		4.5+	Hard black SILT (A-4b), some clay, trace gravel, trace fine to coarse sand, organic; damp.	6	2	--	5	55	32
3.0	537.9	7 10 12 11	21	2			Medium dense to dense brown COARSE AND FINE SAND (A-3a), little gravel, little silt, trace clay; damp.	17	32	--	26	17	8
5		15 15 14 14	20	3									
		16 18 15	18	4									
		13 21 17	18	5			@ 8.5', contains sandstone fragments.						
10.0	530.9						Bottom of Boring - 10.0'						
15													
20													
25													
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1130 | Location: Sta. 3928+41.7, 5.9 ft. LT of US 23 Ramp C BL | Date Drilled: 7/27/05

WATER OBSERVATIONS: Water seepage at: Not Reported
Water level at completion: Not Reported

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	541.4												
0.8	540.6	20 30 15	14	1			Asphalt - 4" Aggregate Base - 6" Dense brown GRAVEL WITH SAND (A-1-b), little clay; damp.	53	19	--	10	18	
3.0	538.4	5 5 5 5	16	2		2.5	Very stiff brown SANDY SILT (A-4a), some gravel, little clay; damp.	21	18	--	22	22	17
5		6 3 2 1	15	3		3.25							
7.5	533.9	10 7 5 3	16	4			Medium dense brown GRAVEL WITH SAND (A-1-b); damp.						
10.0	531.4						Bottom of Boring - 10.0'						
15													
20													
25													
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1131 | Location: Sta. 1933+06.8, 15.9 ft. RT of US 23 Ramp A BL | Date Drilled: 7/27/05

WATER OBSERVATIONS: Water seepage at: None; Water level at completion: None

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	541.0												
0.8	540.2	3 4 4 5	6	1			Asphalt - 5" Aggregate Base - 5" Loose gray COARSE AND FINE SAND (A-3a), little gravel, little silt, little clay; damp.	16	25	--	29	18	12
3.0	538.0	3 4 3 5	16	2			Loose gray GRAVEL WITH SAND AND SILT (A-2-4), little clay; damp.	34	19	--	12	20	15
5.0	536.0	2 4 3 3	15	3		4.5+	Very stiff to hard brown and gray SILT AND CLAY (A-6a), trace fine to coarse sand; damp.	0	2	--	11	57	30
		3 3 3 4	16	4		3.5							
10.0	531.0						Bottom of Boring - 10.0'						
15													
20													
25													
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

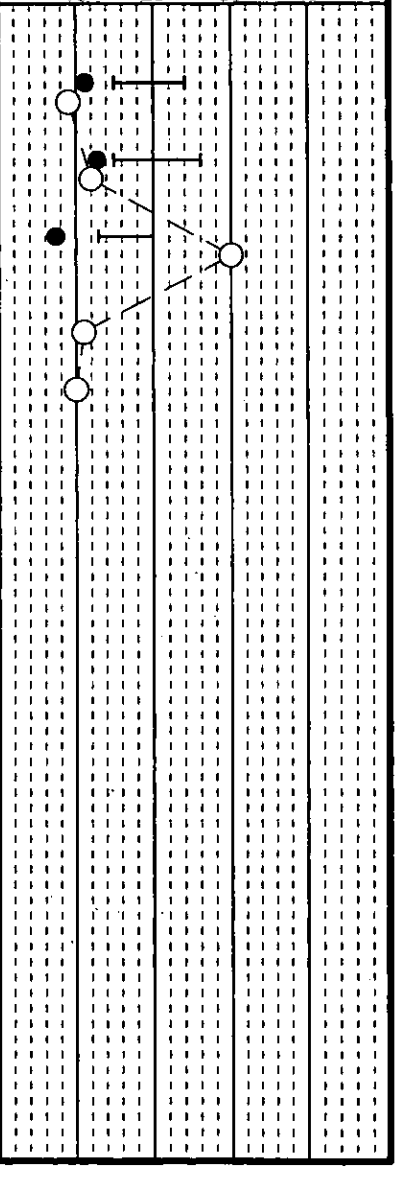
Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1132 | Location: Sta. 1928+97.1, 7.4 ft. RT of US 23 Ramp A BL | Date Drilled: 7/13/05

WATER OBSERVATIONS: Water seepage at: None; Water level at completion: None

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	540.7												
0.8	539.9						Asphalt - 6" Aggregate Base - 4"						
		3 4 5 5	20	1		3.5	Very stiff brown SANDY SILT (A-4a), some clay, little gravel; damp.	16	19	--	18	27	20
3.0	537.7	4 6 6 6	22	2		3.5	Very stiff brown SILT AND CLAY (A-6a), "and" fine to coarse sand, little gravel; damp.	15	24	--	18	23	20
5.0	535.7	7 16 14 8	21	3			Medium dense to dense brown GRAVEL WITH SAND AND SILT (A-2-4), little clay; damp.	19	31	--	20	19	11
7.0	533.7	3 4 7	11	4		3.5	Very stiff brown and gray SILTY CLAY (A-6b), little fine to coarse sand, trace gravel; moist.						
		5 5 5	17	5		3.0							
10.0	530.7						Bottom of Boring - 10.0'						
15													
20													
25													
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

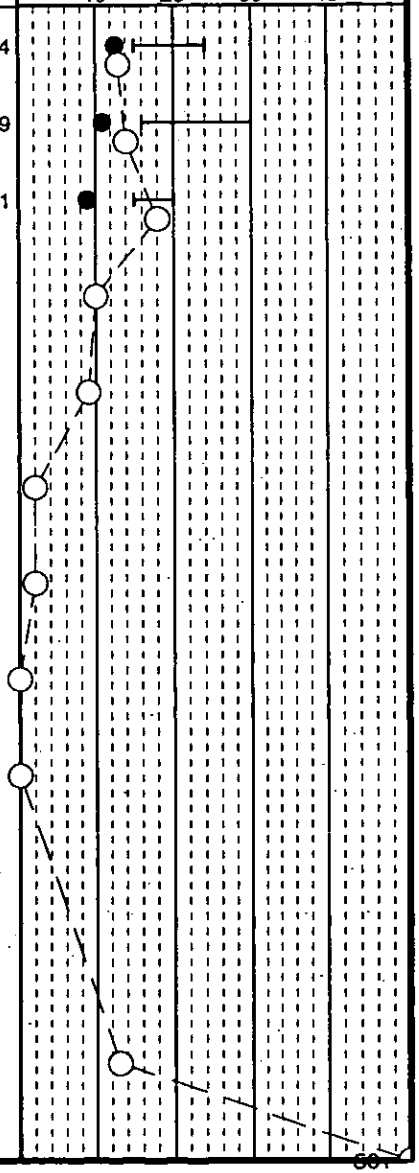
Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1133 | Location: Sta. 1924+94.0, 20.4 ft. RT of US 23 Ramp A BL | Date Drilled: 7/20/05

WATER OBSERVATIONS: Water seepage at: 11.0'-16.0', 27.0'-28.0'
Water level at completion: 11.0' (prior to coring)
7.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	540.2												
0.4	539.8	2 6 7 10	16	1		2.75	Topsoil - 5" / Very stiff brown SANDY SILT (A-4a), little clay, little gravel; moist.	12	22	--	20	32	14
2.0	538.2	6 7 7 9	14	2		4.5+	Hard brown SILT AND CLAY (A-6a), some fine to coarse sand, some gravel; damp.	27	20	--	11	23	19
4.0	536.2	5 6 12 16	16	3		4.0	Very stiff to hard brown SANDY SILT (A-4a), little clay, little gravel; damp.	13	31	--	18	27	11
5		4 5 5	15	4		3.5	@ 6.0'-7.5', very stiff, gray, organic staining.						
10		3 5 4	14	5		4.0							
10.5	529.7	1 1 1	13	6			Very loose brown SANDY SILT (A-4a), some clay, little gravel; wet.						
15		WOH 1 1	17	7			@ 13.5'-15.0', "and" gravel.						
18.0	522.2	W O H	17	8									
20		W O H	17	9		0.25	Soft gray SILTY CLAY (A-6b), trace fine to coarse sand; wet.						
25		W O H	18	10		0.5							
25.5	514.7	W O H	18	11		0.25							
28.0	512.2	1 4 9	15	12			Medium dense gray COARSE AND FINE SAND (A-3a), little gravel; wet.						
30		7 11 50/4	16	13			Very dense brown and gray GRAVEL WITH SAND AND SILT (A-2-4), little clay; contains sandstone fragments; wet.						

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1133 | Location: Sta. 1924+94.0, 20.4 ft. RT of US 23 Ramp A BL | Date Drilled: 7/20/05

WATER OBSERVATIONS: Water seepage at: 11.0'-16.0', 27.0'-28.0'
Water level at completion: 11.0' (prior to coring)
7.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) / Natural Moisture Content, % - ● / PL ⊢—⊣ LL / Blows per foot - ○ (10 20 30 40)
30.0	510.2	Core 60"	Rec 52"	RQD 33%	R1		Medium hard to hard gray SANDSTONE; very fine to fine grained, moderately to highly weathered, micaceous, argillaceous, thinly bedded to medium bedded, moderately to highly fractured. @ 30.4'-30.7', 32.5'-32.9', broken and decomposed. @ 33.0'-33.2', 34.7'-35.0', high angle fractures.							
35.0	505.2						Bottom of Boring - 35.0'							

40 45 50 55 60

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1133A | Location: Sta. 1924+81.1, 21.8 ft. RT of US 23 Ramp A BL | Date Drilled: 07/11/07

WATER OBSERVATIONS: Water seepage at: 13.5'-15.0', 24.0'-28.9'
Water level at completion: 13.3' (prior to adding water)
15.5' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	540.2												
0.7	539.5						Topsoil - 8"						
		4 10 9	12	1		4.5+	POSSIBLE FILL: Hard brown SILT (A-4b), some clay, little fine to coarse sand; trace gravel; damp.						
		7 9 11	18	2		4.5+		9	8	--	9	50	24
5													
		5 14 7	15	3A 3B 3C		4.5+							
6.5	533.7												
7.3	532.9					--	Medium dense brown COARSE AND FINE SAND (A-3a), trace silty clay; damp.						
		4 4 4	5	4		--	Medium stiff to stiff brown SILTY CLAY (A-6b), trace fine to coarse sand; damp to moist.	0	1	--	5	47	47
10													
10.5	529.7												
		WOH 2 2	18	5		-	Soft to medium stiff brown SILT AND CLAY (A-6a), "and" fine to coarse sand; moist.	0	2	--	36	38	24
							@ 13.0', trace fine sand, wet.						
		WOH 1 1	18	6		--							
15							@ 15.0', added water.						
		WOH WOH 1	18	7		--							
18.0	522.2												
18.3	521.9				ST1	0.25	Very loose to loose brown SILT (A-4b), some clay, some fine to coarse sand; wet.	0	2	--	22	52	24
20							Very soft to soft brown CLAY (A-7-6), trace fine sand; wet.						
20.3	519.9				ST2	0.5	Soft to medium stiff gray SILT (A-4b), some clay, little fine sand; wet.	0	0	--	2	67	31
22.7	517.5				ST3		@ 22.0', brownish gray.	0	0	--	11	63	26
23.8	516.4						Loose gray SILT (A-4b), some fine sand, little clay; contains trace organic material; moist to wet.	0	0	--	21	62	17
		WOH WOH 2	12	8			Loose brown and gray GRAVEL WITH SAND (A-1-b), trace silty clay; wet.	4	65	--	27	4	
25													
		3 5 11	16	9									
28.0	512.2												
		16 18 50/4		10			Severely weathered gray SILTSTONE with SANDSTONE fragments.						
30.0	510.2												

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic
Non-Plastic

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1133A | Location: Sta. 1924+81.1, 21.8 ft. RT of US 23 Ramp A BL | Date Drilled: 07/11/07

WATER OBSERVATIONS: Water seepage at: 13.5'-15.0', 24.0'-28.9'
Water level at completion: 13.3' (prior to adding water)
15.5' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
30	510.2						Bottom of Boring - 30.0'							
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1134 | Location: Sta. 1920+97.5, 18.1 ft. RT of US 23 Ramp A BL | Date Drilled: 7/27/05

WATER OBSERVATIONS: Water seepage at: 14.0'-19.0'
Water level at completion: 14.0' (prior to coring)
11.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	534.0												
0.3	533.7	3 4 4	15	1		4.5+	Topsoil - 4" / Hard dark brown SILT AND CLAY (A-6a), little fine to coarse sand; damp.	0	2	--	10	59	29
2.0	532.0	8 6 6 7	16	2		4.5+	Hard brown SILTY CLAY (A-6b), trace fine sand; damp.	0	0	--	2	55	43
4.0	530.0	3 2 1 2	18	3		1.5	Medium stiff brown SANDY SILT (A-4a), some clay; trace gravel; moist.	0	1	--	32	47	20
5		2 1 1	18	4		0.25	@ 6.0'-7.5', soft; wet.						
		WOH 2 1	18	5		0.5							
10		WOH 2 2	17	6		1.0							
13.0	521.0												
		WOH 1 1	16	7			Loose brown COARSE AND FINE SAND (A-3a), trace clay, trace gravel; wet.						
15		2 6 9	15	8									
19.0	515.0	28 50/4	10	9			Dense to very dense brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); contains sandstone fragments; moist to wet.						
20		10 12 21	12	10									
24.0	510.0	18 50/5	8	11			Severely weathered gray SANDSTONE.						
25.0	509.0	Core 60"	Rec 60"	RQD 35%	R1		Medium hard gray SANDSTONE; fine grained, highly weathered to decomposed, micaceous, argillaceous, thinly bedded to medium bedded, highly fractured to broken . @ 25.4'-26.3', 28.1'-28.4', 28.9'-29.2', decomposed zones. @ 29.8', high angle fracture.						
30.0	504.0						Bottom of Boring - 30.0'						

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

50+
50+

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1134 | Location: Sta. 1920+97.5, 18.1 ft. RT of US 23 Ramp A BL | Date Drilled: 7/27/05

WATER OBSERVATIONS: Water seepage at: 14.0'-19.0'
Water level at completion: 14.0' (prior to coring)
11.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL — LL Blows per foot - ○ 10 20 30 40
30	504.0													
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1135 | Location: Sta. 1917+04.6, 8.4 ft. RT of US 23 Ramp A BL | Date Drilled: 7/28/05

WATER OBSERVATIONS: Water seepage at: 11.0'-16.0', 29.0'
Water level at completion: 11.0' (prior to coring)
6.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	533.1												
0.4	532.7						Topsoil - 5"						
		4 5 4	12	1		4.5+	Hard brown SILT AND CLAY (A-6a), trace fine to coarse sand, trace gravel; damp.						
		3 2 2	4	2		4.5+							
5													
6.5	526.6	1 2 3	8	3			Loose to medium dense brown COARSE AND FINE SAND (A-3a), little gravel, trace clay; moist.						
		3 6 5	10	4									
10													
10.5	522.6												
		3 5 3	8	5			Loose to medium dense brown GRAVEL WITH SAND (A-1-b), little clay, little silt; moist to wet.						
		4 6 8	11	6									
15													
		6 10 6	12	7									
18.0	515.1												
		3 3 3	11	8		1.5	Medium stiff to stiff brown and gray SILTY CLAY (A-6b), trace fine to coarse sand; wet.						
20													
		1 4 5	15	9		2.0							
		2 2 2	16	10		1.25	@ 23.5'-25.0', gray.						
25													
		WOH WOH 3	4	11		0.5							
28.5	504.6	50/6	6	12			Dense gray GRAVEL WITH SAND (A-1-b), trace clay; wet.						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40
50+

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1135 | Location: Sta. 1917+04.6, 8.4 ft. RT of US 23 Ramp A BL | Date Drilled: 7/28/05

WATER OBSERVATIONS: Water seepage at: 11.0'-16.0', 29.0'
Water level at completion: 11.0' (prior to coring)
6.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
	503.1												
30.0	503.1	Core 60"	Rec 50"	RQD 58%	R1		Hard gray SANDSTONE; very fine to fine grained, moderately weathered, micaceous, argillaceous, massive, slightly fractured. @ 30.0'-30.4', broken, highly weathered. @ 31.2'-31.5', 32.5'-32.8', decomposed.						
35.0	498.1						Bottom of Boring - 35.0'						

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

40 45 50 55 60

FILE: 0121-3070-03 [11/6/2007 3:22 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1136 | Location: Sta. 1912+58.4, 33.2 ft. RT of US 23 Ramp A BL | Date Drilled: 7/26/05

WATER OBSERVATIONS: Water seepage at: 15.0'-21.0'
Water level at completion: 15.0' (prior to coring)
11.5' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	524.9												
0.3	524.6						Topsoil - 4"						
		3 5 5	8	1		4.5+	Hard dark brown SANDY SILT (A-4a), little clay; slightly organic; damp. @ 3.0', brown.						
		7 2 3	5	2		3.0							
5													
5.5	519.4						Medium stiff brown SILT AND CLAY (A-6a), trace fine to coarse sand; moist.						
		2 2 2	16	3		1.0							
		2 2 2	15	4		0.75							
10													
10.5	514.4						Soft gray SILT (A-4b); moist to wet.						
		1 1 2	14	5		0.5							
13.0	511.9						Loose brown COARSE AND FINE SAND (A-3a), trace clay, trace gravel; wet.						
		WOH 2 2	16	6									
15													
15.5	509.4						Stiff to very stiff brown and gray SILTY CLAY (A-6b), little fine to coarse sand; wet.						
		2 10 50/4	14	7		2.5							
		WOH 1 2	10	8		1.0							
20													
20.5	504.4						Very loose gray COARSE AND FINE SAND (A-3a), some silt, little clay; wet.						
		1 1 1	18	9									
		5 7 12	15	10			@ 23.5'-25.0', medium dense.						
25													
26.0	498.9	50/2	2	11			Severely weathered gray SANDSTONE.						
27.5	497.4						Hard gray SANDSTONE; very fine to fine grained, moderately to highly weathered, micaceous, argillaceous, thinly bedded to medium bedded, highly fractured.						
30		Core 60"	Rec 60"	RQD 48%	R1								

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

50+
50+

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1136 | Location: Sta. 1912+58.4, 33.2 ft. RT of US 23 Ramp A BL | Date Drilled: 7/26/05

WATER OBSERVATIONS: Water seepage at: 15.0'-21.0'
Water level at completion: 15.0' (prior to coring)
11.5' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
30	494.9						Hard gray SANDSTONE; very fine to fine grained, moderately to highly weathered, micaceous, argillaceous, thinly bedded to medium bedded, highly fractured. @ 28.7'-30.3', 31.5'-32.5', decomposed.							
32.5	492.4						Bottom of Boring - 32.5'							
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1136A | Location: Sta. 1912+56.3, 27.4 ft. RT of US 23 Ramp A BL | Date Drilled: 07/10/07

WATER OBSERVATIONS: Water seepage at: 14.0'-19.5', 21.0'-25.0'
Water level at completion: 9.2' (prior to adding water)
4.3' (after 48 hours, includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) / Natural Moisture Content, % / Blows per foot
0	524.7						Topsoil - 8"							
0.7	524.0	4 6 6	12	1		4.5+	Hard brown SILT AND CLAY (A-6a), trace fine sand; damp.							
3.0	521.7	3 2 2	14	2		1.5	Stiff brown SILT (A-4b), some clay, trace fine sand; moist.							
					ST1	2.0 1.0		0	0	--	2	70	28	
					ST2	1.25 1.25 0.5	@ 9.0', medium stiff.	0	1	--	5	71	23	
		WOH WOH 2	18	3		0.75								
13.0	511.7						Loose black SILT (A-4b), some clay, trace fine to coarse sand; organic; moist to wet.	0	2	--	6	67	25	Non-Plastic
14.5	510.2	WOH 2 3	12	4A 4B			Loose brown FINE SAND (A-3), some coarse sand, trace gravel, trace silty clay; wet.							
15		3 5 8	15	5			@ 15.0', added water.	4	34	--	54	8		Non-Plastic
							@ 19.0', little to some silt.							
19.5	505.2	3 4 6	18	6A 6B		0.75	Medium stiff light gray SILT (A-4b), trace clay, trace fine sand; moist.							
20.5	504.2	2 2 3	15	7			Loose dark gray SILT (A-4b); slightly organic; wet.							
23.0	501.7	16 7 7	6	8			Loose brown GRAVEL WITH SAND (A-1-b), trace silty clay; wet.							
25														
26.0	498.7	50/4	3	9			Severely weathered gray SANDSTONE fragments.							50+
26.4	498.3						Bottom of Boring - 26.4'							
30														

STANDARD PENETRATION (N) / Natural Moisture Content, % - ● / PL ⊢⊣ LL / Blows per foot - ○ (10 20 30 40)

FILE: 0121-3070-03 | 11/6/2007 3:38 PM |

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Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1137 | Location: Sta. 1909+15.9, 25.8 ft. RT of US 23 Ramp A BL | Date Drilled: 7/26/05

WATER OBSERVATIONS: Water seepage at: 9.0'-25.0'
Water level at completion: 9.0' (prior to coring)
6.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	525.0												
0.3	524.7						Topsoil - 4"						
		7 5 5	7	1		4.5+	FILL: Hard brown SANDY SILT (A-4a), some clay, trace gravel; contains organic material; damp.						
		4 3 2	4	2		--							
5													
5.5	519.5						Very loose brown COARSE AND FINE SAND (A-3a), little clay, trace gravel; moist to wet.						
		3 1 1	10	3									
		WOH 1 1	11	4									
10													
10.5	514.5						Medium dense to dense brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); moist.						
		5 11 8	12	5									
		6 18 25	11	6									
15													
15.5	509.5						Medium dense brown and gray COARSE AND FINE SAND (A-3a), little gravel, trace clay; wet.						
		3 4 9	10	7									
		2 4 7	13	8									
20													
		2 4 8	12	9			@ 21.0', gray.						
24.0	501.0	28 50/5	11	10			Severely weathered gray SANDSTONE.						
25													
26.0	499.0						Medium hard to hard gray SANDSTONE; fine grained, moderately to highly weathered, micaceous, argillaceous, medium bedded, moderately fractured to broken.						
		Core 60"	Rec 51"	RQD 48%	R1		@ 26.4'-26.6', 27.1'-27.7', high angle fractures.						
30							@ 27.9'-28.3', 29.6'-30.0', decomposed.						

GRADATION

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40
50+

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1137 | Location: Sta. 1909+15.9, 25.8 ft. RT of US 23 Ramp A BL | Date Drilled: 7/26/05

WATER OBSERVATIONS: Water seepage at: 9.0'-25.0'
Water level at completion: 9.0' (prior to coring)
6.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
30	495.0													
31.0	494.0						Medium hard to hard gray SANDSTONE; fine grained, moderately to highly weathered, micaceous, argillaceous, medium bedded, moderately fractured to broken.							
							Bottom of Boring - 31.0'							
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1138 | Location: Sta. 1906+57.1, 23.6 ft. RT of US 23 Ramp A BL | Date Drilled: 7/26/05

WATER OBSERVATIONS: Water seepage at: 11.0'-24.0'
Water level at completion: 11.0' (prior to coring)
6.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	525.3												
0.3	525.0						Topsoil - 4"						
		6 4 7	9	1		4.5+	FILL: Hard dark brown SANDY SILT (A-4a), trace clay, trace gravel; damp.						
		6 5 5	8	2		4.5+							
5.0	520.3						Medium stiff to stiff brown SILTY CLAY (A-6b), little fine to coarse sand, trace gravel; moist.						
		3 3 5	9	3		0.75							
		2 4 4	10	4		1.5							
10													
10.5	514.8						Medium dense brown GRAVEL WITH SAND (A-1-b), trace clay; moist.						
		5 9 10	12	5									
13.0	512.3						Loose brown and gray COARSE AND FINE SAND (A-3a), little gravel, trace clay; wet.						
		4 2 3	13	6									
15													
		4 2 3	14	7									
		1 4 5	10	8									
20													
		10 5 4	11	9			@ 21.0', gray.						
		10 20 28	18	10			@ 23.5'-25.0', dense.						
25.0	500.3						Hard gray SANDSTONE; very fine to fine grained, slightly weathered, micaceous, argillaceous, thinly bedded to medium bedded, highly fractured.						
		Core 60"	Rec 48"	RQD 48%	R1		@ 25.0'-26.2', core loss.						
							@ 26.2'-27.5', broken, decomposed zone.						
							@ 28.6',29.7', filled fracture (decomposed).						
30.0	495.3												

GRADATION

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

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Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1138 | Location: Sta. 1906+57.1, 23.6 ft. RT of US 23 Ramp A BL | Date Drilled: 7/26/05

WATER OBSERVATIONS: Water seepage at: 11.0'-24.0'
Water level at completion: 11.0' (prior to coring)
6.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
30	495.3						@ 29.4'-29.5', decomposed. Bottom of Boring - 30.0'							
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1138A | Location: Sta. 1906+53.4, 25.3 ft. RT of US 23 Ramp A BL | Date Drilled: 07/09/07

WATER OBSERVATIONS: Water seepage at: 11.0'-24.2'
Water level at completion: 8.9' (prior to adding water)
8.3' (after 16 hours, includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	525.0												
0.5	524.5	4 6 7	8	1		4.5+	Topsoil - 6" Hard brown SILT AND CLAY (A-6a), trace fine sand; damp.						
		4 6 7	16	2		4.5+							
5							@ 6.0', stiff, moist.						
		1 1 2	14	3	ST1	1.25		0	1	--	3	64	32
8.0	517.0				ST2	1.25 2.75	Stiff to very stiff light brown SILTY CLAY (A-6b), trace fine sand; moist.	0	0	--	3	53	44
10													
10.5	514.5	1 1 1	7	4		-	Very loose brown GRAVEL WITH SAND (A-1-b), little silty clay; wet. @ 13.05'-15.0, medium dense. @ 15.0', added water.	47	22	--	12	13	6
15		6 10 8	11	5									
15.5	509.5	3 5 8	17	6			Loose to medium dense brown and gray COARSE AND FINE SAND (A-3a), little silty clay, trace gravel; wet.						
		2 4 6	12	7				6	40	--	40	14	
20		2 4 5	10	8			@ 23.0', brown and dark gray, contains organic silt.						
24.0	501.0	4 14 19	12	9			Severely weathered gray SANDSTONE fragments.						
25													
26.8	498.2	7 50/3	6	10			Bottom of Boring - 26.8'						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic

50+

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

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Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1139 | Location: Sta. 903+92.6, 1.5 ft. RT of SR 823 CL | Date Drilled: 7/25/05

WATER OBSERVATIONS: Water seepage at: 11.0'-26.0'
Water level at completion: 11.0' (prior to coring)
9.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N)
0	529.7													Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
0.3	529.4	5 5 4	7	1		4.5+	Topsoil - 4" FILL: Hard brown SILT AND CLAY (A-6a), trace fine to coarse sand, trace gravel; damp.							
3.0	526.7	5 8 22	8	2		2.5	FILL: Stiff to very stiff gray SILTY CLAY (A-6b), trace gravel; contains organic material and odor; moist. @ 6.0', wood fragments.							
5		7 3 3	3	3										
10		2 4 5	6	4		1.5								
10.5	519.2	4 2 2	12	5			Very loose to loose brown GRAVEL WITH SAND (A-1-b), trace silt, trace clay; wet.							
15		1 1 2	10	6				3	53	--	31	8	5	Non-Plastic ●
		2 4 4	13	7										
20		4 5 4	12	8										
20.5	509.2	6 16 14	18	9			Medium dense brown FINE SAND (A-3), some coarse sand trace silt, trace clay, trace gravel; wet.	1	21	--	69	7	2	Non-Plastic ●
23.0	506.7	2 6 9	17	10			Loose to medium dense brown GRAVEL WITH SAND (A-1-b), trace clay; wet. @ 26.0', gray.							
25		4 12 12	14	11										
28.5	501.2	50/3	3	12			Severely weathered gray SANDSTONE, argillaceous.							50+
30														

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1139 | Location: Sta. 903+92.6, 1.5 ft. RT of SR 823 CL | Date Drilled: 7/25/05

WATER OBSERVATIONS: Water seepage at: 11.0'-26.0'
Water level at completion: 11.0' (prior to coring)
9.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL — LL Blows per foot - ○ 10 20 30 40
	499.7													
30.0	499.7	Core 60"	Rec 56"	RQD 68%	R1		Hard gray SANDSTONE; very fine to fine grained, moderately to highly weathered, micaceous, argillaceous, thinly bedded to medium bedded, slightly fractured. @ 30.8'-31.3', 33.1'-33.4', broken argillaceous zones.							
35.0	494.7						Bottom of Boring - 35.0'							
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1140 | Location: Sta. 901+35.7, 4.3 ft. LT of SR 823 CL | Date Drilled: 7/25/05

WATER OBSERVATIONS: Water seepage at: 16.0'-21.0'
Water level at completion: 16.0' (prior to coring)
19.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	535.8												
0.4	535.4						Topsoil - 5"						
		3 6 9	2	1		--	FILL: Medium dense brown SANDY SILT (A-4a); dry to damp.						
3.0	532.8												
		3 2 2	6	2		2.5	FILL: Very stiff brown and gray SILT AND CLAY (A-6a), trace to little fine to coarse sand, trace to little gravel; moist.						
5													
		1 2 3	7	3		2.5		15	10	--	8	39	28
		2 2 4	8	4		2.0		1	3	--	6	55	35
10													
10.5	525.3						Medium stiff brown SANDY SILT (A-4a), little clay; moist.						
		2 2 3	16	5				0	2	--	47	32	19
		1 2 3	15	6									
15													
15.5	520.3						Medium dense brown GRAVEL WITH SAND AND SILT (A-2-4), little clay; moist.						
		7 11 10	12	7									
		8 9 12	14	8									
20													
20.5	515.3						Loose to medium dense brown and gray GRAVEL WITH SAND (A-1-b), trace clay; moist to wet.						
		WOH 2 5	11	9				3	50	--	40	7	Non-Plastic
		3 4 4	10	10									
25													
		7 8 7	12	11									
		3 8 14	13	12									
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1140 | Location: Sta. 901+35.7, 4.3 ft. LT of SR 823 CL | Date Drilled: 7/25/05

WATER OBSERVATIONS: Water seepage at: 16.0'-21.0'
Water level at completion: 16.0' (prior to coring)
19.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○
30	505.8						Loose to medium dense gray GRAVEL WITH SAND (A-1-b), trace clay; moist to wet.							
		2 6 6	13	13										
34.0	501.8	22 50/4	6	14			Severely weathered gray SANDSTONE, argillaceous, micaceous.							50+
35.0	500.8	Core 60"	Rec 51"	RQD 43%	R1		Hard gray SANDSTONE; very fine to fine grained, moderately to highly weathered, micaceous, argillaceous, thinly bedded to medium bedded, highly fractured. @ 35.0'-35.8', lost recovery. @ 37.9'-38.2', 38.8', broken with decomposed layers.							
40.0	495.8						Bottom of Boring - 40.0'							
45														
50														
55														
60														

STANDARD PENETRATION (N) scale: 10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

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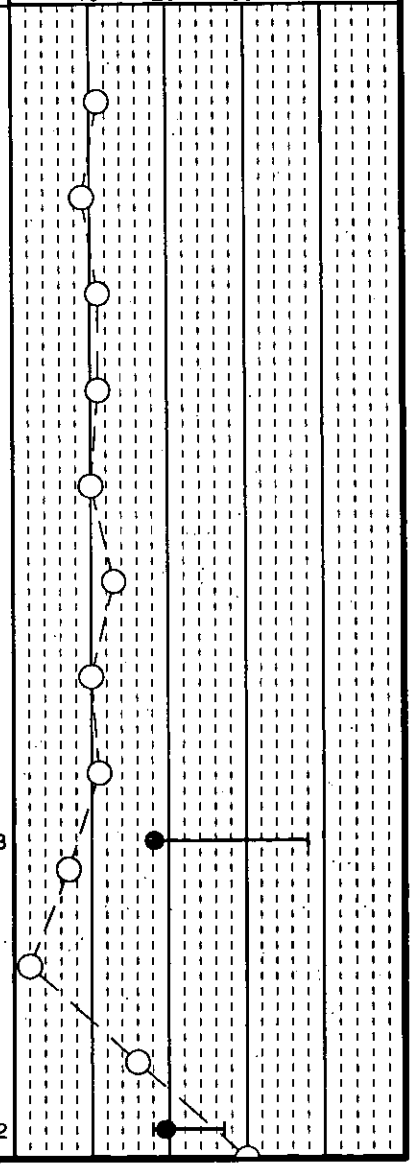
Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1141 | Location: Sta. 895+53.5, 34.0 ft. RT of SR 823 CL | Date Drilled: 10/12/05

WATER OBSERVATIONS: Water seepage at: 21.0'-30.0'
Water level at completion: 31.0' (prior to coring)
7.7' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0.2	556.2						Topsoil - 2"						
0.2	556.0	5 5 6	18	1			FILL: Loose to medium dense gray SANDY SILT (A-4a), trace clay, trace gravel; contains shale fragments; damp to moist.						
		4 4 5	18	2									
5		2 6 5	6	3									
		4 8 3	8	4									
10		15 7 3	5	5			@ 11.0', contains wood fragments.						
		4 5 8	3	6									
15													
15.5	540.7	3 5 5	0	7			Loose to medium dense brown and gray GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); moist to wet. @ 16.0'-20.0', contains wood fragments.						
		5 5 6	3	8									
20		3 4 3	14	9			@ 21.0', brown.	57	15	--	7	8	13
		2 1 1	18	10			@ 23.5'-25.0', very loose.						
25		1 1 15	5	11									
28.0	528.2												
		10 15 15	8	12		1.5	Stiff brown SANDY SILT (A-4a), some clay, little gravel; wet.	11	8	--	27	32	22
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



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DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1141 | Location: Sta. 895+53.5, 34.0 ft. RT of SR 823 CL | Date Drilled: 10/12/05

WATER OBSERVATIONS: Water seepage at: 21.0'-30.0'
Water level at completion: 31.0' (prior to coring)
7.7' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
30	526.2						Stiff brown SANDY SILT (A-4a), some clay, little gravel; wet.						
33.0	523.2	Core 120"	Rec 120"	RQD 78%	R1		Medium hard to hard black SHALE; moderately to highly weathered, carbonaceous, thinly laminated to laminated, highly fractured. @ 33.3', 33.4', 33.5', 33.9', 34.7'-34.8', 35.1', 35.3', 35.4', 36.0', 37.2', 37.4'- 37.6', 38.0', 38.3', 38.8', 39.2', 39.3', 39.9', 40.1', 40.8', 41.1', low angle fractures.						
40													
42.6	513.6												
43.0	513.2						Hard gray SANDSTONE; fine grained, slightly weathered, micaceous, medium bedded, unfractured.						
45							Bottom of Boring - 43.0'						
50													
55													
60													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1142 | Location: Sta. 894+83.0, 33.3 ft. LT of SR 823 CL | Date Drilled: 9/21/05 to 9/22/05

WATER OBSERVATIONS: Water seepage at: 28.0'
Water level at completion: 23.3' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	560.4												
0.3	560.1						Topsoil - 4"						
		5 7 7	5	1		4.0	FILL: Very stiff to hard gray SILTY CLAY (A-6b), trace gravel; damp.						
		3 5 5	6	2		4.25							
5													
		2 1 5	5	3		2.5	@ 6.0', moist.						
8.0	552.4						FILL: Stiff brown SILT AND CLAY (A-6a), little gravel, trace fine to coarse sand; moist.						
		11 5 6	6	4		1.0							
10													
		5 5 4	4	5		1.0	@ 11.0', brown and gray.						
13.0	547.4						FILL: Stiff to very stiff black SANDY SILT (A-4a), trace gravel; contains brick fragments and organic material; moist.						
		5 5 8	18	6		2.0							
15													
15.5	544.9						Very stiff brown SILT (A-4b), some clay, trace fine to coarse sand, trace gravel; damp to moist.	0	3	--	6	62	29
		5 7 6	18	7		3.5							
		5 4 4	18	8		3.0							
20													
20.5	539.9						Loose to medium dense brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); contains red sandstone fragments; moist.	30	26	--	16	11	17
		4 5 5	8	9									
23.0	537.4						Soft brown SILT AND CLAY (A-6a), little fine to coarse sand, trace gravel; wet.						
		5 4 4	2	10		0.5							
25													
25.5	534.9						Loose to medium dense brown COARSE AND FINE SAND (A-3a), "and" clay, little silt, little gravel; wet.						
		5 5 5	1	11									
29.0	531.4	18 50 10	12	12A 12B			Very dense brown GRAVEL WITH SAND AND SILT (A-2-4),	31	28	--	12	21	8
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

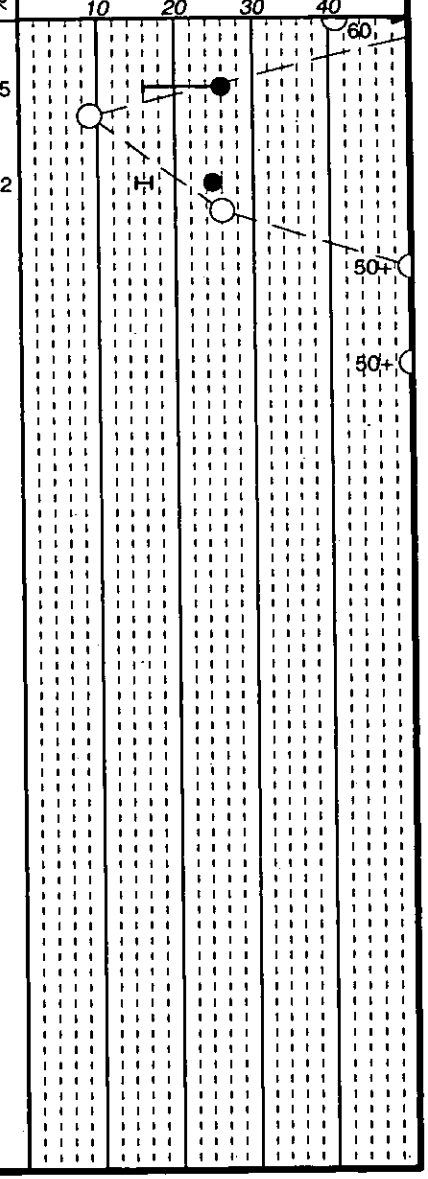
Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1142 | Location: Sta. 894+83.0, 33.3 ft. LT of SR 823 CL | Date Drilled: 9/21/05 to 9/22/05

WATER OBSERVATIONS: Water seepage at: 28.0'
Water level at completion: 23.3' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
30.0	530.4						trace clay; moist.						
		5 4 5	18	13			Loose to medium dense gray SANDY SILT (A-4a), little clay, trace gravel; wet.	0	1	--	37	47	15
34.5	525.9	3 2 24	18	14A 14B			Severely weathered black SHALE, carbonaceous.	1	1	--	42	44	12
		50/4	4	15									
		50/2	2	16									
43.5	516.9						Medium hard black SHALE; moderately to highly weathered, carbonaceous, medium bedded, moderately fractured. @ 43.6'-44.0', high angle fracture.						
45.1	515.3	Core 60"	Rec 60"	RQD 75%	R1		Very hard gray SANDSTONE; very fine to fine grained, moderately to highly weathered, argillaceous, medium bedded, slightly fractured to unfractured. @ 48.0'-48.5', multiple fractures. @ 48.0', moderate siltstone and sandstone laminae.						
48.5	511.9						Bottom of Boring - 48.5'						

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ├──┤ LL
Blows per foot - ○



FILE: 0121-3070-03 [11/6/2007 3:38 PM]

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Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1143 | Location: Sta. 893+80.3, 3.7 ft. RT of SR 823 CL | Date Drilled: 10/13/05

WATER OBSERVATIONS: Water seepage at: 23.5'-26.3'
Water level at completion: None (prior to coring)
3.5' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N)
0.2	563.2 / 563.0						Topsoil - 2"							Natural Moisture Content, % - ● PL ⊢—⊣ LL; Blows per foot - ○ 10 20 30 40
		7 10 11	18	1		--	FILL: Very stiff to hard brown SILT AND CLAY (A-6a), trace fine to coarse sand, trace gravel; damp.							
		4 5 3	14	2		4.5+								
5		5 6 6	18	3		3.0								
		4 5 9	9	4		3.0								
10														
10.5	552.7	5 5 6	8	5			POSSIBLE FILL: Loose to medium dense brown GRAVEL WITH SAND (A-1-b), trace to little silt, trace to little clay; dry to damp.	21	44	--	19	16		● Non-Plastic
		4 5 5	9	6										
15		3 4 7	10	7										
		4 6 8	14	8										
20		3 4 5	18	9										
		3 2 3	3	10			@ 23.5', wet.							
25														
		25 50/4	8	11A 11B										50+
27.0	536.2						Soft greenish gray SHALE; decomposed, micaceous, thinly laminated, highly fractured. @ 28.8'-29.3', loss of recovery from washed out clay.							
30														

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

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Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1143 | Location: Sta. 893+80.3, 3.7 ft. RT of SR 823 CL | Date Drilled: 10/13/05

WATER OBSERVATIONS: Water seepage at: 23.5'-26.3'
Water level at completion: None (prior to coring)
3.5' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) / Natural Moisture Content, % - ● / PL ⊢—⊣ LL / Blows per foot - ○ (10 20 30 40)
30	533.2													
30.5	532.7	Core 120"	Rec 120"	RQD 81%	R1		@ 29.3'-29.4', 29.6'-29.7', high angle fractures. Medium hard black SHALE; moderately weathered, carbonaceous, thinly laminated, moderately fractured. @ 30.5', 31.2', 31.7', 33.6', 34.7', 35.3', 36.7', low angle fractures.							
35														
37.0	526.2						Bottom of Boring - 37.0'							
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

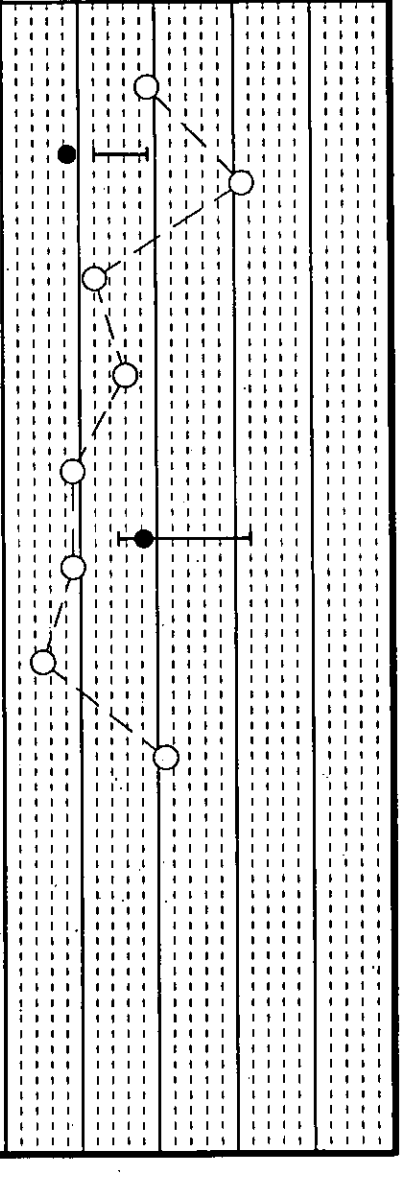
Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1144 | Location: Sta. 892+85.3, 25.8 ft. RT of SR 823 CL | Date Drilled: 9/22/05

WATER OBSERVATIONS: Water seepage at: 16.0'
Water level at completion: Not Reported (used mud rotary)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
	564.9												
		5 8 11	6	1			FILL: Medium dense gray and brown SANDY SILT (A-4a), little clay, little gravel; contains organic material; dry to damp.						
3.0	562.2												
03.0	562.2	12 14 17	12	2		--	Stiff to very stiff reddish brown SANDY SILT (A-4a), little clay, trace gravel; damp to moist. Topsoil - 3"	4	14	--	32	30	20
5							@ 5.0', began using mud rotary to advance hole.						
		9 11 1	13	3		--							
		6 7 9	14	4		--							
10													
		5 4 5	12	5		--							
13.0	552.2												
		3 4 5	8	6			Loose to medium dense brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6), little clay; moist to wet.	13	31	--	30	9	17
15													
		2 3 2	14	7									
		1 1 20	8	8									
20													
21.0	544.2												
		Core 60"	Rec 45"	RQD 14%	R1		Soft to medium hard gray SHALE interbedded with SANDSTONE; very fine grained, highly weathered to decomposed, thinly laminated to thinly bedded, moderately fractured. @ 21.0'-21.1', chert layer.						
25													
26.0	539.2						Bottom of Boring - 26.0'						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1145 | Location: Sta. 891+50.3, 32.7 ft. LT of SR 823 CL | Date Drilled: 10/13/05

WATER OBSERVATIONS: Water seepage at: 10.5'-13.0'
Water level at completion: None (prior to coring)
3.5' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	567.3												
0.2	567.1						Topsoil - 2"						
		5 7 8	18	1		4.5+	Very stiff to hard brown SILTY CLAY (A-6b), trace fine to coarse sand, trace gravel; moist.						
		9 13 16	18	2		4.0		0	1	--	2	58	39
5		3 5 9	18	3		2.0							
		4 7 9	18	4		2.5	@ 8.5', some fine to coarse sand.						
10													
10.5	556.8	4 3 7	18	5			Medium dense dark brown GRAVEL WITH SAND (A-1-b), trace clay, trace silt; moist to wet.	4	47	--	33	16	
		8 50/4	10	6									
14.5	552.8						Soft gray SHALE; highly weathered, micaceous, medium bedded, highly fractured.						
15							@ 14.5', 14.7', 15.6', 16.1', 16.5', 17.1', 17.2', 18.0', low angle fractures.						
							@ 14.9'-15.2', loss of recovery.						
19.0	548.3	Core 120"	Rec 116"	RQD 87%	R1		Medium hard gray SANDSTONE; very fine grained, moderately weathered, argillaceous, micaceous, laminated to thinly bedded, moderately fractured, contains abundant argillaceous laminations.						
20							@ 21.2', 21.3', 21.7', 22.2', low angle fractures.						
24.5	542.8						Bottom of Boring - 24.5'						
25													
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic

50+

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1146 | Location: Sta. 891+40.7, 12.2 ft. RT of SR 823 CL | Date Drilled: 10/13/05

WATER OBSERVATIONS: Water seepage at: 10.5'-13.0'
Water level at completion: None (prior to coring)
3.3' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
	567.7												
0.2	567.5						Topsoil - 2"						
		6 7 9	18	1		4.5+	Very stiff to hard brown SILT AND CLAY (A-6a), trace fine to coarse sand, trace gravel; damp to moist.	0	3	--	5	50	42
		7 12 17	18	2		4.5+							
5		2 6 8	18	3		3.0							
		5 8 8	18	4		1.75	@ 8.5', stiff, contains sand seam.						
10													
10.5	557.2						Medium dense dark brown GRAVEL WITH SAND (A-1-b), trace clay, trace silt; moist.	30	29	--	25	16	
		2 4 6	14	5									
13.0	554.7						Severely weathered gray SHALE.						
		35 50/2	8	6									
14.5	553.2						Soft brownish gray SHALE; highly weathered to decomposed, micaceous, medium bedded, highly fractured, many broken areas from low angle fractures. @ 14.8'-14.9', high angle fracture.						
15													
19.0	548.7	Core 120"	Rec 120"	RQD 77%	R1		Medium hard gray SANDSTONE; very fine grained, moderately to highly weathered, micaceous, laminated to thinly bedded, moderately fractured, contains abundant argillaceous laminations. @ 21.3', 22.4', low angle fractures.						
20													
24.5	543.2						Bottom of Boring - 24.5'						
25													
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic

50+

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1147 | Location: Sta. 4913+98.9, 1.2 ft. RT of US 23 Ramp D BL | Date Drilled: 7/27/05

WATER OBSERVATIONS: Water seepage at: 9.0'-16.0', 25.0'-26.0'
Water level at completion: 9.0' (prior to coring)
7.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	529.7												
0.4	529.3						Topsoil - 5"						
		7 6 7	13	1		4.5+	FILL: Hard brown SANDY SILT (A-4a), little clay, trace gravel; damp.						
		4 2 2	9	2		4.5+							
5													
5.5	524.2	2 2 3	10	3			Loose to medium dense brown GRAVEL WITH SAND AND SILT (A-2-4), some clay; moist to wet.						
		3 4 4	12	4									
10													
		4 8 7	13	5									
13.0	516.7						Loose brown COARSE AND FINE SAND (A-3a), little clay, little gravel; wet.						
		3 3 2	13	6									
15													
15.5	514.2						Stiff to very stiff brown SILTY CLAY (A-6b), little gravel, trace fine to coarse sand; moist.						
		3 5 6	15	7		1.5							
		3 5 5	12	8		2.5							
20													
20.5	509.2						Very stiff gray SILT (A-4b), little fine to coarse sand, trace clay; moist.						
		1 2 4	11	9		2.5							
23.0	506.7						Loose gray COARSE AND FINE SAND (A-3a), little gravel, trace clay; wet.						
		1 2 5	13	10									
25													
25.5	504.2	25 50/2	10	11			Dense gray GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); contains sandstone fragments; moist.						
28.0	501.7						Hard gray SANDSTONE; fine grained, moderately to highly weathered, argillaceous, micaceous, massive, highly fractured.						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40
50+

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1147 | Location: Sta. 4913+98.9, 1.2 ft. RT of US 23 Ramp D BL | Date Drilled: 7/27/05

WATER OBSERVATIONS: Water seepage at: 9.0'-16.0', 25.0'-26.0'
Water level at completion: 9.0' (prior to coring)
7.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
30	499.7	Core 60"	Rec 52"	RQD 43%	R1		Hard gray SANDSTONE; fine grained, moderately to highly weathered, argillaceous, micaceous, massive, highly fractured. @ 28.0'-28.6', lost recovery. @ 29.6'-29.9', 31.5'-31.9', broken, decomposed.						
33.0	496.7						Bottom of Boring - 33.0'						

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

35 40 45 50 55 60

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1148 | Location: Sta. 4918+00.2, 1.5 ft. RT of US 23 Ramp D BL | Date Drilled: 7/20/05

WATER OBSERVATIONS: Water seepage at: 11.0'-14.0'
Water level at completion: 11.0' (prior to coring)
9.0' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	530.2												
0.3	529.9						Topsoil - 4"						
		2 3 5	12	1		3.0	FILL: Very stiff grayish brown SANDY SILT (A-4a), little clay, trace gravel; slightly organic; damp.						
3.0	527.2												
		2 3 4	8	2		2.5	Very stiff brown SILT AND CLAY (A-6a), trace fine to coarse sand, trace gravel; contains one large rock; damp to moist.						
5													
5.5	524.7												
		2 4 4	11	3		2.5	Stiff to very stiff brown SILTY CLAY (A-6b), trace fine to coarse sand; moist to wet.						
		3 2 2	14	4		1.25							
10													
10.5	519.7												
		WOH 1 1	11	5		0.5	Very soft to soft brown SANDY SILT (A-4a), little clay; contains sand seams; wet.						
13.0	517.2												
		WOH WOH 1	13	6			Very loose to medium dense brown GRAVEL WITH SAND (A-1-b), trace clay; wet.						
15													
		3 10 11	17	7									
		5 15 50/4	10	8									
20.0	510.2												
		Core 60"	Rec 60"	RQD 60%	R1		Medium hard to hard gray SANDSTONE; very fine to fine grained, moderately to highly weathered, argillaceous, micaceous, thinly bedded to medium bedded, highly fractured. @ 22.0'-24.0', broken, decomposed zones.						
25.0	505.2						Bottom of Boring - 25.0'						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40
50+

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

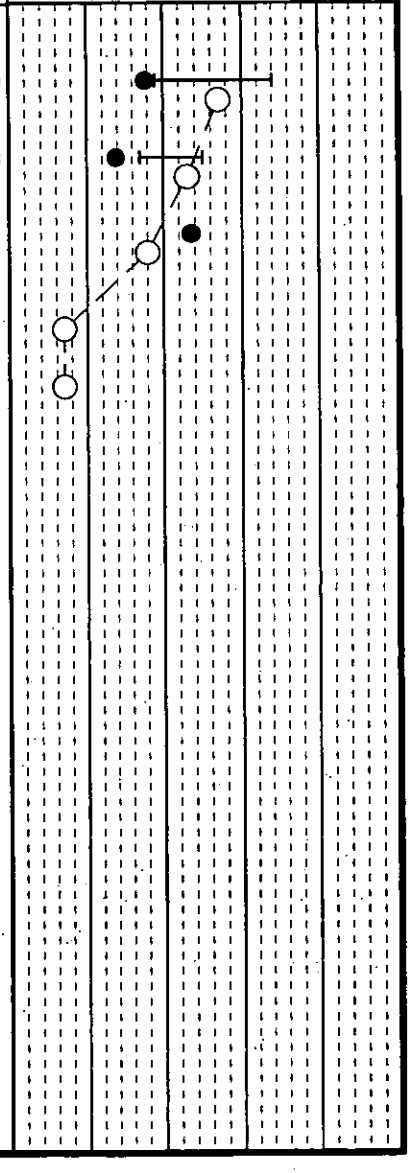
LOG OF: Boring B-1149 | Location: Sta. 4921+98.8, 3.0 ft. LT of US 23 Ramp D BL | Date Drilled: 7/13/05

WATER OBSERVATIONS: Water seepage at: None; Water level at completion: None

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	540.4												
0.9	539.5						Asphalt - 7" Aggregate Base - 4"						
		10 17 10 13	21	1		4.5+	Hard brown SILT AND CLAY (A-6a), trace gravel, trace fine to coarse sand; damp.	1	4	--	5	50	40
3.0	537.4	6 10 13 12	20	2		2.5	Very stiff brown SANDY SILT (A-4a), some clay, little gravel; damp.	20	12	--	11	34	23
5		17 10 8 10	23	3		2.25							
7.0	533.4	3 3 4	15	4		4.0	Very stiff brown SILT AND CLAY (A-6a), trace fine to coarse sand; moist.						
		3 4 3	17	5		2.5							
10.0	530.4						Bottom of Boring - 10.0'						
15													
20													
25													
30													

GRADATION

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

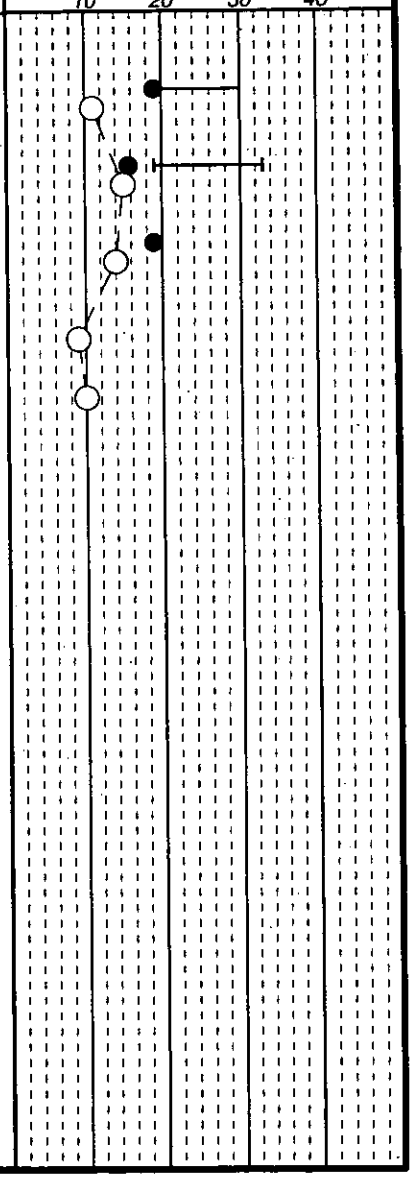
LOG OF: Boring B-1150 | Location: Sta. 4926+81.3, 0.6 ft. RT of US 23 Ramp D BL | Date Drilled: 7/13/05

WATER OBSERVATIONS: Water seepage at: None
Water level at completion: None

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	540.8												
0.9	539.9	6 5 6 6	22	1		4.0	Asphalt - 6" Aggregate Base - 5" Very stiff to hard dark gray SANDY SILT (A-4a), some clay, trace gravel; organic; damp.	7	6	--	8	48	31
3.0	537.8	3 6 9 9	22	2		4.5+	Very stiff to hard brown and gray SILT AND CLAY (A-6a), trace fine to coarse sand, trace gravel; damp. @ 3.0'-5.0', slightly organic.	0	2	--	5	57	36
5		8 7 7 8	24	3		2.5							
		3 4 5	18	4		4.0							
		4 5 5	17	5		3.5							
10.0	530.8						Bottom of Boring - 10.0'						
15													
20													
25													
30													

GRADATION

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1151 | Location: Sta. 4929+67.2, 3.5 ft. LT of US 23 Ramp D BL | Date Drilled: 7/27/05

WATER OBSERVATIONS: Water seepage at: Not Reported; Water level at completion: Not Reported

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	541.1						Asphalt - 4" Aggregate Base - 8"						
1.0	540.1	18 11 4 5	13	1			Medium dense gray COARSE AND FINE SAND (A-3a), little clay, little gravel; damp.	18	23	--	32	16	11
3.0	538.1	3 5 8 5	15	2		3.0	Very stiff to hard brown and gray SILTY CLAY (A-6b), little fine to coarse sand, trace gravel; damp.	4	5	--	7	42	42
5		7 6 6 7	12	3		4.5+							
		5 9 8 8	16	4		--							
10.0	531.1						Bottom of Boring - 10.0'						

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1152 | Location: Sta. 3893+96.5, 23.1 ft. LT of US 23 Ramp C BL | Date Drilled: 10/18/2005 to 10/19/2005

WATER OBSERVATIONS: Water seepage at: 15.5'-20.5'
Water level at completion: 21.6' (prior to coring)
13.9' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	563.0												
0.3	562.7						Topsoil - 3"						
		8 12 18	18	1		4.5+	FILL: Very stiff to hard brownish gray SILTY CLAY (A-6b), trace fine to coarse sand, trace gravel; damp.						
		6 7 9	18	2		4.0							
5													
5.5	557.5						POSSIBLE FILL: Medium dense brown GRAVEL WITH SAND (A-1-b), trace clay; dry to damp.						
		6 8 8	10	3									
		8 9 8	18	4				32	43	--	19	6	
10													
		7 12 12	11	5									
		8 7 8	14	6									
15													
15.5	547.5						Medium dense brown GRAVEL WITH SAND AND SILT (A-2-4), trace clay; moist.						
		5 4 5	16	7									
		6 8 11	18	8									
20													
21.0	542.0	27 50/3	9	9			Severely weathered gray SHALE.						
22.0	541.0						Very soft to medium hard gray SHALE interbedded with SANDSTONE; very fine to fine grained, highly weathered to decomposed, micaceous, thinly laminated to medium bedded, highly fractured to broken.						
25		Core 120"	Rec 120"	RQD 50%	R1								
30							@ 29.3'-32.9', light gray.						

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic

50+

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring B-1152 | Location: Sta. 3893+96.5, 23.1 ft. LT of US 23 Ramp C BL | Date Drilled: 10/18/2005 to 10/19/2005

WATER OBSERVATIONS: Water seepage at: 15.5'-20.5'
Water level at completion: 21.6' (prior to coring)
13.9' (inside hollowstem augers)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
30.0	533.0						Very soft to medium hard gray SHALE; highly weathered to decomposed, micaceous, medium bedded, broken. @ 30.5'-32.9', calcareous. @ 32.0'-32.7', lost recovery.						
32.9	530.1	Core 60"	Rec 52"	RQD 82%	R2		Medium hard black SHALE; highly weathered, carbonaceous, laminated, moderately fractured. @ 35.6', low angle fracture.						
37.0	526.0						Bottom of Boring - 37.0'						

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:38 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring C-120 | Location: Sta. 609+46.0, 74.4 ft. LT of US 23 CL | Date Drilled: 08/01/07

WATER OBSERVATIONS: Water seepage at: 18.5'-27.0'
Water level at completion: 18.2' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	536.1												
0.3	535.8						Topsoil - 4"						
		10 11 11	16	1		4.5+	Hard brown SILTY CLAY (A-6b), little silt, trace fine to coarse sand; damp.						
3.0	533.1												
		2 3 4	14	2		1.0	Stiff to very stiff mottled brown and gray SILT AND CLAY (A-6a), trace to little fine to coarse sand, trace gravel; moist.	1	6	--	7	53	34
5		2 2 3	15	3	ST1	1.5							
		3 4 5	18	4		1.75		0	0	--	1	58	41
10		3 4 6	18	5	ST2	2.5							
		3 4 6	18	6		1.5		1	2	--	3	60	34
15													
15.5	520.6				ST3		Loose to medium dense brown GRAVEL WITH SAND (A-1-b), trace silty clay; moist.						
		2 2 2	16	7									
		2 2 4	11	8			@ 18.5', becomes wet.	40	41	--	10	9	
20							@ 20.0', added water to reduce sand heave.						
		2 4 12	12	9									
		7 7 7	12	10									
25													
		6 20 50/3	15	11A 11B									
27.0	509.1												
27.5	508.6						Severely weathered brown SANDSTONE.						
		Core 60"	Rec 60"	RQD 61%	R-1		Medium hard gray SANDSTONE; very fine to fine grained. @ 27.8'-28.0',28.5'-28.7', high angle fractures.						
30													

GRADATION

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic

50+

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring C-120 | Location: Sta. 609+46.0, 74.4 ft. LT of US 23 CL | Date Drilled: 08/01/07

WATER OBSERVATIONS: Water seepage at: 18.5'-27.0'
Water level at completion: 18.2' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
30	506.1						Medium hard gray SANDSTONE; very fine to fine grained, slightly weathered, argillaceous, micaceous, thinly bedded, moderately fractured, with typical low angle clay-filled fractures.							
32.5	503.6						Bottom of Boring - 32.5'							
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring C-121 | Location: Sta. 609+50.3, 73.7 ft. RT of US 23 CL | Date Drilled: 07/30/07

WATER OBSERVATIONS: Water seepage at: 6.0'-14.0'
Water level at completion: 12.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	537.7												
0.5	537.2						Topsoil - 6"						
		4 4 5	14	1		4.5+	Hard brown SILT (A-4b), little to some clay, little fine to coarse sand, trace gravel; damp to moist.						
		3 3 2	18	2		1.0	@ 3.5'-7.5', medium stiff to stiff, mottled brown and gray.	1	7	--	11	55	26
5		1 3 4	18	3	ST1	1.0							
8.0	529.7				ST2								
		WOH 2 1	18	4			Very loose brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); moist.	21	23	--	26	11	19
10													
10.5	527.2	WOH 1 1	18	5			Very loose brown and gray GRAVEL WITH SAND (A-1-b), little silt; wet. @ 12.5', added water to reduce sand heave.	22	46	--	16	16	
14.5	523.2	4 39 31	12	6A 6B			Severely weathered brown SANDSTONE; very fine to fine grained, argillaceous, micaceous.						
15													
16.0	521.7	7 4 7	10	7			Severely weathered brown and gray SHALE; micaceous. @ 18.5'-20.0', dark gray, carbonaceous.						
20		3 4 7	12	8									
21.3	516.4	50/3		9									
21.6	516.1						Medium hard dark gray SHALE; moderately weathered, carbonaceous, thinly laminated, slightly fractured.						
		Core 60"	Rec 60"	RQD 64%	R-1		Medium hard gray SANDSTONE; moderately weathered, argillaceous, pyritic, thinly bedded, moderately fractured, with typical low angle fractures.						
25													
26.3	511.4						Bottom of Boring - 26.3'						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic

70

50+

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring C-123 | Location: Sta. 619+33.7, 102.7 ft. LT of US 23 CL | Date Drilled: 08/01/07

WATER OBSERVATIONS: Water seepage at: 11.0'-19.5'
Water level at completion: 8.9' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	529.7												
0.3	529.4						Topsoil - 4"						
		1 2 4	13	1		1.0	Stiff brown SILT (A-4b), little clay; damp.						
3.0	526.7												
		2 2 4	15	2		1.5	Stiff brown CLAY (A-7-6), trace fine to coarse sand; moist.	0	2	--	5	46	47
5													
		3 2 3	17	3	ST1	1.5							
8.0	521.7												
		3 3 2	12	4	ST2	0.5	Soft to medium stiff brown and gray SILT AND CLAY (A-6a), trace to little fine to coarse sand; moist.	0	0	--	10	63	27
10													
10.5	519.2						Very loose to loose brown and gray GRAVEL WITH SAND (A-1-b), trace silt; wet.						
		WOH 1 1	18	5									
		WOH 1 1	16	6				24	61	--	9	6	Non-Plastic
15													
		3 3 4	18	7									
19.5	510.2	10 21 26	16	8A 8B			Severely weathered brown SANDSTONE interbedded with SHALE; very fine to fine grained, argillaceous, micaceous.						
20													
		14 33 50/3	10	9									
22.5	507.2						Medium hard gray SANDSTONE; very fine to fine grained, slightly weathered, argillaceous, micaceous, thinly bedded, moderately fractured, with typical low angle fractures. @ 25.6'-26.0',26.6'-27.0', broken zones.						
		Core 60"	Rec 55"	RQD 45%	R-1								
25													
27.5	502.2						Bottom of Boring - 27.5'						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

50+

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-46 | Location: Sta. 3900+40.8, 47.7 ft. RT of US 23 Ramp C BL | Date Drilled: 03/17/05

WATER OBSERVATIONS: Water seepage at: 13.5'-19.0'
Water level at completion: 16.0' (prior to coring)
5.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0.1	543.0						Topsoil - 1"						
		2 1 1	2	1			FILL: Very loose brown and black GRAVEL WITH SAND (A-1-b), some silty clay; contains roots; damp. @ 1.0'-2.5', organic odor.						
		2 2 2	4	2				44	19	--	13	16	8
5													
5.5	537.6												
		3 3 3	18	3		2.0	Stiff to very stiff brown SILT AND CLAY (A-6a), little fine to coarse gravel, trace fine to coarse sand; damp to moist.						
8.5	534.6												
		2 6 6	12	4			Medium dense brown and gray GRAVEL WITH SAND (A-1-b), little silty clay; moist.						
10													
		2 11 7	11	5				56	15	--	9	16	4
13.5	529.6												
		3 4 3	8	6			Loose brown GRAVEL WITH SAND (A-1-b), some silt, trace clay; wet.						
15													
		5 4 4	12	7			@ 18.0', heaving sand.	33	31	--	13	20	3
19.0	524.1												
		16 15 20	14	8			Dense light brown GRAVEL WITH SAND AND SILT (A-2-4), trace to little clay; moist to wet.						
20													
		14 19 20	8	9			@ 23.0', gray.						
		5 5 12	14	10				30	11	--	24	25	10
25													
25.5	517.6												
		50/3	3	11			Severely weathered gray SANDSTONE, argillaceous, micaceous.						
27.0	516.1						Hard gray SANDSTONE; very fine to fine grained, slightly weathered, argillaceous, micaceous, thickly bedded to massive, slightly fractured.						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic
Non-Plastic
50+

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-46 | Location: Sta. 3900+40.8, 47.7 ft. RT of US 23 Ramp C BL | Date Drilled: 03/17/05

WATER OBSERVATIONS: Water seepage at: 13.5'-19.0'
Water level at completion: 16.0' (prior to coring)
5.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
30	513.1	Core 120"	Rec 118"	RQD 83%	R1		Hard gray SANDSTONE; very fine to fine grained, slightly weathered, argillaceous, micaceous, thickly bedded to massive, slightly fractured. @ 29.4',31.4',35.9', very thin clay seams. @ 29.8',30.8', thin clay seams. @ 31.6'-32.0', broken zone with clay and rock fragments. @ 33.4'-33.7', clay seam. @ 33.7'-34.2', cross bedded.							
35														
37.0	506.1						Bottom of Boring - 37.0'							
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-47 | Location: Sta. 3898+88.1, 20.9 ft. RT of US 23 Ramp C BL | Date Drilled: 03/17/05

WATER OBSERVATIONS: Water seepage at: 13.0'-18.0'
Water level at completion: 18.0' (prior to coring)
9.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
543.1													
0.1	543.0						Topsoil - 1"						
		1 2 4	10	1		1.5	Stiff to very stiff brown and gray CLAY (A-7-6), trace fine sand; damp to moist. @ 1.0'-2.5', slightly organic.						
		2 4 5	13	2		2.5							
5													
		4 6 10	15	3		4.5	@ 6.0'-7.5', hard.	0	0	--	2	48	50
8.0	535.1												
		1 3 2	10	4		0.5	Medium stiff brown SANDY SILT (A-4a), trace gravel, trace clay; moist to wet.						
10													
		2 2 2	7	5		--							
13.0	530.1												
		W O H	18	6			Very loose brown COARSE AND FINE SAND (A-3a), little silty clay; wet.	0	2	--	83	15	Non-Plastic
15													
		WOH WOH 1	18	7									
18.0	525.1												
		11 14 12	10	8		1.5	Stiff brown GRAVEL WITH SAND AND SILT (A-2-4), little clay; moist.	30	11	--	24	22	13
20													
21.0	522.1												
		42 34 17	12	9		--	Very stiff to hard dark gray SANDY SILT (A-4a), little clay, little gravel; damp to moist.	15	9	--	35	26	15
23.0	520.1												
		4 10 21	11	10			Severely weathered black SHALE, carbonaceous.	29	23	--	31	12	5
25													
26.5	516.6	50/4	4	11			Hard gray SANDSTONE; very fine to fine grained, slightly weathered, argillaceous, micaceous, massive, slightly fractured. @ 26.7'-28.4', healed vertical fracture.						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

51
Non-Plastic
50+

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-47 | Location: Sta. 3898+88.1, 20.9 ft. RT of US 23 Ramp C BL | Date Drilled: 03/17/05

WATER OBSERVATIONS: Water seepage at: 13.0'-18.0'
Water level at completion: 18.0' (prior to coring)
9.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
30	513.1	Core 120"	Rec 120"	RQD 74%	R1		Hard gray SANDSTONE; very fine to fine grained, slightly weathered, argillaceous, micaceous, massive, slightly fractured. @ 30.0'-30.2', healed vertical fracture. @ 30.2'-32.4', 34.7'-35.4', high angle bedding. @ 31.8'-32.4, broken zone with thin clay seam. @ 33.1'-33.6', low angle healed fracture. @ 33.1'-33.6', high angle healed fracture. @ 33.7', highly weathered fracture. @ 33.7'-34.0', very argillaceous.						
36.5	506.6						Bottom of Boring - 36.5'						
40													
45													
50													
55													
60													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-48 | Location: Sta. 3897+72.5, 52.7 ft. RT of US 23 Ramp C BL | Date Drilled: 3/21/05

WATER OBSERVATIONS: Water seepage at: 16.0'-18.0'
Water level at completion: 8.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	546.3						No Topsoil						
		2 2 3	14	1			FILL: Loose black GRAVEL WITH SAND (A-1-b); contains mostly coal fragments and cinders; damp.						
3.0	543.3												
		W O H	1	2			FILL: Very loose gray and black SILT AND CLAY (A-6a), little fine to coarse sand; contains roots, coal and cinder fragments; damp.						
5													
5.5	540.8						Very stiff brown SILT (A-4b), some clay, trace fine sand; moist.						
		WOH 2 3	16	3		2.5							
8.0	538.3						Very stiff brown and gray CLAY (A-7-6), trace fine sand; damp to moist.						
		2 5 7	17	4		3.5		0	0	--	2	43	55
10													
		2 5 6	15	5		3.5							
13.0	533.3						Very loose brown GRAVEL WITH SAND (A-1-b), little silt, trace clay; moist to wet.						
		1 2 2	5	6									
15													
		1 1 1	8	7				37	27	--	17	19	
							@ 18.5', medium dense; moist.	52	14	--	15	12	7
		6 6 7	10	8									
20							@ 21.0', dense, trace gravel, trace clay.						
		2 7 30	15	9									
23.5	522.8						Severely weathered black SHALE.						
		20 15 50	12	10									
25.0	521.3						Soft to medium hard black SHALE; carbonaceous, slightly weathered, very thinly bedded, highly fractured.						
							@ 25.3'-25.6', 26.0'-26.4', broken.						
							@ 27.1'-27.2', sandstone seam.						
30		Core 120"	Rec 120"	RQD 97%	R1								

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic
Non-Plastic
65

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-48 | Location: Sta. 3897+72.5, 52.7 ft. RT of US 23 Ramp C BL | Date Drilled: 3/21/05

WATER OBSERVATIONS: Water seepage at: 16.0'-18.0'
Water level at completion: 8.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢——⊣ LL Blows per foot - ○ 10 20 30 40
	516.3													
30.0	516.3						Hard gray SANDSTONE; very fine to fine grained, argillaceous, micaceous, slightly weathered, massive, slightly fractured .							
35.0	511.3						Bottom of Boring - 35.0'							
40														
45														
50														
55														
60														

FILE: 0121-3070-03 (11/6/2007 3:40 PM)

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

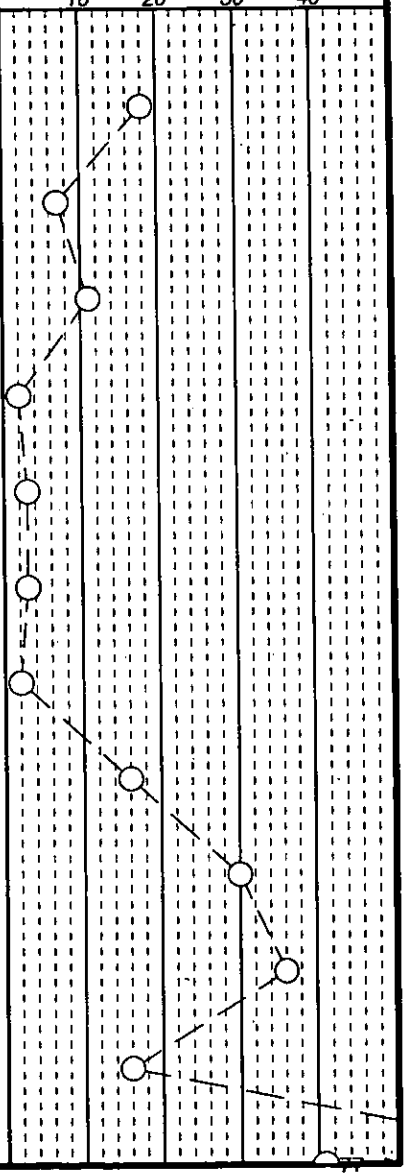
Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-49 | Location: Sta. 898+89.3, 21.2 ft RT of SR 823 CL | Date Drilled: 7/7/04

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION
0	539.8						WATER OBSERVATIONS: Water seepage at: 19.0' Water level at completion: 22.0' (includes drilling water)
0.3	539.5						Aggregate - 3"
		8 9 9	15	1		4.5+	Stiff to very stiff brown SILT AND CLAY (A-6a), little fine to coarse sand, little to some gravel; damp. @ 0.3'-2.5', hard. @ 3.5'-7.5', contains rock fragments.
		3 3 4	16	2		1.75	
5		3 6 5	15	3		3.0	
		1 1 1	18	4		1.75	
10		1 1 2	15	5		2.25	
13.5	526.3	1 1 2	16	6			Very loose brown SANDY SILT (A-4a), some clay; moist.
15							
16.0	523.8	1 1 1	18	7		0.5	Soft to medium stiff brown SILT AND CLAY (A-6a), little fine to coarse sand; moist.
18.5	521.3	6 6 10	13	8			Medium dense to dense brown GRAVEL WITH SAND (A-1-b), some fine to coarse sand, little to some silty clay; wet.
20		4 9 21	14	9			
		13 18 18	17	10			
25		5 9 7	13	11			
28.5	511.3	4 27 50/3	11	12			Severely weathered gray SANDSTONE fragments.
30							

GRADATION: % Aggregate | % C. Sand | % M. Sand | % F. Sand | % Silt | % Clay

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-49 | Location: Sta. 898+89.3, 21.2 ft RT of SR 823 CL | Date Drilled: 7/7/04

WATER OBSERVATIONS: Water seepage at: 19.0'
Water level at completion: 22.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
30	509.8						Severely weathered gray SANDSTONE fragments.						
32.0	507.8						Hard gray SANDSTONE; very fine to fine grained, slightly weathered, argillaceous, micaceous, massive, slightly fractured.						
35		Core 120"	Rec 110"	RQD 70%	R-1		@ 35.4'-35.9', probable core loss.						
40							@ 37.6'-37.8',38.5',38.9'- 39.2',39.4'-39.5',40.4'- 40.7', decomposed argillaceous bands with fractures.						
42.0	497.8						Bottom of Boring - 42.0'						
45													
50													
55													
60													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-49A | Location: Sta. 899+54.2, 10.9 ft. RT of SR 823 CL | Date Drilled: 3/21/05

WATER OBSERVATIONS: Water seepage at: 18.0'-28.0'
Water level at completion: 14.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	538.1						No Topsoil						
		4 5 7	17	1		4.5+	Hard brown SANDY SILT (A-4a), some clay, some gravel; contains sandstone fragments; damp.						
		3 4 4	16	2		4.0							
5		3 5 5	16	3		1.5	@ 6.0', stiff, moist.						
		2 2 3	17	4		1.0							
10		3 4 5	18	5		1.5	@ 11.0', little gravel.	23	16	--	9	30	22
13.0	525.1												
		WOH 2 2	18	6		<0.25	Very soft brown SILT AND CLAY (A-6a), trace to little fine to coarse sand; wet.	0	5	--	16	54	25
15		1 2 3	18	7		<0.25		0	0	--	1	67	32
18.0	520.1												
		W O H	3	8			Loose to medium dense brown GRAVEL (A-1-a), some to "and" fine to coarse sand, little clay; wet. @ 18.5'-20.0', very loose.						
20		5 9 18	12	9				62	16	--	8	14	
		2 2 6	18	10									
25		6 5 8	13	11									
		10 43 50/4	16	12			@ 28.5'-30.0', very dense.						
30													

GRADATION

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40 50+

Non-Plastic

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-49A | Location: Sta. 899+54.2, 10.9 ft. RT of SR 823 CL | Date Drilled: 3/21/05

WATER OBSERVATIONS: Water seepage at: 18.0'-28.0'
Water level at completion: 14.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL — LL Blows per foot - ○ 10 20 30 40 50+
	508.1													
30.0	508.1						Severely weathered gray SANDSTONE							
		50/2	1	13										
35.0	503.1						Medium hard to hard gray SANDSTONE; very fine to fine grained, slightly to moderately weathered, argillaceous, micaceous, massive, highly fractured to broken.							
40		Core 120"	Rec 84"	RQD 13%	R1									
45.0	493.1						Bottom of Boring - 45.0'							
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-50 | Location: Sta. 897+47.1, 23.7 ft. LT of SR 823 CL | Date Drilled: 7/7/04

WATER OBSERVATIONS: Water seepage at: 13.5', 16.0'
Water level at completion: 14.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	540.5												
0.3	540.2						Topsoil - 3"						
		3 3 4	16	1		4.5+	Very stiff to hard brown SILT AND CLAY (A-6a), little fine to coarse sand, trace gravel; damp to moist.						
		1 2 3	14	2		2.0							
5		2 3 3	13	3		3.25							
		2 3 3	16	4		2.5							
10		2 3 4	13	5		2.75							
		W O H	6	6		1.0	@ 13.5'-17.2', stiff, contains interbedded sand seams.						
15		6 7 31	16	7a		1.0							
17.2	523.3			7b		1.25	Severely weathered brown and gray SANDSTONE fragments.						
		10 15 32	4	8									
20													
21.0	519.5	Core 42"	Rec 19"	RQD 0%	R-1		Soft to medium hard gray SANDSTONE; decomposed, argillaceous, broken. @ 24.4'-24.5', dark gray carbonaceous shale.						
25.2	515.3	Core 78"	Rec 70"	RQD 53%	R-2		Hard gray SANDSTONE; very fine to fine grained, micaceous, argillaceous, massive, slightly to highly fractured. @ 25.3'-25.7', 25.8'-25.9', 27.5'-27.8', 30.3'-30.3', high angle fractures. @ 26.1',28.3',29.6', thin clay seams.						
30													

GRADATION

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-50 | Location: Sta. 897+47.1, 23.7 ft. LT of SR 823 CL | Date Drilled: 7/7/04

WATER OBSERVATIONS: Water seepage at: 13.5', 16.0'
Water level at completion: 14.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢⊣ LL Blows per foot - ○ 10 20 30 40
30	510.5						Hard gray SANDSTONE; very fine to fine grained, micaceous, argillaceous, massive, slightly to highly fractured.							
		Core 42"	Rec 42"	RQD 100%	R-3									
34.5	506.0						Bottom of Boring - 34.5'							
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-50A | Location: Sta. 898+09.3, 34.1 ft. LT of SR 823 CL | Date Drilled: 3/22/05

WATER OBSERVATIONS: Water seepage at: 18.0'-25.0'
Water level at completion: 18.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) / Natural Moisture Content, % / Blows per foot
0.0	539.3													
0.1	539.2						Topsoil - 1"							
		3 2 3	10	1			FILL: Loose dark brown SANDY SILT (A-4a), trace gravel; contains roots; damp.							
3.0	536.3													
		2 1 2	8	2		1.0	Stiff brown SILT AND CLAY (A-6a), trace to little fine to coarse sand, trace gravel; moist.							
5														
		2 3 3	13	3		2.0								
		1 2 3	16	4		1.5		1	4	--	6	56	33	
10														
10.5	528.8													
		1 2 3	18	5		1.25	Stiff brown SILTY CLAY (A-6b), some gravel, some fine to coarse sand; moist.	32	20	--	12	18	18	
		WOH 2 3	18	6		1.5								
15														
		1 1 2	18	7		1.25								
18.0	521.3													
		WOH 1 3	16	8			Very loose brown GRAVEL WITH SAND (A-1-b), little to some clay; wet.	16	40	--	23	21		Non-Plastic
20														
		2 5 11	16	9			@ 21.0', medium dense.	42	24	--	20	14		Non-Plastic
24.5	514.8	2 7 50	18	10			Severely weathered brownish gray SANDSTONE.							57
25														
		25 37 50/4	10	11										
27.5	511.8						Hard gray SANDSTONE; very fine to fine grained, slightly to moderately weathered, argillaceous, micaceous, medium bedded, moderately fractured.							87
30														

PL ⊢——⊣ LL

10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-50A | Location: Sta. 898+09.3, 34.1 ft. LT of SR 823 CL | Date Drilled: 3/22/05

WATER OBSERVATIONS: Water seepage at: 18.0'-25.0'
Water level at completion: 18.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N)
30	509.3	Core 120"	Rec 117"	RQD 68%	R1		Hard gray SANDSTONE; very fine to fine grained, slightly to moderately weathered, argillaceous, micaceous, medium bedded, moderately fractured. @ 28.1',-28.7', 29.0'-29.1', filled fractures. @ 33.3', 34.3'-34.4', 36.2', 37.2', clay-filled fractures.							
37.5	501.8						Bottom of Boring - 37.5'							

Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 (11/6/2007 3:40 PM)

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-51 | Location: Sta. 896+74.9, 4.3 ft. RT of SR 823 CL | Date Drilled: 03/17/05

WATER OBSERVATIONS: Water seepage at: 13.0'-18.0'
Water level at completion: 21.0' (prior to coring)
13.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N)
0.1	544.4						Topsoil - 2"							Natural Moisture Content, % - ● PL — LL Blows per foot - ○ 10 20 30 40
		1 2 1	7	1		2.0	Stiff dark brown SILT AND CLAY (A-6a), little fine to coarse sand, trace fine to coarse gravel; damp to moist.							
		1 2 3	13	2		1.0								
5.5	539.0						Very stiff brown SILTY CLAY (A-6b), trace fine to coarse sand, trace fine to coarse gravel; damp.							
		2 3 6	8	3		3.5								
8.0	536.5						Very loose to loose brown GRAVEL WITH SAND (A-1-b), little clay, trace silt; damp.							
		3 3 4	10	4										
		1 1 1	7	5			@ 11.0', moist.	43	28	--	11	7	11	Non-Plastic
13.0	531.5						Very loose brown COARSE AND FINE SAND (A-3a), little gravel, trace clay; wet.	12	28	--	45	15		Non-Plastic
		W O H	18	6										
		W O H	18	7										
18.0	526.5						Medium dense reddish brown GRAVEL WITH SAND AND SILT (A-2-4), trace clay; contains sandstone fragments; damp to moist.							
		16 7 8	18	8										
		7 14 11	14	9				19	19	--	30	24	8	Non-Plastic
23.0	521.5						Stiff gray CLAY (A-7-6), trace fine sand; moist.							
		1 3 5	11	10		1.5		0	0	--	1	43	56	
25.5	519.0						Severely weathered black SHALE carbonaceous.							
		20 50/3	8	11										50+
27.5	517.0						Medium hard black SHALE; moderately weathered, pyritic, laminated, broken. @ 28.1'-28.2', gray.							
30														

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-51 | Location: Sta. 896+74.9, 4.3 ft. RT of SR 823 CL | Date Drilled: 03/17/05

WATER OBSERVATIONS: Water seepage at: 13.0'-18.0'
Water level at completion: 21.0' (prior to coring)
13.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
30	514.5	Core 120"	Rec 116"	RQD 71%	R1		Hard gray SANDSTONE; very fine to fine grained, slightly weathered, argillaceous, micaceous, thickly bedded, moderately fractured. @ 28.7'-28.8', pyritic. @ 31.8', very thin clay seam. @ 33.1'-33.3', clay and gravel infilled fracture. @ 34.5', very thin clay infilled fracture. @ 35.5'-36.2', broken zone with clay infilling. @ 36.6'-36.8', highly weathered.						
35													
37.5	507.0						Bottom of Boring - 37.5'						
40													
45													
50													
55													
60													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-52 | Location: Sta. 895+21.1, 24.8 ft. LT of SR 823 CL | Date Drilled: 03/15/05

WATER OBSERVATIONS: Water seepage at: 23.0'-30.0'
Water level at completion: 27.0' (prior to coring)
6.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) / Natural Moisture Content, % / Blows per foot
0	558.0													
0.1	557.9						Topsoil - 1"							
		2 2 3	4	1		4.5+	Hard gray SILTY CLAY (A-6b), trace to little fine to coarse sand; contains shale fragments; damp.							
		3 5 7	10	2		4.5+								
5		10 7 4	9	3		4.5+								
		1 2 3	8	4		4.5+								
10														
10.5	547.5	2 2 3	7	5			Loose gray GRAVEL WITH SAND AND SILT (A-2-4), trace to little clay; damp.	66	4	--	2	18	10	Non-Plastic
13.0	545.0	2 3 3	16	6		3.75	Very stiff gray SILT AND CLAY (A-6a), trace fine to coarse sand, trace fine to coarse gravel; moist.							
15		3 5 6	16	7		4.0	@ 16.0', brown.							
		2 2 2	18	8		1.0	@ 18.5'-20.0', stiff, moist to wet.							
20														
20.5	537.5	2 4 4	12	9			Loose brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); damp.	35	20	--	17	14	14	
23.0	535.0	WOH WOH 1	18	10		<0.25	Very soft brown CLAY (A-7-6), trace fine sand; wet.							
25														
25.5	532.5	W O H	18	11			Very loose brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); wet.							
		13 15 5	17	12			@ 28.5-30.0', medium dense.							
30														

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-52 | Location: Sta. 895+21.1, 24.8 ft. LT of SR 823 CL | Date Drilled: 03/15/05

WATER OBSERVATIONS: Water seepage at: 23.0'-30.0'
Water level at completion: 27.0' (prior to coring)
6.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION
30	528.0						Medium dense brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); wet.
32.0	526.0						Severely weathered black SHALE.
		22 50/5	10	13			
35.0	523.0						Medium hard black SHALE; moderately weathered, carbonaceous, laminated, broken to moderately fractured.
40		Core 120°	Rec 120°	RQD 35%	R1		
40.4	517.6						Hard gray SANDSTONE; very fine to fine grained, slightly weathered, argillaceous, micaceous, thickly bedded, slightly fractured.
45.0	513.0						Bottom of Boring - 45.0'
50							
55							
60							

GRADATION: % Aggregate | % C. Sand | % M. Sand | % F. Sand | % Silt | % Clay

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40
50+

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-53 | Location: Sta. 3893+05.9, 100.7 ft. RT of US 23 Ramp C BL | Date Drilled: 7/8/04

WATER OBSERVATIONS: Water seepage at: 7.0', 8.5', 11.0', 15.5'
Water level at completion: 17.5' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0.2	566.7 / 566.5						Topsoil - 2"						
		9 6 4	18	1		4.0	Stiff to very stiff brown SILT AND CLAY (A-6a), some fine to coarse sand, trace gravel; damp to moist.						
		2 3 4	16	2		1.25							
5		2 2 4	16	3		1.75	@ 6.0'-7.5', contains interbedded sand seams.						
8.5	558.2	6 4 3	17	4			Loose to medium dense brown COARSE AND FINE SAND (A-3a), little to some silty clay, trace gravel; moist to wet.						
10		3 2 3	15	5									
		3 3 3	18	6									
15							@ 16.0', wet.						
		2 4 20	14	7									
17.5	549.2						Severely weathered gray SILTSTONE.						
19.0	547.7	50/5	5	8			Soft, gray, SANDSTONE; decomposed.						
20.0	546.7	Core 12"	Rec 11"	RQD 92%	R-1		Medium hard to hard gray SANDSTONE; very fine to fine grained, argillaceous, micaceous, laminated to thinly bedded, moderately to highly fractured. @ 22.0'-22.3',22.6'-22.8',23.2'- 23.3', 24.4'-24.6', 26.3'-26.5', vertical fractures. @ 22.0'-22.2',23.0'-23.1',26.3'- 26.5',28.6'-28.8', ferric bands.						
25		Core 108"	Rec 104"	RQD 67%	R-2								
29.0	537.7						Bottom of Boring - 29.0'						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40
50+

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-53A | Location: Sta. 3893+60.3, 19.3 ft. RT of US 23 Ramp C BL | Date Drilled: 3/15/05

WATER OBSERVATIONS: Water seepage at: 18.5'
Water level at completion: None (Prior to coring)
11.0' (Includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	565.3												
0.6	564.7	5 5 5	4	1		--	Topsoil - 7" Stiff gray SILTY CLAY (A-6b), trace gravel; contains shale fragments; damp.						
3.0	562.3	3 4 4	11	2		4.5+	Hard brown SANDY SILT (A-4a), some gravel, little clay; damp.	28	16	--	15	24	17
5													
5.5	559.8	5 3 3	12	3			Loose brown COARSE AND FINE SAND (A-3a), some gravel, some silty clay; dry to damp.	21	20	--	36	23	
		3 3 5	13	4									
10		4 4 5	12	5									
		4 7 9	10	6			@ 13.5'-15.0', medium dense.						
15		5 3 2	8	7									
18.0	547.3	1 2 1	8	8			Very loose dark brown GRAVEL WITH SAND (A-1-b), trace clay; wet.						
20													
20.5	544.8	50/4	4	9			Severely weathered gray SHALE.						
22.5	542.8	Core 120"	Rec 120"	RQD 78%	R-1		Medium hard gray SHALE; moderately weathered, thinly laminated, arenaceous, slightly fractured, contains ferric sandstone bands, fissile after desiccation. @ 22.5'-28.0', highly fractured. @ 28.8'-28.9', high angle fracture. @ 23.5',27.8',31.3', clay seams. @ 29.2'-30.0', very fine sandstone.						
25													
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic
Non-Plastic
50+

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-53A | Location: Sta. 3893+60.3, 19.3 ft. RT of US 23 Ramp C BL | Date Drilled: 3/15/05

WATER OBSERVATIONS: Water seepage at: 18.5'
Water level at completion: None (Prior to coring)
11.0' (Includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
30	535.3						Medium hard gray SHALE; moderately weathered, thinly laminated, arenaceous, slightly fractured, contains ferric sandstone bands, fissile after desiccation.							
32.5	532.8						Bottom of Boring - 32.5'							
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-54 | Location: Sta. 3891+87.0, 16.7 ft. LT of US 23 Ramp C BL | Date Drilled: 3/16/05

WATER OBSERVATIONS: Water seepage at: None
Water level at completion: None (prior to coring)
11.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0.2	566.7						Topsoil - 3"						
		2 2 2	14	1		1.0	Stiff to very stiff brown SILTY CLAY (A-6b), trace fine sand; damp. @ 0.0'-2.5', contains roots.						
		2 5 6	17	2		3.5		0	0	--	4	61	35
5.5	561.4						Very stiff brown SILT (A-4b), some clay, little fine sand; damp.						
		3 5 6	18	3		2.25		0	0	--	12	67	21
8.0	558.9						Loose dark brown COARSE AND FINE SAND (A-3a), trace to little clay, trace gravel; damp. -						
		1 3 2	11	4									
		1 2 3	13	5				7	38	--	37	18	
13.6	553.3	7 35 50/4	14	6			Severely weathered gray SHALE.						
15.0	551.9						Medium hard gray SHALE; arenaceous, decomposed to highly weathered, laminated, moderately fractured. @ 15.0'-17.3', broken with high angles fractures and thin clay seams. @ 18.9'-19.0', 20.6'-20.9', high angle fractures.						
20		Core 120"	Rec 120"	RQD 83%	R-1								
22.6	544.3						Hard gray SANDSTONE; very fine to fine grained, slightly weathered, argillaceous, medium bedded, slightly fractured.						
23.5	543.4						Hard gray SHALE; highly weathered, arenaceous, very thinly bedded, slightly fractured.						
25.0	541.9						Bottom of Boring - 25.0'						
30													

GRADATION

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic

50+

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-55 | Location: Sta. 892+28.2, 7.5 ft. RT of SR 823 CL | Date Drilled: 7/8/04

WATER OBSERVATIONS: Water seepage at: 13.5', 16.0'
Water level at completion: None (prior to coring)
16.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	567.1												
0.3	566.8						Topsoil - 3"						
		20 14 11	15	1			FILL: Medium dense brown SANDY SILT (A-4a), little gravel; dry.						
3.0	564.1												
		5 3 4	13	2		2.0	Very stiff to hard brown SILT AND CLAY (A-6a), some fine to coarse sand, trace to little gravel; damp to moist.						
5													
		5 7 9	16	3		4.25							
		10 12 13	18	4		4.5+							
10													
11.0	556.1	3 4 4	17	5			Loose brown COARSE AND FINE SAND (A-3a), little to some silty clay, trace gravel; moist to wet.						
		2 2 3	13	6									
15													
16.0	551.1	1 2 3	14	7		<0.25	Very soft brownish gray SILT AND CLAY (A-6a), some fine to coarse sand, some gravel; contains rock fragments; wet.						
18.5	548.6	30 50/5	11	8			Severely weathered gray SILTSTONE.						
19.5	547.6						Medium hard to hard gray SANDSTONE; slightly weathered, argillaceous, micaceous, moderately to highly fractured, contains abundant argillaceous laminations.						
20													
		Core 120"	Rec 120"	RQD 94%	R-1		@ 22.8'-23.1',23.6'- 23.7',25.6' ferric sandstone seams.						
25													
29.5	537.6												

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

50+

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-55 | Location: Sta. 892+28.2, 7.5 ft. RT of SR 823 CL | Date Drilled: 7/8/04

WATER OBSERVATIONS: Water seepage at: 13.5', 16.0'
Water level at completion: None (prior to coring)
16.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
30	537.1						Bottom of Boring - 29.5'							
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-55A | Location: Sta. 892+52.3, 7.8 ft. LT of SR 823 CL | Date Drilled: 3/15/05

WATER OBSERVATIONS: Water seepage at: 13.5'-18.0'
Water level at completion: 18.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) / Natural Moisture Content, % / Atterberg Limits
0	565.4	3 5 5	10	1		4.5+	No Topsoil Hard gray SILTY CLAY (A-6b); damp.							
3.0	562.4	6 7 7	9	2		4.5+	Hard brown SILT AND CLAY (A-6a), "and" fine to coarse sand, some gravel; damp.							
5		11 11 9	12	3		4.5+		22	15	--	23	21	19	
8.0	557.4	4 5 4	14	4			Loose brown COARSE AND FINE SAND (A-3a), trace to little clay, trace gravel; damp.	4	25	--	39	16	16	Non-Plastic
10		5 4 3	12	5										
15		2 2 2	15	6			@ 13.5', becomes wet.	9	38	--	40	13		Non-Plastic
		1 2 2	7	7										
18.0	547.4	35 50/5	11	8			Severely weathered gray SHALE.							50+
20.0	545.4						Medium hard gray SHALE interbedded with SANDSTONE; highly weathered, very thinly bedded, highly fractured. @ 20.0'-22.0', 26.7'-27.5', 28.3'-28.5', 29.3'-29.6', highly fractured with clay seams. @ 21.0'-21.3', 21.7'-21.9', 26.5'-26.7', 26.9'-22.0', hard brown ferric sandstone, slightly weathered, laminated.							
25		Core 120"	Rec 120"	RQD 64%	R-1									
30.0	535.4						Bottom of Boring - 30.0'							

STANDARD PENETRATION (N) / Natural Moisture Content, % - ● / PL ⊢—⊣ LL / Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-55A | Location: Sta. 892+52.3, 7.8 ft. LT of SR 823 CL | Date Drilled: 3/15/05

WATER OBSERVATIONS: Water seepage at: 13.5'-18.0'
Water level at completion: 18.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL — LL Blows per foot - ○ 10 20 30 40
30	535.4													
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 (11/6/2007 3:40 PM)

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-56 | Location: Sta. 890+95.4, 24.6 ft. LT of SR 823 CL | Date Drilled: 3/16/05

WATER OBSERVATIONS: Water seepage at: None
Water level at completion: None (prior to coring)
7.5' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0.2	570.0 / 569.8						Topsoil -3"						
		2 2 3	15	1		2.5	Very stiff to hard brown SILTY CLAY (A-6b), trace fine sand; damp.						
		4 6 9	17	2		4.5+							
5		4 6 9	16	3		4.25		0	0	--	2	57	41
8.0	562.0												
		2 2 3	18	4			Loose brown and gray SILT (A-4b), some fine to coarse sand, some clay; damp to moist.	0	1	--	19	55	25
10		2 6 4	9	5									
14.1	555.9	8 23 50/4	15	6			Severely weathered grayish brown SILTSTONE.						
15.0	555.0						Medium hard grayish brown SANDSTONE interbedded with SHALE; very fine to fine grained, slightly weathered, argillaceous, laminated to thinly bedded, highly fractured.						
20		Core 120"	Rec 120"	RQD 68%	R-1		@ 16.4'-17.2', high angle fracture and clay seam. @ 17.2', gray. @ 19.2'-19.7', clay seam. @ 20.4'-20.8', broken, clay seam.						
25.0	545.0						Bottom of Boring - 25.0'						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40
50+

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-57 | Location: Sta. 2611+74.6, 27.9 ft. RT of US 23 Ramp B BL | Date Drilled: 3/16/04

WATER OBSERVATIONS: Water seepage at: None
Water level at completion: None (Prior to coring)
3.5' (Includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	569.5												
0.3	569.2						Topsoil - 4"						
		2 3 4	14	1		4.0	Very stiff to hard brown SILTY CLAY (A-6b), trace fine sand; damp to moist.						
		3 5 7	12	2		4.5							
5		4 5 6	17	3		3.5		0	0	--	1	64	35
8.0	561.5												
		1 2 2	18	4		1.0	Stiff brown SILT (A-4b), some clay, little fine to coarse sand; moist.	0	0	--	10	67	23
10													
10.5	559.0												
		2 5 5	14	5		--	Stiff brown SILT AND CLAY (A-6a), some fine to coarse sand, some gravel; damp.	23	15	--	19	26	17
14.0	555.5	12 27 50/3	13	6			Severely weathered gray SHALE.	0	2	--	3	64	31
15.0	554.5						Soft to medium hard gray SHALE; highly weathered to decomposed, argillaceous, laminated to thinly bedded, moderately to highly fractured. @ 15.8'-16.3', 19.1'-19.5', clay seams.						
20		Core 120"	Rec 120"	RQD 90%	R-1								
20.9	548.6						Hard gray SANDSTONE interbedded with SHALE; slightly weathered, laminated. @ 22.7-22.9', high angle fracture.						
22.9	546.6						Hard gray SHALE; moderately weathered, argillaceous, laminated, slightly fractured.						
25.0	544.5						Bottom of Boring - 25.0'						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40
50+

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-58 Location: Sta. 2611+25.3, 14.7 ft. RT of US 23 Ramp B BL Date Drilled: 3/16/05

WATER OBSERVATIONS: Water seepage at: None
Water level at completion: None (prior to coring)
4.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	567.1												
0.3	566.8						Topsoil - 4"						
		1 2 2	16	1		--	Soft brown SILTY CLAY (A-6b), trace fine sand; damp to moist. @ 0.0'-2.5', contains roots.						
		3 6 8	15	2		4.25	@ 3.5', very stiff to hard.						
5		5 6 7	18	3		3.5		0	0	--	6	65	29
8.0	559.1												
		2 4 3	16	4			Loose dark brown COARSE AND FINE SAND (A-3a), trace to little clay, trace gravel; damp.	7	34	--	40	19	
10		4 4 3	15	5									
14.0	553.1												
		2 20 50/5	16	6			Severely weathered brownish gray SHALE.						
15.0	552.1						Soft to medium hard gray SHALE; highly weathered to decomposed, thinly bedded, slightly fractured. @ 15.0'-16.7', broken with clay seams and high angle fractures. @ 17.5'-17.8', 19.5'-20.1', clay seams with high angle fractures. @ 20.9'-21.0', clay seam. @ 24.2',24.4', very thin clay seams.						
20		Core 120"	Rec 120"	RQD 82%	R-1								
25.0	542.1						Bottom of Boring - 25.0'						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic

50+

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

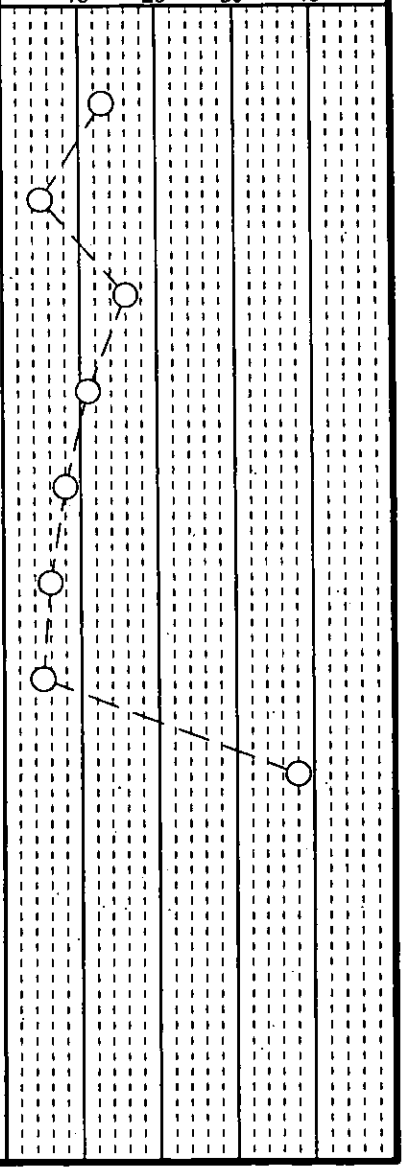
Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-59 | Location: Sta. 2610+61.7, 45.7 ft. RT of US 23 Ramp B BL | Date Drilled: 7/8/04

WATER OBSERVATIONS: Water seepage at: 13.5'-18.5'
Water level at completion: 17.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0.2	567.1						Topsoil - 2"						
		8 8 5	14	1		--	FILL: Stiff brown SANDY SILT (A-4a), little gravel, trace clay; damp.						
3.0	564.3												
		2 2 3	12	2		1.0	Stiff to very stiff brown SILT AND CLAY (A-6a), little fine to coarse sand, trace gravel; moist.						
5													
		5 7 9	18	3		2.5							
		5 5 6	16	4		2.0							
10													
11.0	556.3	3 4 4	15	5		1.25	Stiff brown SANDY SILT (A-4a), "and" fine to coarse sand, trace gravel; contains thin seam of organic material; moist.						
13.5	553.8	3 3 3	14	6			Loose brown COARSE AND FINE SAND (A-3a), some silty clay, trace gravel; wet.						
15													
		2 2 3	15	7									
18.5	548.8	5 8 30	16	8			Severely weathered gray and brown SANDSTONE fragments, argillaceous.						
20													
21.0	546.3	Core 120"	Rec 115"	RQD 90%	R-1		Medium hard gray SANDSTONE; very fine to fine grained, slightly to moderately weathered, argillaceous, micaceous, thinly laminated to thinly bedded, broken to highly fractured, contains moderate argillaceous laminations and few ferric bands. @ 21.0'-21.2',22.0'- 22.2',23.3'-23.4', 23.8'- 23.9', 25.9'-26.2', vertical fractures. @ 26.0'-26.2', argillaceous sandstone.						
25													
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-59 | Location: Sta. 2610+61.7, 45.7 ft. RT of US 23 Ramp B BL | Date Drilled: 7/8/04

WATER OBSERVATIONS: Water seepage at: 13.5'-18.5'
Water level at completion: 17.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL — LL Blows per foot - ○ 10 20 30 40
30	537.3						Medium hard gray SANDSTONE.							
31.0	536.3						Bottom of Boring - 31.0'							
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-59A Location: Sta. 2609+82.8, 15.0 ft. RT of US 23 Ramp B BL Date Drilled: 3/14/05

WATER OBSERVATIONS: Water seepage at: 19.0'-21.5'
Water level at completion: None (prior to coring)
17.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	563.9												
0.3	563.6						Topsoil - 3"						
		3 3 3	14	1		-	Medium stiff dark gray SANDY SILT (A-4a), some clay, trace gravel; damp to moist.						
		2 2 2	12	2		--	@ 3.5', brown.	7	13	--	26	32	22
5													
5.5	558.4						Very loose to loose brown GRAVEL WITH SAND (A-1-b), little clay; moist.						
		2 2 3	15	3				15	36	--	37	12	
		2 2 1	13	4									
10													
10.5	553.4						Loose brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); damp to moist.						
		2 2 2	16	5				14	25	--	31	9	21
		1 2 3	15	6									
15													
		2 3 3	12	7									
		0 1 1	14	8			@ 19.0'-21.5', very loose; wet.						
20													
21.5	542.4	1 36 50	12	9			Severely weathered gray SHALE.						
		32 50/3	9	10									
25.0	538.9						Medium hard to hard gray SANDSTONE interbedded with SHALE; very fine to fine grained, highly weathered to decomposed, laminated to thinly bedded, slightly fractured.						
		Core 120"	Rec 119"	RQD 65%	R-1		@ 25.4'-25.7', 28.5', 29.6', clay seams.						
							@ 25.9', 26.5-26.7', 27.8', high angle fractures.						
30							@ 28.6'-29.6', moderately weathered SHALE.						

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

Non-Plastic

86

50+

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-59A | Location: Sta. 2609+82.8, 15.0 ft. RT of US 23 Ramp B BL | Date Drilled: 3/14/05

WATER OBSERVATIONS: Water seepage at: 19.0'-21.5'
Water level at completion: None (prior to coring)
17.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
30	533.9						Medium hard to hard gray SANDSTONE interbedded with SHALE; very fine to fine grained, highly weathered to decomposed, laminated to thinly bedded, slightly fractured. @ 31.4'-31.7', clay seams with high angle fractures.						
33.0	530.9						Hard black SHALE; carbonaceous, moderately weathered, laminated, slightly fractured. @ 33.8'-34.0', broken, high angle fracture.						
35.0	528.9						Bottom of Boring - 35.0'						
40													
45													
50													
55													
60													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-60 | Location: Sta. 2607+31.2, 19.6 ft. RT of US 23 Ramp B BL | Date Drilled: 3/14/05

WATER OBSERVATIONS: Water seepage at: 18.0'-28.0'
Water level at completion: 26.0' (prior to coring)
19.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) / Natural Moisture Content, % / Blows per foot
0.0	552.3													
0.1	552.2	4 8 7	12	1			Topsoil - 1" FILL: Medium dense brown SANDY SILT (A-4a), little gravel, little clay; damp.							
3.0	549.3	4 4 4	12	2			Loose brown GRAVEL WITH SAND (A-1-b), little silt, trace clay; damp.	33	43	--	11	13		Non-Plastic
5		3 2 2	9	3										
		3 2 3	13	4										
10		3 3 3	14	5				50	20	--	9	17	4	Non-Plastic
		3 3 4	1	6			@ 13.5', moist.							
15		2 3 3	14	7										
18.0	534.3	1 1 2	17	8			Very loose to loose brown COARSE AND FINE SAND (A-3a), little clay, trace gravel; wet.	10	53	--	20	17		Non-Plastic
20		4 3 3	16	9										
23.0	529.3	7 4 4	18	10			Loose brown GRAVEL WITH SAND AND SILT (A-2-4), little clay; wet.	31	27	--	12	18	12	
25														
25.5	526.8	3 6 4	18	11			Loose reddish brown COARSE AND FINE SAND (A-3a), some clay, trace gravel; wet.	7	14	--	58	21		Non-Plastic
28.0	524.3	50/4	4	12			Severely weathered black SHALE.							50/4"
30														

PL — LL

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-60 | Location: Sta. 2607+31.2, 19.6 ft. RT of US 23 Ramp B BL | Date Drilled: 3/14/05

WATER OBSERVATIONS: Water seepage at: 18.0'-28.0'
Water level at completion: 26.0' (prior to coring)
19.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
30.0	522.3						Soft to medium hard black SHALE; carbonaceous, moderately weathered to decomposed, laminated, slightly fractured.						
							@ 30.0'-32.3', clay seam.						
							@ 32.3', hard.						
		Core 120"	Rec 119"	RQD 79%	R-1		@ 33.2', 38.0'-38.2', clay seams.						
35													
							@ 39.4'-39.8', high angle fracture.						
							@ 39.9'-40.0', hard gray SANDSTONE.						
40.0	512.3						Bottom of Boring - 40.0'						
45													
50													
55													
60													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

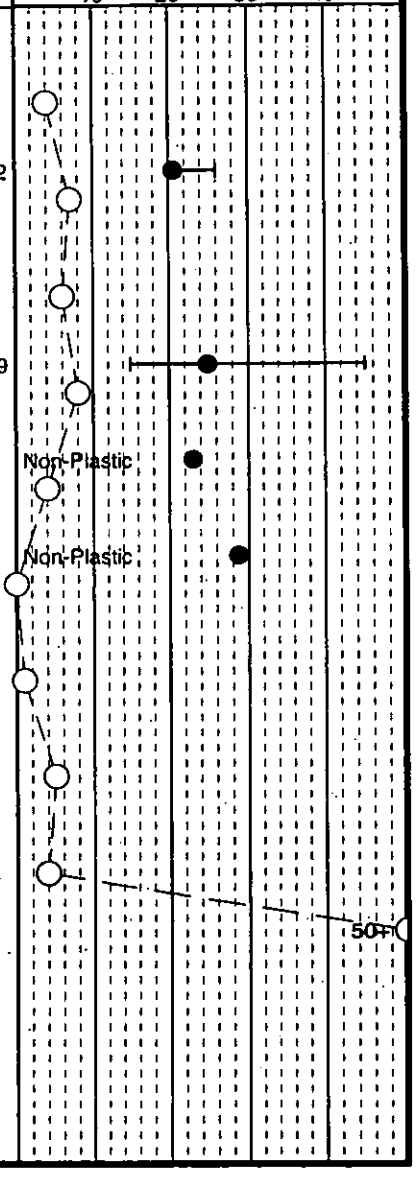
Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-61 | Location: Sta. 2605+26.3, 18.1 ft. RT of US 23 Ramp B BL | Date Drilled: 3/16/05

WATER OBSERVATIONS: Water seepage at: 13.5'-23.0'
Water level at completion: 14.0' (prior to coring)
9.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	543.4												
0.3	543.1						Topsoil - 4"						
		2 2 2	2	1			FILL: Loose black SANDY SILT (A-4a), little clay, little gravel; organic; dry to damp.						
		3 4 3	1	2				14	20	--	26	28	12
5													
5.5	537.9						Very stiff light brown CLAY (A-7-6), some fine to coarse sand, trace gravel; damp.						
		2 3 3	16	3		2.5							
							@ 8.5', brown.						
		1 3 5	12	4		2.25		8	12	--	12	29	39
10													
10.5	532.9						Very loose brown GRAVEL WITH SAND (A-1-b), little silty clay; moist to wet.						
		1 2 2	13	5				9	46	--	32	13	Non-Plastic
13.0	530.4						Very loose brown COARSE AND FINE SAND (A-3a), little silty clay, trace gravel; wet.						
		W O H	16	6				1	22	--	62	15	Non-Plastic
15													
		WOH WOH 1	18	7									
17.0	526.4						Very loose to loose brown GRAVEL WITH SAND (A-1-b), little silty clay; moist to wet.						
		1 3 2	18	8									
20													
		1 1 3	18	9									
23.0	520.4						Severely weathered black SHALE.						
		50/3	3	10									
25.0	518.4						Hard black SHALE; carbonaceous, moderately weathered, thinly bedded, moderately fractured. @ 25.0'-25.2', 27.5'-27.6', 28.1'-28.2', 29.3'-30.0', high angle fractures						
30		Core 120"	Rec 114"	RQD 92%	R-1								

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40



FILE: 0121-3070-03 [11/6/2007 3:40 PM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring TR-61 | Location: Sta. 2605+26.3, 18.1 ft. RT of US 23 Ramp B BL | Date Drilled: 3/16/05

WATER OBSERVATIONS: Water seepage at: 13.5'-23.0'
Water level at completion: 14.0' (prior to coring)
9.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
30	513.4												
30.5	512.9						Hard gray SANDSTONE; very fine to fine grained, slightly weathered, thinly to medium bedded, slightly fractured. @ 31.2'-31.6', high angle fracture. @ 33.7'-33.9', clay seam.						
35.0	508.4						Bottom of Boring - 35.0'						
40													
45													
50													
55													
60													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢——⊣ LL
Blows per foot - ○
10 20 30 40

FILE: 0121-3070-03 [11/6/2007 3:40 PM]

APPENDIX C

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APPENDIX C

Summary of Shear Strength and Consolidation Test Results
Shear Strength Test Results
Consolidation Test Results

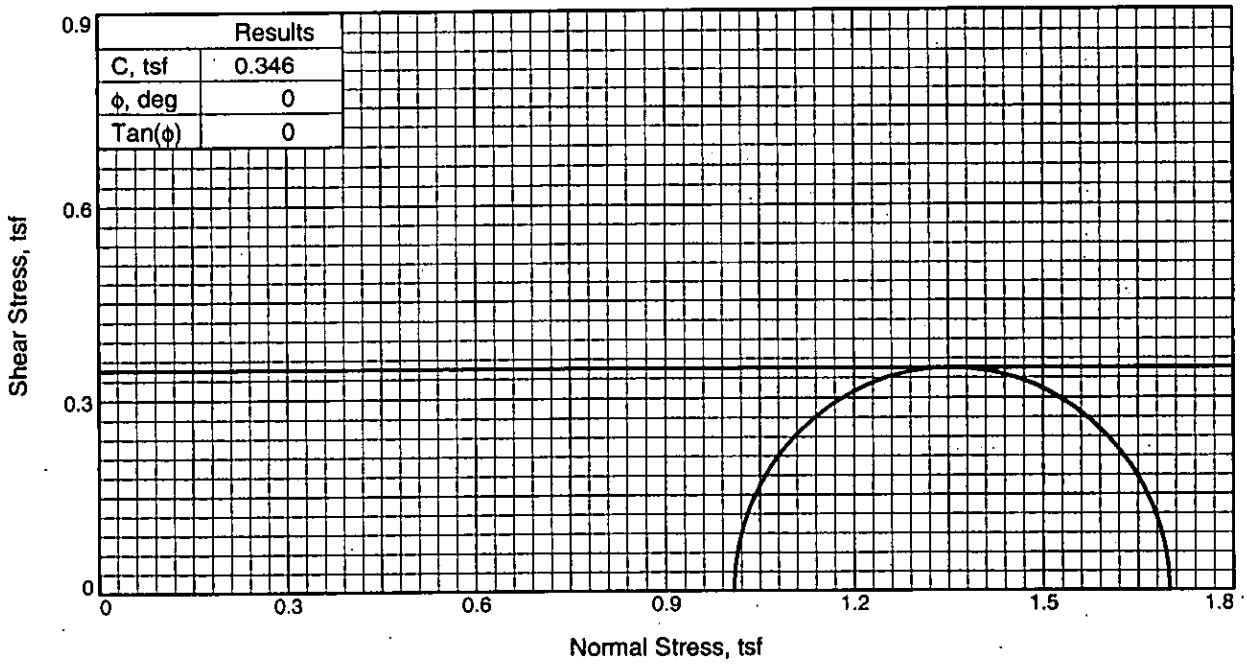
PROJECT SCI-823-0.00
US 23 Interchange
SUMMARY TEST RESULTS

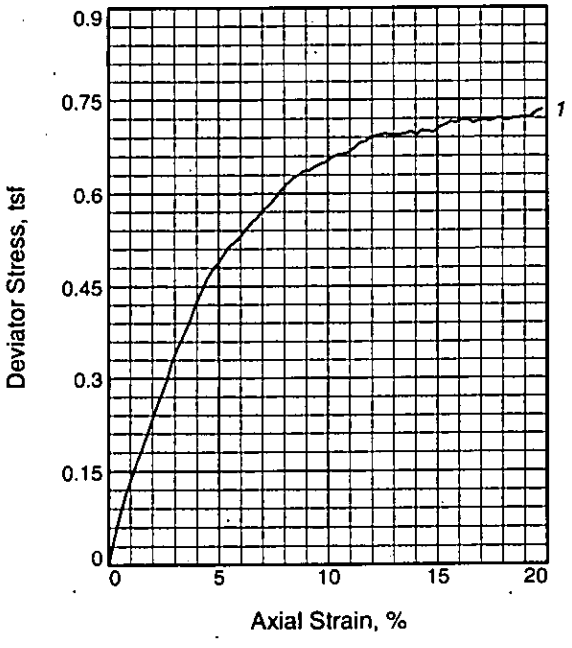
Boring	Sample	Depth (ft.)	Test Performed	Results											
				ODOT Classification	γ_D (pcf)	WC (%)	e_o	Cc	Cr	p_c (psf)	c (psf)	c' (psf)	φ (deg)	φ' (deg)	q_u (tsf)
B-1105A	ST2	8.0	UU	A-4b	97.0	27.5					692				
B-1105A	ST2	8.0	CIU	A-4b	98.7	24.7					0	0	22.4	34.9	
B-1105A	ST3	12.0	UU / Consol.	A-6a	100.0	24.1	0.694	0.240	0.060	5100	1396				
B-1105A	ST4	16.0	CIU	A-6b	91.6	27.6					182	0	20.4	36.8	
B-1105A	In-situ	10.0	FVS Test	A-4b/A-6a							1093*				
B-1105A	In-situ	11.6	FVS Test	A-6a							779*				
B-1105A	In-situ	13.7	FVS Test	A-6a							3933*				
B-1108	P1	10.0	UC / Consol.	A-6a / A-6b	103.4	22.4	0.639	0.170	0.030	3700					2.618
B-1108	P2	14.0	UU	A-6b	95.2	30.2					896				
B-1108	P3	18.0	CIU / Consol.	A-6b	95.8	28.4	0.734	0.210	0.050	2160	0	0	22.2	37.4	
B-1109A	ST2	8.0	UU / Consol.	A-7-6	97.9	26.2	0.883	0.150	0.040	3000	978				
B-1109A	In-situ	8.0	FVS Test	A-7-6							1687*				
B-1122A	ST1	12.0	UC / Consol.	A-6a	84.2	32.0	1.108	0.370	0.070	3000					0.835
B-1122A	ST1	12.0	UC	A-6a	90.9	30.9									1.046
B-1122A	ST2	15.0	CIU	A-6a	98.0	27.4					718	654	15.1	31.1	
B-1133A	ST1	18.0	UU	A-4b / A-6a	96.1	28.9					306				
B-1133A	ST2	20.3	CIU / Consol.	A-7-6	84.1	37.7	1.108	0.430	0.080	3500	658	0	14.2	35.6	
B-1133A	ST3	22.0	UU	A-4b	85.5	36.1					322				
B-1133A	In-situ	15.5	FVS Test	A-6a							822*				
B-1133A	In-situ	20.4	FVS Test	A-6a / A-4b							786*				
B-1136A	ST1	6.0	UU / Consol.	A-4b	97.2	26.0	0.752	0.230	0.050	2300	1060				
B-1136A	ST2	8.0	CIU	A-4b	99.0	26.6					770	0	16.3	35.2	
B-1136A	In-situ	7.8	FVS Test	A-4b							1242*				
B-1136A	In-situ	10.6	FVS Test	A-4b							991*				
B-1138A	ST2	8.0	UU / Consol.	A-6a	100.0	24.9	0.721	0.250	0.050	2600	1764				

PROJECT SCI-823-0.00
US 23 Interchange
SUMMARY TEST RESULTS

Boring	Sample	Depth (ft.)	Test Performed	Results											
				ODOT Classification	γ_D (pcf)	WC (%)	e_o	Cc	Cr	p_c (psf)	c (psf)	c' (psf)	φ (deg)	φ' (deg)	q_u (tsf)
B-1138A	In-situ	7.0	FVS Test	A-6a							2057*				
B-1138A	In-situ	9.1	FVS Test	A-6a							2161*				
B-54	ST1	6.0	UC / Consol.	A-6a	103.9	20.3	0.629	0.170	0.030	4400					0.973
B-54	ST2	10.0	UC	A-6a											0.535
B-54	ST2	10.0	UC	A-6a											1.258
B-54	ST3	15.0	CIU	A-4b	98.3	26.5					336	302	17.2	31.7	
B-45	P-1	5.0	UU	A-6b	103.5	22.1					1488				
B-45	P-1	5.0	Consol.	A-6b	105.2	20.0	0.632	0.090	0.010	600					
B-45	In-situ	6.0	FVS TEST	A-6b							1116*				
B-45	P-2	8.0	CIU	A-6b/A-2-6	114.1	18.0					1490	720	6.9	24.5	
B-46	P-1	5.0	UU	A-6b	99.7	23.6					3036				
B-46	P-1	5.0	Consol.	A-6b	100.0	23.1	0.692	0.240	0.040	2700					
B-46	P-2	8.0	CIU	A-6b	108.2	18.9					256	0	23.8	35.8	
B-47	ST-1	4.0	UU	A-4b	97.6	22.7					2238				
B-47	In-situ	6.0	FVS TEST	A-4b							1306*				
B-47	ST-2	6.0	UU	A-4b	102.7	18.4					3616				

* Raw field data, values used for geotechnical analyses require the application of the appropriate correction factor.





Sample No.		1
Initial	Water Content,	27.5
	Dry Density, pcf	97.0
	Saturation,	98.2
	Void Ratio	0.7700
	Diameter, in.	2.84
	Height, in.	5.22
At Test	Water Content,	27.4
	Dry Density, pcf	97.0
	Saturation,	97.9
	Void Ratio	0.7700
	Diameter, in.	2.84
	Height, in.	5.22
Strain rate, in./min.		0.06
Back Pressure, tsf		0.00
Cell Pressure, tsf		1.01
Fail. Stress, tsf		0.69
Ult. Stress, tsf		0.69
σ_1 Failure, tsf		1.70
σ_3 Failure, tsf		1.01

Type of Test:
Unconsolidated Undrained

Sample Type: Press Tube

Description:

Assumed Specific Gravity= 2.75

Remarks:

Figure _____

Client: TranSystems, Inc.

Project: SCI-823-0.00

Source of Sample: B-1105A **Depth:** 8.0

Sample Number: ST2

Proj. No.: 0121-3070.03 **Date:**

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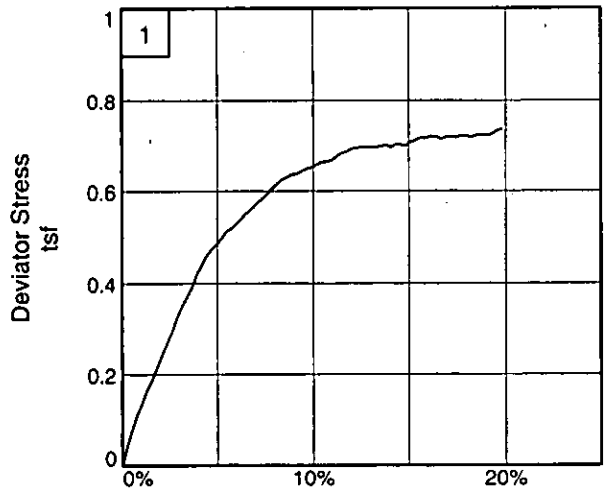
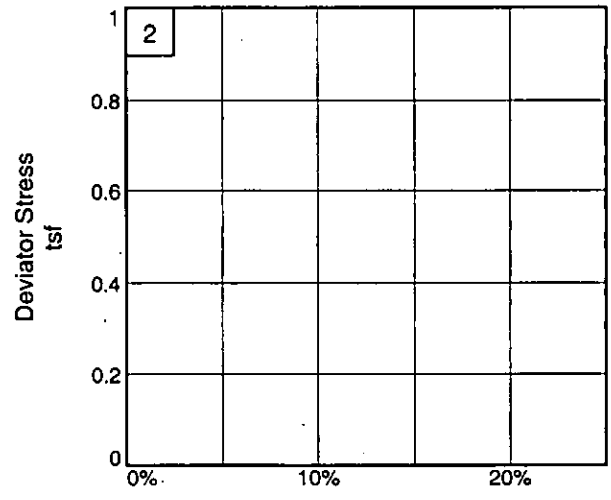
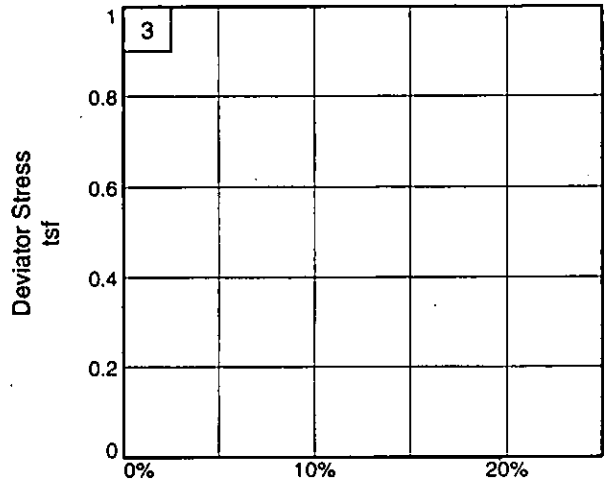
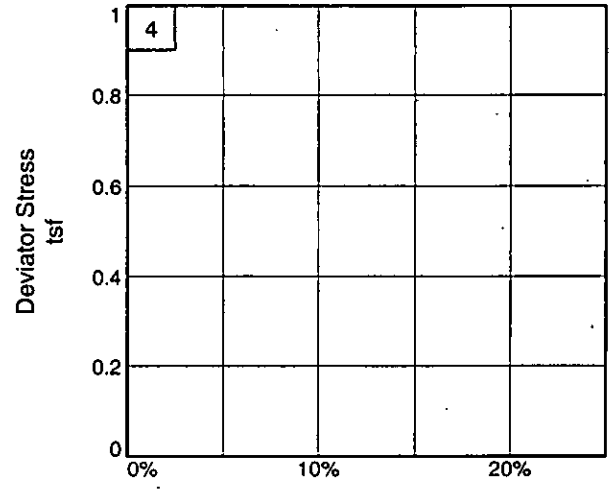
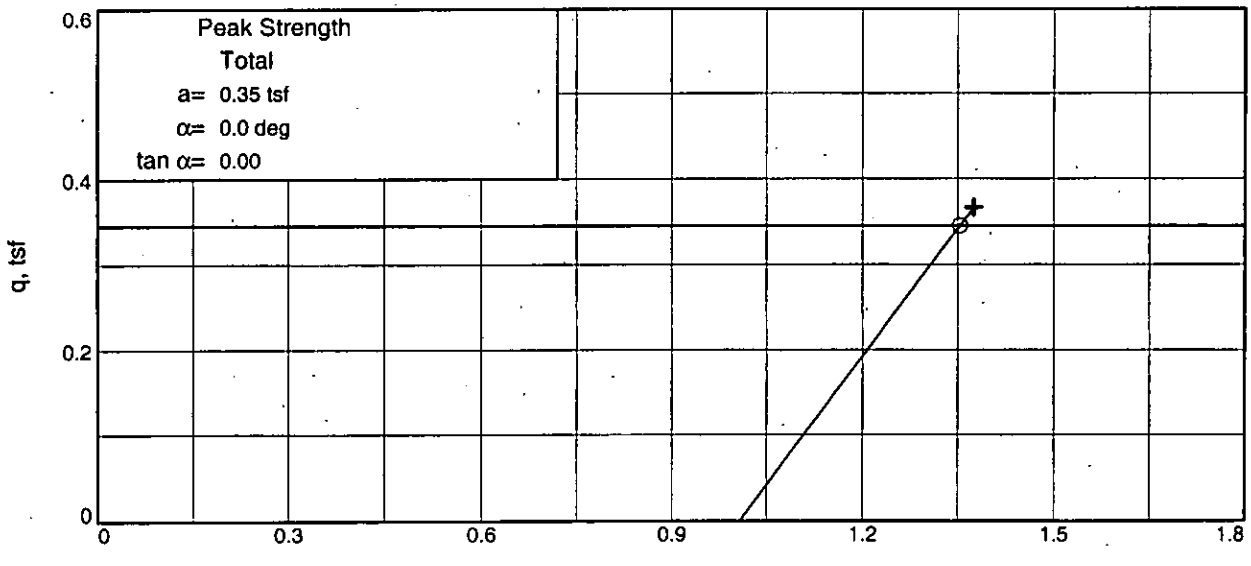






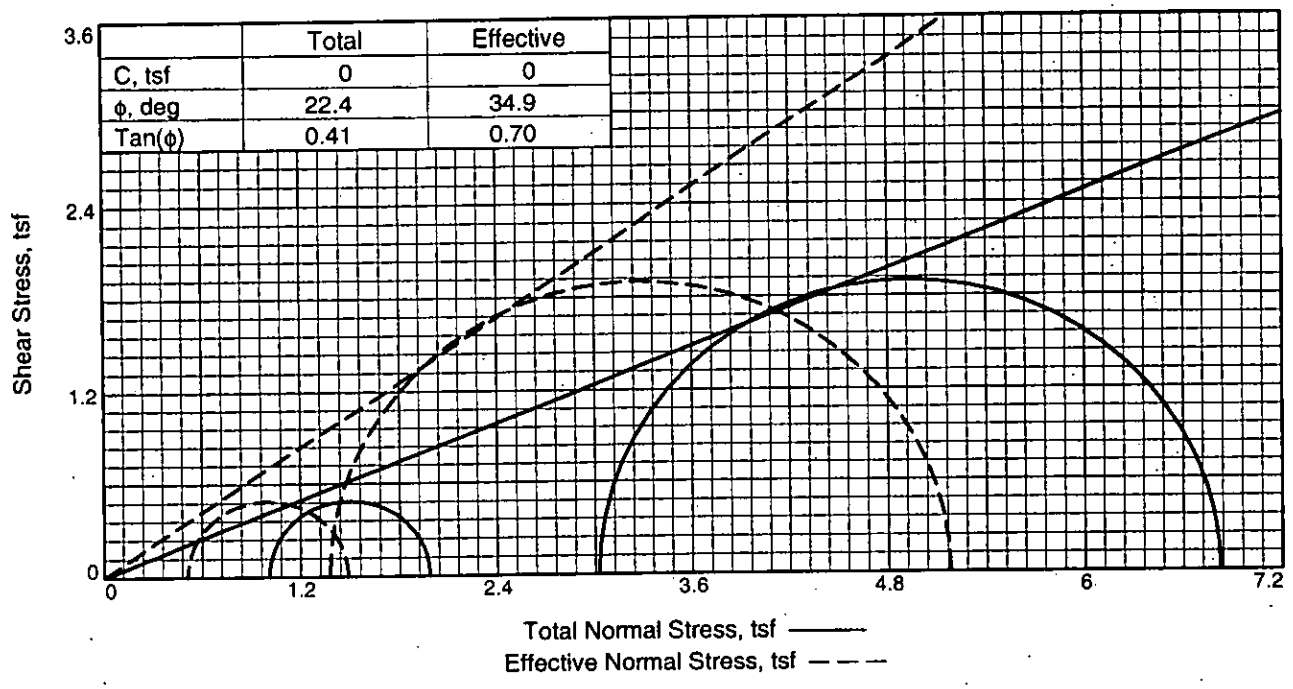


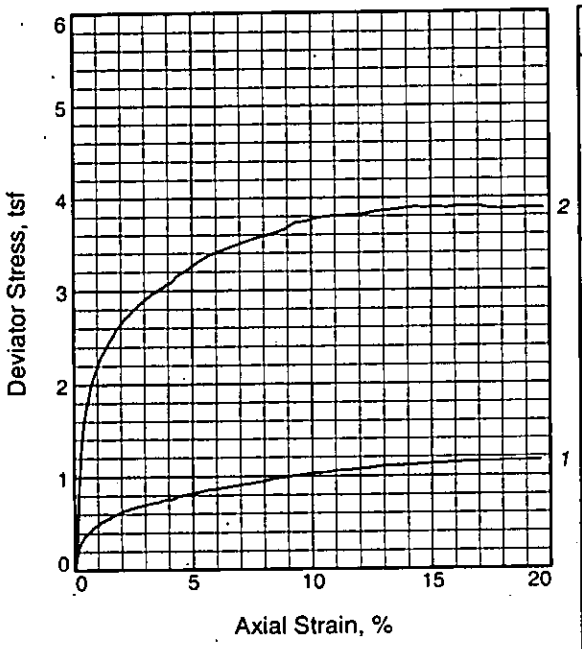


Stress Paths: o indicates peak + indicates end

Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-1105A **Depth:** 8.0 **Sample Number:** ST2
Project No.: 0121-3070.03 **Figure** _____

DLZ, INC.





Sample No.		1	2
Initial	Water Content,	24.7	26.0
	Dry Density, pcf	98.7	97.8
	Saturation,	92.0	94.6
	Void Ratio	0.7397	0.7559
	Diameter, in.	2.84	2.84
	Height, in.	5.32	5.29
At Test	Water Content,	24.2	22.2
	Dry Density, pcf	101.0	105.0
	Saturation,	95.2	96.1
	Void Ratio	0.6992	0.6354
	Diameter, in.	2.82	2.76
	Height, in.	5.27	5.21
Strain rate, in./min.		0.01	0.01
Back Pressure, tsf		3.31	3.31
Cell Pressure, tsf		4.32	6.34
Fail. Stress, tsf		0.98	3.80
Total Pore Pr., tsf		3.81	4.96
Ult. Stress, tsf		0.98	3.80
Total Pore Pr., tsf		3.81	4.96
$\bar{\sigma}_1$ Failure, tsf		1.49	5.18
$\bar{\sigma}_3$ Failure, tsf		0.51	1.38

Type of Test:
CU with Pore Pressures
Sample Type: Press Tube
Description: Lean clay

LL= 28 **PL=** 18 **PI=** 10
Assumed Specific Gravity= 2.75
Remarks:

Figure _____

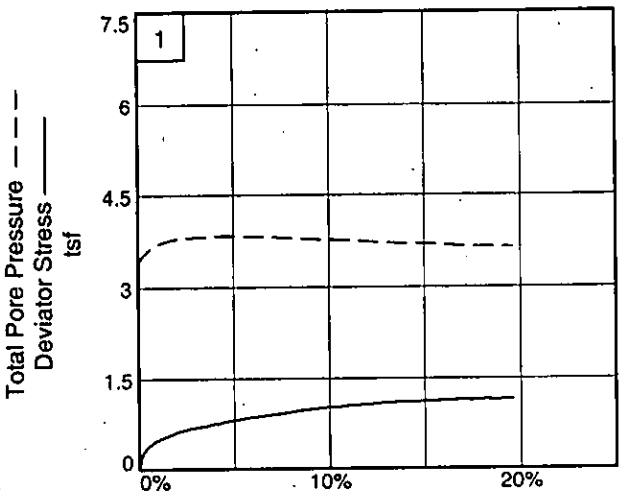
Client: TranSystems, Inc.

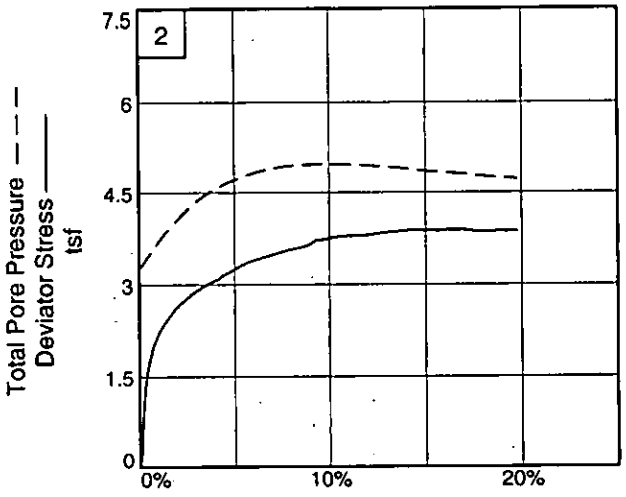
Project: SCI-823-0.00

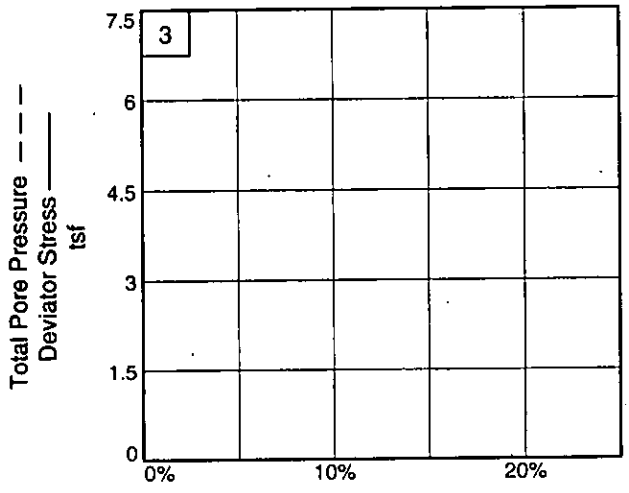
Source of Sample: B-1105A **Depth:** 8.0
Sample Number: ST2

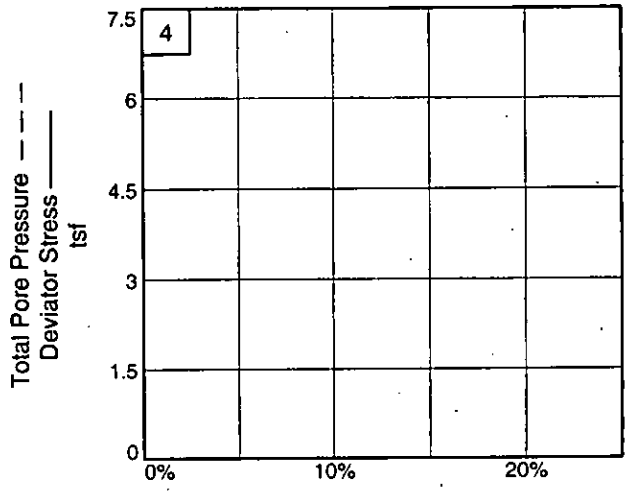
Proj. No.: 0121-3070.03 **Date:** 8/24/07

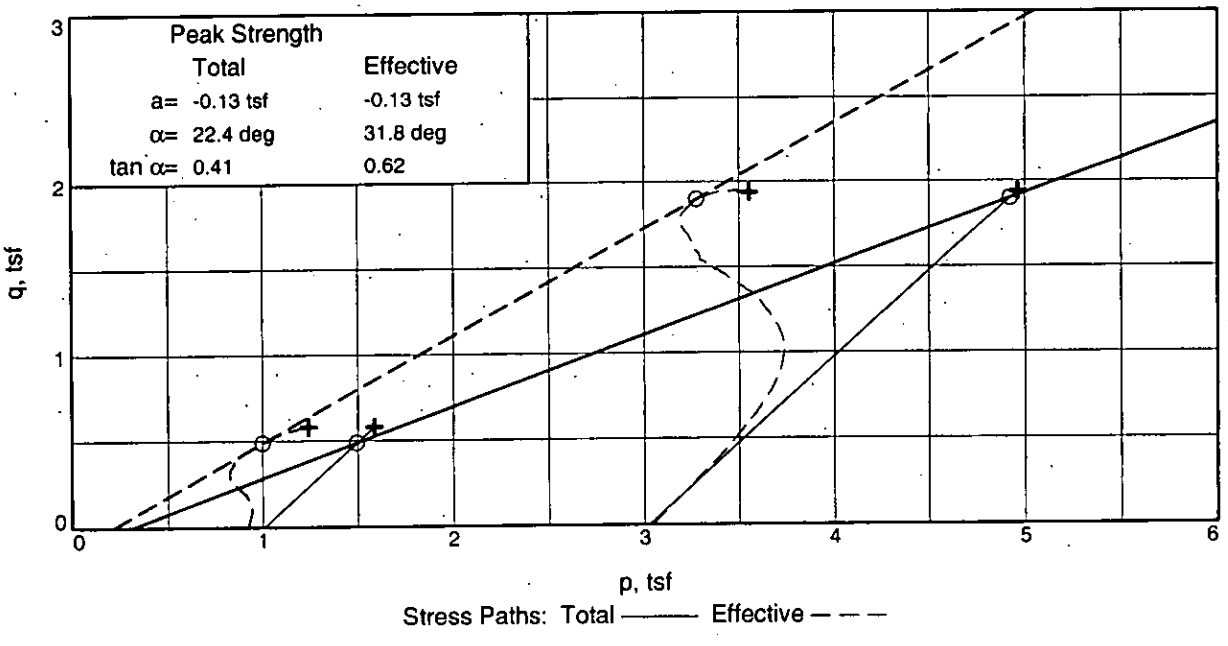
DLZ











Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-1105A
Project No.: 0121-3070.03

Depth: 8.0
Figure _____

Sample Number: ST2

DLZ, INC.

Vane Shear Test Report

Project	SCI-823-0.00	Date and Time	7/27/2007	Begin 10:50am
Project No.	0121-3070-03	Boring Number	B-1105a	End 11:30am
Client	ODOT			Depth 10.0' First
Drill Rig & Crew	D Wamsley			
Tested By	B Mott			
Weather / Temp.	overcast 75			
Soil Type				

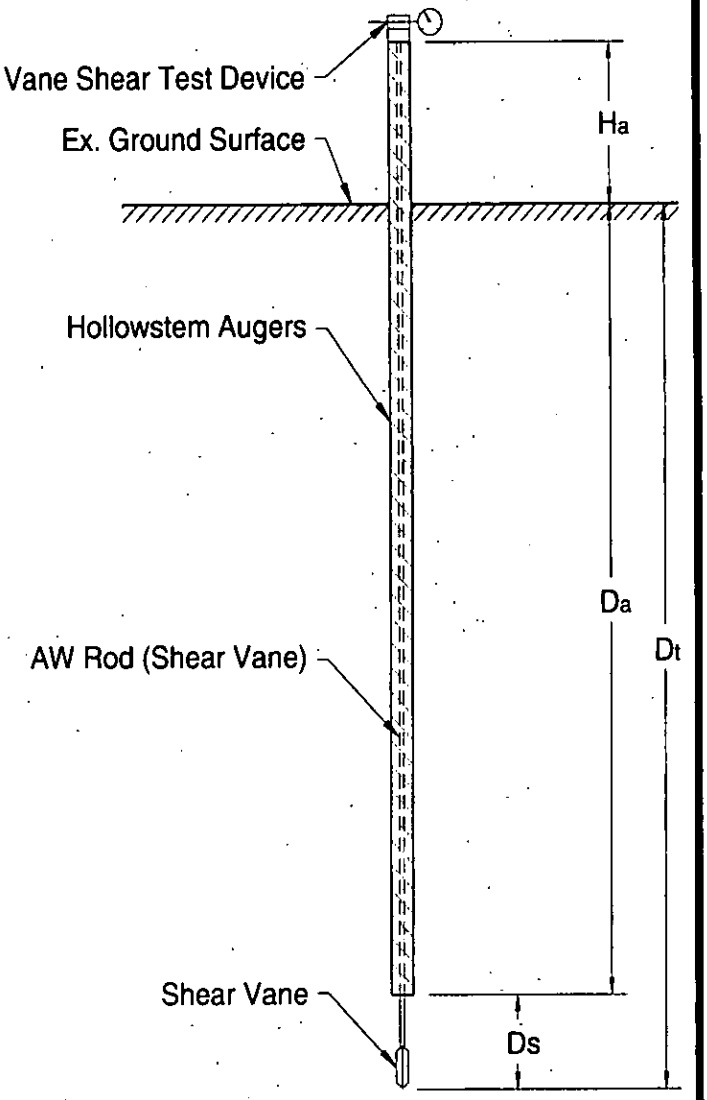
DRILLING

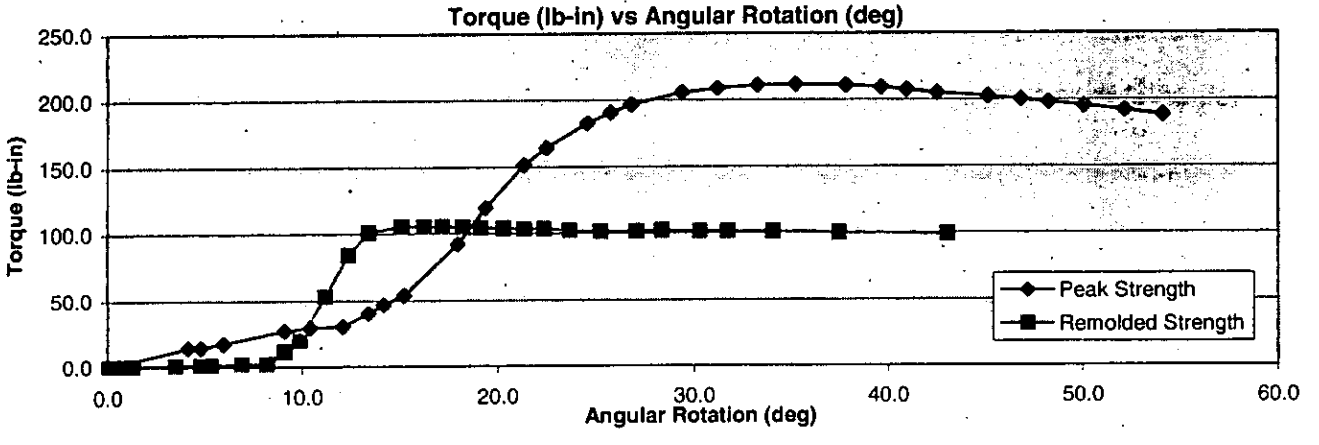
Hollowstem augers to depth	D_a	9
Vane Depth below bottom of augers	D_s	1
Augers above ground surface	H_a	6
Depth to vane tip	D_t	10

SHEAR VANE

Vane Used	2.0"	2.5"	3.625"
Vane constant, k (lb-in to psf)	5.17	2.59	0.905
Masurement by	Automatic/torque cell		
Max Torque	211	lb-in	
Max UD Shear Strength	**1093**	**psf**	

Test Setup





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Vane Shear Test Report

Read Time	Δ time	Rotation (degrees)	Torque (in-lbs.)
Peak Strength Test			
11:04:12	0:00:00	0.0	0.0
11:04:44	0:00:32	4.2	14.5
11:04:49	0:00:37	4.8	14.5
11:04:58	0:00:46	6.0	17.6
11:05:22	0:01:10	9.1	27.3
11:05:32	0:01:20	10.4	29.7
11:05:45	0:01:33	12.1	30.7
11:05:55	0:01:43	13.4	40.4
11:06:01	0:01:49	14.2	46.8
11:06:09	0:01:57	15.2	54.0
11:06:30	0:02:18	17.9	92.4
11:06:41	0:02:29	19.4	119.2
11:06:56	0:02:44	21.3	151.4
11:07:05	0:02:53	22.5	164.2
11:07:21	0:03:09	24.6	182.6
11:07:30	0:03:18	25.7	190.7
11:07:38	0:03:26	26.8	196.8
11:07:58	0:03:46	29.4	205.4
11:08:12	0:04:00	31.2	208.6
11:08:28	0:04:16	33.3	210.8
11:08:43	0:04:31	35.2	211.5
11:09:03	0:04:51	37.8	211.0
11:09:17	0:05:05	39.7	209.2
11:09:27	0:05:15	41.0	207.6
11:09:39	0:05:27	42.5	205.0
11:09:59	0:05:47	45.1	202.4
11:10:12	0:06:00	46.8	200.2
11:10:23	0:06:11	48.2	198.0
11:10:37	0:06:25	50.0	195.3
11:10:53	0:06:41	52.1	192.0
11:11:08	0:06:56	54.1	188.6

Read Time	Δ time	Rotation (degrees)	Torque (in-lbs.)
Remolded Strength Test			
11:20:02	0:00:00	0.0	0.0
11:20:07	0:00:05	0.6	0.1
11:20:12	0:00:10	1.3	0.5
11:20:29	0:00:27	3.5	1.1
11:20:39	0:00:37	4.8	1.5
11:20:43	0:00:41	5.3	1.4
11:20:55	0:00:53	6.9	2.5
11:21:05	0:01:03	8.2	2.2
11:21:12	0:01:10	9.1	11.7
11:21:18	0:01:16	9.9	20.4
11:21:28	0:01:26	11.2	52.9
11:21:37	0:01:35	12.3	84.4
11:21:45	0:01:43	13.4	101.1
11:21:58	0:01:56	15.1	105.4
11:22:07	0:02:05	16.2	105.4
11:22:14	0:02:12	17.2	105.4
11:22:22	0:02:20	18.2	105.0
11:22:29	0:02:27	19.1	104.4
11:22:38	0:02:36	20.3	103.9
11:22:46	0:02:44	21.3	103.4
11:22:54	0:02:52	22.4	103.2
11:23:04	0:03:02	23.7	102.2
11:23:16	0:03:14	25.2	101.4
11:23:30	0:03:28	27.0	101.6
11:23:40	0:03:38	28.3	102.0
11:23:55	0:03:53	30.3	101.4
11:24:06	0:04:04	31.7	101.2
11:24:24	0:04:22	34.1	101.1
11:24:50	0:04:48	37.4	100.1
11:25:33	0:05:31	43.0	99.2

Peak Torque	*211.5*	(lb-in)
Vane Constant	*5.17*	
Peak Shear Strength	*1093*	*psf*

Remolded Torque	*105.4*	(lb-in)
Vane Constant	*5.17*	
Remolded Shear Strength	*545*	*psf*
Sensitivity	*2.0*	

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Vane Shear Test Report

Project	SCI-823-0.00	Date and Time	7/27/2007	Begin 1:50pm End 2:25pm
Project No.	0121-3070-03	Boring Number	B-1105A	Depth 11.6'
Client	ODOT			
Drill Rig & Crew	D Wamsley			
Tested By	B Mott			
Weather / Temp.	sunny 90			
Soil Type				

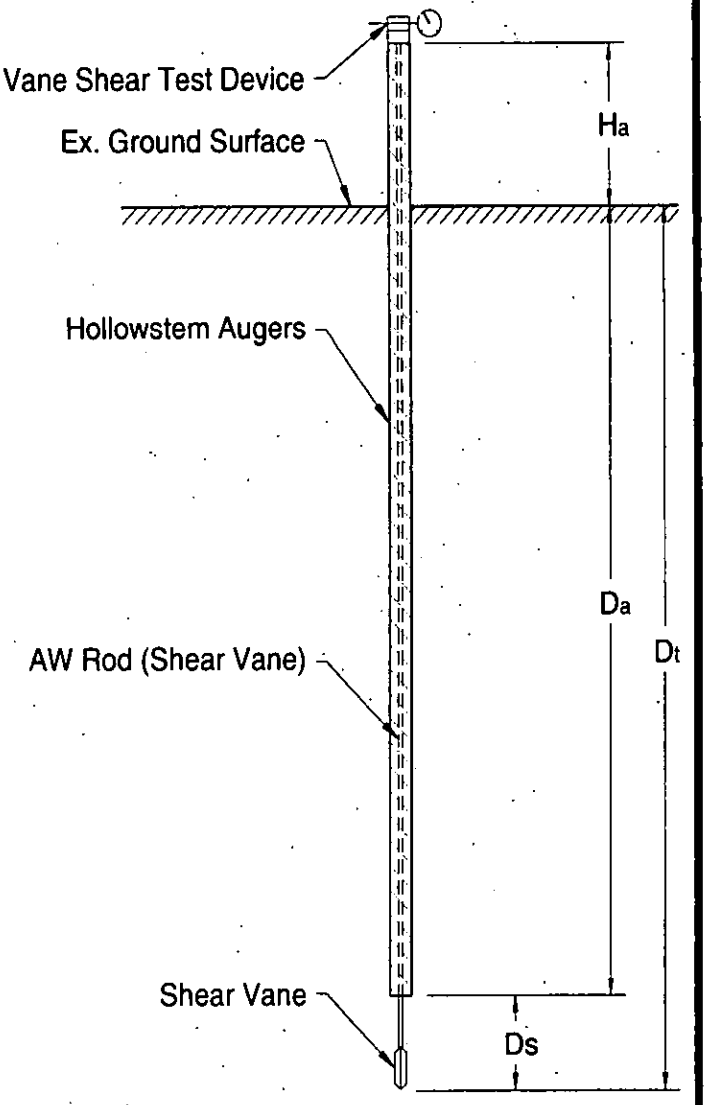
DRILLING

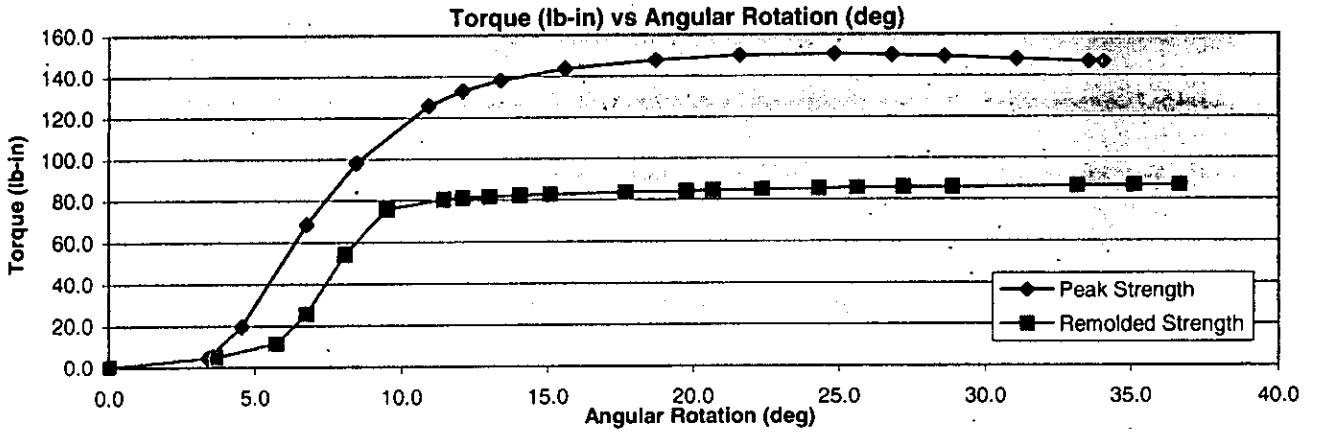
Hollowstem augers to depth	D_a	10.8	
Vane Depth below bottom of augers	D_s	0.8	
Augers above ground surface	H_a	7	
Depth to vane tip	D_t	11.6	

SHEAR VANE

Vane Used	2.0"	2.5"	3.625"
Vane constant, k (lb-in to psf)	5.17	2.59	0.905
Masurement by	Automatic/torque cell		
Max Torque	151	lb-in	
Max UD Shear Strength	***779***	***psf***	

Test Setup





Vane Shear Test Report

Peak Strength Test

Read Time	Δ time	Rotation *(degrees)*	Torque *(in-lbs.)*
14:03:57	0:00:00	0.0	0.0
14:04:23	0:00:26	3.4	4.6
14:04:32	0:00:35	4.5	19.7
14:04:49	0:00:52	6.8	68.6
14:05:02	0:01:05	8.5	98.3
14:05:21	0:01:24	10.9	125.9
14:05:30	0:01:33	12.1	133.1
14:05:40	0:01:43	13.4	138.1
14:05:57	0:02:00	15.6	143.7
14:06:21	0:02:24	18.7	147.7
14:06:43	0:02:46	21.6	149.9
14:07:08	0:03:11	24.8	150.7
14:07:23	0:03:26	26.8	150.1
14:07:37	0:03:40	28.6	149.4
14:07:56	0:03:59	31.1	148.0
14:08:15	0:04:18	33.5	146.6
14:08:19	0:04:22	34.1	146.6

Remolded Strength Test

Read Time	Δ time	Rotation *(degrees)*	Torque *(in-lbs.)*
14:14:10	0:00:00	0.0	0.0
14:14:38	0:00:28	3.6	5.0
14:14:54	0:00:44	5.7	11.5
14:15:02	0:00:52	6.8	25.7
14:15:12	0:01:02	8.1	54.1
14:15:23	0:01:13	9.5	75.8
14:15:38	0:01:28	11.4	80.2
14:15:43	0:01:33	12.1	80.9
14:15:50	0:01:40	13.0	81.4
14:15:58	0:01:48	14.0	82.1
14:16:06	0:01:56	15.1	82.5
14:16:26	0:02:16	17.7	83.6
14:16:42	0:02:32	19.8	83.9
14:16:49	0:02:39	20.7	84.4
14:17:02	0:02:52	22.4	84.7
14:17:17	0:03:07	24.3	85.2
14:17:27	0:03:17	25.6	85.5
14:17:39	0:03:29	27.2	85.8
14:17:52	0:03:42	28.9	85.8
14:18:25	0:04:15	33.2	86.5
14:18:40	0:04:30	35.1	86.7
14:18:52	0:04:42	36.7	86.8

Peak Torque	*150.7*	(lb-in)
Vane Constant	*5.17*	
Peak Shear Strength	*779*	*psf*

Remolded Torque	*86.8*	(lb-in)
Vane Constant	*5.17*	
Remolded Shear Strength	*449*	*psf*
Sensitivity	*1.7*	

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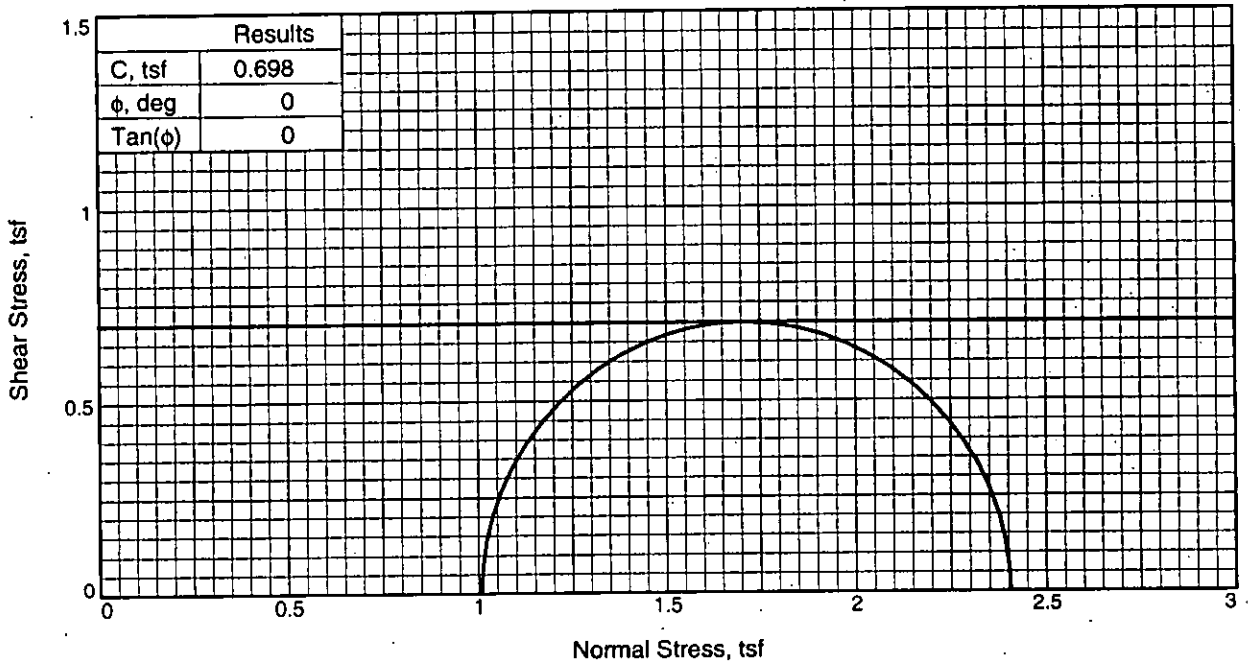

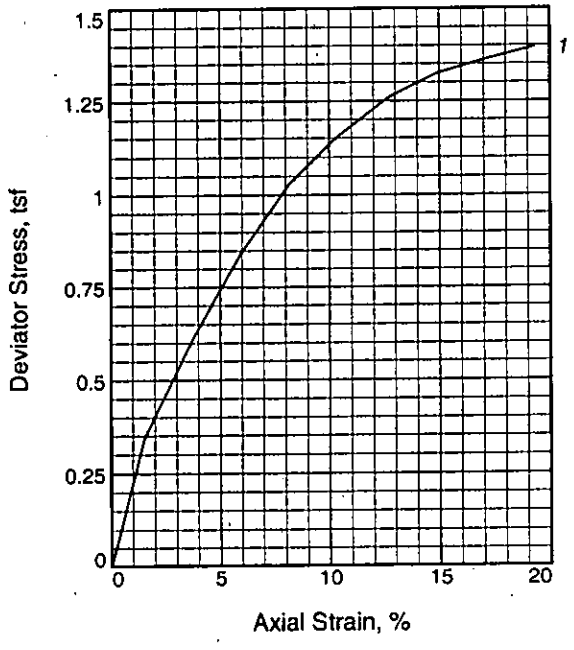

Sample No.		1
Initial	Water Content,	24.1
	Dry Density, pcf	100.0
	Saturation,	92.4
	Void Ratio	0.7176
	Diameter, in.	2.82
	Height, in.	5.54
At Test	Water Content,	24.1
	Dry Density, pcf	100.0
	Saturation,	92.4
	Void Ratio	0.7176
	Diameter, in.	2.82
	Height, in.	5.54
Strain rate, in./min.		0.06
Back Pressure, tsf		0.00
Cell Pressure, tsf		1.01
Fail. Stress, tsf		1.40
Ult. Stress, tsf		
σ_1 Failure, tsf		2.40
σ_3 Failure, tsf		1.01

Type of Test:
Unconsolidated Undrained
Sample Type: Press Tube
Description:

LL= 30 **PL=** 19 **PI=** 11
Assumed Specific Gravity= 2.75
Remarks:

Figure _____

Client: TranSystems, Inc.

Project: SCI-823-0.00

Source of Sample: B-1105A **Depth:** 12.0

Sample Number: ST3

Proj. No.: 0121-3070.03 **Date:** 8/24/07

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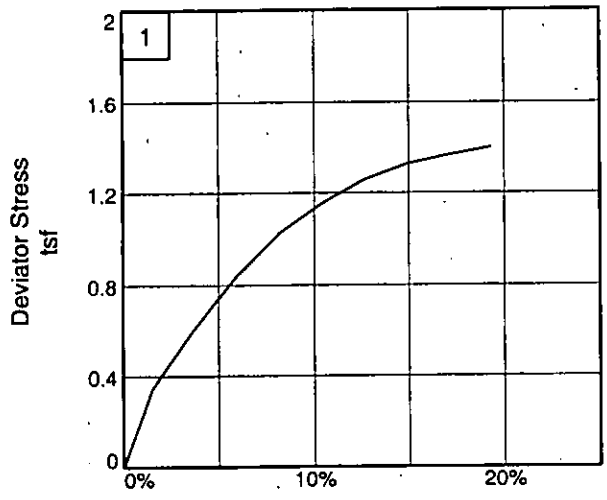
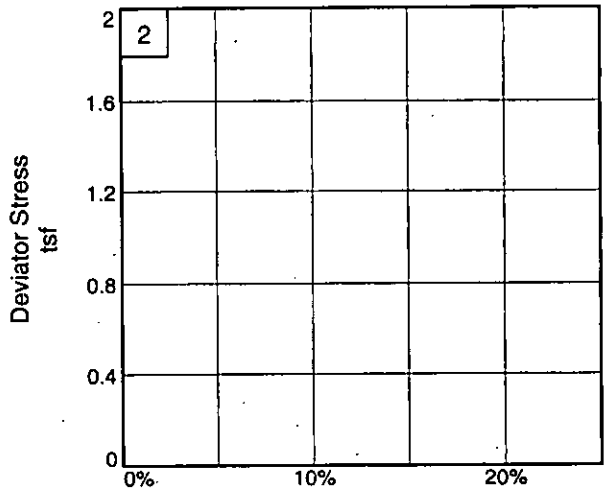
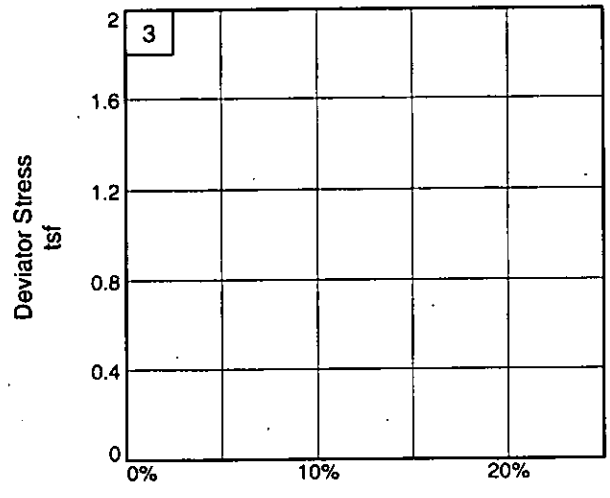
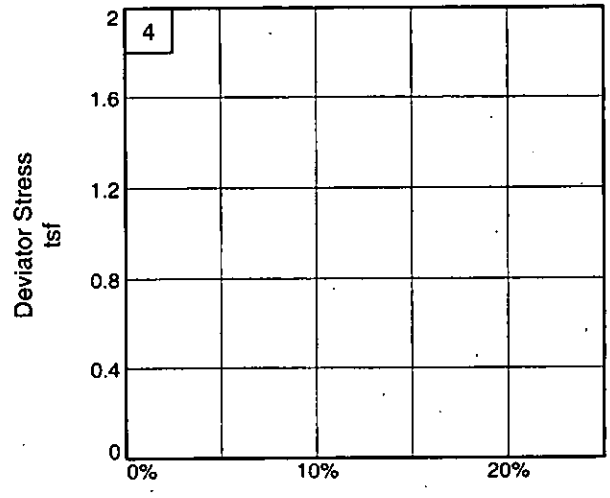
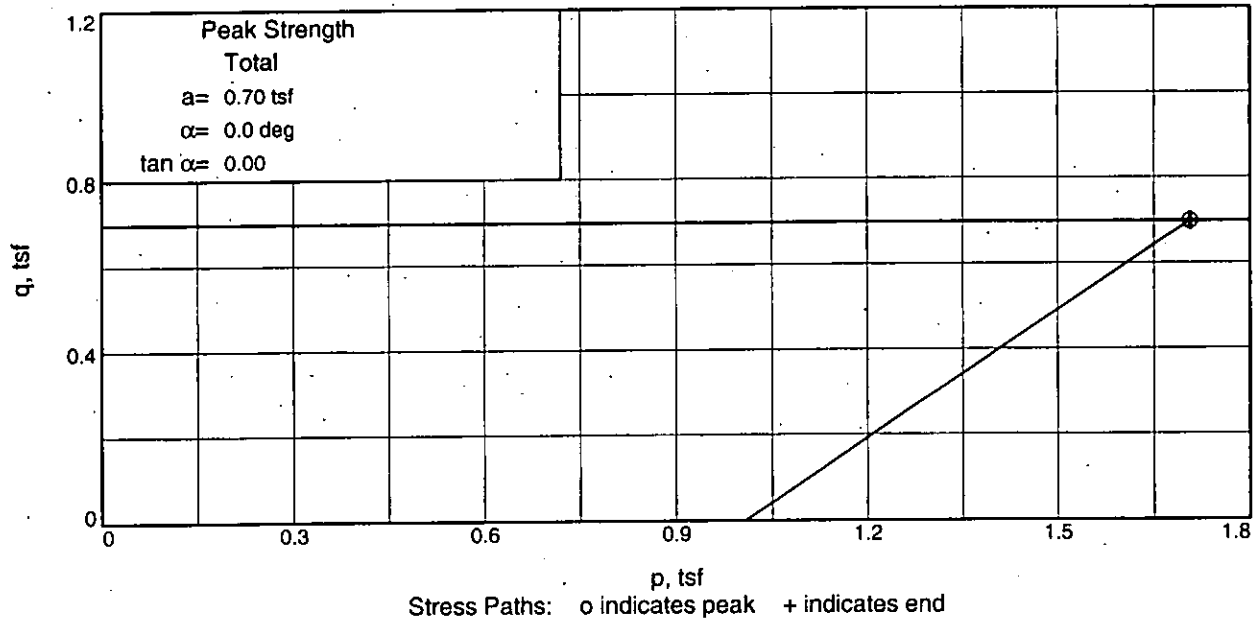










Stress Paths: o indicates peak + indicates end

Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-1105A
Project No.: 0121-3070.03

Depth: 12.0
Figure _____

Sample Number: ST3

DLZ, INC.

Vane Shear Test Report

Project	SCI-823-0.00	Date and Time	7/27/2007	Begin 2:30pm
Project No.	0121-3070-03	Boring Number	B-1105A	End 3:00pm
Client	ODOT			Depth 13.7'
Drill Rig & Crew	D Wamsley			
Tested By	B Mott			
Weather / Temp.	sunny 90			
Soil Type				

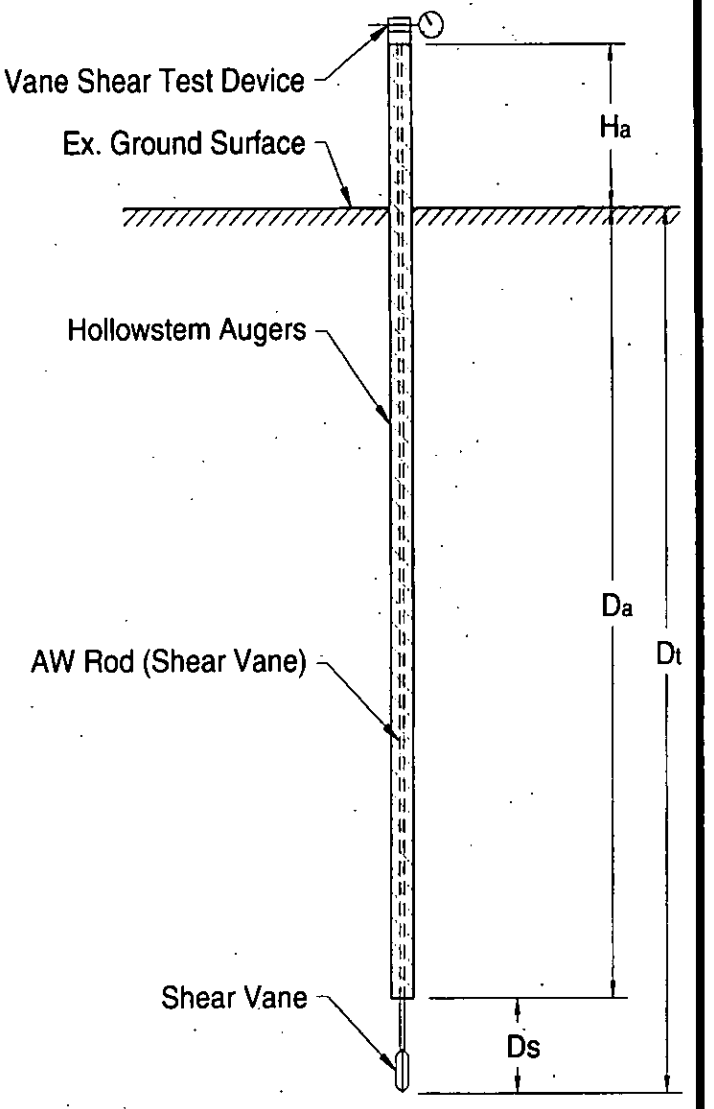
DRILLING

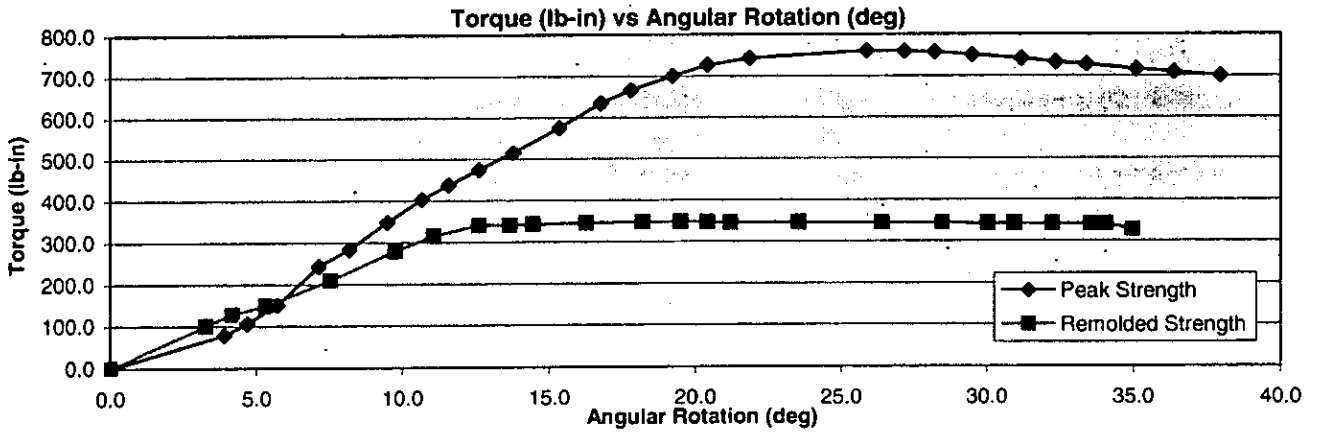
Hollowstem augers to depth	D_a	12.9
Vane Depth below bottom of augers	D_s	0.8
Augers above ground surface	H_a	7
Depth to vane tip	D_t	13.7

SHEAR VANE

Vane Used	2.0"	2.5"	3.625"
Vane constant, k (lb-in to psf)	5.17	2.59	0.905
Masurement by	Automatic/torque cell		
Max Torque	761	lb-in	
Max UD Shear Strength	***3933***	***psf***	

Test Setup





Vane Shear Test Report

Read Time	Δ time	Rotation *(degrees)*	Torque *(in-lbs.)*
Peak Strength Test			
14:34:18	0:00:00	*0.0*	0.0
14:34:48	0:00:30	*3.9*	78.2
14:34:54	0:00:36	*4.7*	106.8
14:35:02	0:00:44	*5.7*	151.1
14:35:13	0:00:55	*7.2*	243.3
14:35:21	0:01:03	*8.2*	282.7
14:35:31	0:01:13	*9.5*	348.3
14:35:40	0:01:22	*10.7*	402.7
14:35:47	0:01:29	*11.6*	437.9
14:35:55	0:01:37	*12.6*	474.1
14:36:04	0:01:46	*13.8*	515.1
14:36:16	0:01:58	*15.3*	576.4
14:36:27	0:02:09	*16.8*	634.8
14:36:35	0:02:17	*17.8*	666.4
14:36:46	0:02:28	*19.2*	700.1
14:36:55	0:02:37	*20.4*	727.2
14:37:06	0:02:48	*21.8*	743.2
14:37:37	0:03:19	*25.9*	760.7
14:37:47	0:03:29	*27.2*	759.3
14:37:55	0:03:37	*28.2*	757.0
14:38:05	0:03:47	*29.5*	750.8
14:38:18	0:04:00	*31.2*	741.6
14:38:27	0:04:09	*32.4*	733.3
14:38:35	0:04:17	*33.4*	727.3
14:38:48	0:04:30	*35.1*	716.1
14:38:58	0:04:40	*36.4*	708.7
14:39:10	0:04:52	*38.0*	699.8

Read Time	Δ time	Rotation *(degrees)*	Torque *(in-lbs.)*
Remolded Strength Test			
14:46:36	0:00:00	0.0	0.0
14:47:01	0:00:25	3.3	100.6
14:47:08	0:00:32	4.2	128.0
14:47:17	0:00:41	5.3	149.2
14:47:34	0:00:58	7.5	209.5
14:47:51	0:01:15	9.8	279.2
14:48:01	0:01:25	11.1	315.0
14:48:13	0:01:37	12.6	339.6
14:48:21	0:01:45	13.7	340.0
14:48:27	0:01:51	14.4	342.0
14:48:41	0:02:05	16.3	345.0
14:48:56	0:02:20	18.2	346.9
14:49:06	0:02:30	19.5	347.5
14:49:13	0:02:37	20.4	346.2
14:49:19	0:02:43	21.2	345.2
14:49:37	0:03:01	23.5	344.9
14:49:59	0:03:23	26.4	344.0
14:50:15	0:03:39	28.5	343.6
14:50:27	0:03:51	30.0	342.4
14:50:34	0:03:58	30.9	342.3
14:50:44	0:04:08	32.2	341.5
14:50:54	0:04:18	33.5	340.9
14:50:58	0:04:22	34.1	340.5
14:51:05	0:04:29	35.0	327.4

Peak Torque	*760.7*	(lb-in)
Vane Constant	*5.17*	
Peak Shear Strength	*3933*	*psf*

Remolded Torque	*347.5*	(lb-in)
Vane Constant	*5.17*	
Remolded Shear Strength	*1796*	*psf*
Sensitivity	*2.2*	

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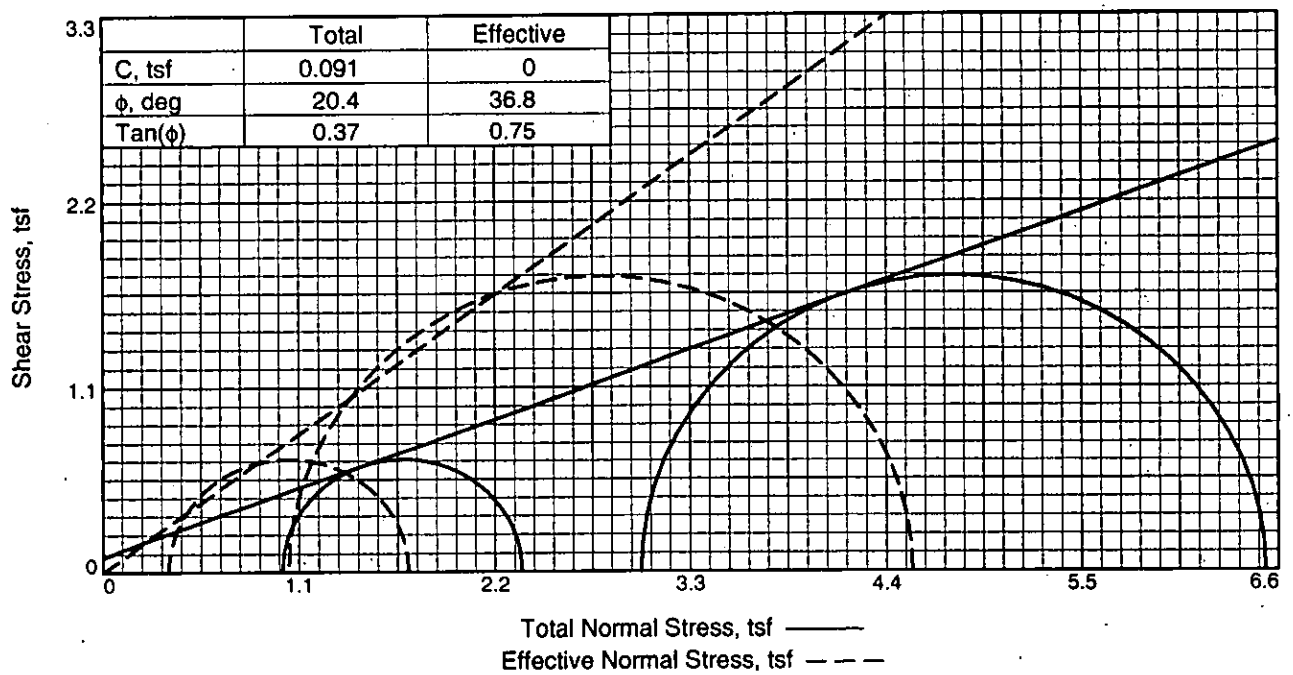

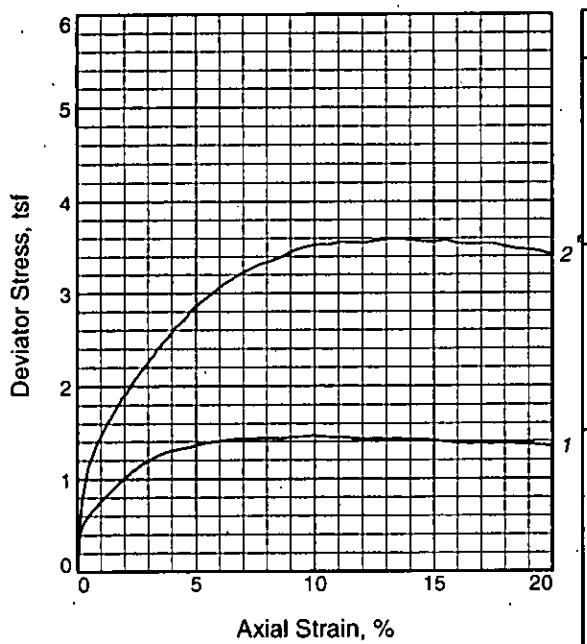

Sample No.		1	2
Initial	Water Content,	27.6	24.7
	Dry Density, pcf	91.6	96.3
	Saturation,	86.8	86.9
	Void Ratio	0.8742	0.7830
	Diameter, in.	2.82	2.79
	Height, in.	5.54	4.95
At Test	Water Content,	28.5	24.2
	Dry Density, pcf	96.3	103.1
	Saturation,	100.0	100.0
	Void Ratio	0.7834	0.6657
	Diameter, in.	2.78	2.74
	Height, in.	5.44	4.79
Strain rate, in./min.		0.01	0.01
Back Pressure, tsf		3.31	3.31
Cell Pressure, tsf		4.32	6.34
Fail. Stress, tsf		1.34	3.50
Total Pore Pr., tsf		3.95	5.29
Ult. Stress, tsf		1.34	3.50
Total Pore Pr., tsf		3.95	5.29
$\bar{\sigma}_1$ Failure, tsf		1.71	4.55
$\bar{\sigma}_3$ Failure, tsf		0.37	1.04

Type of Test:
CU with Pore Pressures
Sample Type: Press tube
Description:

LL= 38 **PL=** 21 **PI=** 17
Assumed Specific Gravity= 2.75
Remarks:

Figure _____

Client: TranSystems, Inc.

Project: SCI-823-0.00

Source of Sample: B-1105A **Depth:** 16.0
Sample Number: ST4

Proj. No.: 0121-3070.03 **Date:** 8/24/07

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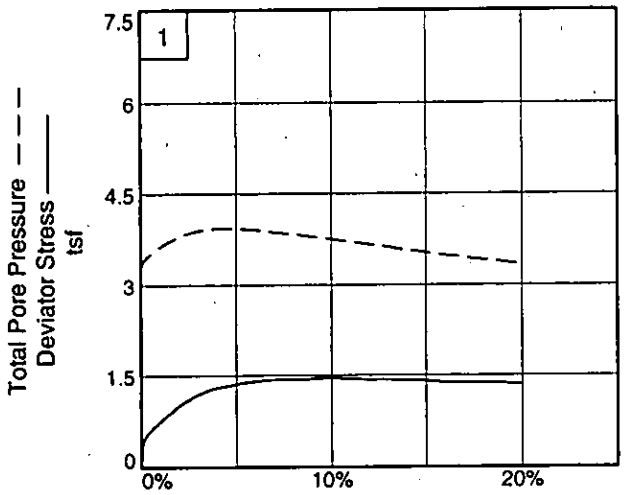
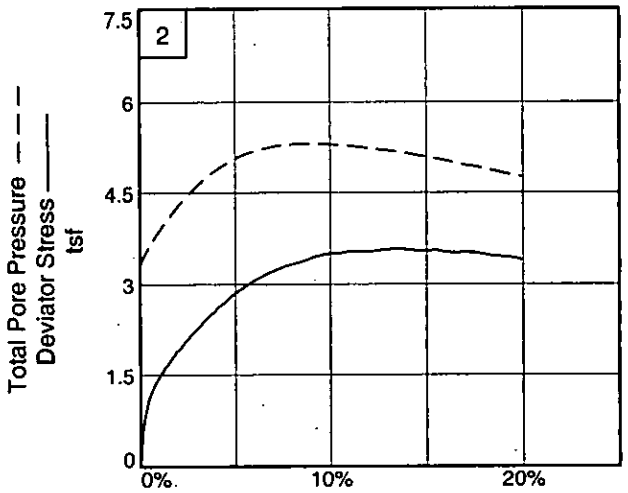
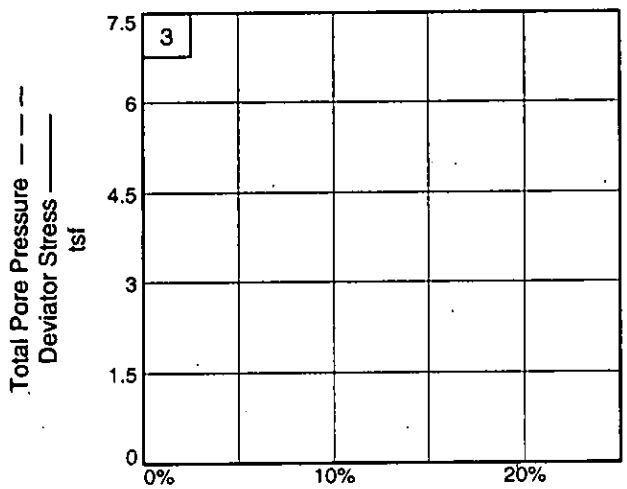
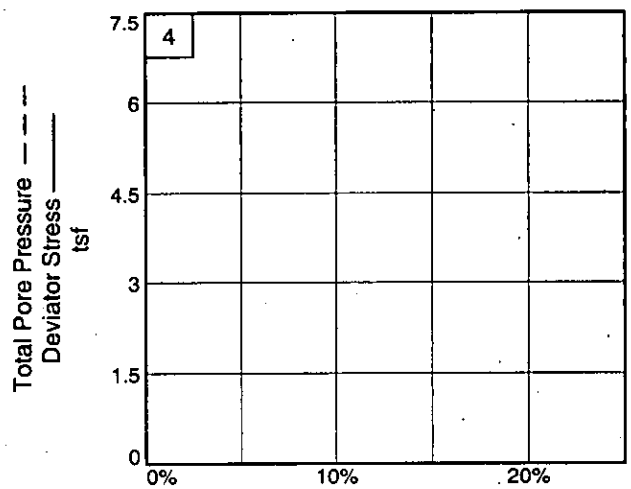
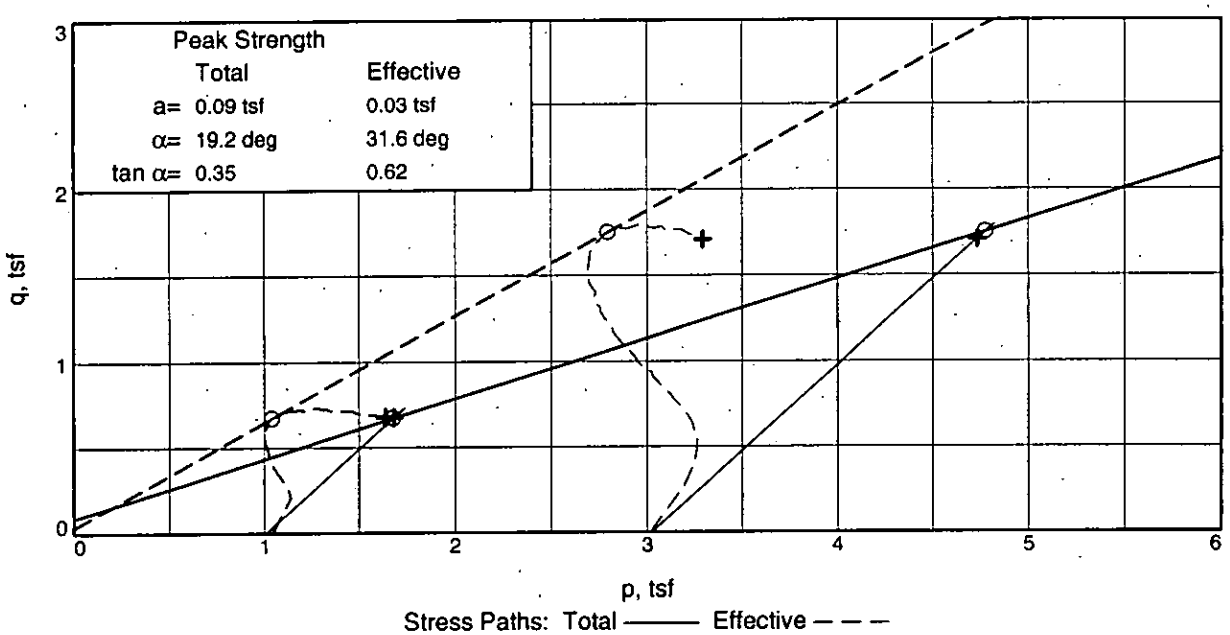






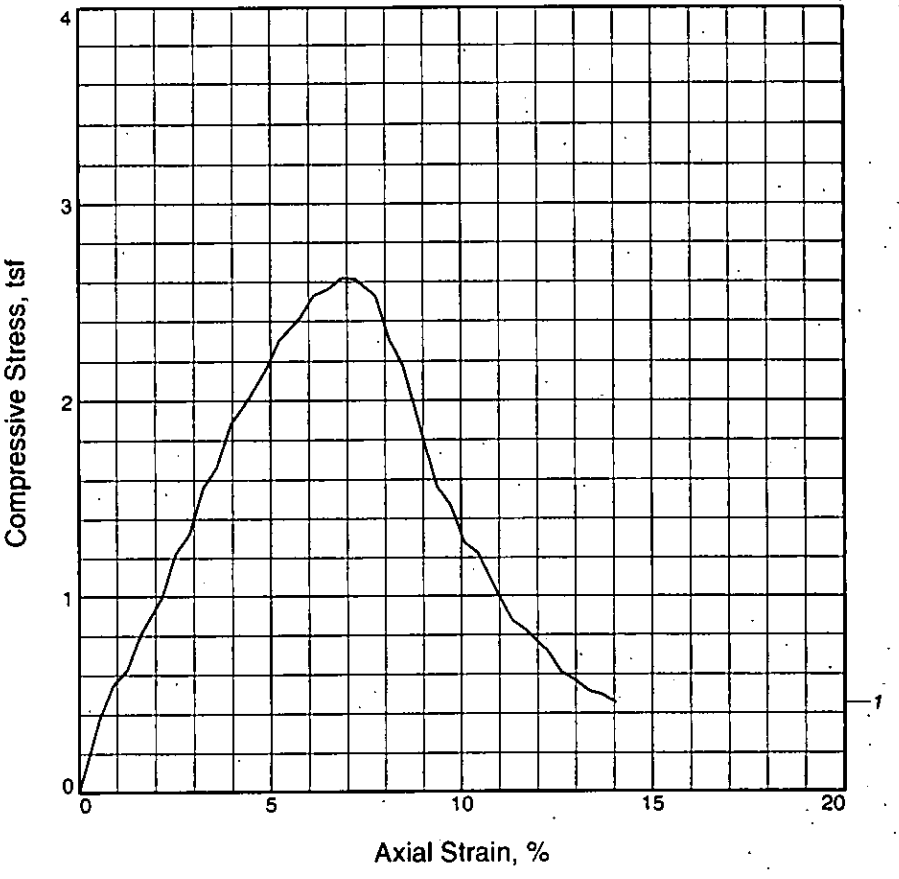




Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-1105A
Project No.: 0121-3070.03
Depth: 16.0
Figure _____
Sample Number: ST4

DLZ, INC.

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	2.618			
Undrained shear strength, tsf	1.309			
Failure strain,	6.8			
Strain rate, in./min.	0.06			
Water content, %	22.4			
Wet density, pcf	126.5			
Dry density, pcf	103.4			
Saturation, %	93.1			
Void ratio	0.6602			
Specimen diameter, in.	2.83			
Specimen height, in.	5.55			
Height/diameter ratio	1.96			

Description: Moisture Content = 22.4%

LL = 36	**PL** = 21	**PI** = 15	**Assumed GS=** 2.75	**Type:** 3" Press Tubes

Project No.: 0121-3070.03

Date: 08/16/06

Remarks:

Figure _____

Client: TranSystems, Inc.

Project: SCI-823-0.00

Source of Sample: B-1108 **Depth:** 10.0

Sample Number: P1

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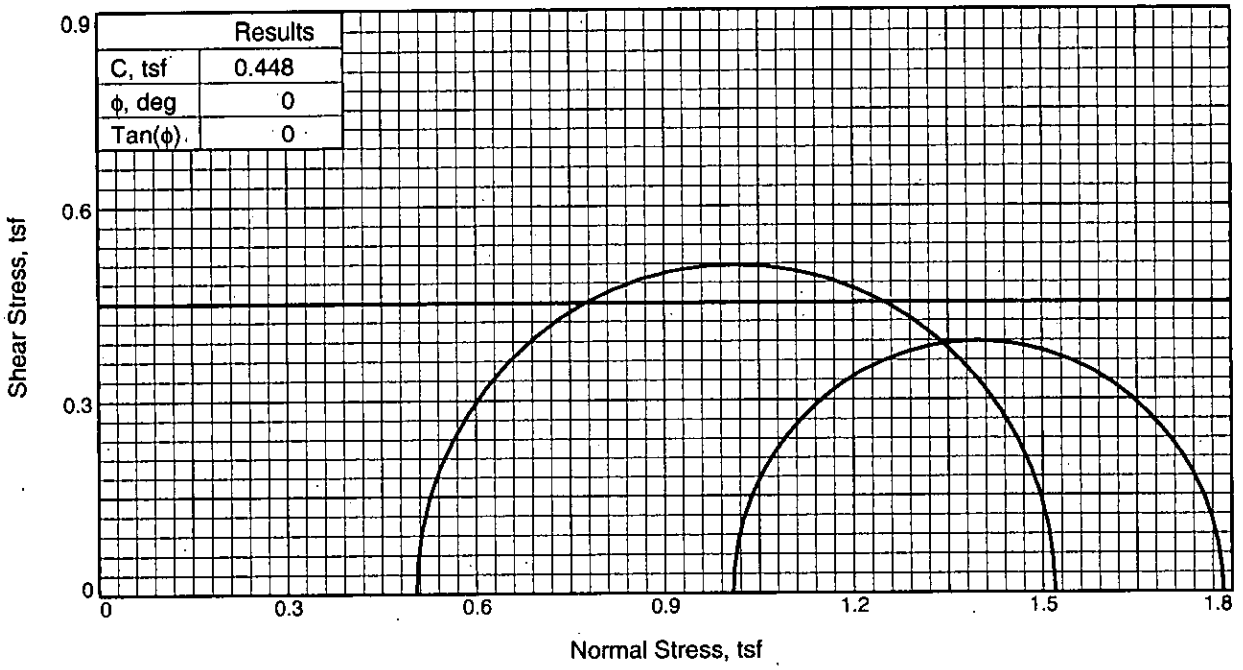
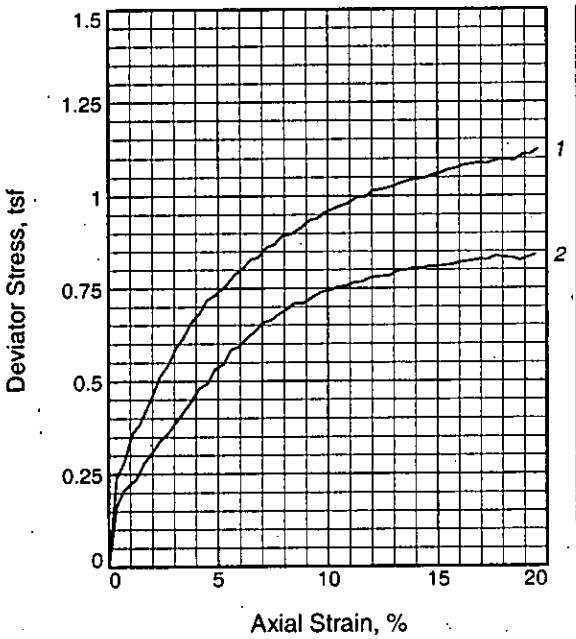




Sample No.		1	2
Initial	Water Content,	30.2	32.6
	Dry Density, pcf	95.2	89.5
	Saturation,	103.3	97.8
	Void Ratio	0.8041	0.9172
	Diameter, in.	2.83	2.84
	Height, in.	5.56	5.54
At Test	Water Content,	27.0	31.8
	Dry Density, pcf	95.2	89.5
	Saturation,	92.2	95.2
	Void Ratio	0.8041	0.9172
	Diameter, in.	2.83	2.84
	Height, in.	5.56	5.54
Strain rate, in./min.		0.06	0.06
Back Pressure, tsf		0.00	0.00
Cell Pressure, tsf		0.50	1.01
Fail. Stress, tsf		1.02	0.78
Ult. Stress, tsf		1.02	0.78
σ_1 Failure, tsf		1.52	1.79
σ_3 Failure, tsf		0.50	1.01

Type of Test:
Unconsolidated Undrained
Sample Type: 3" Press Tube
Description: Lean clay with sand

LL= 38 **PL=** 19 **PI=** 19
Assumed Specific Gravity= 2.75
Remarks:

Client: TranSystems, Inc.

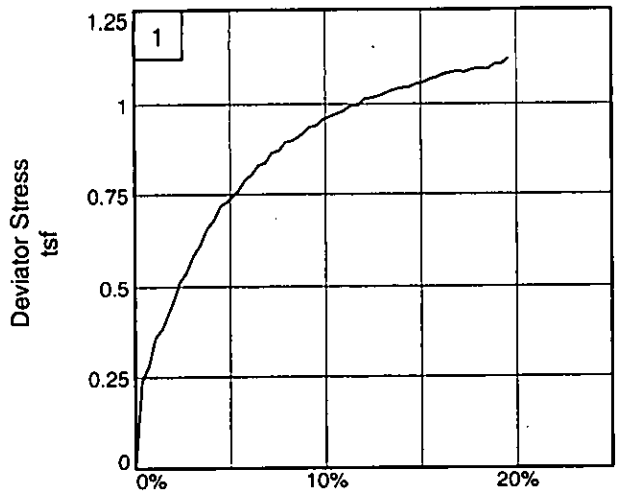
Project: SCI-823-0.00

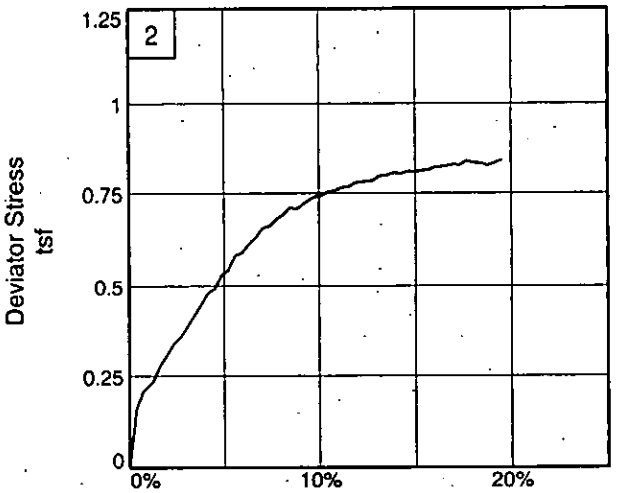
Source of Sample: B-1108 **Depth:** 14.0
Sample Number: P2

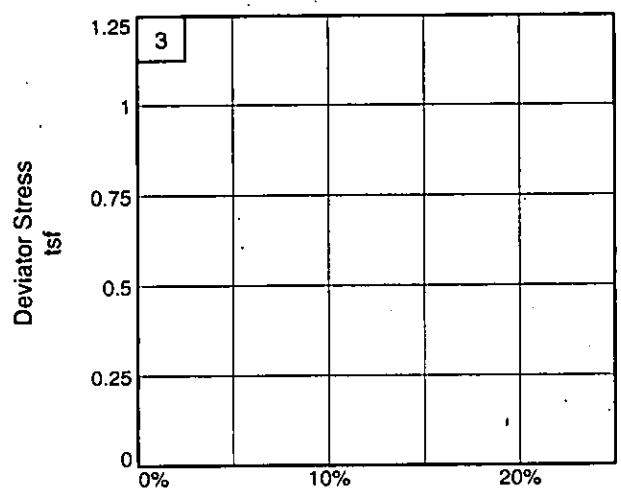
Proj. No.: 0121-3070.03 **Date:** 08/16/06

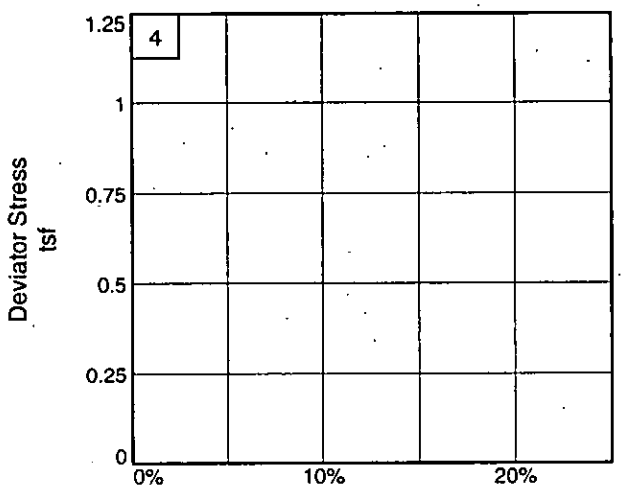
DLZ

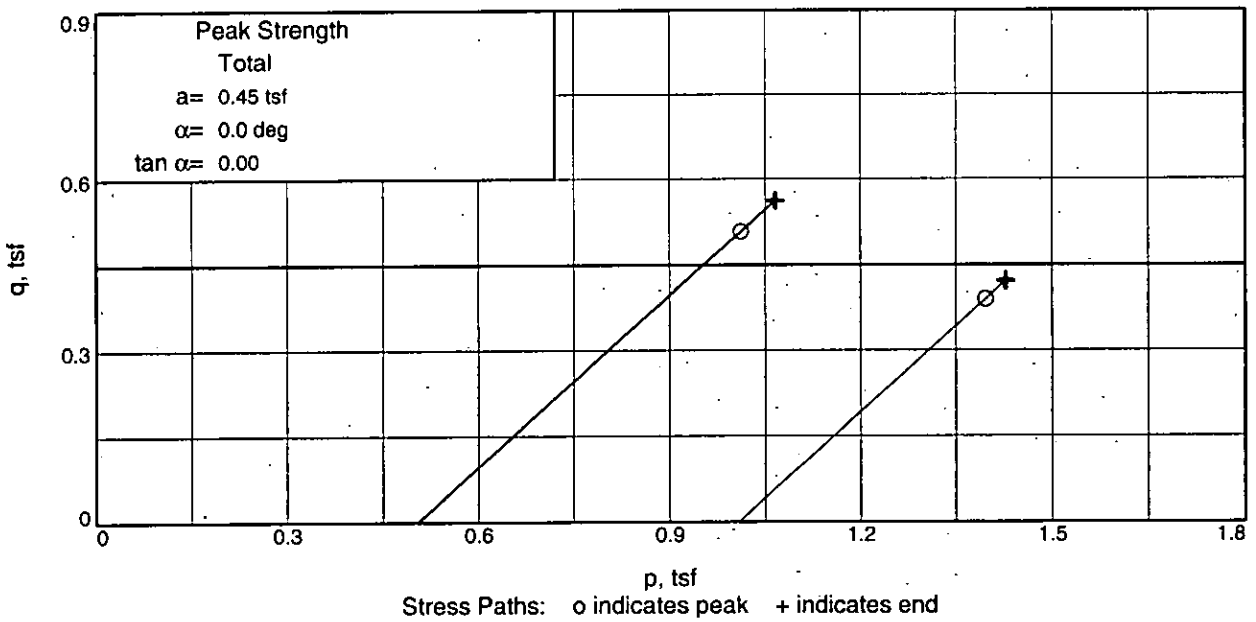
Figure _____







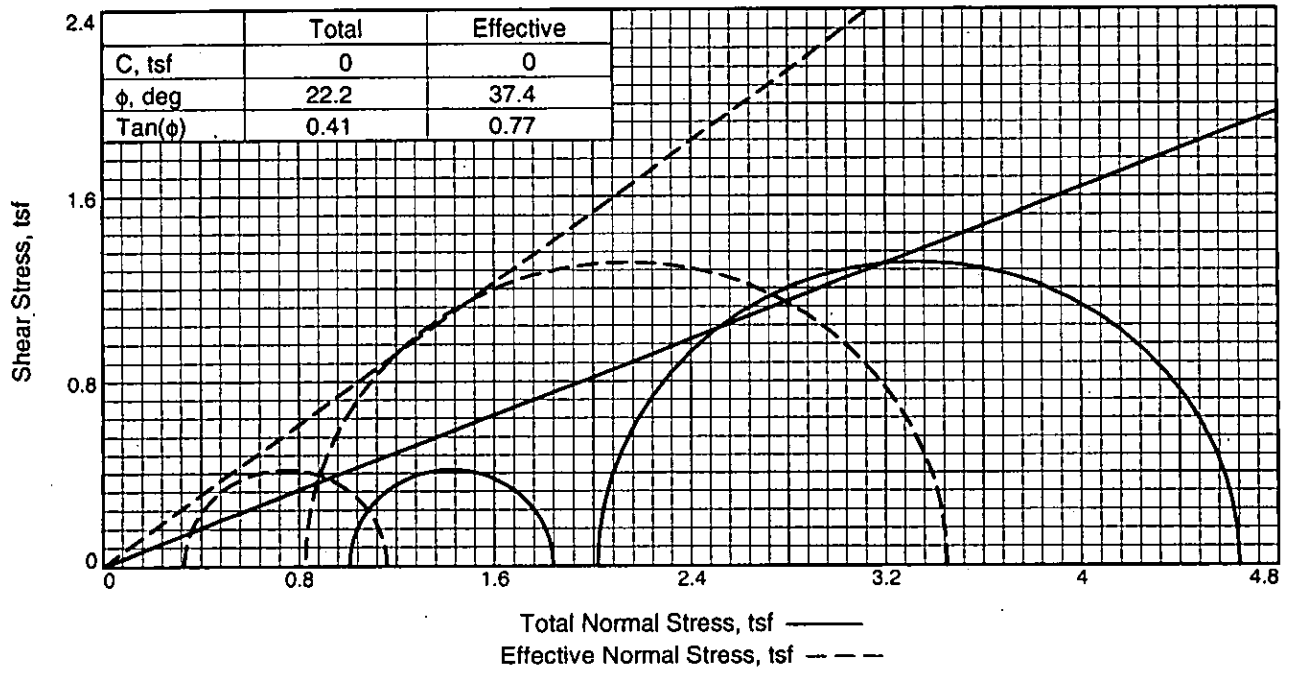


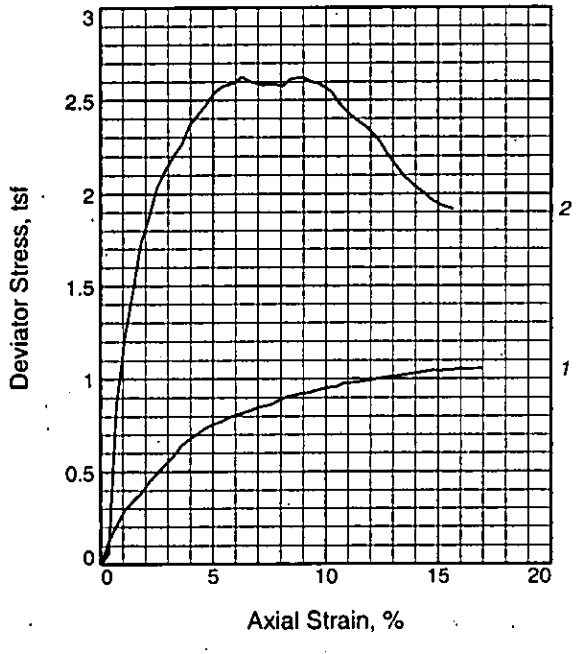


Stress Paths: o indicates peak + indicates end

Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-1108
Depth: 14.0
Sample Number: P2
Project No.: 0121-3070.03
Figure _____

DLZ, INC.





Sample No.		1	2
Initial	Water Content,	28.4	29.1
	Dry Density, pcf	95.8	95.6
	Saturation,	98.7	100.4
	Void Ratio	0.7914	0.7964
	Diameter, in.	2.84	2.83
	Height, in.	5.56	5.56
At Test	Water Content,	26.3	25.7
	Dry Density, pcf	99.7	100.6
	Saturation,	100.0	100.0
	Void Ratio	0.7223	0.7068
	Diameter, in.	2.79	2.76
	Height, in.	5.56	5.56
Strain rate, in./min.		0.06	0.06
Back Pressure, tsf		4.03	4.03
Cell Pressure, tsf		5.04	6.05
Fail. Stress, tsf		0.83	2.63
Total Pore Pr., tsf		4.71	5.22
Ult. Stress, tsf		0.83	2.63
Total Pore Pr., tsf		4.71	5.22
$\bar{\sigma}_1$ Failure, tsf		1.16	3.45
$\bar{\sigma}_3$ Failure, tsf		0.33	0.82

Type of Test:
CU with Pore Pressures
Sample Type: 3" Press TUbe
Description: Lean clay

LL= 38 **PL=** 19 **PI=** 19
Assumed Specific Gravity= 2.75
Remarks:

Client: TranSystems, Inc.

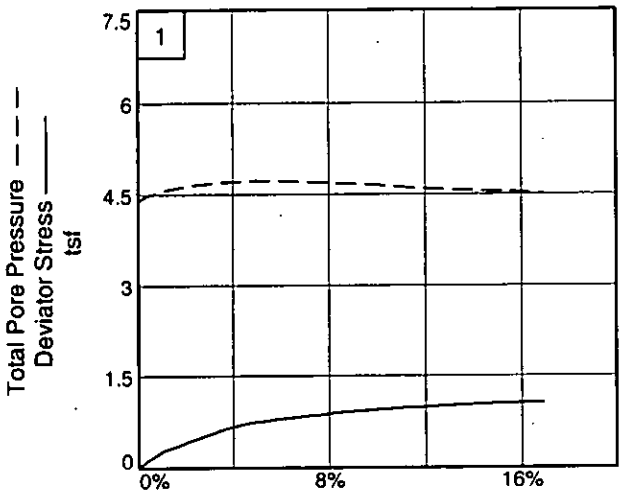
Project: SCI-823-0.00

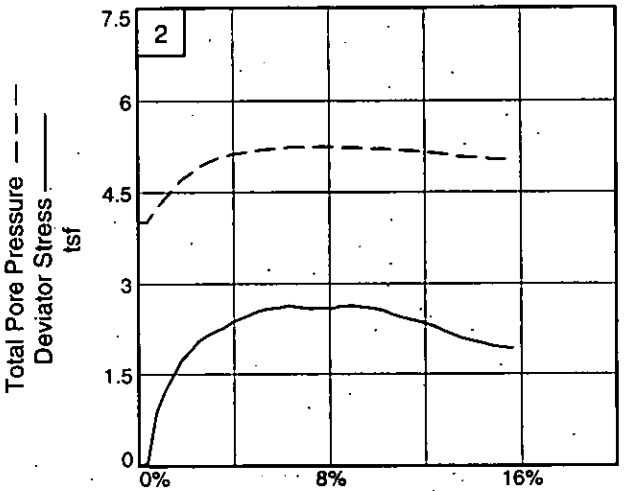
Source of Sample: B-1108 **Depth:** 18.0
Sample Number: P3

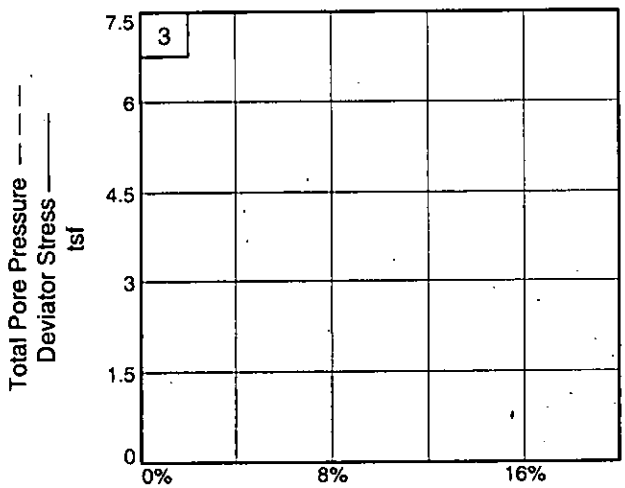
Proj. No.: 0121-3070.03 **Date:** 08/16/06

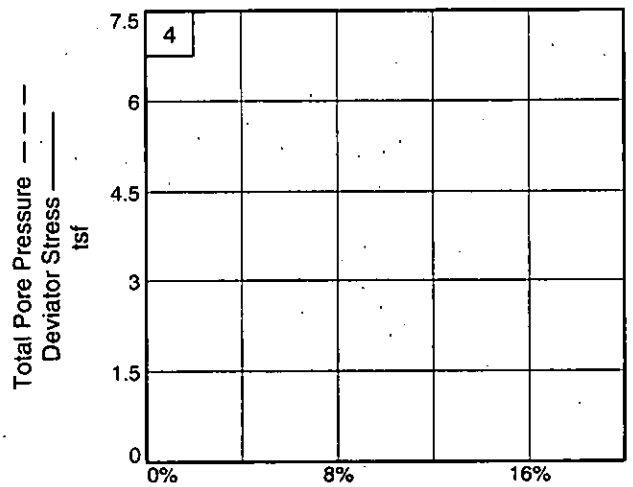
DLZ

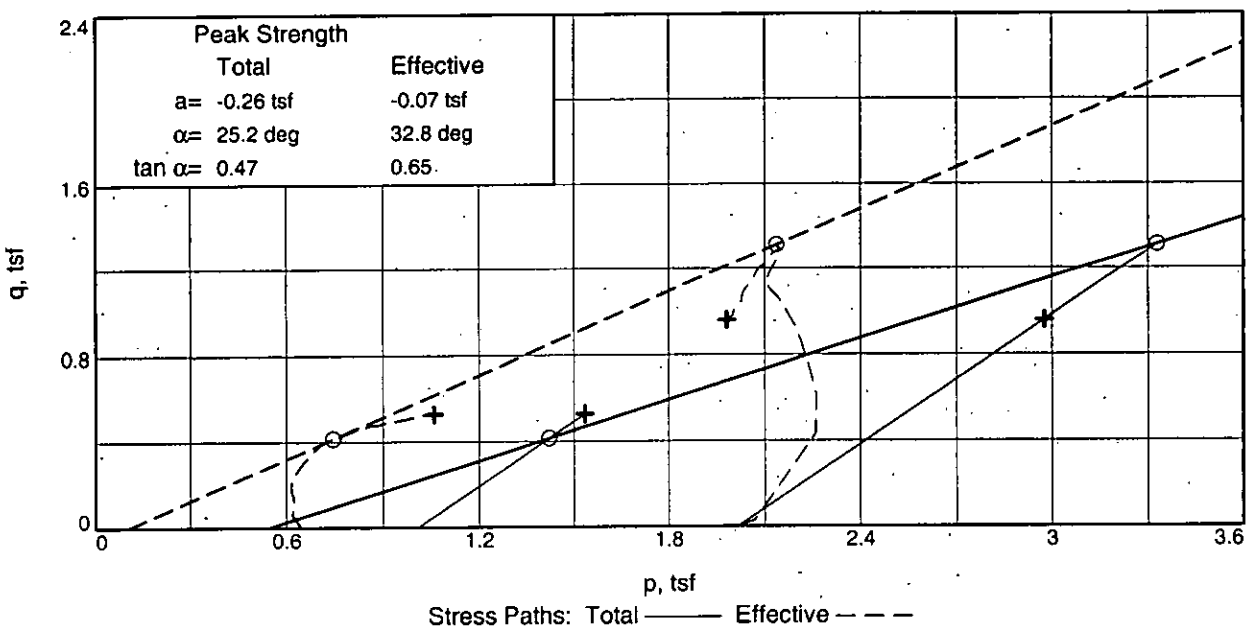
Figure _____









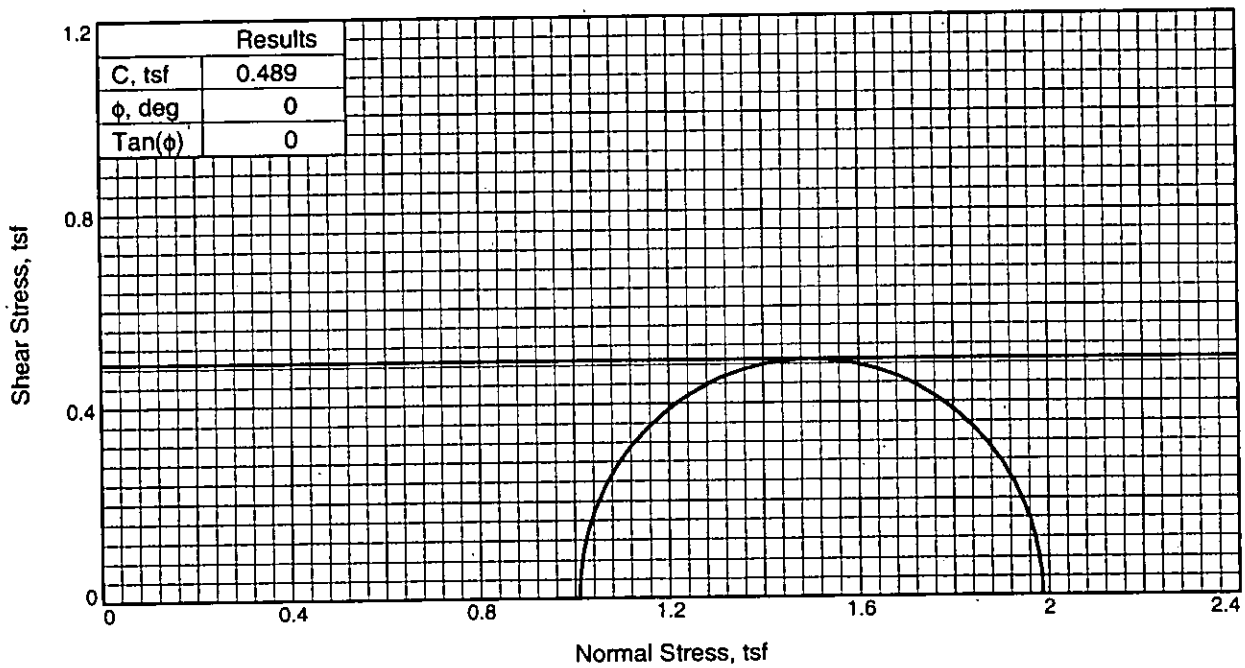


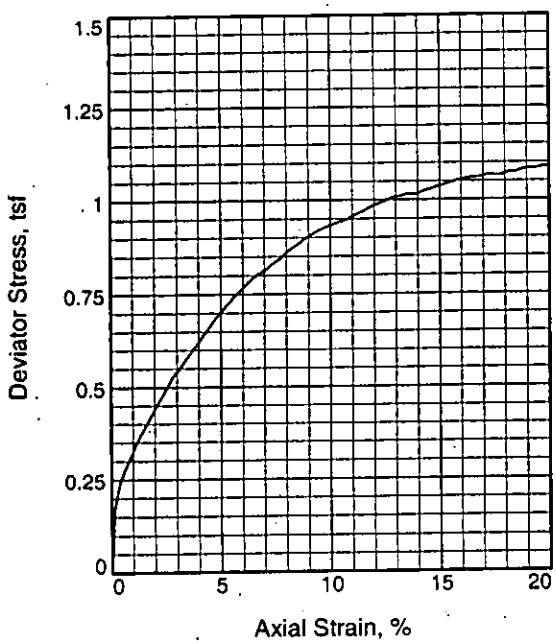
Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-1108
Project No.: 0121-3070.03

Depth: 18.0
Figure _____

Sample Number: P3

DLZ, INC.





Sample No.		1
Initial	Water Content,	26.2
	Dry Density, pcf	97.9
	Saturation,	96.8
	Void Ratio	0.7405
	Diameter, in.	2.84
	Height, in.	5.56
At Test	Water Content,	26.8
	Dry Density, pcf	97.9
	Saturation,	98.7
	Void Ratio	0.7405
	Diameter, in.	2.84
	Height, in.	5.56
Strain rate, in./min.		0.06
Back Pressure, tsf		0.00
Cell Pressure, tsf		1.01
Fail. Stress, tsf		0.98
Ult. Stress, tsf		0.98
σ_1 Failure, tsf		1.99
σ_3 Failure, tsf		1.01

Type of Test:
Unconsolidated Undrained
Sample Type: Press Tube
Description:

LL= 57 **PL=** 30 **PI=** 27
Assumed Specific Gravity= 2.73
Remarks:

Figure _____

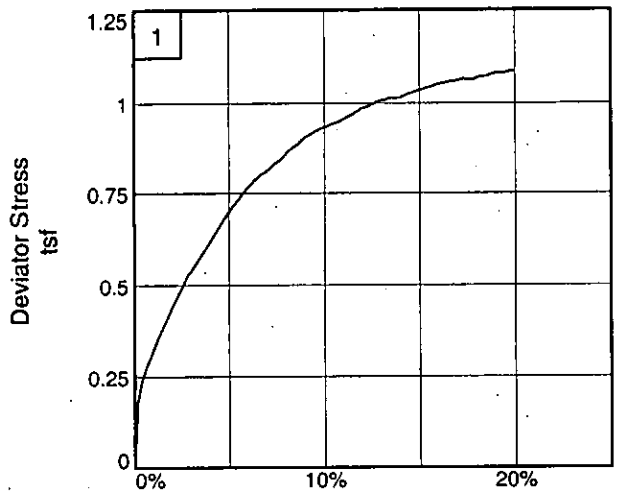
Client: TranSystems, Inc.

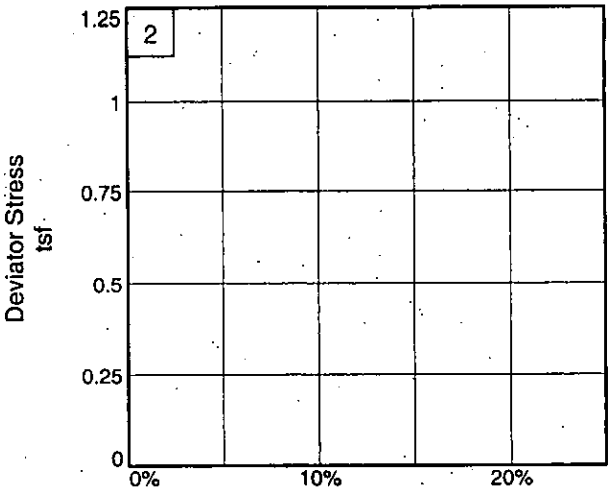
Project: SCI-823-0.00

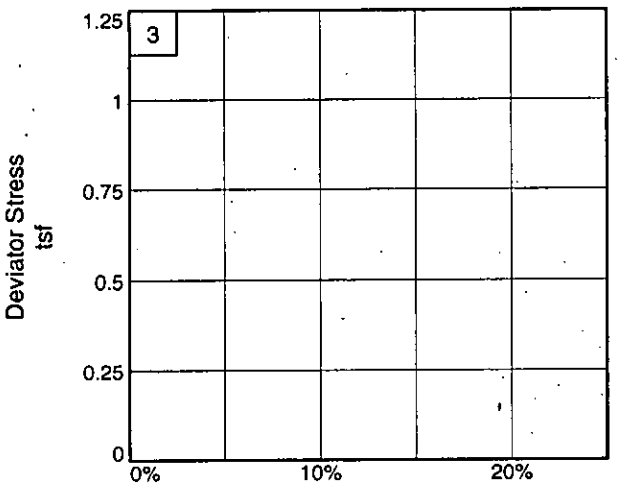
Source of Sample: B-1109A **Depth:** 8.0
Sample Number: ST2

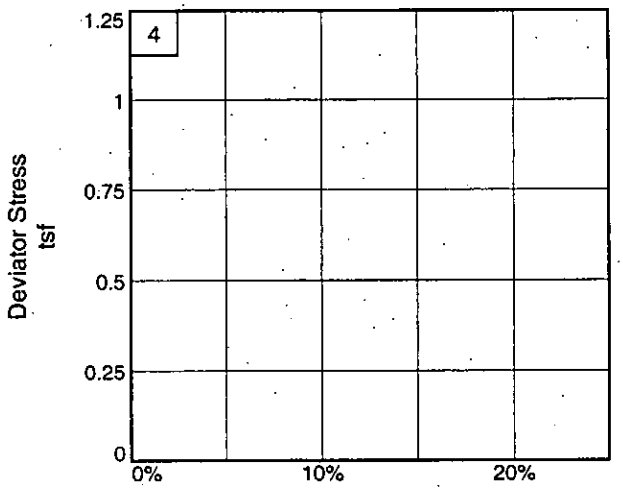
Proj. No.: 0121-3070.03 **Date:** 8/24/07

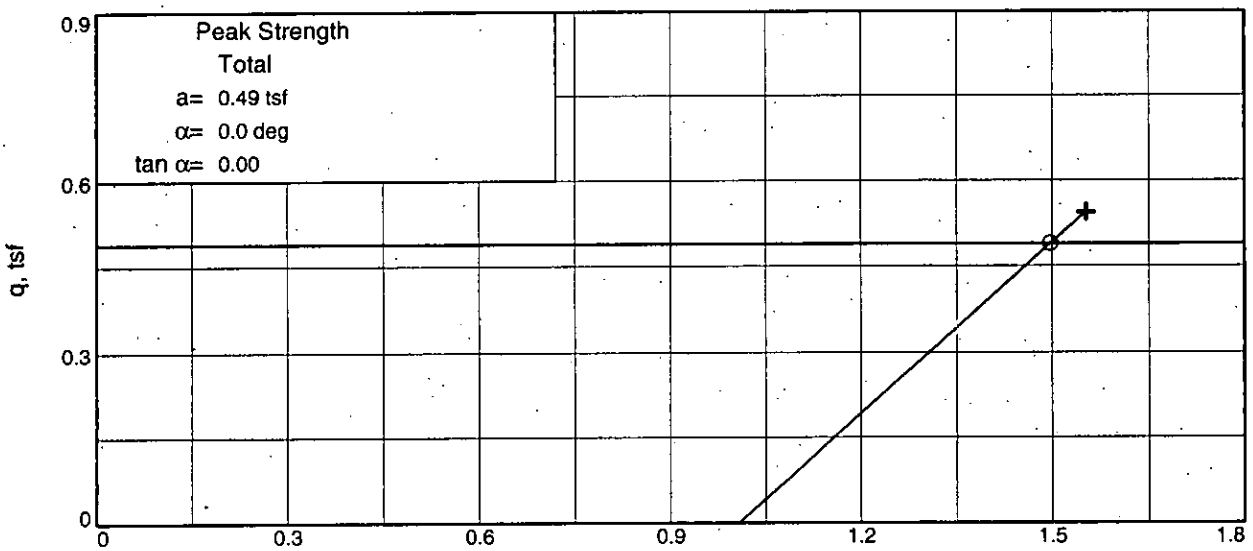
DLZ











Stress Paths: o indicates peak + indicates end

Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-1109A
Project No.: 0121-3070.03
Depth: 8.0
Figure _____
Sample Number: ST2

DLZ, INC.

Vane Shear Test Report

Project	SCI-823-0.00	Date and Time	7/27/2007 Begin 3:30pm End 3:50pm
Project No.	0121-3070-03	Boring Number	B-1109a Depth 8.0
Client	ODOT		
Drill Rig & Crew	D Wamsley		
Tested By	B Mott		
Weather / Temp.	sunny 85		
Soil Type			

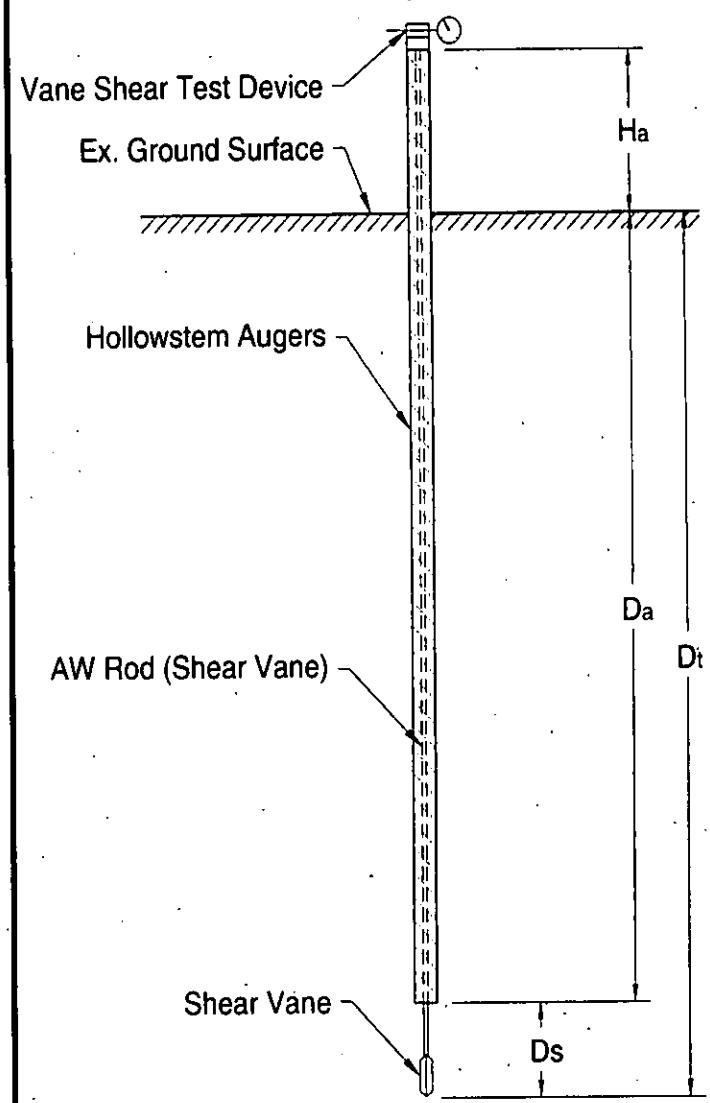
DRILLING

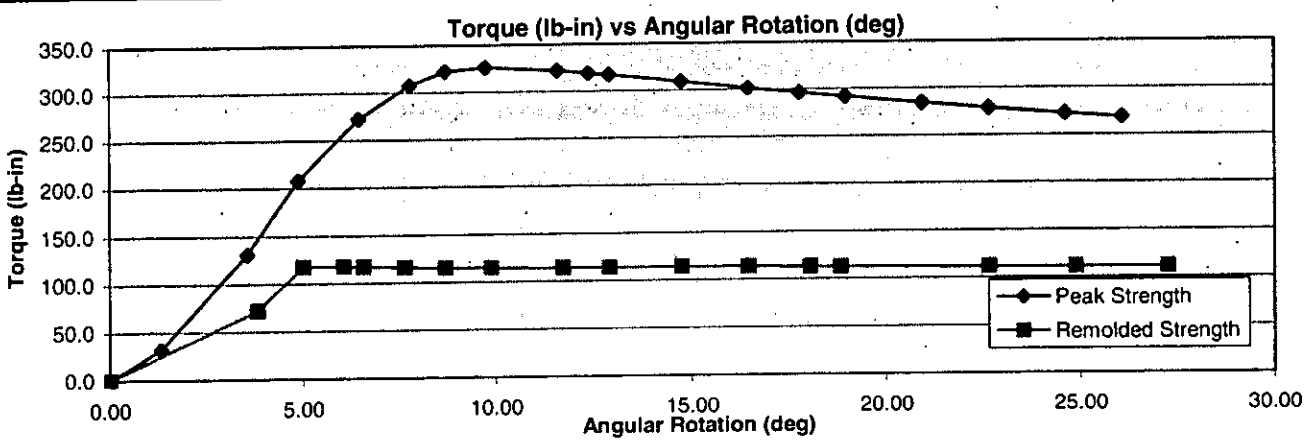
Hollowstem augers to depth	D_a	7.5
Vane Depth below bottom of augers	D_s	1
Augers above ground surface	H_a	7
Depth to vane tip	D_t	8

SHEAR VANE

Vane Used	**2.0"**	2.5"	3.625"
Vane constant, k (lb-in to psf)	**5.17**	2.59	0.905
Masurement by	Automatic/torque cell		
Max Torque	326	lb-in	
Max UD Shear Strength	***1687***	***psf***	

Test Setup





Vane Shear Test Report

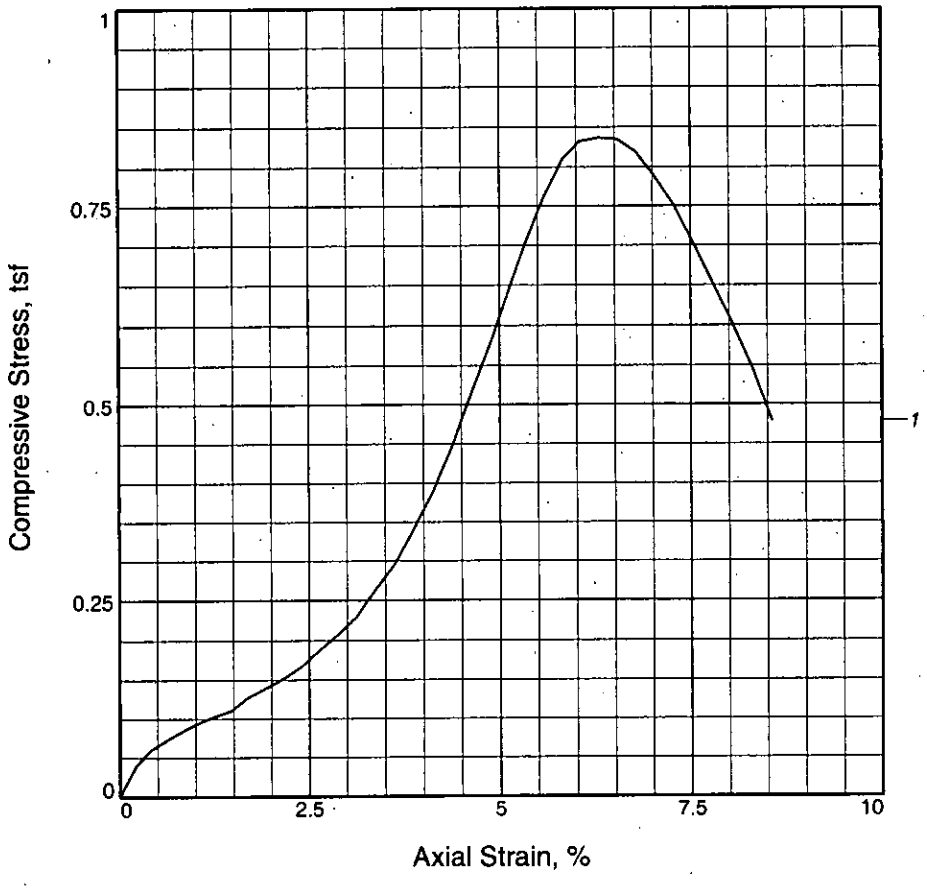
Read Time	Δ time	Rotation *(degrees)*	Torque *(in-lbs.)*
Peak Strength Test			
15:32:12	0:00:00	0.00	0.0
15:32:22	0:00:10	1.32	32.0
15:32:39	0:00:27	3.55	131.0
15:32:49	0:00:37	4.87	207.9
15:33:01	0:00:49	6.45	272.8
15:33:11	0:00:59	7.77	307.7
15:33:18	0:01:06	8.69	322.0
15:33:26	0:01:14	9.74	326.3
15:33:40	0:01:28	11.59	322.1
15:33:46	0:01:34	12.38	319.2
15:33:50	0:01:38	12.90	317.3
15:34:04	0:01:52	14.75	309.2
15:34:17	0:02:05	16.46	301.6
15:34:27	0:02:15	17.77	296.3
15:34:36	0:02:24	18.96	291.8
15:34:51	0:02:39	20.93	284.9
15:35:04	0:02:52	22.65	279.1
15:35:19	0:03:07	24.62	273.0
15:35:30	0:03:18	26.07	268.7

Read Time	Δ time	Rotation *(degrees)*	Torque *(in-lbs.)*
Remolded Strength Test			
15:42:11	0:00:00	0.00	0.0
15:42:40	0:00:29	3.82	72.1
15:42:49	0:00:38	5.00	117.3
15:42:57	0:00:46	6.06	117.3
15:43:01	0:00:50	6.58	116.8
15:43:09	0:00:58	7.64	115.8
15:43:17	0:01:06	8.69	114.8
15:43:26	0:01:15	9.87	114.4
15:43:40	0:01:29	11.72	113.8
15:43:49	0:01:38	12.90	113.5
15:44:03	0:01:52	14.75	113.7
15:44:16	0:02:05	16.46	113.4
15:44:28	0:02:17	18.04	112.7
15:44:34	0:02:23	18.83	112.4
15:45:03	0:02:52	22.65	111.3
15:45:20	0:03:09	24.89	111.1
15:45:38	0:03:27	27.25	111.0

Peak Torque	*326.3333*	(lb-in)
Vane Constant	*5.17*	
Peak Shear Strength	*1687*	*psf*

Remolded Torque	*117.35*	(lb-in)
Vane Constant	*5.17*	
Remolded Shear Strength	*606.69*	*psf*

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	0.835			
Undrained shear strength, tsf	0.418			
Failure strain,	6.5			
Strain rate, in./min.	0.06			
Water content, %	32.0			
Wet density, pcf	111.1			
Dry density, pcf	84.2			
Saturation, %	84.7			
Void ratio	1.0397			
Specimen diameter, in.	2.84			
Specimen height, in.	5.53			
Height/diameter ratio	1.95			

Description:

LL =	**PL =**	**PI =**	**Assumed GS=** 2.75	**Type:** 3" press tube

Project No.: 0121-3070.03

Date:

Remarks:

Figure _____

Client: TranSystems, Inc.

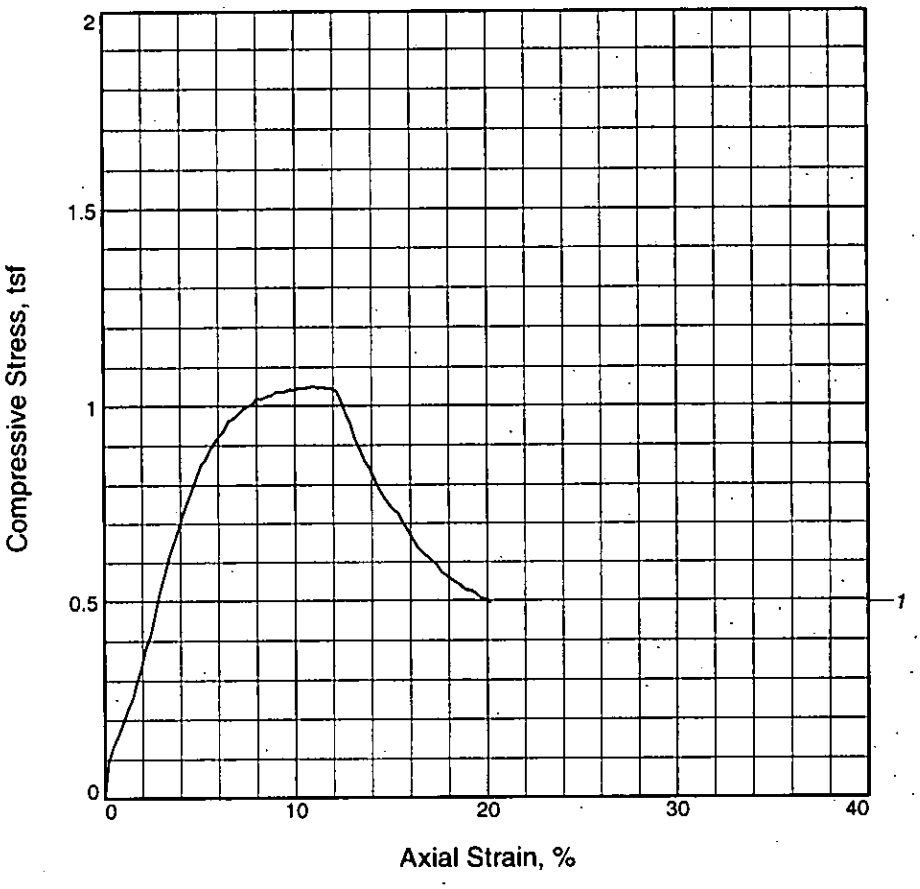
Project: SCI-823-0.00

Source of Sample: B-1122A **Depth:** 12.0

Sample Number: ST1

DLZ

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	1.046			
Undrained shear strength, tsf	0.523			
Failure strain,	11.4			
Strain rate, in./min.	0.06			
Water content, %	30.9			
Wet density, pcf	119.0			
Dry density, pcf	90.9			
Saturation, %	95.6			
Void ratio	0.8890			
Specimen diameter, in.	2.84			
Specimen height, in.	5.54			
Height/diameter ratio	1.95			

Description:

LL =	**PL =**	**PI =**	**Assumed GS=** 2.75	**Type:** 3" press tube

Project No.: 0121-3070.03

Date:

Remarks:

Figure _____

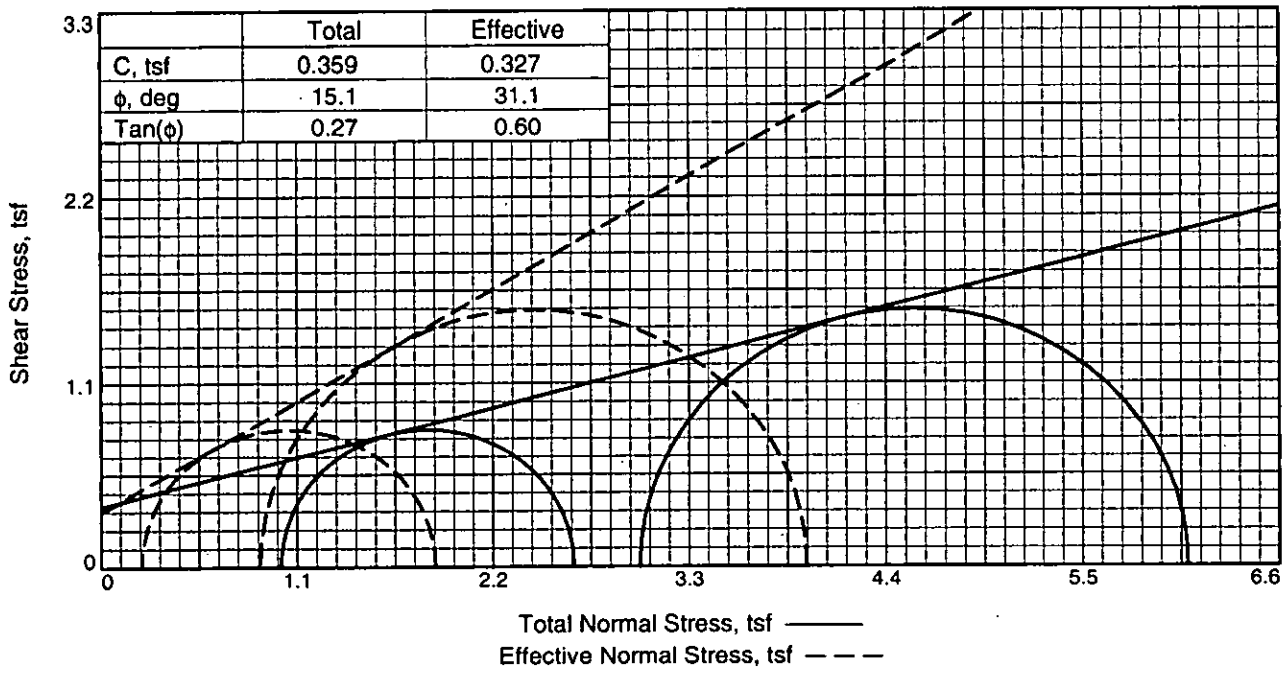
Client: TranSystems, Inc.

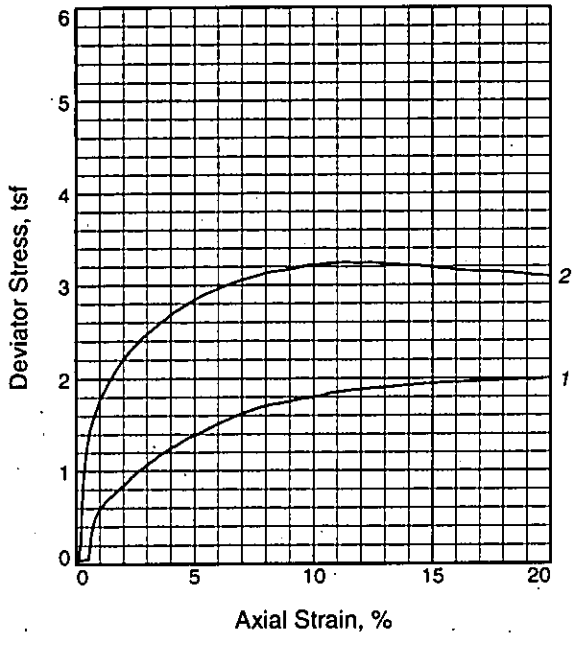
Project: SCI-823-0.00

Source of Sample: B-1122A **Depth:** 12.0

Sample Number: ST1

DLZ





Sample No.		1	2
Initial	Water Content,	27.4	26.1
	Dry Density, pcf	98.0	99.4
	Saturation,	100.3	98.6
	Void Ratio	0.7515	0.7267
	Diameter, in.	2.81	2.77
	Height, in.	5.55	5.55
At Test	Water Content,	25.0	23.6
	Dry Density, pcf	98.0	99.4
	Saturation,	91.6	89.2
	Void Ratio	0.7515	0.7267
	Diameter, in.	2.81	2.77
	Height, in.	5.55	5.55
Strain rate, in./min.		0.01	0.01
Back Pressure, tsf		3.31	3.31
Cell Pressure, tsf		4.32	6.34
Fail. Stress, tsf		1.65	3.06
Total Pore Pr., tsf		4.09	5.44
Ult. Stress, tsf		1.68	3.13
Total Pore Pr., tsf		4.09	5.43
$\bar{\sigma}_1$ Failure, tsf		1.87	3.96
$\bar{\sigma}_3$ Failure, tsf		0.23	0.89

Type of Test:
CU with Pore Pressures
Sample Type: Press Tube
Description:

LL= 34 **PL=** 19 **PI=** 15
Assumed Specific Gravity= 2.75
Remarks:

Figure _____

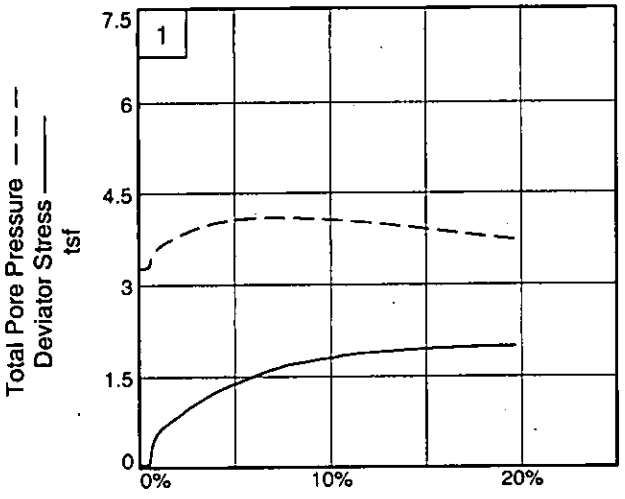
Client: TranSystems, Inc.

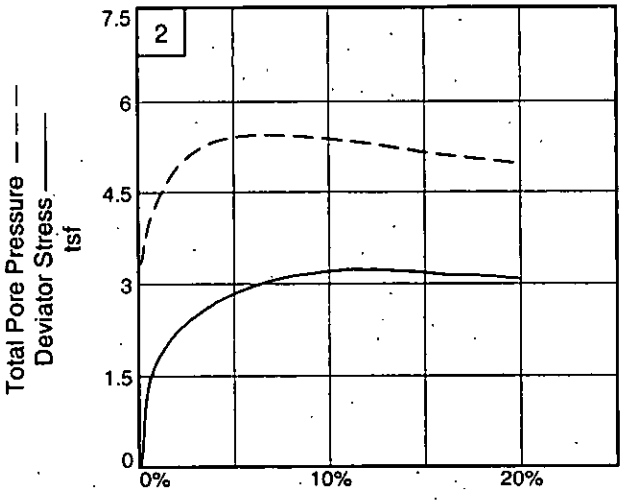
Project: SCI-823-0.00

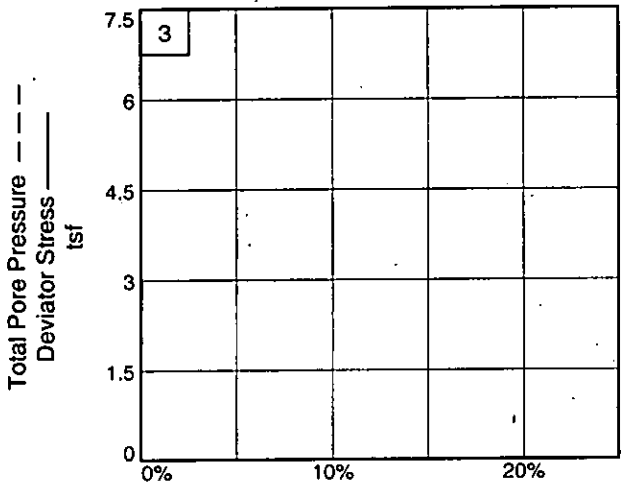
Source of Sample: B-1122A **Depth:** 15.0
Sample Number: ST2

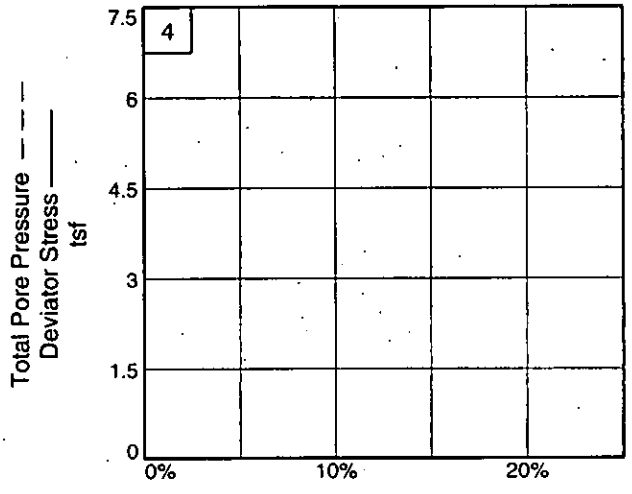
Proj. No.: 0121-3070.03 **Date:** 9/18/07

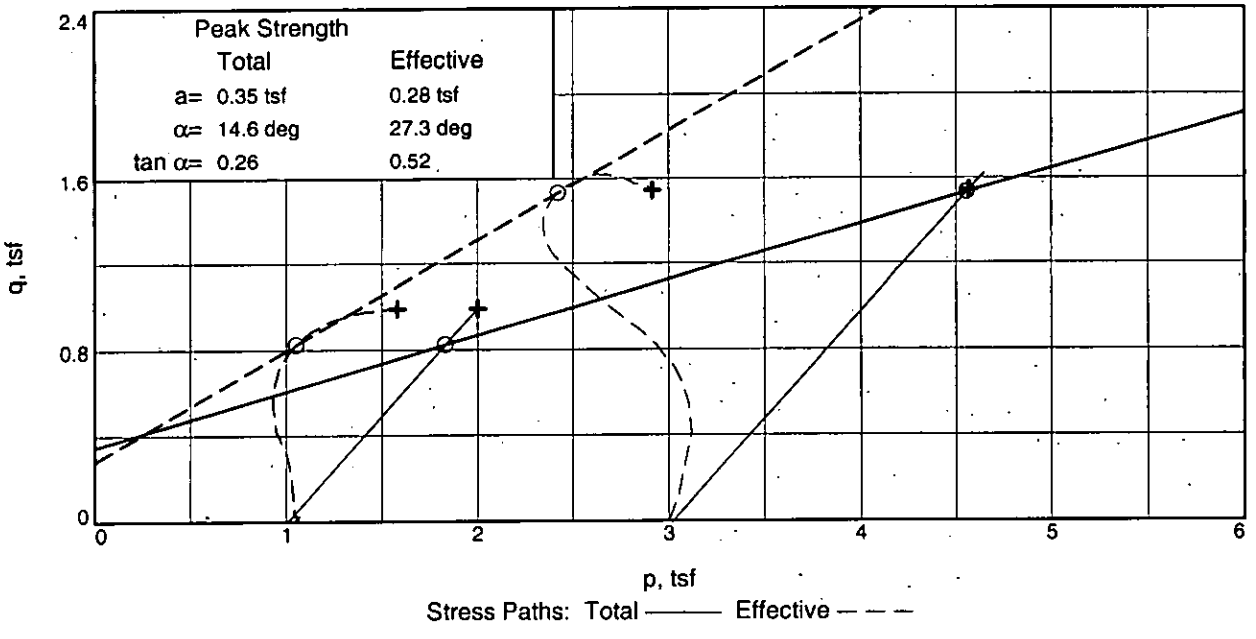
DLZ











Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-1122A
Project No.: 0121-3070.03

Depth: 15.0
Figure _____

Sample Number: ST2

DLZ, INC.

Vane Shear Test Report

Project	SCI-823-0.00	Date and Time	7/27/2006	Begin 8:00am
Project No.	0121-3070-03	Boring Number	B-1133A	End 8:35am
Client	ODOT			Depth 15.5'
Drill Rig & Crew	D Wamsley			
Tested By	B Mott			
Weather / Temp.	70 overcast			
Soil Type				

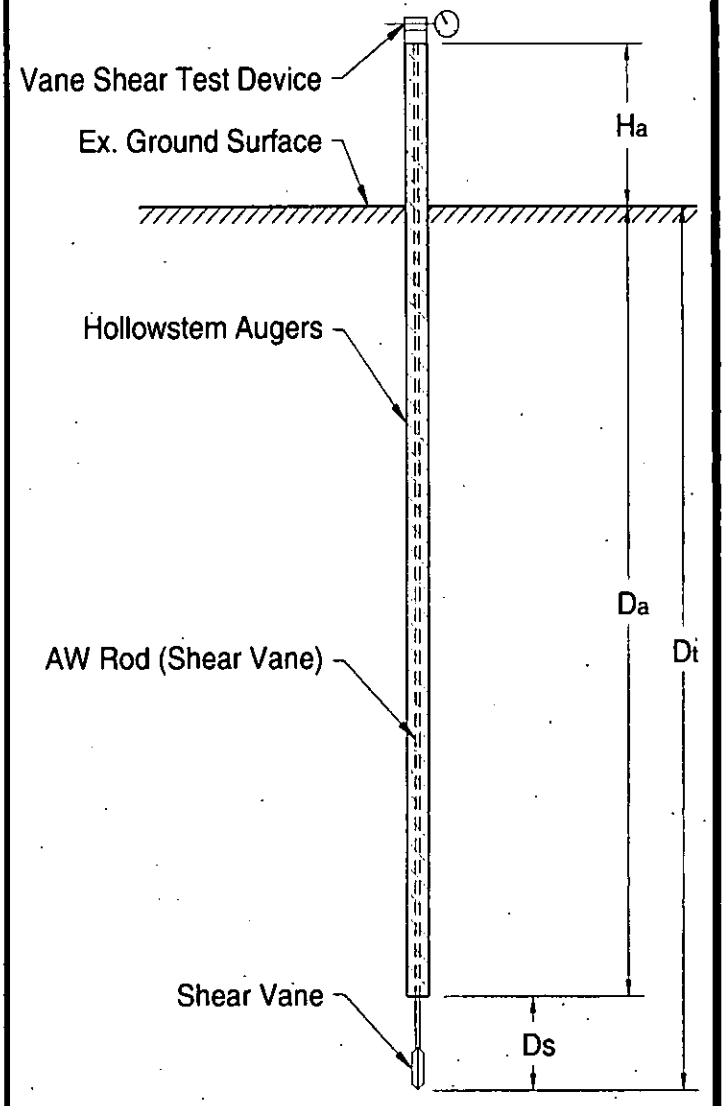
DRILLING

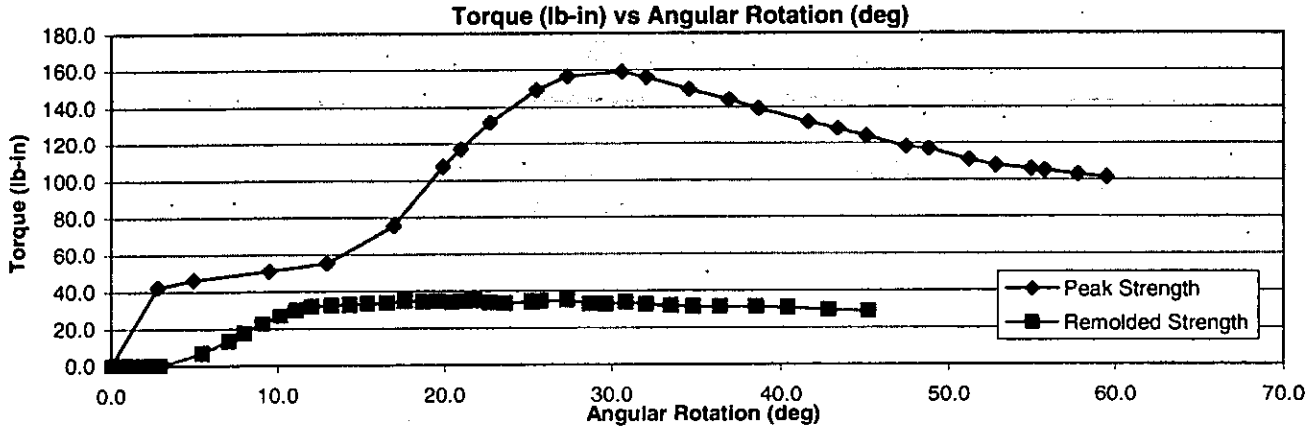
Hollowstem augers to depth	D_a	15.1
Vane Depth below bottom of augers	D_s	0.8
Augers above ground surface	H_a	6.8
Depth to vane tip	D_t	15.5

SHEAR VANE

Vane Used	2.0"	2.5"	3.625"
Vane constant, k (lb-in to psf)	5.17	2.59	0.905
Masurement by	Automatic/torque cell		
Max Torque	159	lb-in	
Max UD Shear Strength	***822***	***psf***	

Test Setup





DLZ

DLZ Ohio, Inc.
ENGINEERS * ARCHITECTS * SCIENTISTS
PLANNERS * SURVEYORS

Vane Shear Test Report

Peak Strength Test

Read Time	Δ time	Rotation (degrees)	Torque (in-lbs.)
08:10:32	0:00:00	0.0	0.0
08:10:53	0:00:21	2.8	42.5
08:11:09	0:00:37	4.9	46.4
08:11:43	0:01:11	9.5	51.0
08:12:09	0:01:37	12.9	55.4
08:12:39	0:02:07	16.9	75.6
08:13:01	0:02:29	19.9	107.8
08:13:09	0:02:37	20.9	117.0
08:13:22	0:02:50	22.7	131.6
08:13:43	0:03:11	25.5	149.2
08:13:57	0:03:25	27.3	156.6
08:14:21	0:03:49	30.5	159.1
08:14:32	0:04:00	32.0	156.0
08:14:51	0:04:19	34.5	149.4
08:15:09	0:04:37	36.9	143.8
08:15:22	0:04:50	38.7	139.1
08:15:44	0:05:12	41.6	131.8
08:15:57	0:05:25	43.3	127.9
08:16:10	0:05:38	45.1	123.8
08:16:28	0:05:56	47.5	117.9
08:16:38	0:06:06	48.8	116.9
08:16:56	0:06:24	51.2	110.9
08:17:08	0:06:36	52.8	108.0
08:17:24	0:06:52	54.9	106.0
08:17:30	0:06:58	55.7	105.2
08:17:45	0:07:13	57.7	103.1
08:17:58	0:07:26	59.5	101.4

Remolded Strength Test

Read Time	Δ time	Rotation (degrees)	Torque (in-lbs.)
08:25:41	0:00:00	0.0	0.0
08:25:46	0:00:05	0.7	0.0
08:25:52	0:00:11	1.5	0.0
08:25:57	0:00:16	2.1	0.1
08:26:03	0:00:22	2.9	0.0
08:26:22	0:00:41	5.5	6.9
08:26:34	0:00:53	7.1	13.2
08:26:41	0:01:00	8.0	17.7
08:26:49	0:01:08	9.1	22.7
08:26:57	0:01:16	10.1	26.9
08:27:04	0:01:23	11.1	30.0
08:27:11	0:01:30	12.0	32.0
08:27:20	0:01:39	13.2	32.7
08:27:28	0:01:47	14.3	33.0
08:27:36	0:01:55	15.3	33.6
08:27:45	0:02:04	16.5	33.9
08:27:53	0:02:12	17.6	34.8
08:28:01	0:02:20	18.7	34.5
08:28:08	0:02:27	19.6	34.6
08:28:14	0:02:33	20.4	34.2
08:28:18	0:02:37	20.9	34.6
08:28:24	0:02:43	21.7	35.0
08:28:31	0:02:50	22.7	33.7
08:28:38	0:02:57	23.6	33.4
08:28:50	0:03:09	25.2	34.3
08:28:54	0:03:13	25.7	34.6
08:29:06	0:03:25	27.3	35.1
08:29:16	0:03:35	28.7	33.1
08:29:23	0:03:42	29.6	33.0
08:29:32	0:03:51	30.8	33.9
08:29:41	0:04:00	32.0	32.7
08:29:52	0:04:11	33.5	32.0
08:30:02	0:04:21	34.8	31.6
08:30:14	0:04:33	36.4	31.4
08:30:30	0:04:49	38.5	31.4
08:30:44	0:05:03	40.4	30.7
08:31:02	0:05:21	42.8	29.6
08:31:20	0:05:39	45.2	29.0

Peak Torque	*159.1*	(lb-in)
Vane Constant	*5.17*	
Peak Shear Strength	*822*	*psf*

Remolded Torque	*35.1*	(lb-in)
Vane Constant	*5.17*	
Remolded Shear Strength	*181*	*psf*
Sensitivity	*4.5*	

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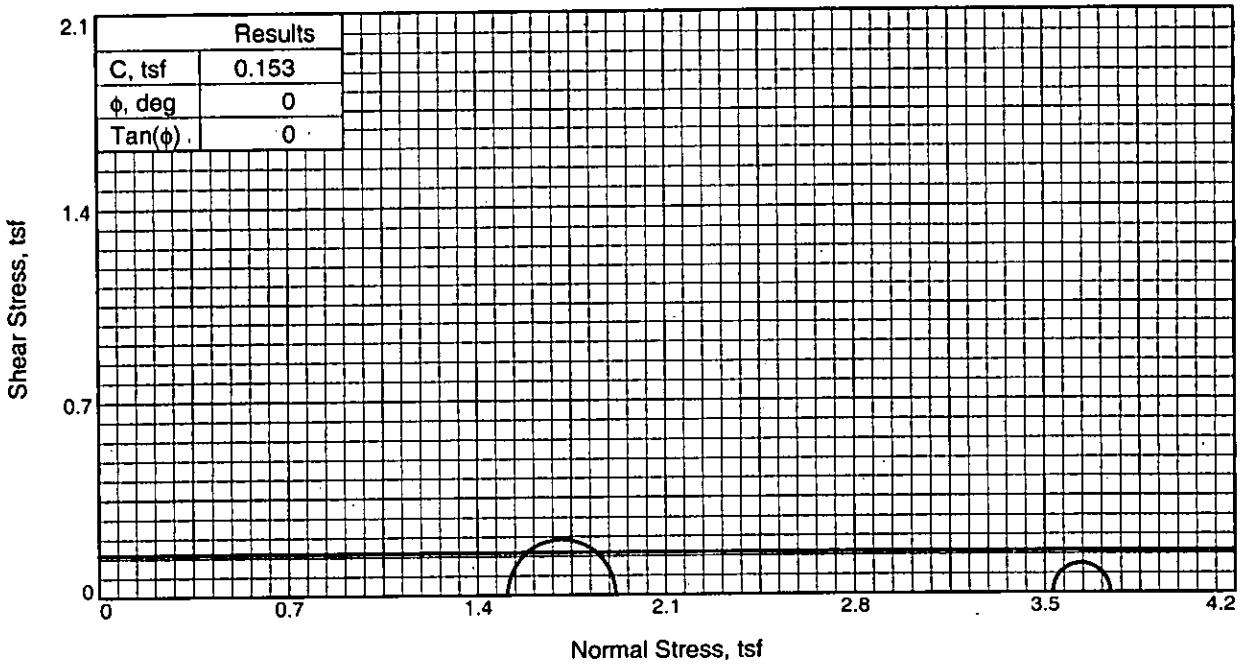

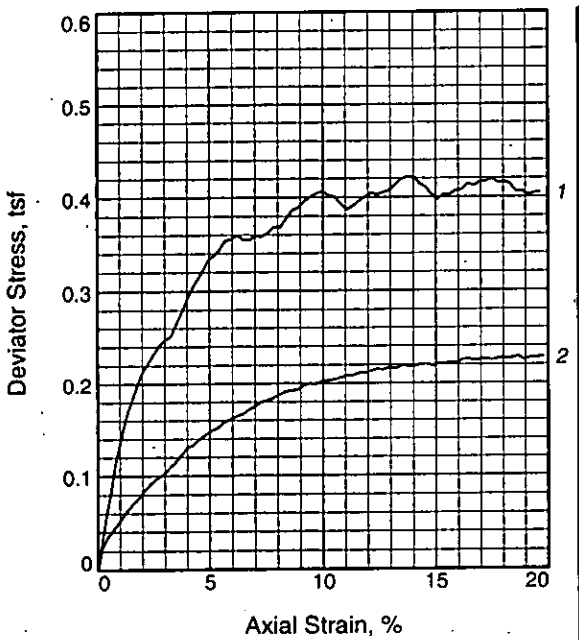

Sample No.		1	2
Initial	Water Content,	28.9	27.5
	Dry Density, pcf	96.1	97.0
	Saturation,	101.2	98.2
	Void Ratio	0.7868	0.7690
	Diameter, in.	2.85	2.91
	Height, in.	5.04	5.00
At Test	Water Content,	28.6	28.0
	Dry Density, pcf	96.1	97.0
	Saturation,	100.0	100.0
	Void Ratio	0.7868	0.7690
	Diameter, in.	2.85	2.91
	Height, in.	5.04	5.00
Strain rate, in./min.		0.06	0.06
Back Pressure, tsf		0.00	0.00
Cell Pressure, tsf		1.51	3.53
Fail. Stress, tsf		0.40	0.21
Ult. Stress, tsf		0.40	0.21
σ_1 Failure, tsf		1.91	3.74
σ_3 Failure, tsf		1.51	3.53

Type of Test:
Unconsolidated Undrained

Sample Type: Press Tube

Description: Lean clay with sand

LL= 25 **PL=** 17 **PI=** 8

Assumed Specific Gravity= 2.75

Remarks:

Client: TranSystems, Inc.

Project: SCI-823-0.00

Source of Sample: B-1133A **Depth:** 18.0

Sample Number: ST1

Proj. No.: 0121-3070.03 **Date:** 8/24/07

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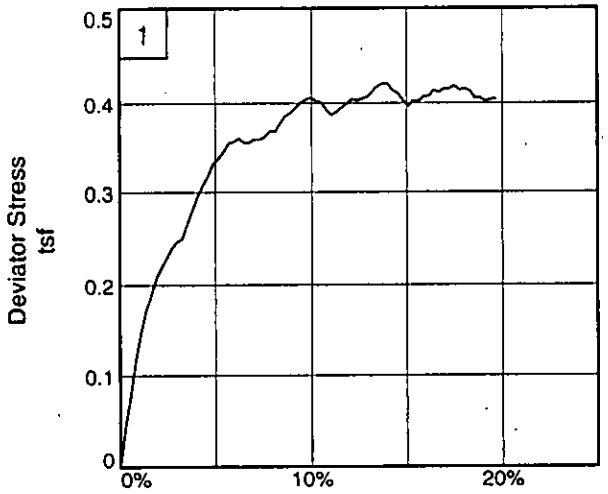
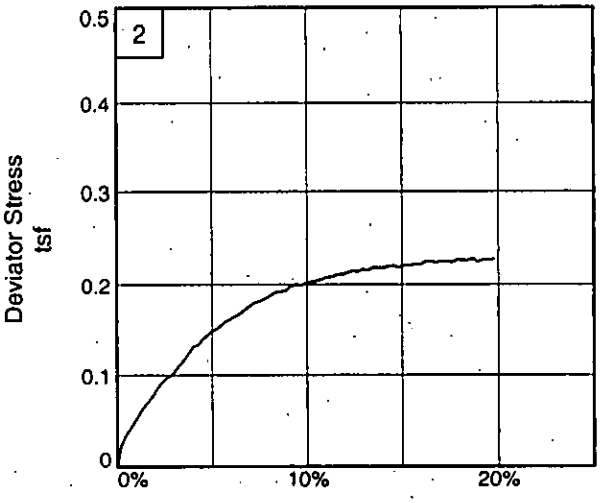
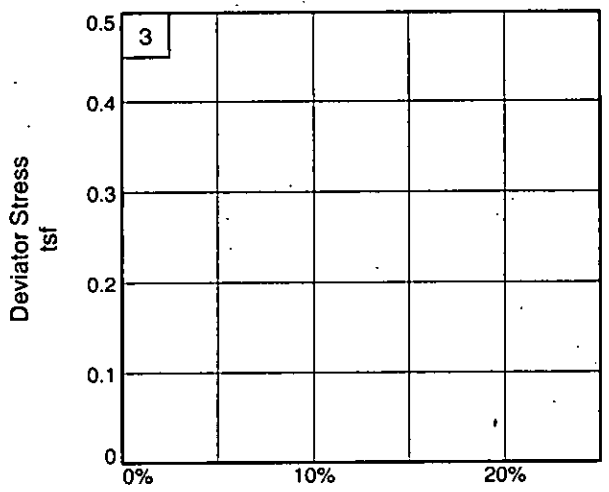
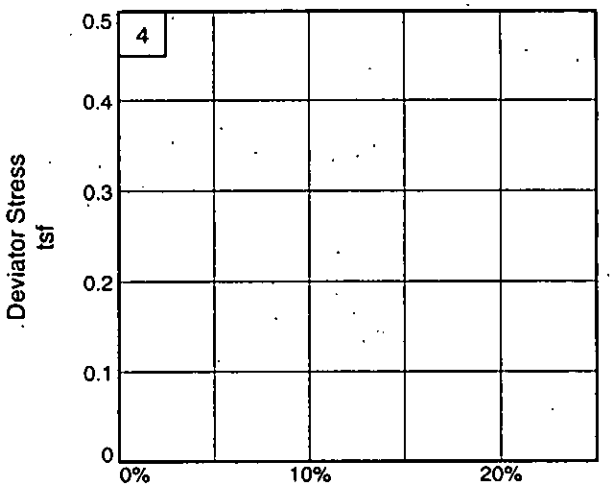
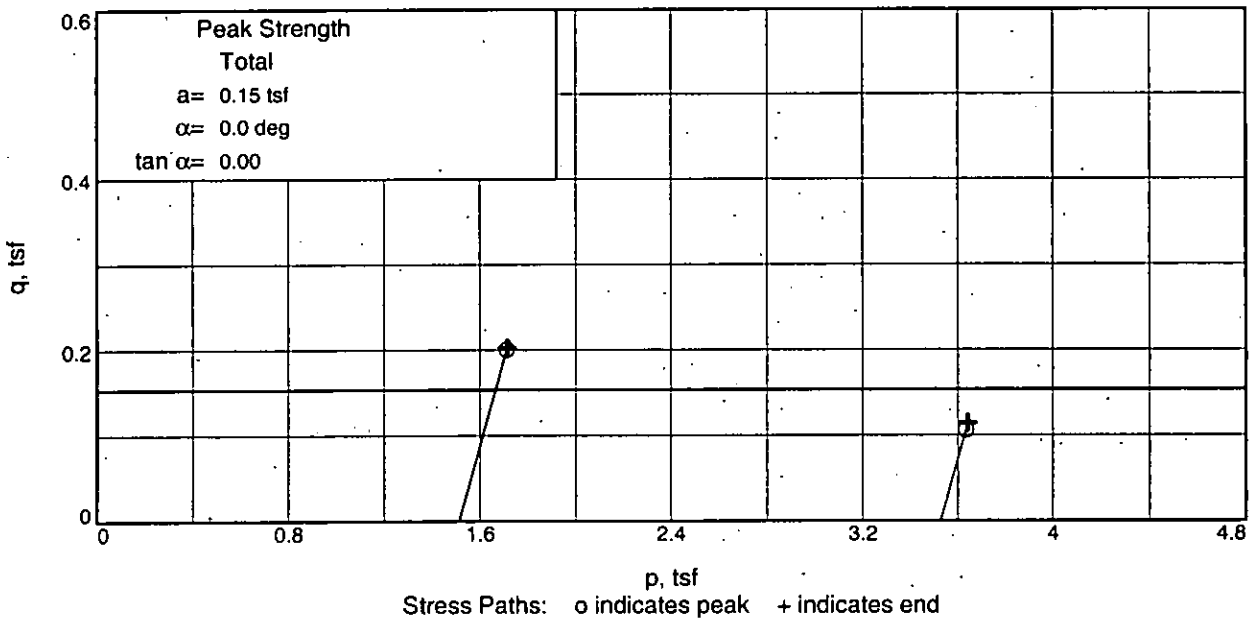
Figure _____











Stress Paths: o indicates peak + indicates end

Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-1133A
Project No.: 0121-3070.03
Depth: 18.0
Figure _____
Sample Number: ST1

DLZ, INC.

Vane Shear Test Report

Project	SCI-823-0.00	Date and Time	7/27/2006	Begin 8:40am
Project No.	0121-3070-03	Boring Number	B-1133a	End 9:30am
Client	ODOT			Depth 20.4'
Drill Rig & Crew	D Wamsley			
Tested By	B Mott			
Weather / Temp.	overcast 70			
Soil Type				

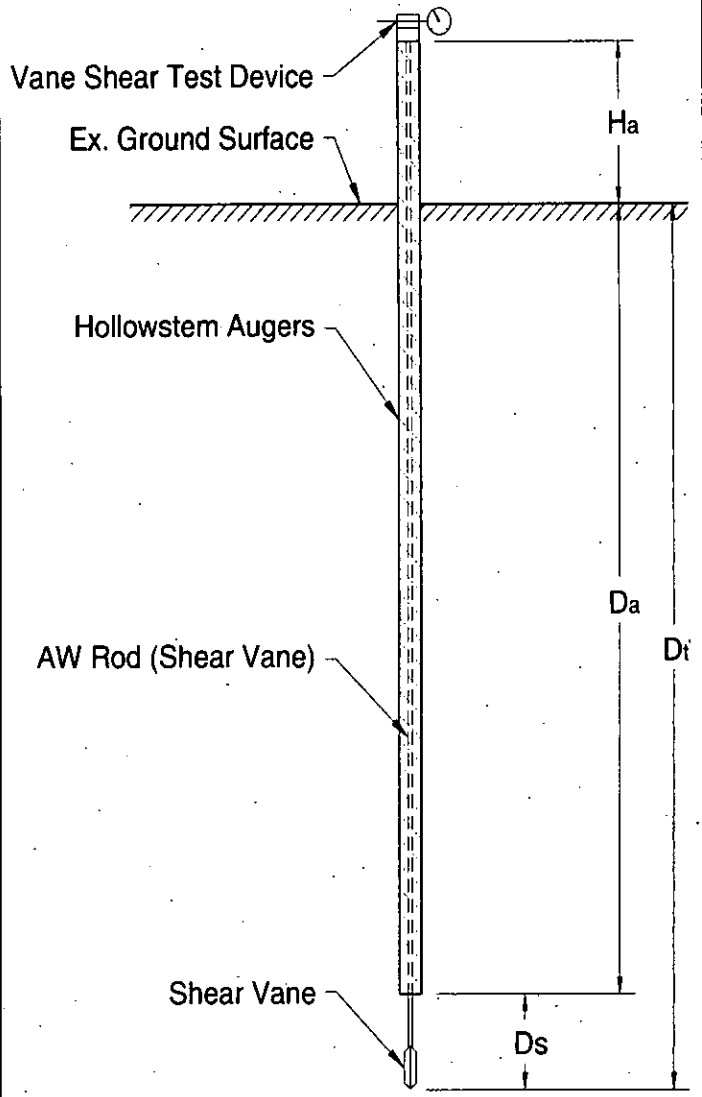
DRILLING

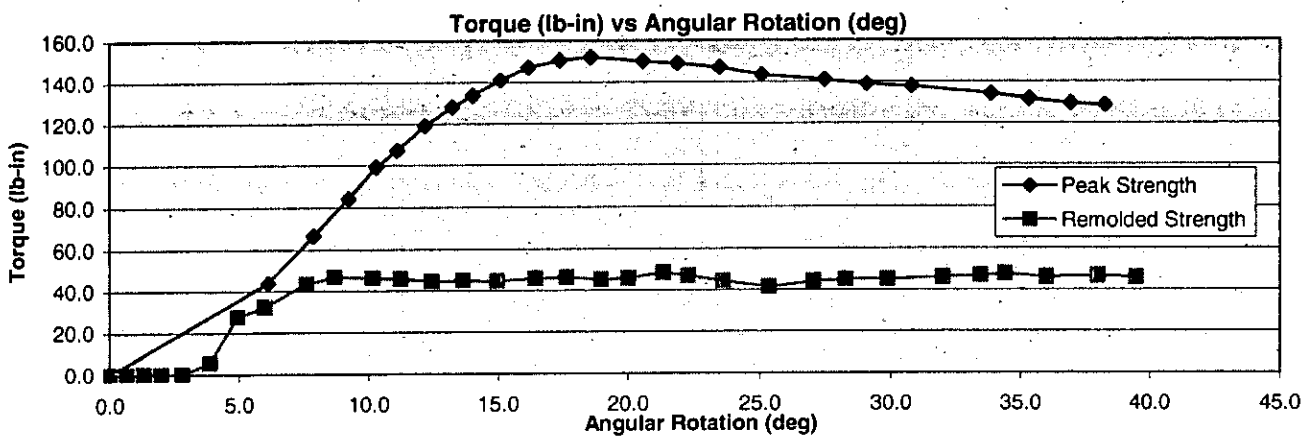
Hollowstem augers to depth	D_a	19.1
Vane Depth below bottom of augers	D_s	0.8
Augers above ground surface	H_a	6.8
Depth to vane tip	D_t	20.4

SHEAR VANE

Vane Used	2.0"	2.5"	3.625"
Vane constant, k (lb-in to psf)	5.17	2.59	0.905
Masurement by	Automatic/torque cell		
Max Torque	152	lb-in	
Max UD Shear Strength	***786***	***psf***	

Test Setup





Vane Shear Test Report

Read Time	Δ time	Rotation *(degrees)*	Torque *(in-lbs.)*
Peak Strength Test			
08:57:33	0:00:00	0.0	0.0
08:58:19	0:00:46	6.1	44.0
08:58:32	0:00:59	7.9	66.5
08:58:42	0:01:09	9.2	84.3
08:58:50	0:01:17	10.3	99.2
08:58:56	0:01:23	11.1	107.1
08:59:04	0:01:31	12.1	119.1
08:59:12	0:01:39	13.2	128.2
08:59:18	0:01:45	14.0	133.7
08:59:26	0:01:53	15.1	141.1
08:59:34	0:02:01	16.1	147.1
08:59:43	0:02:10	17.3	150.5
08:59:52	0:02:19	18.5	152.1
09:00:07	0:02:34	20.5	150.0
09:00:17	0:02:44	21.9	149.0
09:00:29	0:02:56	23.5	146.9
09:00:41	0:03:08	25.1	143.4
09:00:59	0:03:26	27.5	140.9
09:01:11	0:03:38	29.1	138.9
09:01:24	0:03:51	30.8	137.7
09:01:47	0:04:14	33.9	134.0
09:01:58	0:04:25	35.3	131.6
09:02:10	0:04:37	36.9	129.4
09:02:20	0:04:47	38.3	128.6

Read Time	Δ time	Rotation *(degrees)*	Torque *(in-lbs.)*
Remolded Strength Test			
09:08:54	0:00:00	0.0	0.0
09:08:59	0:00:05	0.7	0.0
09:09:04	0:00:10	1.3	0.1
09:09:09	0:00:15	2.0	0.0
09:09:15	0:00:21	2.8	0.1
09:09:23	0:00:29	3.9	5.7
09:09:31	0:00:37	4.9	27.7
09:09:39	0:00:45	6.0	32.3
09:09:51	0:00:57	7.6	43.3
09:09:59	0:01:05	8.7	46.8
09:10:10	0:01:16	10.1	46.4
09:10:18	0:01:24	11.2	45.8
09:10:27	0:01:33	12.4	44.6
09:10:36	0:01:42	13.6	44.9
09:10:46	0:01:52	14.9	44.7
09:10:57	0:02:03	16.4	45.8
09:11:06	0:02:12	17.6	46.3
09:11:16	0:02:22	18.9	45.3
09:11:24	0:02:30	20.0	45.8
09:11:34	0:02:40	21.3	48.5
09:11:41	0:02:47	22.3	47.0
09:11:51	0:02:57	23.6	44.5
09:12:04	0:03:10	25.3	41.6
09:12:17	0:03:23	27.1	44.1
09:12:26	0:03:32	28.3	45.1
09:12:38	0:03:44	29.9	45.1
09:12:54	0:04:00	32.0	46.1
09:13:05	0:04:11	33.5	46.8
09:13:12	0:04:18	34.4	47.7
09:13:24	0:04:30	36.0	46.0
09:13:39	0:04:45	38.0	46.7
09:13:50	0:04:56	39.5	45.9

Peak Torque	*152.1*	(lb-in)
Vane Constant	*5.17*	
Peak Shear Strength	*786*	*psf*

Remolded Torque	*48.5*	(lb-in)
Vane Constant	*5.17*	
Remolded Shear Strength	*251*	*psf*
Sensitivity	*3.1*	

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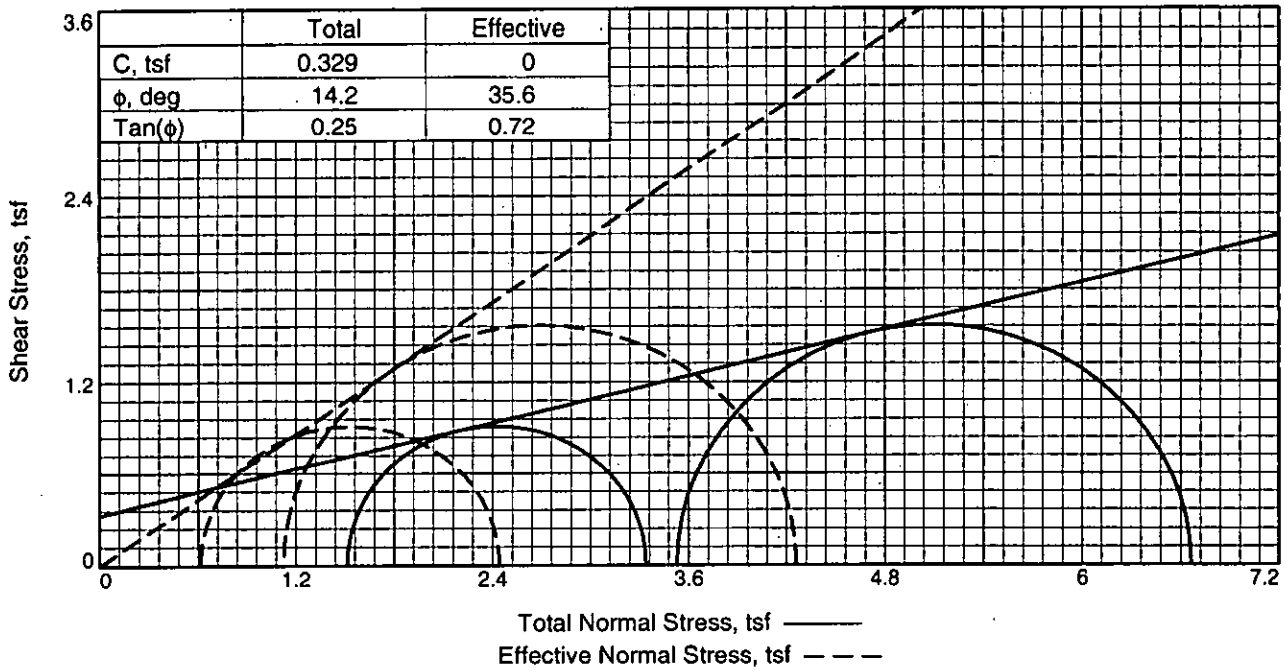
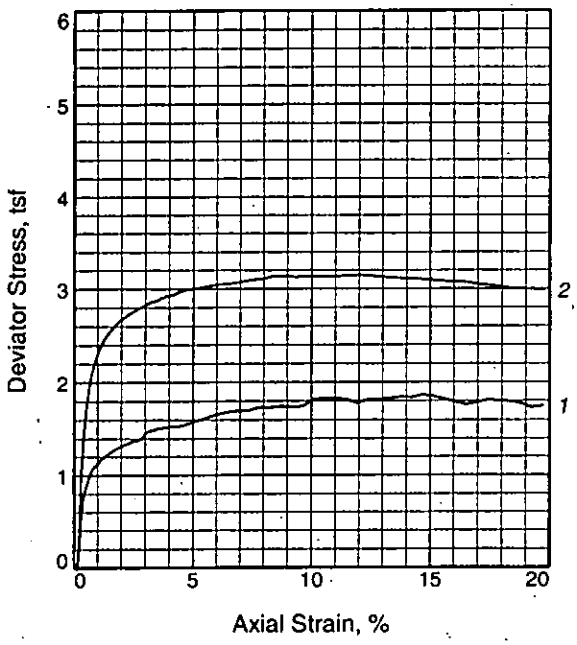


	Total	Effective
C, tsf	0.329	0
ϕ, deg	14.2	35.6
Tan(ϕ)	0.25	0.72



Sample No.		1	2
Initial	Water Content,	37.7	38.6
	Dry Density, pcf	84.1	82.3
	Saturation,	99.5	97.7
	Void Ratio	1.0412	1.0871
	Diameter, in.	2.84	2.82
	Height, in.	5.25	5.37
At Test	Water Content,	32.3	30.7
	Dry Density, pcf	90.9	93.2
	Saturation,	100.0	100.0
	Void Ratio	0.8890	0.8430
	Diameter, in.	2.75	2.69
	Height, in.	5.16	5.21
Strain rate, in./min.		0.01	0.01
Back Pressure, tsf		3.31	3.31
Cell Pressure, tsf		4.82	6.84
Fail. Stress, tsf		1.83	3.13
Total Pore Pr., tsf		4.21	5.72
Ult. Stress, tsf		1.83	3.14
Total Pore Pr., tsf		4.21	5.71
$\bar{\sigma}_1$ Failure, tsf		2.44	4.26
$\bar{\sigma}_3$ Failure, tsf		0.61	1.12

Type of Test:
CU with Pore Pressures

Sample Type: Press tube

Description:

LL= 41 **PL=** 27 **PI=** 14

Assumed Specific Gravity= 2.75

Remarks:

Figure _____

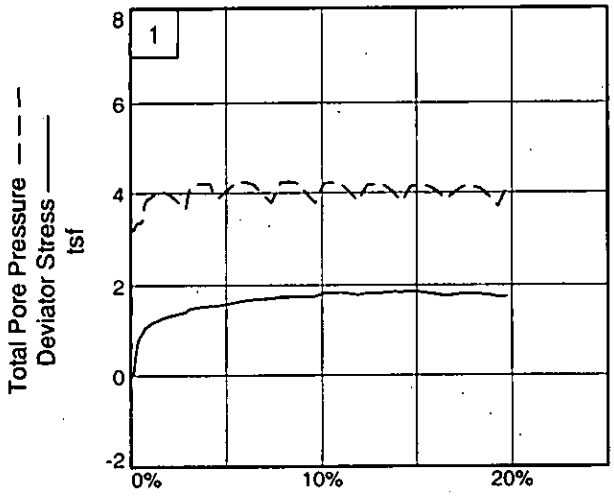
Client: TranSystems, Inc.

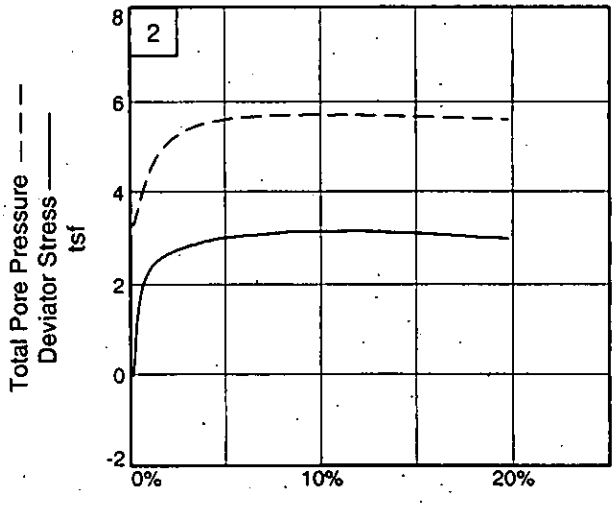
Project: SCI-823-0.00

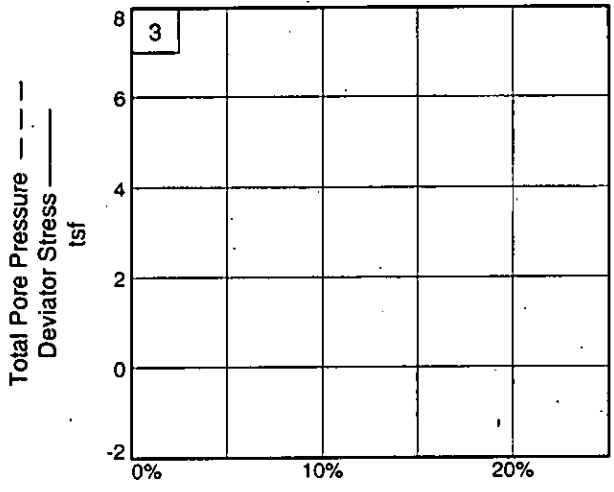
Source of Sample: B-1133A **Depth:** 20.3

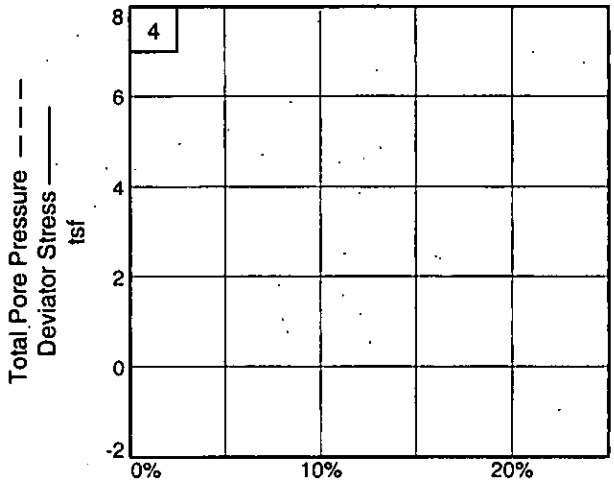
Proj. No.: 0121-3070.03 **Date:** 8/24/07

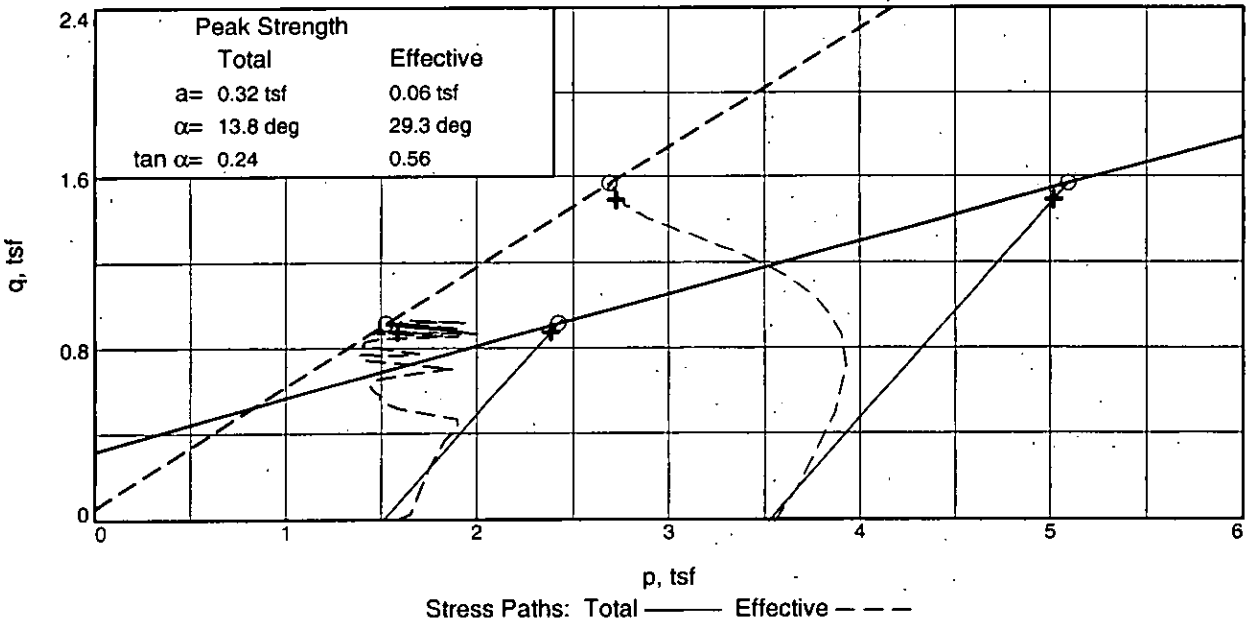
DLZ





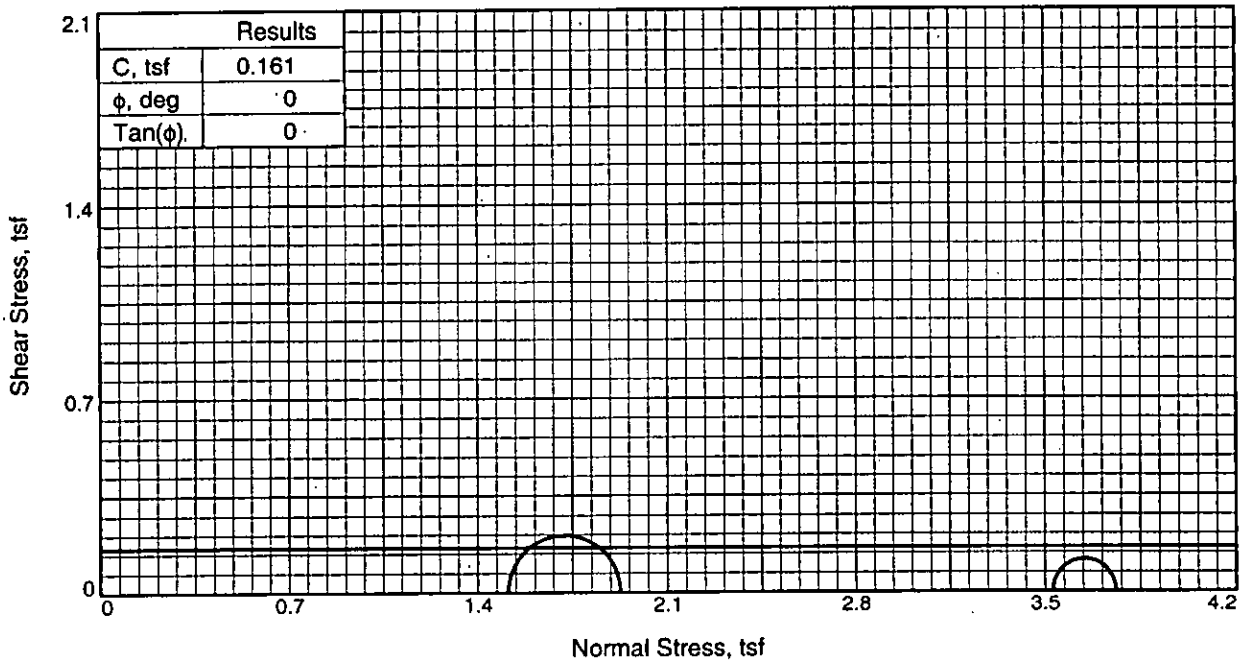


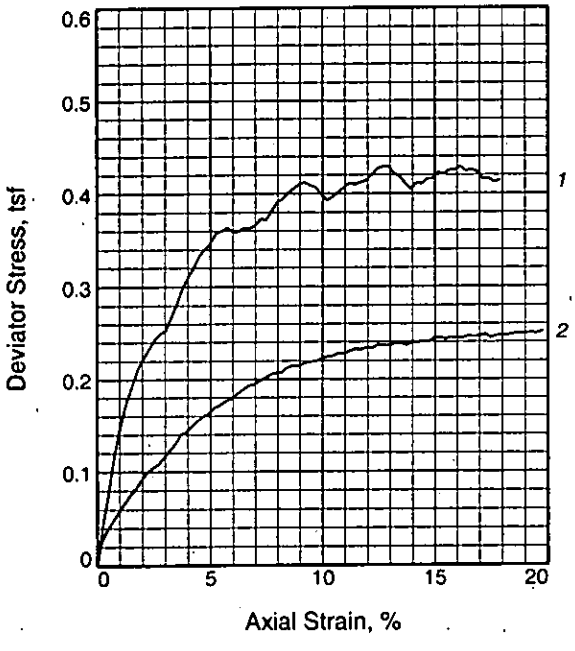




Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-1133A
Depth: 20.3
Project No.: 0121-3070.03
Figure _____

DLZ, INC.





Sample No.		1	2
Initial	Water Content,	36.1	31.9
	Dry Density, pcf	85.5	92.8
	Saturation,	98.4	103.5
	Void Ratio	1.0086	0.8490
	Diameter, in.	2.84	2.82
	Height, in.	5.46	5.41
At Test	Water Content,	35.8	31.3
	Dry Density, pcf	85.5	92.8
	Saturation,	97.5	101.3
	Void Ratio	1.0086	0.8490
	Diameter, in.	2.84	2.82
	Height, in.	5.46	5.41
Strain rate, in./min.		0.06	0.06
Back Pressure, tsf		0.00	0.00
Cell Pressure, tsf		1.51	3.53
Fail. Stress, tsf		0.41	0.23
Ult. Stress, tsf		0.41	0.23
σ_1 Failure, tsf		1.93	3.76
σ_3 Failure, tsf		1.51	3.53

Type of Test:
Unconsolidated Undrained

Sample Type: Press Tube

Description: Silty clay

LL= 28 **PL=** 21 **PI=** 7

Assumed Specific Gravity= 2.75

Remarks:

Figure _____

Client: TranSystems, Inc.

Project: SCI-823-0.00

Source of Sample: B-1133A **Depth:** 22.0

Sample Number: ST3

Proj. No.: 0121-3070.03 **Date:** 8/24/07

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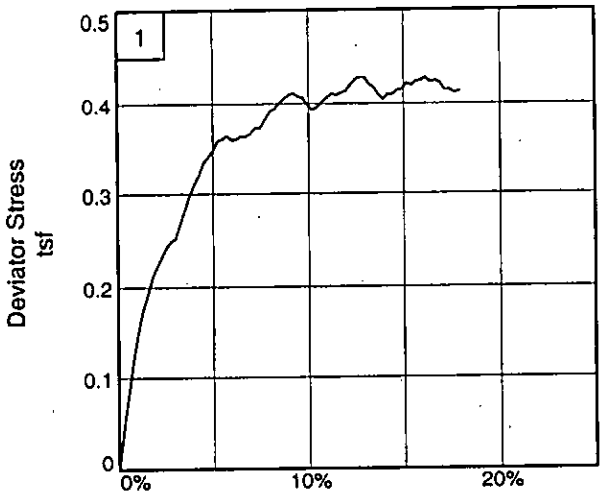
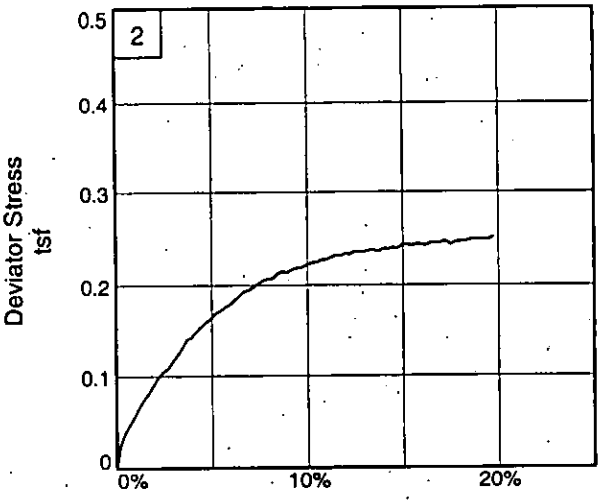
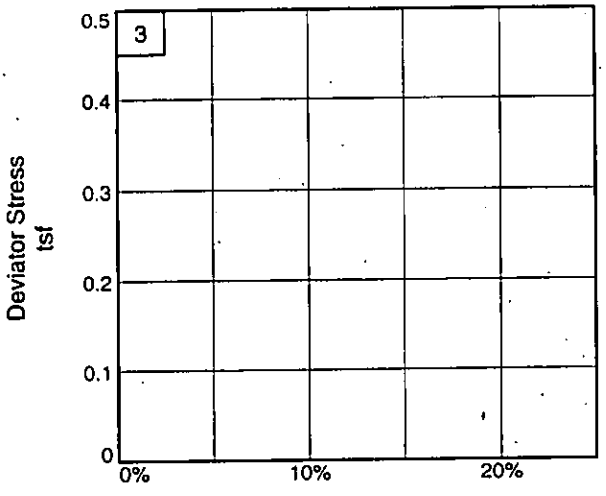
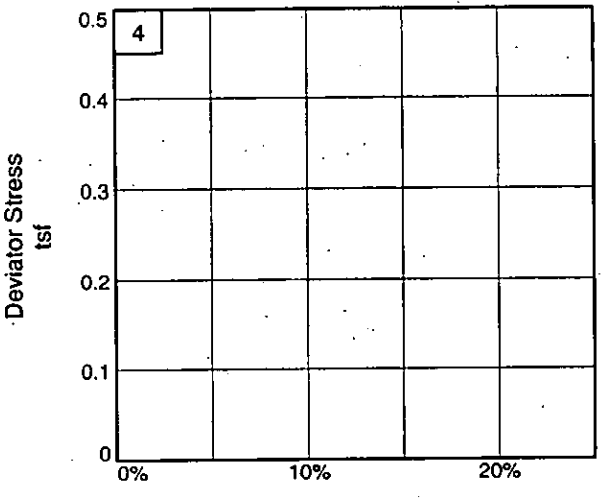
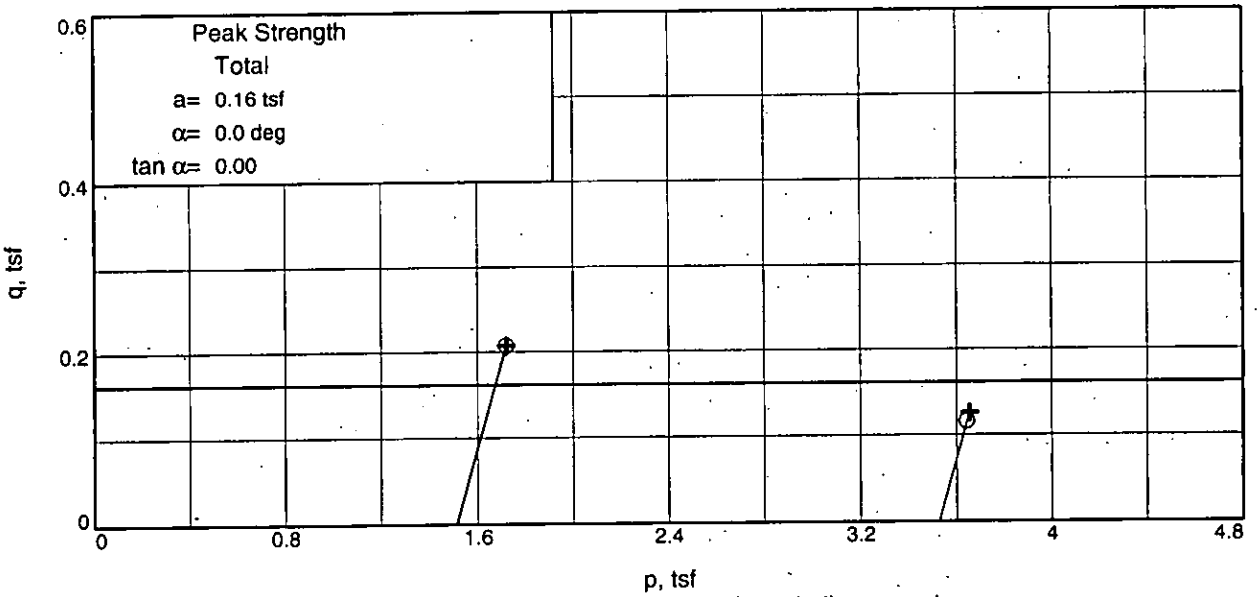










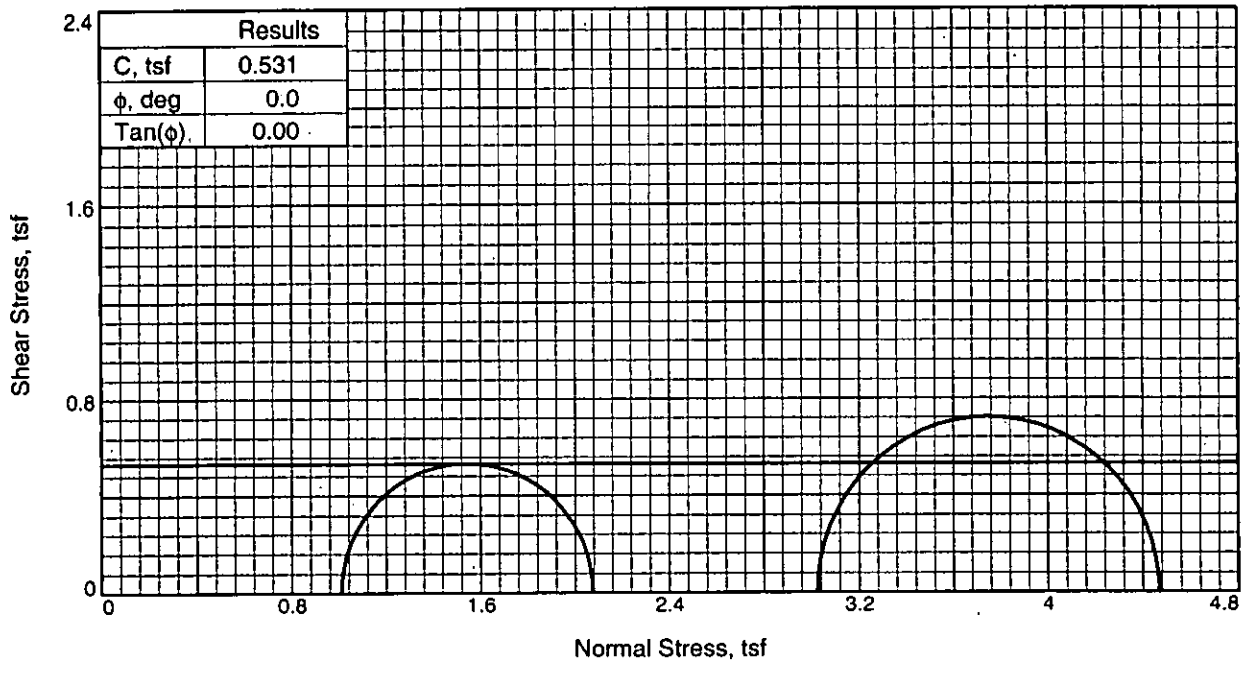
Stress Paths: o indicates peak + indicates end

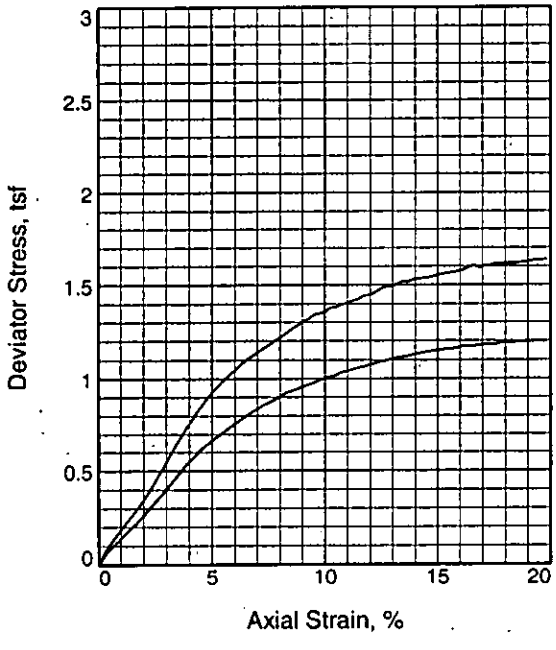
Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-1133A
Project No.: 0121-3070.03

Depth: 22.0
Figure _____

Sample Number: ST3

DLZ, INC.





Sample No.		1	2
Initial	Water Content,	26.0	24.6
	Dry Density, pcf	97.2	100.8
	Saturation,	93.5	96.0
	Void Ratio	0.7659	0.7039
	Diameter, in.	2.81	2.81
	Height, in.	5.53	5.53
At Test	Water Content,	26.0	24.4
	Dry Density, pcf	97.2	100.8
	Saturation,	93.5	95.4
	Void Ratio	0.7659	0.7039
	Diameter, in.	2.81	2.81
	Height, in.	5.53	5.53
Strain rate, in./min.		0.06	0.06
Back Pressure, tsf		0.00	0.00
Cell Pressure, tsf		1.01	3.02
Fail. Stress, tsf		1.07	1.44
Ult. Stress, tsf		1.07	1.44
σ_1 Failure, tsf		2.07	4.47
σ_3 Failure, tsf		1.01	3.02

Type of Test:
Unconsolidated Undrained

Sample Type: 3" press tube

Description:

Assumed Specific Gravity= 2.75

Remarks:

Figure _____

Client: TranSystems, Inc.

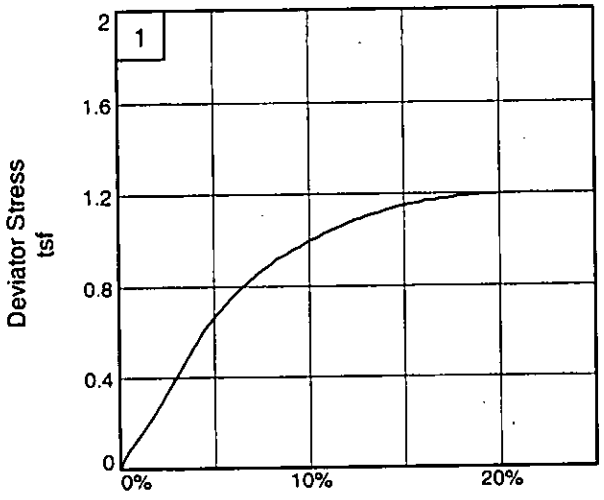
Project: SCI-823-0.00

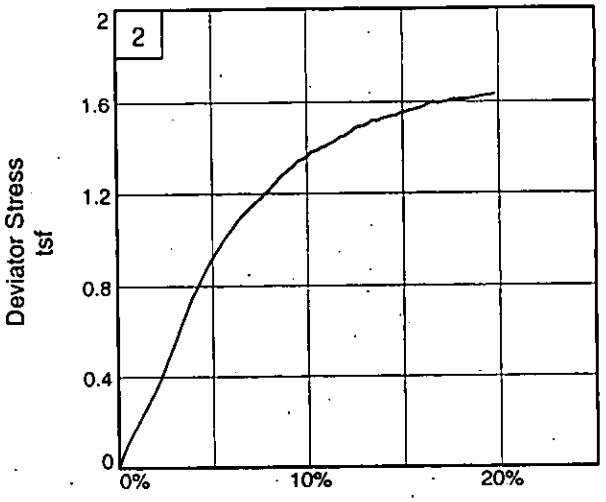
Source of Sample: B-1136A **Depth:** 6.0

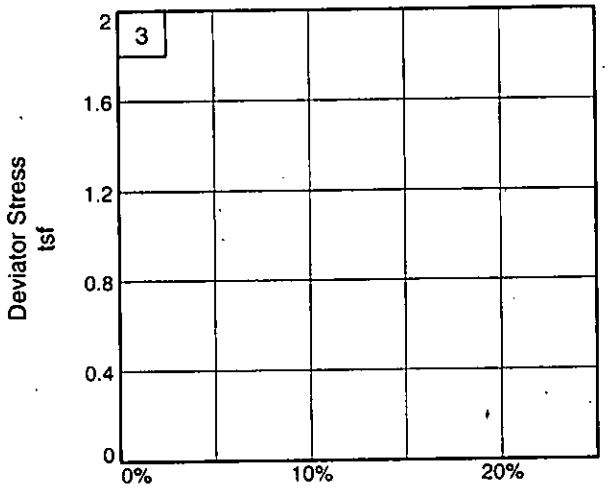
Sample Number: ST1

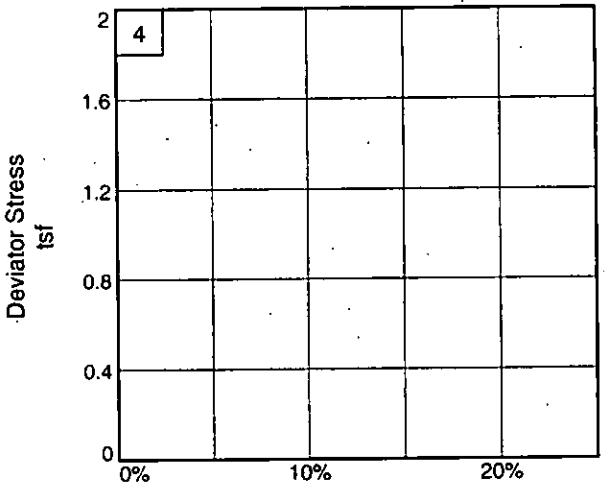
Proj. No.: 0121-3070.03 **Date:**

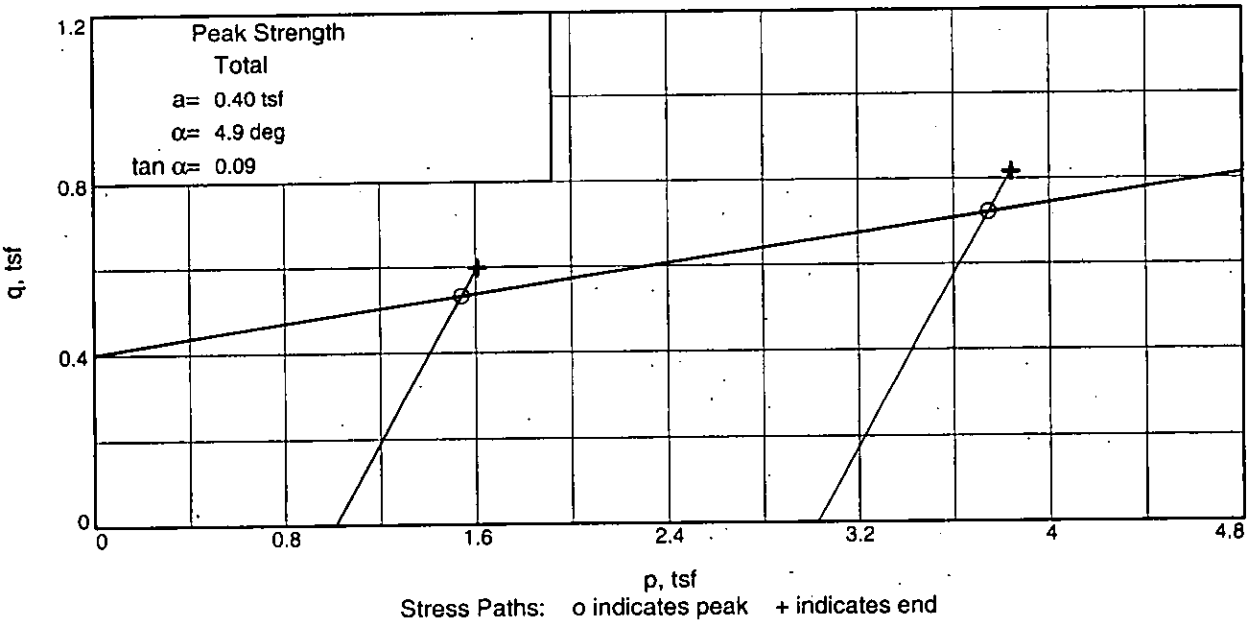
DLZ











Stress Paths: o indicates peak + indicates end

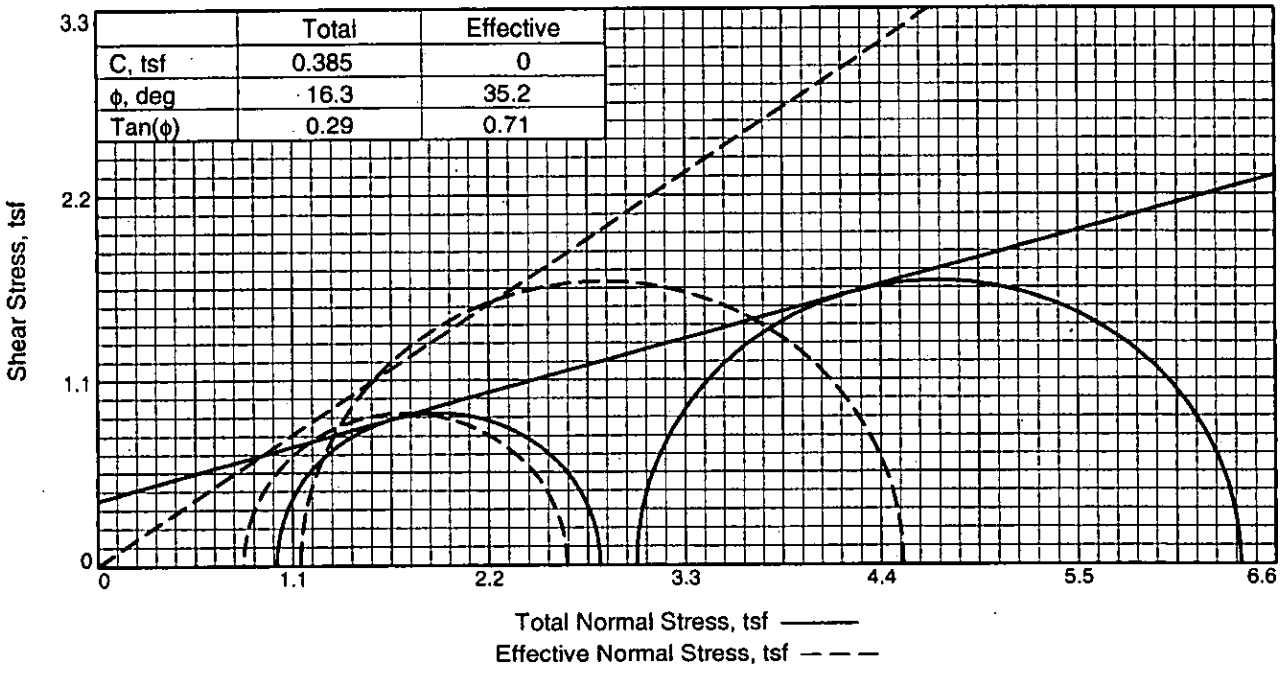
Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-1136A
Project No.: 0121-3070.03

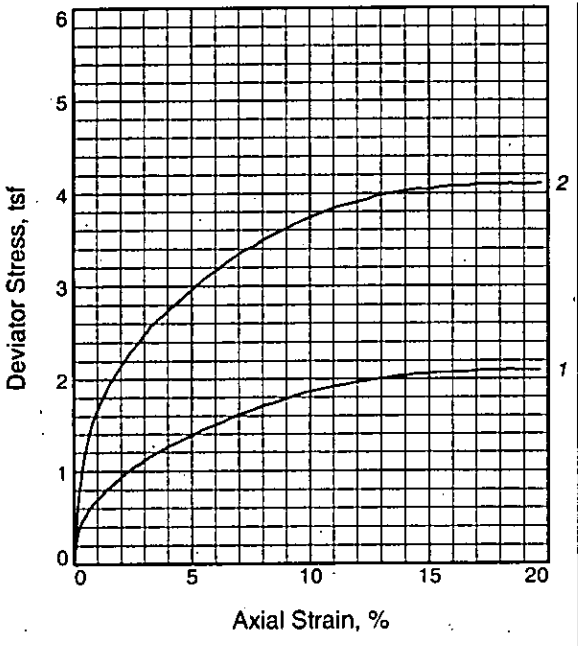
Depth: 6.0
Figure _____

Sample Number: ST1

DLZ, INC.

	Total	Effective
C, tsf	0.385	0
ϕ, deg	16.3	35.2
Tan(ϕ)	0.29	0.71





Sample No.		1	2
Initial	Water Content,	26.6	26.6
	Dry Density, pcf	99.0	99.0
	Saturation,	99.8	99.8
	Void Ratio	0.7345	0.7341
	Diameter, in.	2.82	2.81
	Height, in.	5.52	5.51
At Test	Water Content,	24.0	22.0
	Dry Density, pcf	103.4	107.0
	Saturation,	100.0	100.0
	Void Ratio	0.6597	0.6051
	Diameter, in.	2.76	2.72
	Height, in.	5.49	5.47
Strain rate, in./min.		0.01	0.01
Back Pressure, tsf		3.31	3.31
Cell Pressure, tsf		4.32	6.34
Fail. Stress, tsf		1.81	3.38
Total Pore Pr., tsf		3.50	5.19
Ult. Stress, tsf		1.81	3.38
Total Pore Pr., tsf		3.50	5.19
$\bar{\sigma}_1$ Failure, tsf		2.63	4.52
$\bar{\sigma}_3$ Failure, tsf		0.82	1.14

Type of Test:
CU with Pore Pressures
Sample Type: Press Tube
Description:

Assumed Specific Gravity= 2.75
Remarks:

Figure _____

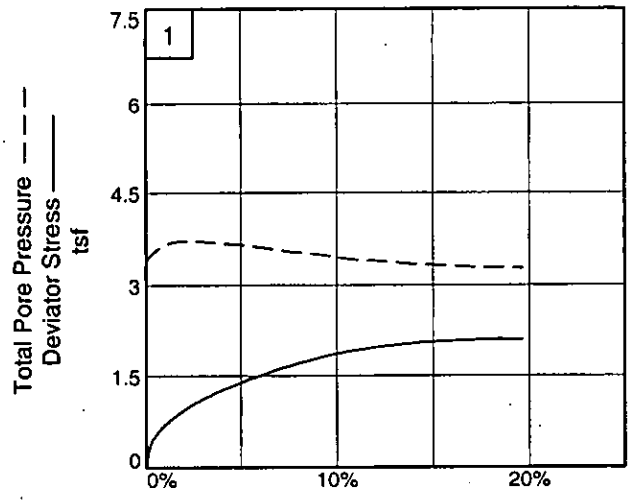
Client: TranSystems, Inc.

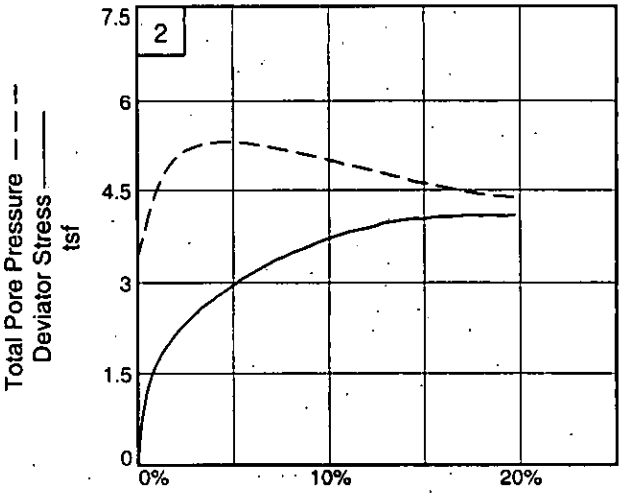
Project: SCI-823-0.00

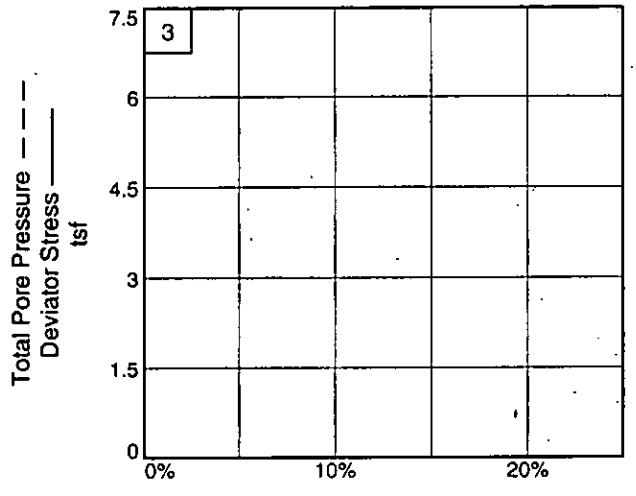
Source of Sample: B-1136A **Depth:** 8.0
Sample Number: ST2

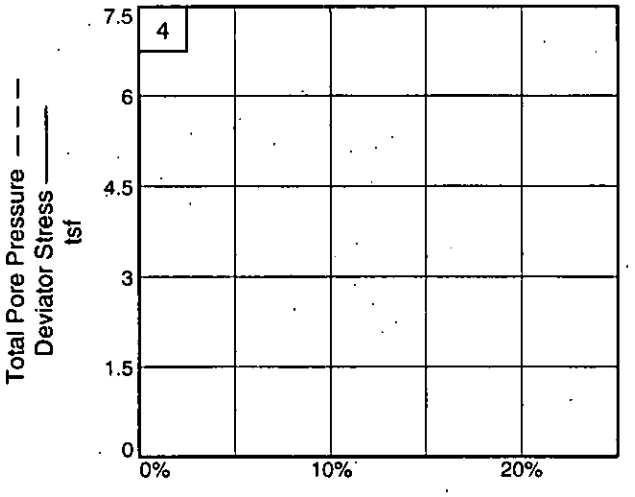
Proj. No.: 0121-3070.03 **Date:**

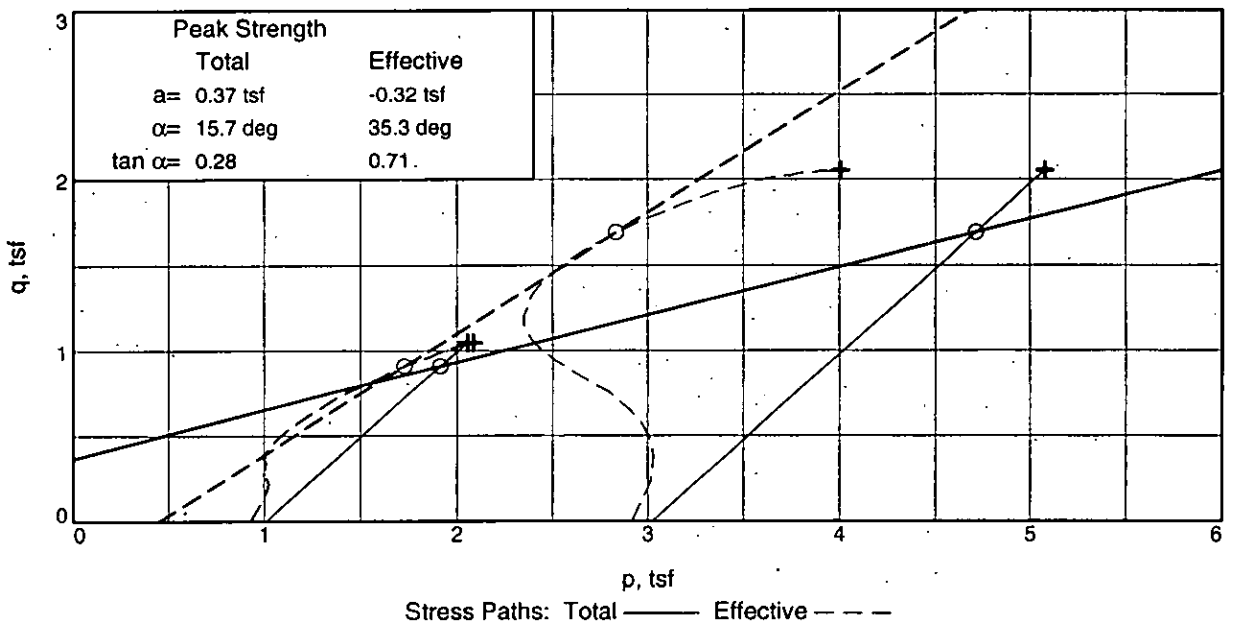
DLZ











Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-1136A
Depth: 8.0
Sample Number: ST2
Project No.: 0121-3070.03
Figure _____

DLZ, INC.

Vane Shear Test Report

Project	SCI-823-0.00	Date and Time	7/26/2007	Begin 3:30pm
Project No.	0121-3070-03	Boring Number	B-1136A	End 4:00pm
Client	ODOT			Depth 10.6'
Drill Rig & Crew	D Wamsley			
Tested By	B Mott			
Weather / Temp.	sunny / 96			
Soil Type	SILTY CLAY with sand			

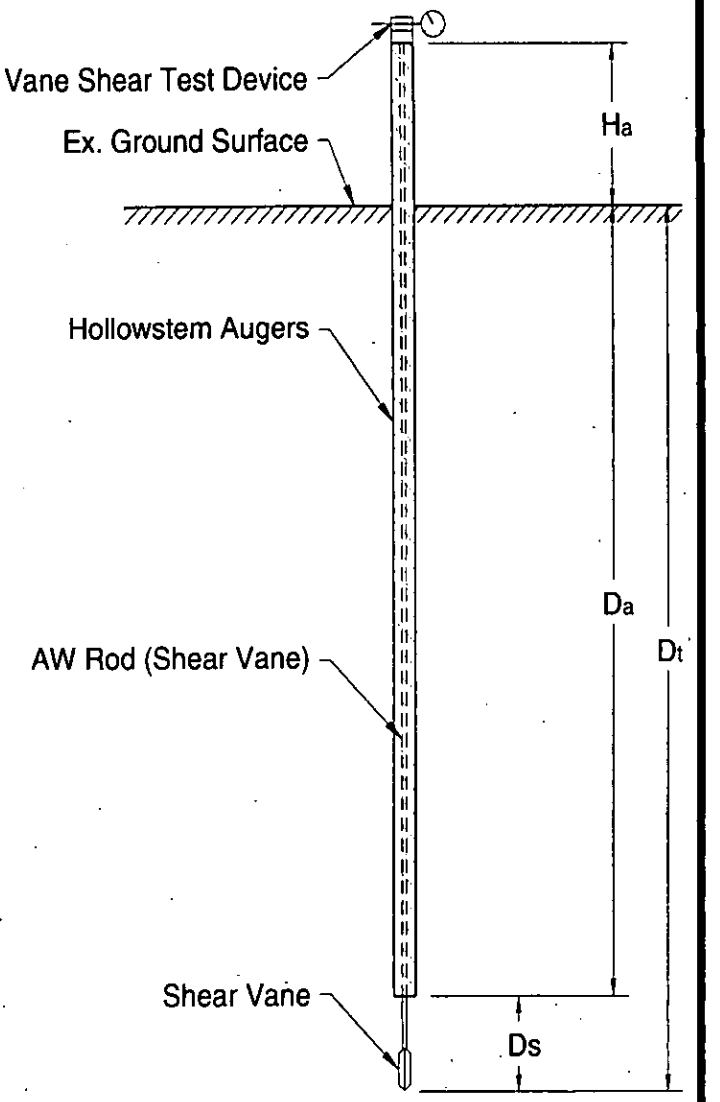
DRILLING

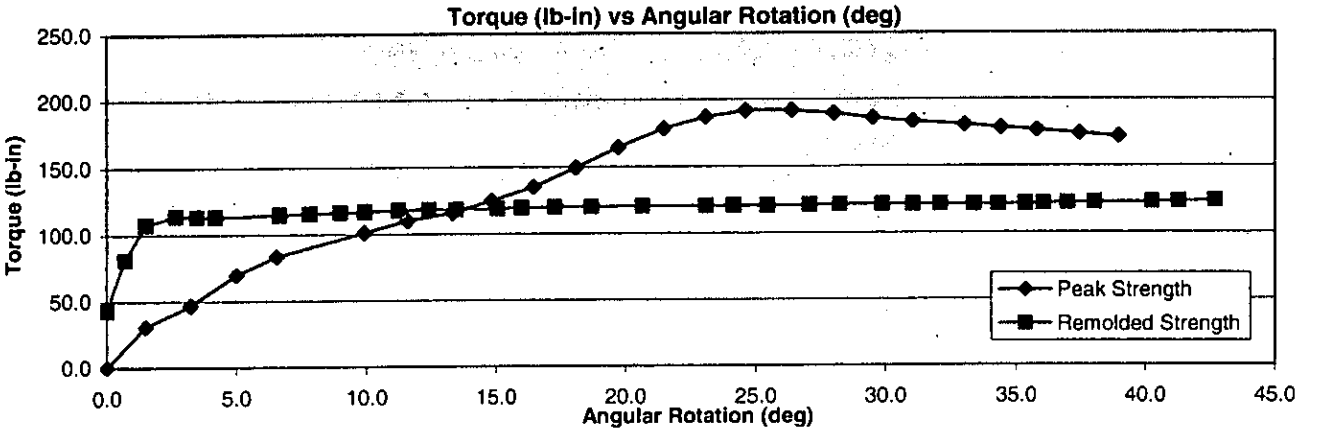
Hollowstem augers to depth	D_a	9.9
Vane Depth below bottom of augers	D_s	0.8
Augers above ground surface	H_a	7
Depth to vane tip	D_t	10.6

SHEAR VANE

Vane Used	2.0"	2.5"	3.625"
Vane constant, k (lb-in to psf)	5.17	2.59	0.905
Masurement by	Automatic/torque cell		
Max Torque	192	lb-in	
Max UD Shear Strength	***991***	***psf***	

Test Setup





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Vane Shear Test Report

Read Time	Δ time	Rotation (degrees)	Torque (in-lbs.)
Peak Strength Test			
15:34:18	0:00:00	0.0	0.0
15:34:31	0:00:13	1.5	30.9
15:34:46	0:00:28	3.3	46.8
15:35:01	0:00:43	5.0	69.7
15:35:14	0:00:56	6.5	83.6
15:35:43	0:01:25	9.9	101.2
15:35:57	0:01:39	11.5	110.0
15:36:12	0:01:54	13.3	115.9
15:36:25	0:02:07	14.8	124.5
15:36:39	0:02:21	16.4	135.1
15:36:53	0:02:35	18.1	149.3
15:37:07	0:02:49	19.7	164.5
15:37:22	0:03:04	21.5	178.4
15:37:36	0:03:18	23.1	186.9
15:37:49	0:03:31	24.6	191.7
15:38:04	0:03:46	26.4	191.7
15:38:18	0:04:00	28.0	189.5
15:38:31	0:04:13	29.5	186.1
15:38:44	0:04:26	31.0	183.5
15:39:01	0:04:43	33.0	180.8
15:39:13	0:04:55	34.4	178.6
15:39:25	0:05:07	35.8	176.6
15:39:39	0:05:21	37.4	174.2
15:39:52	0:05:34	39.0	171.8

Read Time	Δ time	Rotation (degrees)	Torque (in-lbs.)
Remolded Strength Test			
15:45:18	0:00:00	0.0	42.8
15:45:24	0:00:06	0.7	81.1
15:45:31	0:00:13	1.5	107.4
15:45:41	0:00:23	2.7	113.9
15:45:48	0:00:30	3.5	113.2
15:45:54	0:00:36	4.2	113.1
15:46:15	0:00:57	6.6	114.8
15:46:25	0:01:07	7.8	115.4
15:46:35	0:01:17	9.0	116.3
15:46:43	0:01:25	9.9	116.7
15:46:54	0:01:36	11.2	117.6
15:47:04	0:01:46	12.4	118.1
15:47:13	0:01:55	13.4	118.1
15:47:27	0:02:09	15.1	118.7
15:47:35	0:02:17	16.0	119.4
15:47:46	0:02:28	17.3	119.7
15:47:58	0:02:40	18.7	119.8
15:48:15	0:02:57	20.6	120.2
15:48:36	0:03:18	23.1	120.3
15:48:45	0:03:27	24.1	120.5
15:48:56	0:03:38	25.4	120.6
15:49:10	0:03:52	27.1	120.8
15:49:20	0:04:02	28.2	121.2
15:49:34	0:04:16	29.9	121.2
15:49:44	0:04:26	31.0	121.1
15:49:53	0:04:35	32.1	121.1
15:50:04	0:04:46	33.4	121.2
15:50:12	0:04:54	34.3	121.0
15:50:21	0:05:03	35.3	121.4
15:50:27	0:05:09	36.1	121.7
15:50:35	0:05:17	37.0	121.9
15:50:44	0:05:26	38.0	122.5
15:51:03	0:05:45	40.2	122.8
15:51:12	0:05:54	41.3	123.1
15:51:24	0:06:06	42.7	123.6

Peak Torque	*191.7*	(lb-in)
Vane Constant	*5.17*	
Peak Shear Strength	*991*	*psf*

Remolded Torque	*123.6*	(lb-in)
Vane Constant	*5.17*	
Remolded Shear Strength	*639*	*psf*
Sensitivity	*1.55*	

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Vane Shear Test Report

Project	SCI-823-0.00	Date and Time	7/26/2007	Begin 2:30pm
Project No.	0121-3070-03	Boring Number	B-1136A	End 3:20pm
Client	ODOT			Depth 7.8'
Drill Rig & Crew	D Wamsley			
Tested By	B Mott			
Weather / Temp.	sunny 85			
Soil Type				

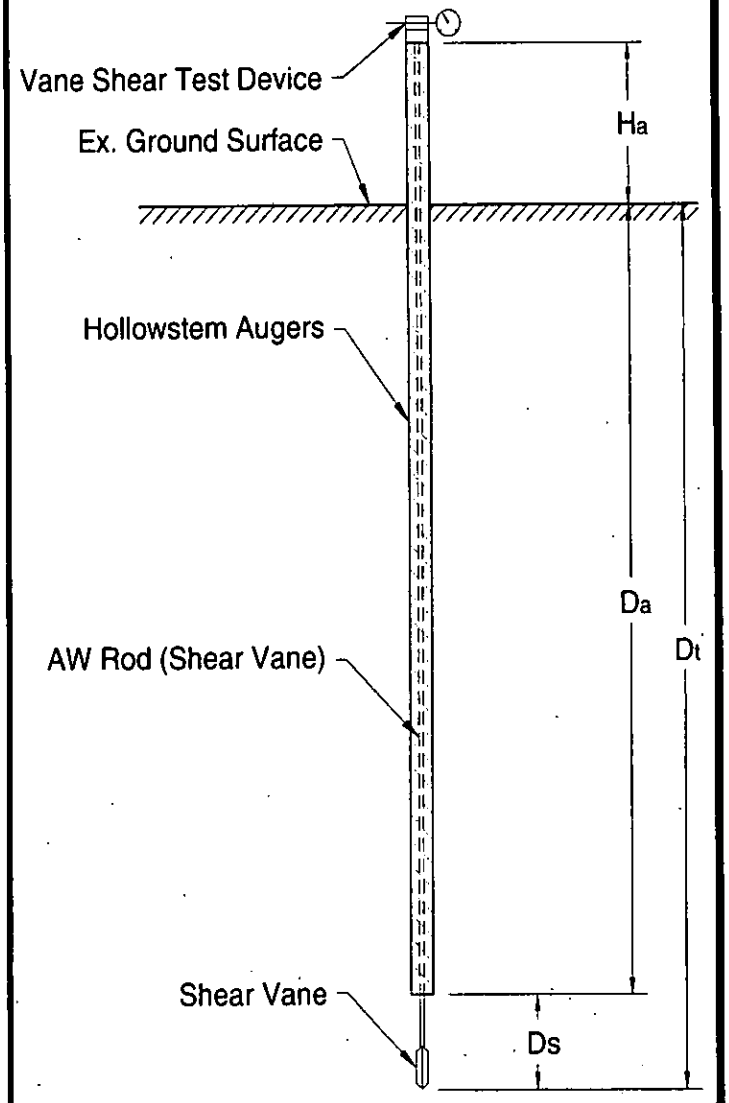
DRILLING

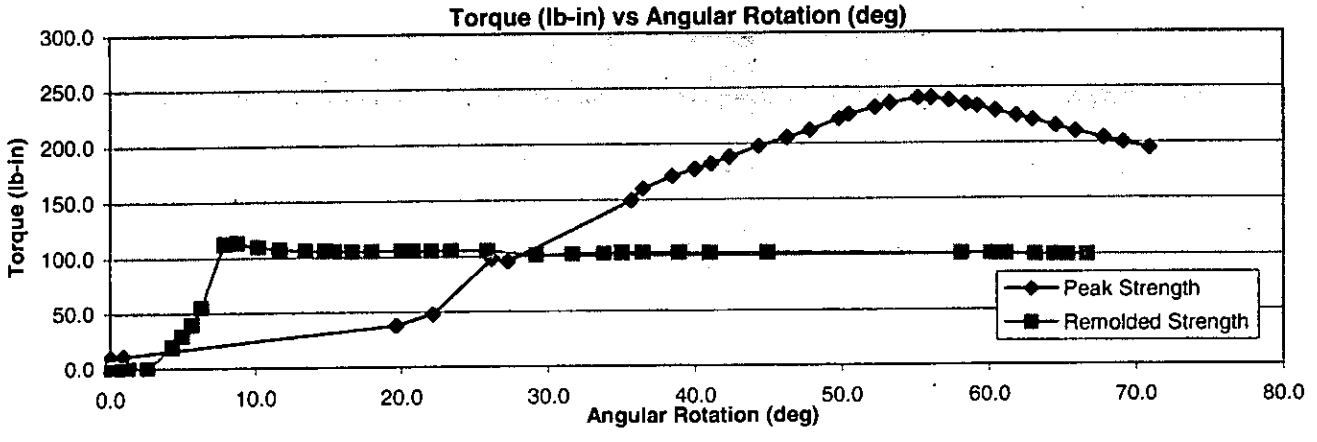
Hollowstem augers to depth	D_a	7
Vane Depth below bottom of augers	D_s	0.8
Augers above ground surface	H_a	7
Depth to vane tip	D_t	7.8

SHEAR VANE

Vane Used	**2.0"**	2.5"	3.625"
Vane constant, k (lb-in to psf)	**5.17**	2.59	0.905
Masurement by	Automatic/torque cell		
Max Torque	240	lb-in	
Max UD Shear Strength	***1242***	***psf***	

Test Setup





Vane Shear Test Report

Peak Strength Test

Read Time	Δ time	Rotation (degrees)	Torque (in-lbs.)
14:47:26	0:00:00	0.0	10.8
14:47:34	0:00:08	0.9	11.6
14:50:22	0:02:56	19.7	38.0
14:50:44	0:03:18	22.1	48.1
14:51:20	0:03:54	26.1	97.4
14:51:30	0:04:04	27.2	95.4
14:52:45	0:05:19	35.6	149.4
14:52:52	0:05:26	36.4	159.8
14:53:10	0:05:44	38.4	171.3
14:53:24	0:05:58	40.0	177.7
14:53:34	0:06:08	41.1	182.2
14:53:45	0:06:19	42.3	188.1
14:54:03	0:06:37	44.3	197.8
14:54:20	0:06:54	46.2	205.4
14:54:34	0:07:08	47.8	211.8
14:54:52	0:07:26	49.8	222.0
14:54:58	0:07:32	50.5	225.7
14:55:14	0:07:48	52.3	231.9
14:55:23	0:07:57	53.3	235.6
14:55:40	0:08:14	55.2	240.3
14:55:48	0:08:22	56.1	240.2
14:55:59	0:08:33	57.3	238.0
14:56:09	0:08:43	58.4	234.9
14:56:16	0:08:50	59.2	232.9
14:56:27	0:09:01	60.4	228.6
14:56:40	0:09:14	61.9	224.1
14:56:50	0:09:24	63.0	220.3
14:57:04	0:09:38	64.5	215.0
14:57:16	0:09:50	65.9	210.0
14:57:33	0:10:07	67.8	204.1
14:57:45	0:10:19	69.1	200.0
14:58:01	0:10:35	70.9	194.8

Remolded Strength Test

Read Time	Δ time	Rotation (degrees)	Torque (in-lbs.)
15:07:20	0:00:00	0.0	0.1
15:07:26	0:00:06	0.7	0.0
15:07:31	0:00:11	1.2	0.0
15:07:43	0:00:23	2.6	0.1
15:07:58	0:00:38	4.2	19.7
15:08:04	0:00:44	4.9	29.7
15:08:10	0:00:50	5.6	39.8
15:08:16	0:00:56	6.3	55.2
15:08:30	0:01:10	7.8	113.0
15:08:38	0:01:18	8.7	113.9
15:08:51	0:01:31	10.2	109.8
15:09:04	0:01:44	11.6	107.8
15:09:20	0:02:00	13.4	106.3
15:09:32	0:02:12	14.7	105.9
15:09:38	0:02:18	15.4	105.6
15:09:49	0:02:29	16.6	105.3
15:10:01	0:02:41	18.0	105.4
15:10:19	0:02:59	20.0	105.5
15:10:26	0:03:06	20.8	105.3
15:10:37	0:03:17	22.0	105.3
15:10:49	0:03:29	23.3	105.4
15:11:11	0:03:51	25.8	105.2
15:11:41	0:04:21	29.1	101.0
15:12:03	0:04:43	31.6	101.5
15:12:22	0:05:02	33.7	101.9
15:12:33	0:05:13	35.0	102.4
15:12:46	0:05:26	36.4	102.8
15:13:08	0:05:48	38.9	102.5
15:13:27	0:06:07	41.0	102.3
15:14:02	0:06:42	44.9	102.2
15:16:00	0:08:40	58.1	101.0
15:16:18	0:08:58	60.1	100.8
15:16:27	0:09:07	61.1	100.3
15:16:45	0:09:25	63.1	99.9
15:16:57	0:09:37	64.4	99.5
15:17:05	0:09:45	65.3	99.3
15:17:17	0:09:57	66.7	99.2

Peak Torque	*240.3*	(lb-in)
Vane Constant	*5.17*	
Peak Shear Strength	*1242*	*psf*

Remolded Torque	*113.9*	(lb-in)
Vane Constant	*5.17*	
Remolded Shear Strength	*589*	*psf*
Sensitivity	*2.11*	

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Vane Shear Test Report

Project	SCI-823-0.00	Date and Time	7/26/2008	Begin 11:15pm End 12:00pm
Project No.	0121-3070-03	Boring Number	B-1138a	Depth 7.0'
Client	ODOT			
Drill Rig & Crew	D Wamsley			
Tested By	B Mott			
Weather / Temp.	sunny 80			
Soil Type				

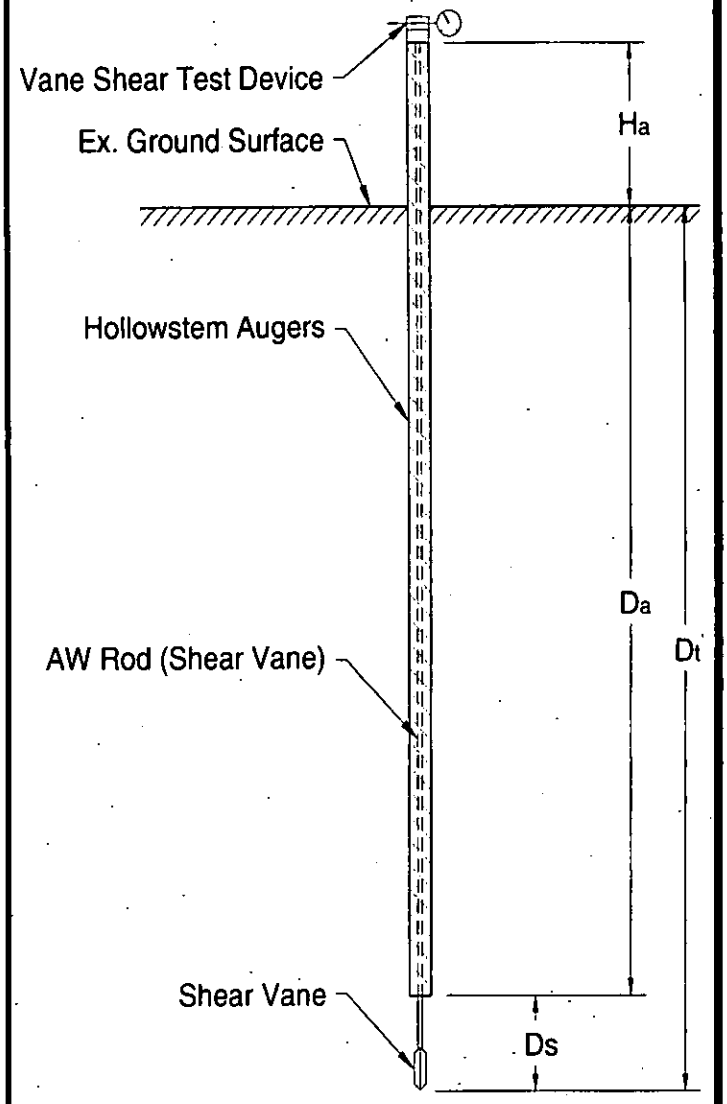
DRILLING

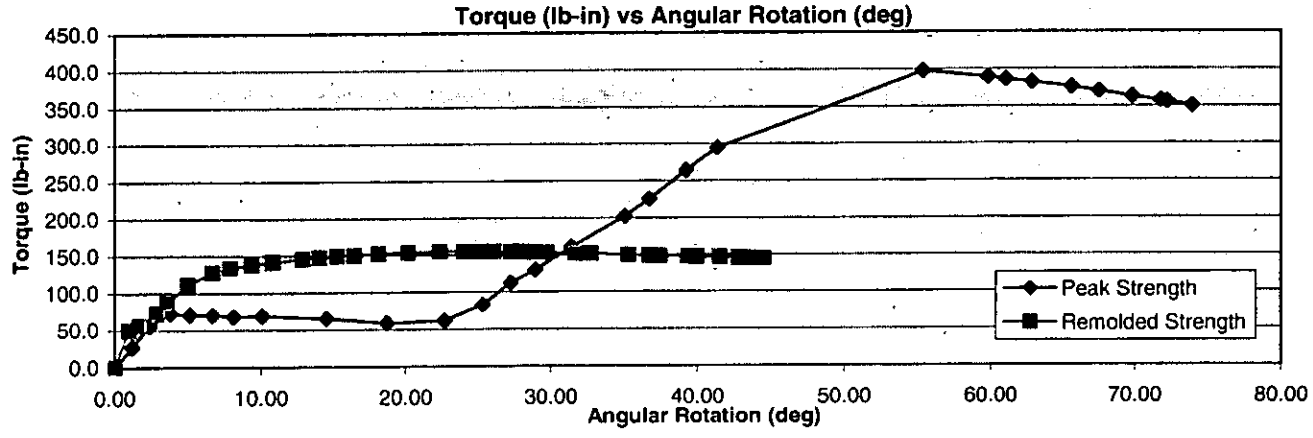
Hollowstem augers to depth	D_a	6
Vane Depth below bottom of augers	D_s	1
Augers above ground surface	H_a	7.8
Depth to vane tip	D_t	7

SHEAR VANE

Vane Used	2.0"	2.5"	3.625"
Vane constant, k (lb-in to psf)	5.17	2.59	0.905
Masurement by	Automatic/torque cell		
Max Torque	398	lb-in	
Max UD Shear Strength	**2057**	**psf**	

Test Setup





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Vane Shear Test Report

Read Time	Δ time	Rotation *(degrees)*	Torque *(in-lbs.)*
Peak Strength Test			
11:28:50	0:00:00	*0.00*	0.0
11:29:00	0:00:10	*1.20*	27.7
11:29:10	0:00:20	*2.40*	55.5
11:29:22	0:00:32	*3.84*	72.6
11:29:33	0:00:43	*5.16*	70.6
11:29:46	0:00:56	*6.72*	69.9
11:29:58	0:01:08	*8.16*	68.0
11:30:14	0:01:24	*10.08*	68.7
11:30:51	0:02:01	*14.52*	64.5
11:31:26	0:02:36	*18.72*	58.6
11:31:59	0:03:09	*22.68*	61.3
11:32:21	0:03:31	*25.32*	83.2
11:32:37	0:03:47	*27.24*	112.2
11:32:51	0:04:01	*28.92*	130.1
11:33:12	0:04:22	*31.44*	160.4
11:33:42	0:04:52	*35.04*	202.0
11:33:56	0:05:06	*36.72*	225.2
11:34:17	0:05:27	*39.24*	264.1
11:34:35	0:05:45	*41.40*	294.1
11:36:32	0:07:42	*55.44*	397.8
11:37:09	0:08:19	*59.88*	389.5
11:37:19	0:08:29	*61.08*	386.5
11:37:34	0:08:44	*62.88*	382.5
11:37:57	0:09:07	*65.64*	376.0
11:38:13	0:09:23	*67.56*	370.2
11:38:32	0:09:42	*69.84*	363.0
11:38:48	0:09:58	*71.76*	357.8
11:38:52	0:10:02	*72.24*	356.1
11:39:06	0:10:16	*73.92*	350.1

Read Time	Δ time	Rotation *(degrees)*	Torque *(in-lbs.)*
Remolded Strength Test			
11:48:56	0:00:00	0.00	0.0
11:49:04	0:00:08	0.96	49.0
11:49:10	0:00:14	1.68	56.0
11:49:20	0:00:24	2.88	72.2
11:49:26	0:00:30	3.60	86.6
11:49:38	0:00:42	5.04	111.1
11:49:52	0:00:56	6.72	127.9
11:50:02	0:01:06	7.92	133.7
11:50:14	0:01:18	9.36	138.3
11:50:26	0:01:30	10.80	141.5
11:50:43	0:01:47	12.84	145.4
11:50:53	0:01:57	14.04	147.4
11:51:03	0:02:07	15.24	148.9
11:51:13	0:02:17	16.44	150.1
11:51:27	0:02:31	18.12	152.1
11:51:44	0:02:48	20.16	153.7
11:52:02	0:03:06	22.32	154.6
11:52:16	0:03:20	24.00	154.3
11:52:25	0:03:29	25.08	154.2
11:52:33	0:03:37	26.04	154.3
11:52:43	0:03:47	27.24	153.9
11:52:49	0:03:53	27.96	153.8
11:52:56	0:04:00	28.80	153.5
11:53:04	0:04:08	29.76	153.0
11:53:20	0:04:24	31.68	151.9
11:53:29	0:04:33	32.76	151.6
11:53:50	0:04:54	35.28	149.7
11:54:02	0:05:06	36.72	148.8
11:54:08	0:05:12	37.44	148.2
11:54:24	0:05:28	39.36	147.3
11:54:29	0:05:33	39.96	147.0
11:54:42	0:05:46	41.52	146.3
11:54:53	0:05:57	42.84	145.4
11:54:59	0:06:03	43.56	145.0
11:55:07	0:06:11	44.52	144.2

Peak Torque	*397.8*	(lb-in)
Vane Constant	*5.17*	
Peak Shear Strength	*2057*	*psf*

Remolded Torque	*154.6*	(lb-in)
Vane Constant	*5.17*	
Remolded Shear Strength	*799*	*psf*
Sensitivity	*2.57*	

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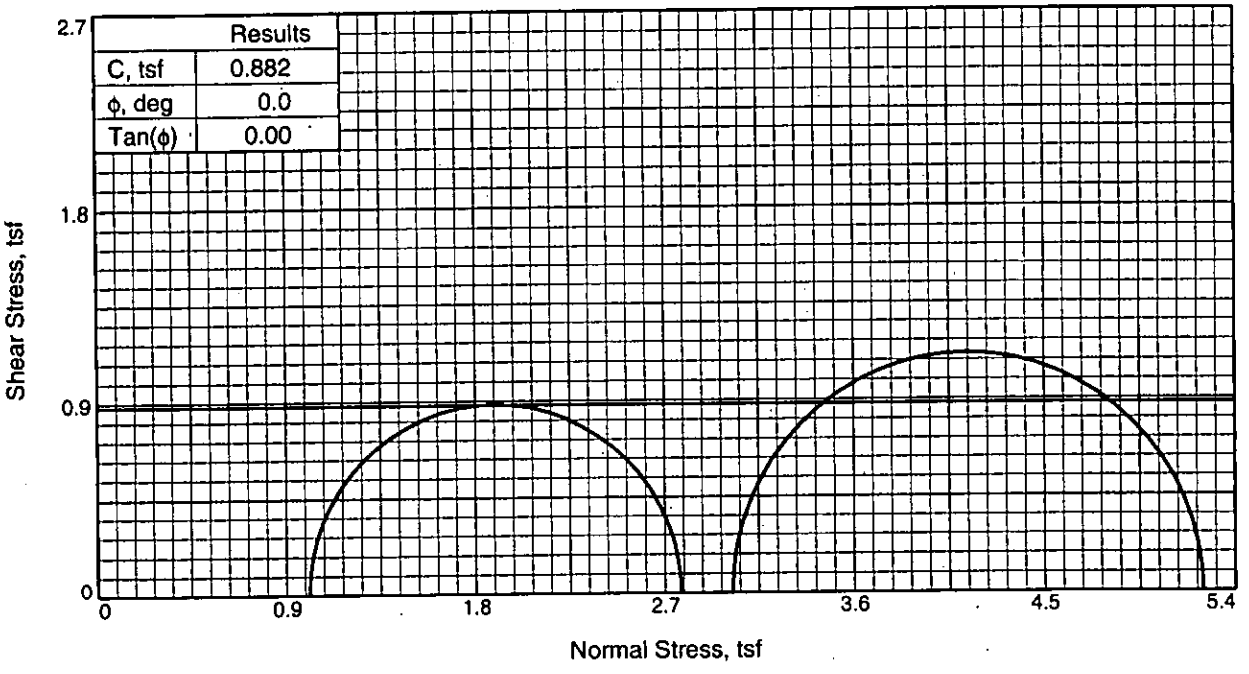

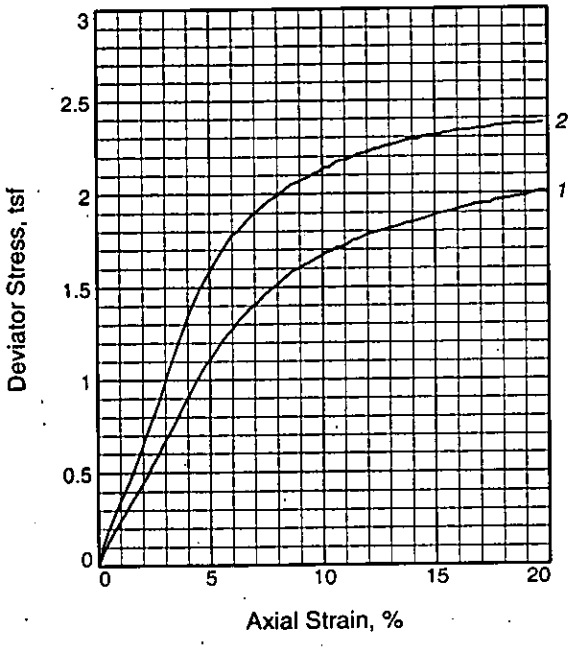

Sample No.		1	2
Initial	Water Content,	24.9	24.9
	Dry Density, pcf	100.0	100.5
	Saturation,	98.7	99.8
	Void Ratio	0.6786	0.6712
	Diameter, in.	2.82	2.81
	Height, in.	5.57	5.59
At Test	Water Content,	25.1	26.7
	Dry Density, pcf	100.0	100.5
	Saturation,	99.5	107.2
	Void Ratio	0.6786	0.6712
	Diameter, in.	2.82	2.81
	Height, in.	5.57	5.59
Strain rate, in./min.		0.06	0.06
Back Pressure, tsf		0.00	0.00
Cell Pressure, tsf		1.01	3.02
Fail. Stress, tsf		1.77	2.22
Ult. Stress, tsf		1.77	2.22
σ_1 Failure, tsf		2.78	5.25
σ_3 Failure, tsf		1.01	3.02

Type of Test:
Unconsolidated Undrained

Sample Type: Press Tube

Description:

Specific Gravity= 2.69

Remarks:

Figure _____

Client: TranSystems, Inc.

Project: SCI-823-0.00

Source of Sample: B-1138A **Depth:** 8.0

Sample Number: ST2

Proj. No.: 0121-3070.03 **Date:**

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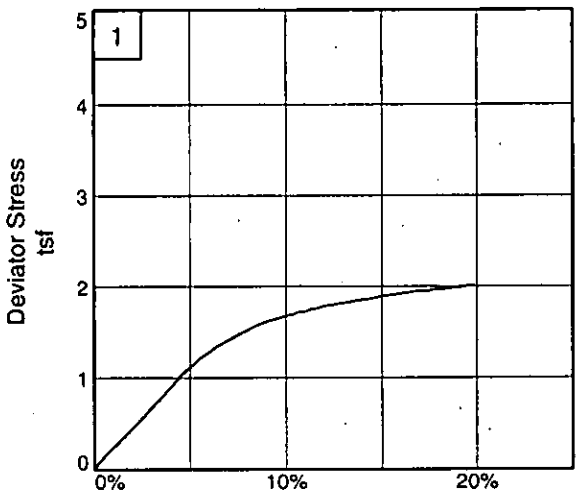
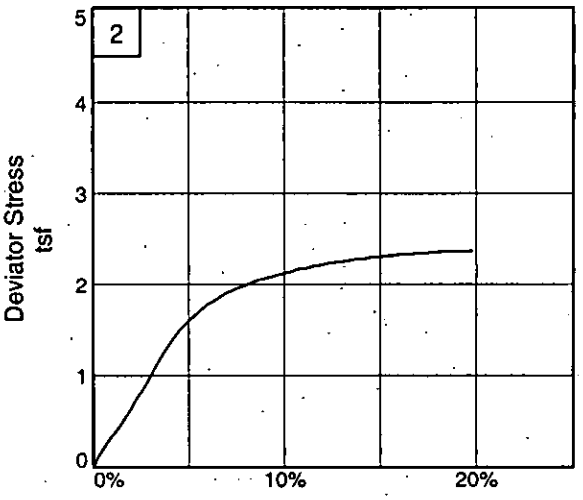
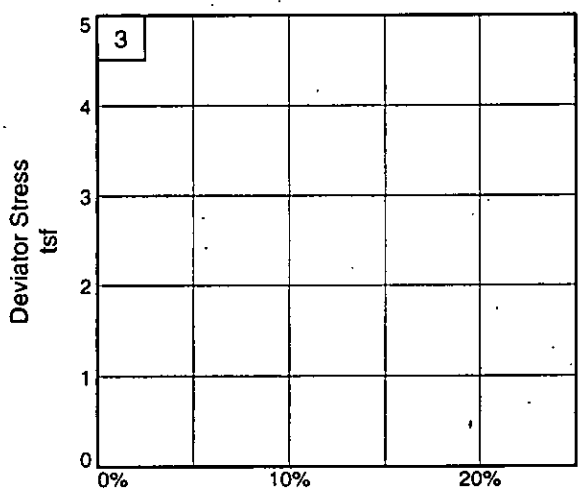
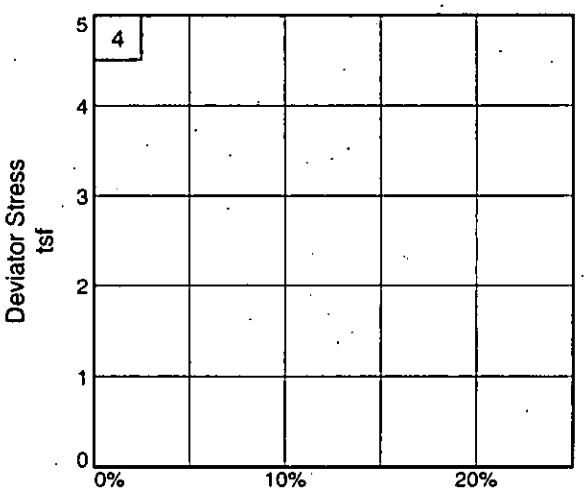
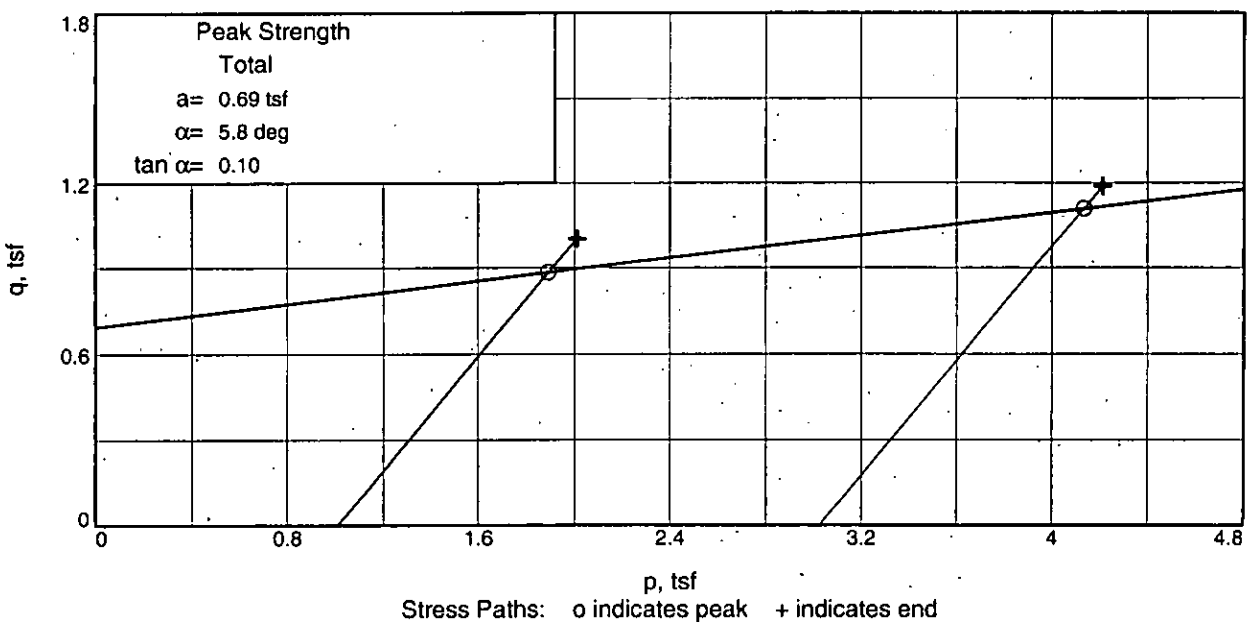










Stress Paths: o indicates peak + indicates end

Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-1138A **Depth:** 8.0 **Sample Number:** ST2
Project No.: 0121-3070.03 **Figure** _____

DLZ, INC.

Vane Shear Test Report

Project	SCI-823-0.00	Date and Time	7/26/2007 Begin 1:15pm End 1:50pm
Project No.	0121-3070-03	Boring Number	B-1138A Depth 9.1
Client	ODOT		
Drill Rig & Crew	D Wamsley		
Tested By	B Mott		
Weather / Temp.	sunny 85		
Soil Type	SILTY CLAY with sand		

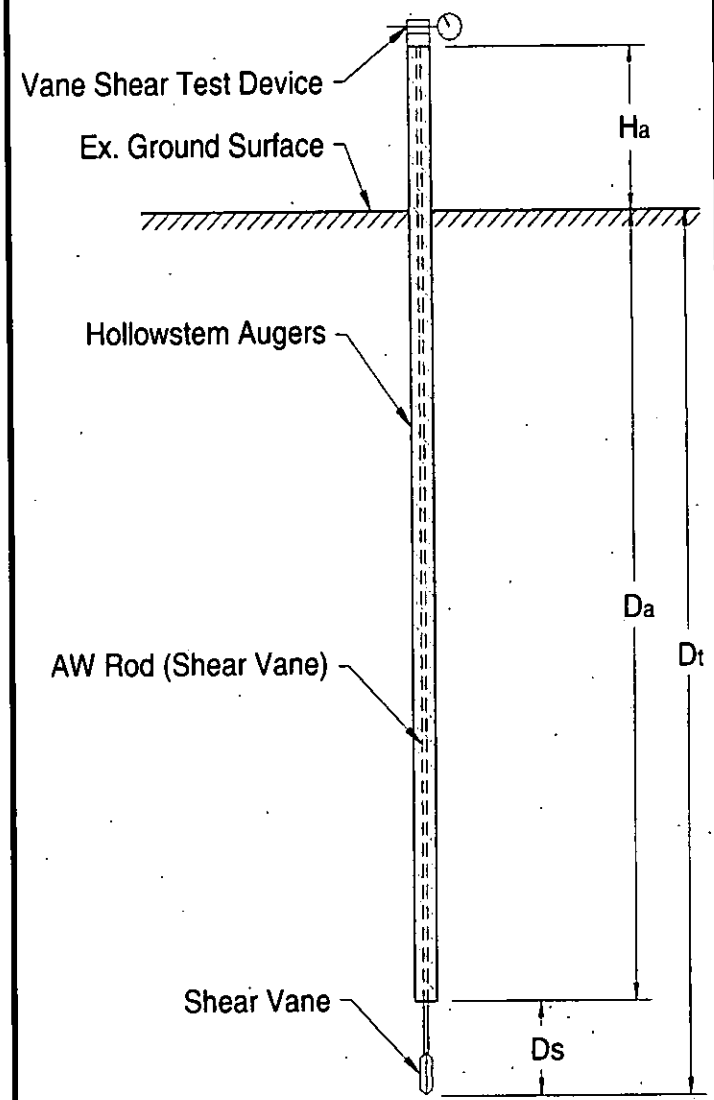
DRILLING

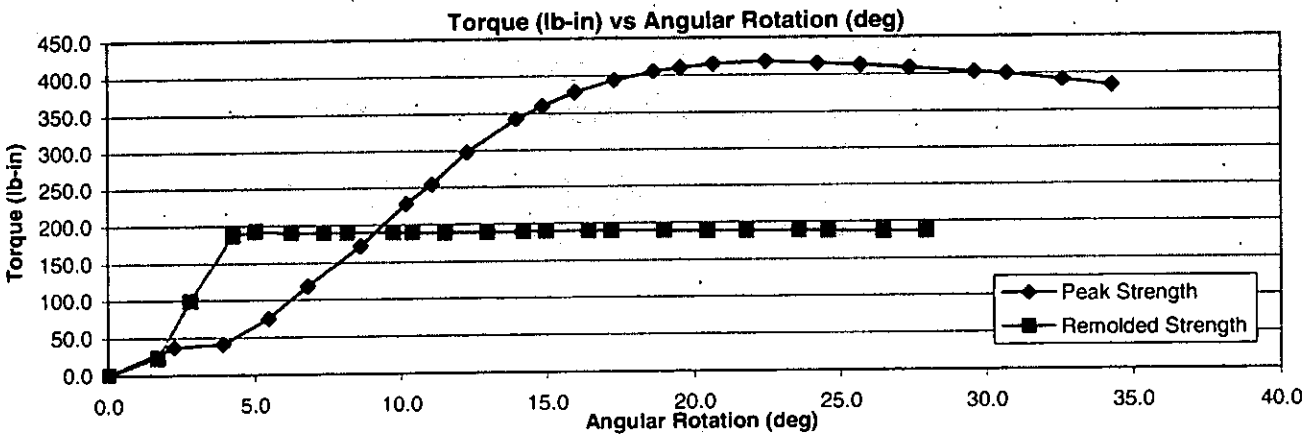
Hollowstem augers to depth	D_a	7.3
Vane Depth below bottom of augers	D_s	1
Augers above ground surface	H_a	8.7
Depth to vane tip	D_t	9.1

SHEAR VANE

Vane Used	[2.0"]	2.5"	3.625"
Vane constant, k (lb-in to psf)	[5.17]	2.59	0.905
Masurement by	Automatic/torque cell		
Max Torque	418	lb-in	
Max UD Shear Strength	**2161**	**psf**	

Test Setup





Vane Shear Test Report

Read Time	Δ time	Rotation *(degrees)*	Torque *(in-lbs.)*
Peak Strength Test			
13:25:51	0:00:00	0.0	0.0
13:26:11	0:00:20	2.2	37.3
13:26:26	0:00:35	3.9	41.2
13:26:40	0:00:49	5.5	75.2
13:26:52	0:01:01	6.8	118.4
13:27:08	0:01:17	8.6	172.0
13:27:22	0:01:31	10.2	228.1
13:27:30	0:01:39	11.1	254.6
13:27:41	0:01:50	12.3	297.6
13:27:56	0:02:05	14.0	342.4
13:28:04	0:02:13	14.9	359.8
13:28:14	0:02:23	16.0	378.5
13:28:26	0:02:35	17.3	394.1
13:28:38	0:02:47	18.6	405.5
13:28:46	0:02:55	19.5	410.2
13:28:56	0:03:05	20.7	414.9
13:29:12	0:03:21	22.4	418.1
13:29:28	0:03:37	24.2	415.2
13:29:41	0:03:50	25.7	412.7
13:29:56	0:04:05	27.4	408.9
13:30:16	0:04:25	29.6	402.5
13:30:26	0:04:35	30.7	400.1
13:30:43	0:04:52	32.6	391.2
13:30:58	0:05:07	34.3	383.5

Read Time	Δ time	Rotation *(degrees)*	Torque *(in-lbs.)*
Remolded Strength Test			
13:42:11	0:00:00	0.0	0.0
13:42:26	0:00:15	1.7	22.9
13:42:36	0:00:25	2.8	99.1
13:42:49	0:00:38	4.2	187.3
13:42:56	0:00:45	5.0	192.3
13:43:07	0:00:56	6.3	190.1
13:43:17	0:01:06	7.4	189.9
13:43:24	0:01:13	8.2	190.2
13:43:38	0:01:27	9.7	189.2
13:43:44	0:01:33	10.4	189.3
13:43:54	0:01:43	11.5	189.0
13:44:07	0:01:56	13.0	189.1
13:44:18	0:02:07	14.2	189.3
13:44:25	0:02:14	15.0	189.3
13:44:38	0:02:27	16.4	189.5
13:44:45	0:02:34	17.2	189.3
13:45:01	0:02:50	19.0	189.3
13:45:14	0:03:03	20.4	188.9
13:45:26	0:03:15	21.8	188.7
13:45:42	0:03:31	23.6	187.9
13:45:51	0:03:40	24.6	187.8
13:46:08	0:03:57	26.5	186.9
13:46:21	0:04:10	27.9	186.7

Peak Torque	*418.1*	(lb-in)
Vane Constant	*5.17*	
Peak Shear Strength	*2161*	*psf*

Remolded Torque	*192.3*	(lb-in)
Vane Constant	*5.17*	
Remolded Shear Strength	*994*	*psf*
Sensitivity	*2.2*	

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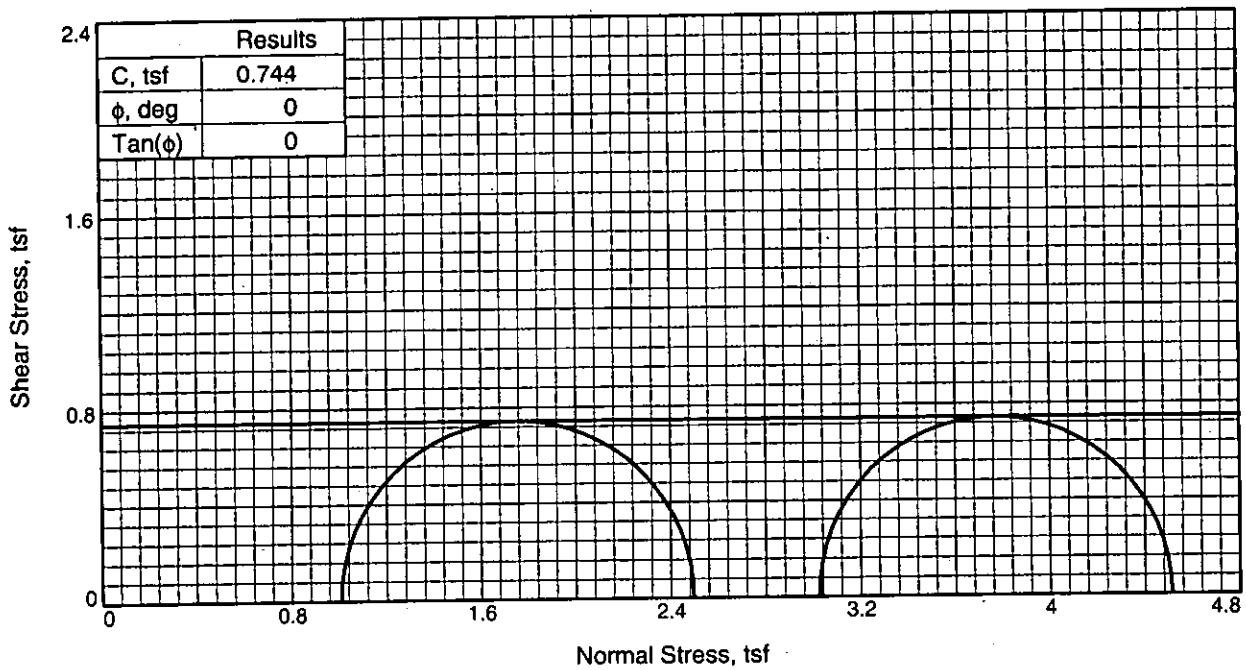

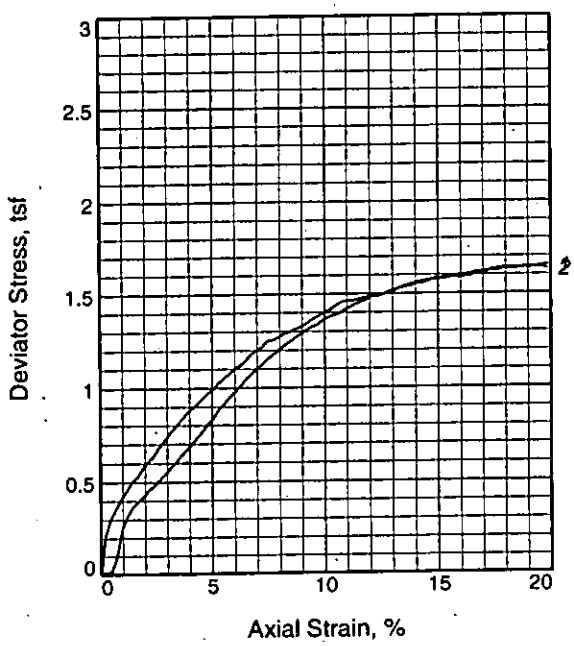

Sample No.		1	2
Initial	Water Content,	21.6	21.6
	Dry Density, pcf	103.5	102.3
	Saturation,	89.8	87.1
	Void Ratio	0.6646	0.6850
	Diameter, in.	2.79	2.82
	Height, in.	5.58	5.58
At Test	Water Content,	22.1	22.1
	Dry Density, pcf	103.5	102.3
	Saturation,	91.6	88.9
	Void Ratio	0.6646	0.6850
	Diameter, in.	2.79	2.82
	Height, in.	5.58	5.58
Strain rate, in./min.		0.06	0.06
Back Pressure, tsf		0.00	0.00
Cell Pressure, tsf		1.01	3.02
Fail. Stress, tsf		1.49	1.49
Ult. Stress, tsf		1.65	1.63
σ_1 Failure, tsf		2.50	4.51
σ_3 Failure, tsf		1.01	3.02

Type of Test:
Unconsolidated Undrained

Sample Type: 3" press tube

Description:

Assumed Specific Gravity= 2.76

Remarks:

Figure _____

Client: TranSystems, Inc.

Project: SCI-823-0.00

Source of Sample: B-45 **Depth:** 5.0

Sample Number: P-1

Proj. No.: 0121-3070.03 **Date:**

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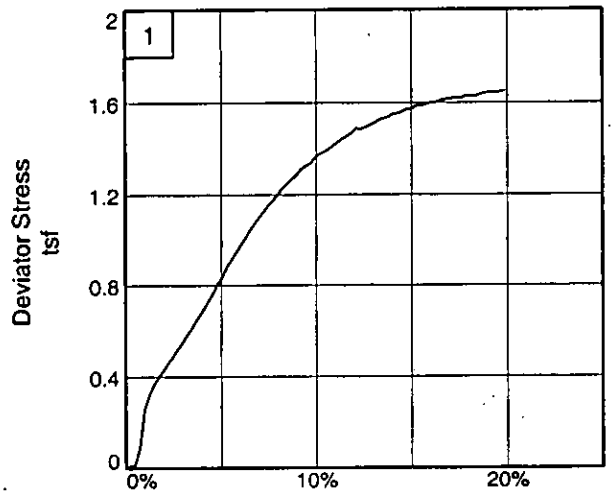
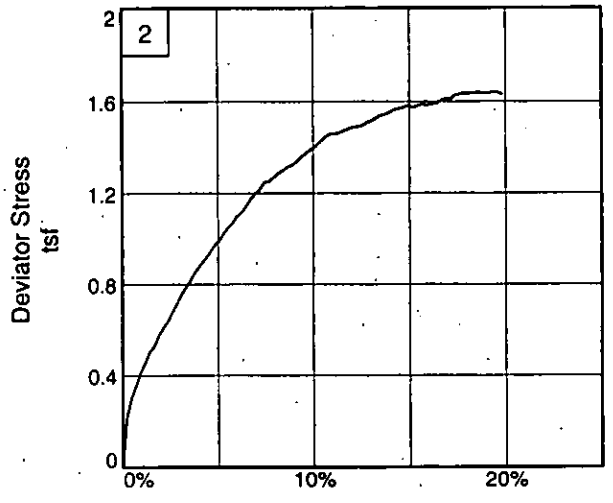
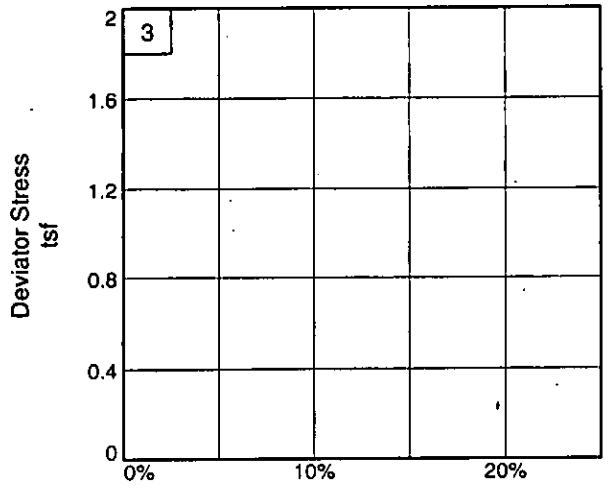
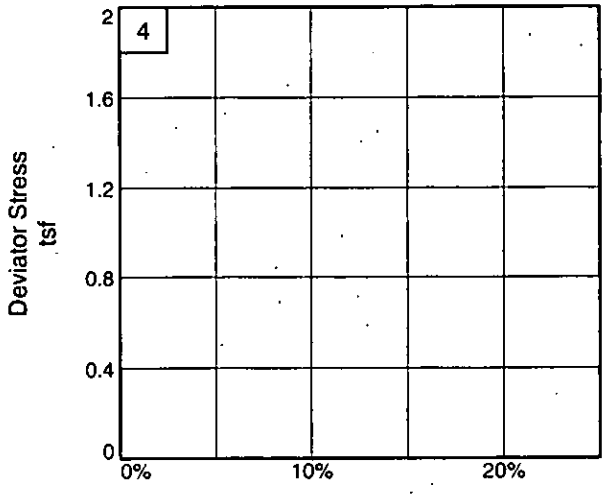
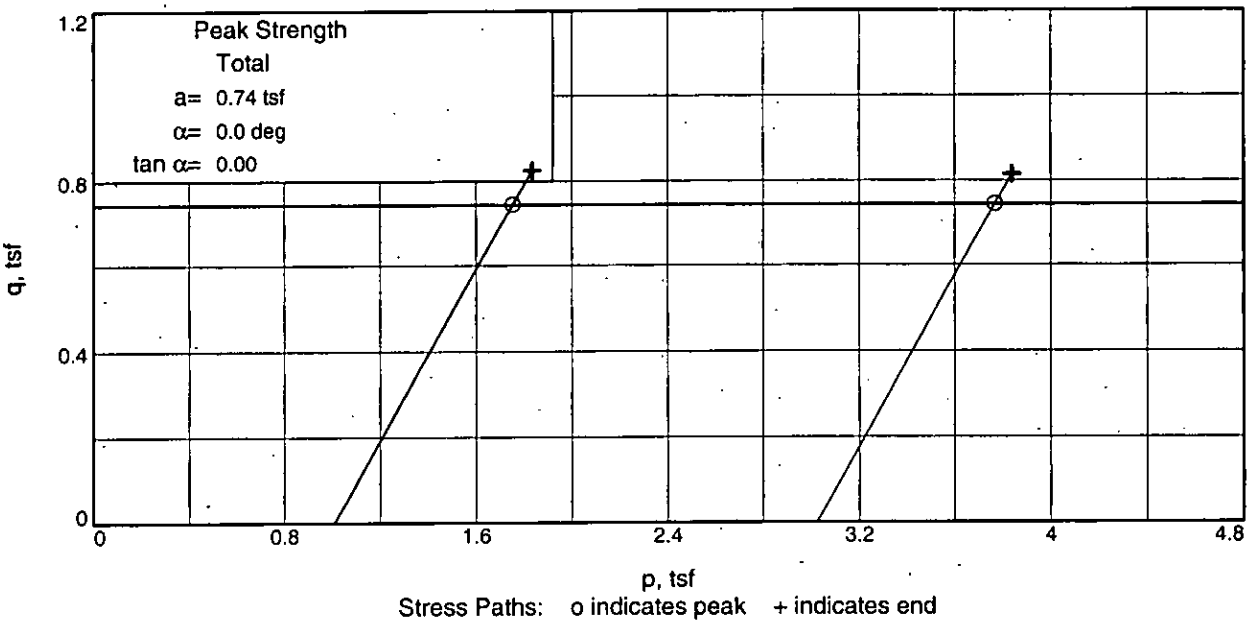










Stress Paths: o indicates peak + indicates end

Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-45 **Depth:** 5.0 **Sample Number:** P-1
Project No.: 0121-3070.03 **Figure** _____

DLZ, INC.

Vane Shear Test Report

Project	SCI-823 Portsmouth Bypass	Date and Time	6/14/2007
Project No.	0121-3070.03	Boring Number	B-45 Depth 6'
Client	TranSystems Corp		
Drill Rig & Crew	Doug W. on CME 850		
Tested By	Riedy / Mott		
Weather / Temp.	Sun / 85 deg		
Soil Type	Silty Clay (A-6b)		

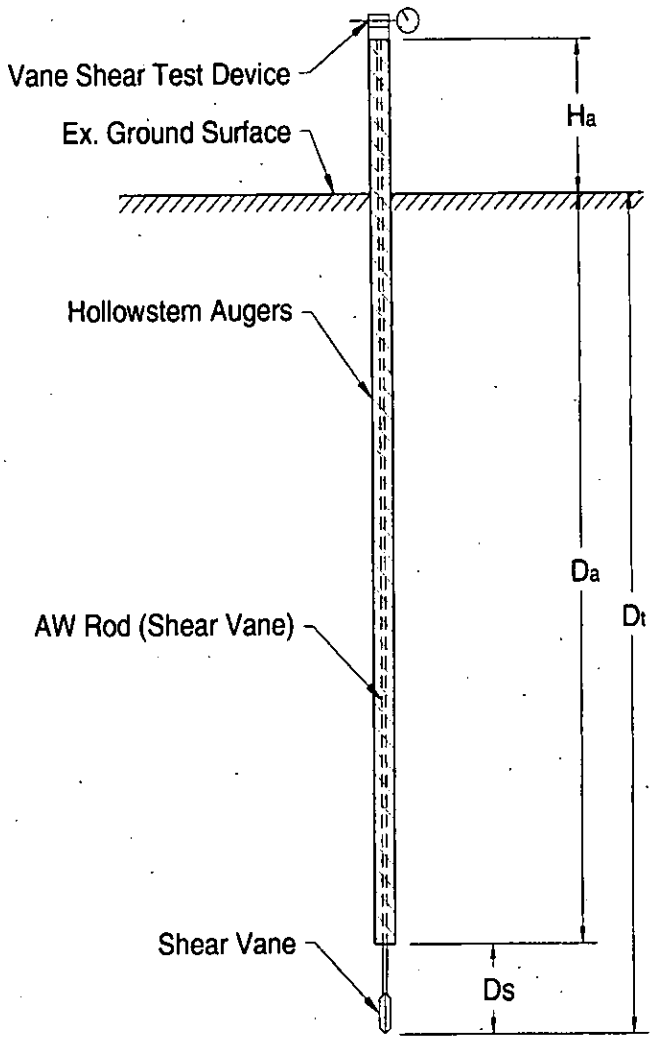
DRILLING

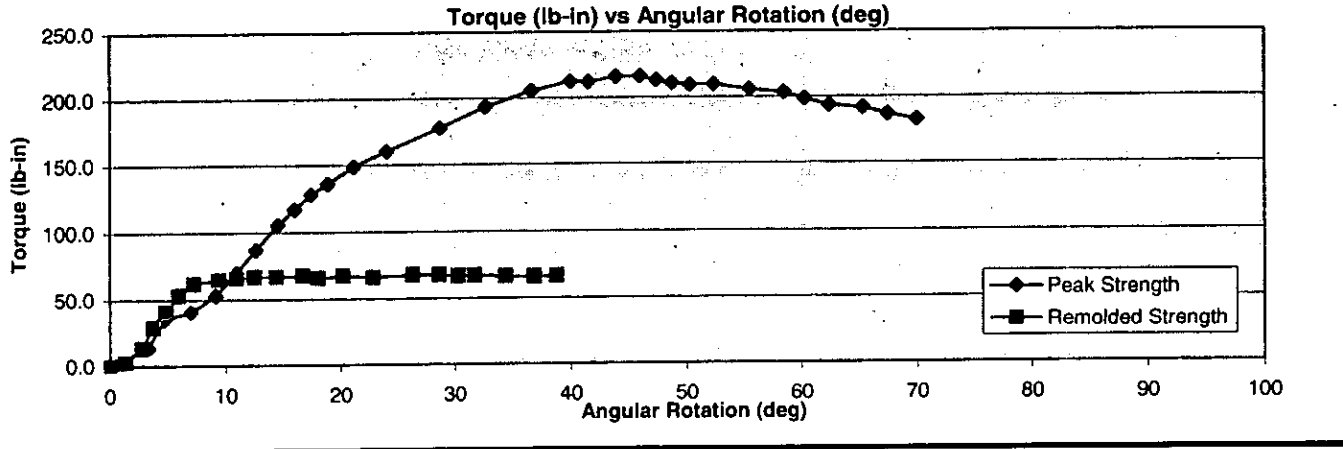
Hollowstem augers to depth	D_a	5'
Vane Depth below bottom of augers	D_s	1'
Augers above ground surface	H_a	2'
Depth to vane tip	D_t	6'

SHEAR VANE

Vane Used	2.0"	2.5"	3.625"
Vane constant, k (lb-in to psf)	5.17	2.59	0.905
Masurement by	Automatic Drive / Torque Cell		
Max Torque	216	lb-in	
Max UD Shear Strength	**1116**	**psf**	

Test Setup





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Vane Shear Test Report

Peak Strength Test

Read Time	Δ time	Rotation (degrees)	Torque (in-lbs.)
15:32:01	0:00:00	0	0.0
15:32:28	0:00:27	3.2	13.4
15:32:40	0:00:39	4.7	34.9
15:32:59	0:00:58	7.0	40.4
15:33:17	0:01:16	9.1	52.9
15:33:32	0:01:31	10.9	69.9
15:33:46	0:01:45	12.6	87.0
15:34:02	0:02:01	14.52	105.6
15:34:14	0:02:13	15.96	117.2
15:34:26	0:02:25	17.4	128.3
15:34:38	0:02:37	18.84	136.2
15:34:57	0:02:56	21.12	148.8
15:35:21	0:03:20	24	160.3
15:36:00	0:03:59	28.68	177.9
15:36:33	0:04:32	32.64	193.7
15:37:06	0:05:05	36.6	205.4
15:37:34	0:05:33	39.96	212.2
15:37:47	0:05:46	41.52	211.7
15:38:07	0:06:06	43.92	215.7
15:38:24	0:06:23	45.96	215.8
15:38:36	0:06:35	47.4	213.0
15:38:47	0:06:46	48.72	210.6
15:39:00	0:06:59	50.28	209.2
15:39:17	0:07:16	52.32	209.6
15:39:43	0:07:42	55.44	205.7
15:40:08	0:08:07	58.44	203.5
15:40:23	0:08:22	60.24	198.6
15:40:41	0:08:40	62.4	193.7
15:41:05	0:09:04	65.28	191.7
15:41:23	0:09:22	67.44	187.1
15:41:44	0:09:43	69.96	182.8

Remolded Strength Test

Read Time	Δ time	Rotation (degrees)	Torque (in-lbs.)
15:48:20	0:00:00	0	0
15:48:31	0:00:11	1.3	2.6519108
15:48:43	0:00:23	2.8	13.496029
15:48:51	0:00:31	3.7	28.912601
15:49:00	0:00:40	4.8	40.501919
15:49:09	0:00:49	5.9	53.374943
15:49:20	0:01:00	7.2	61.857727
15:49:38	0:01:18	9.4	64.540031
15:49:51	0:01:31	10.92	65.733902
15:50:04	0:01:44	12.48	66.995094
15:50:20	0:02:00	14.4	66.730019
15:50:39	0:02:19	16.68	67.381081
15:50:50	0:02:30	18	65.608727
15:51:08	0:02:48	20.16	67.27784
15:51:30	0:03:10	22.8	66.025963
15:51:59	0:03:39	26.28	67.752907
15:52:18	0:03:58	28.56	67.584648
15:52:32	0:04:12	30.24	66.863716
15:52:44	0:04:24	31.68	67.083794
15:53:06	0:04:46	34.32	66.254555
15:53:27	0:05:07	36.84	66.090385
15:53:43	0:05:23	38.76	66.317818

Peak Torque	*215.7953*	(lb-in)
Vane Constant	*5.17*	
Peak Shear Strength	***1116***	*psf*

Remolded Torque	*67.75291*	(lb-in)
Vane Constant	*5.17*	
Remolded Shear Strength	*350*	*psf*
Sensitivity	*3.2*	

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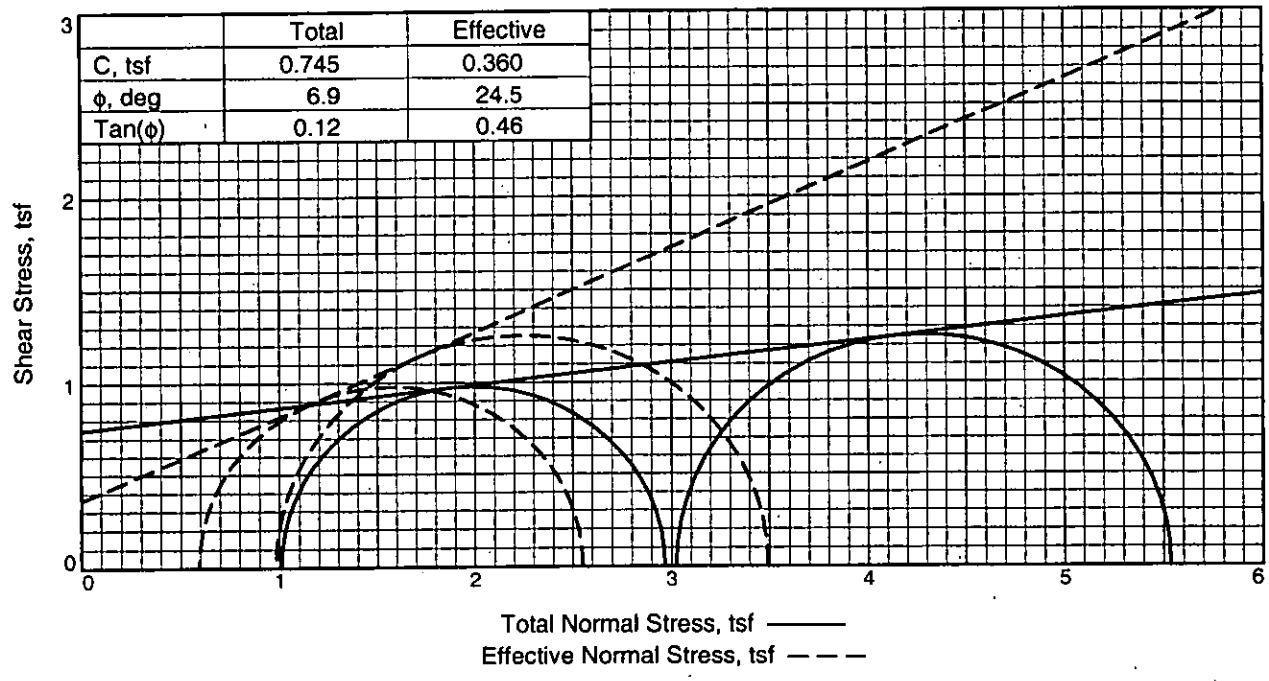
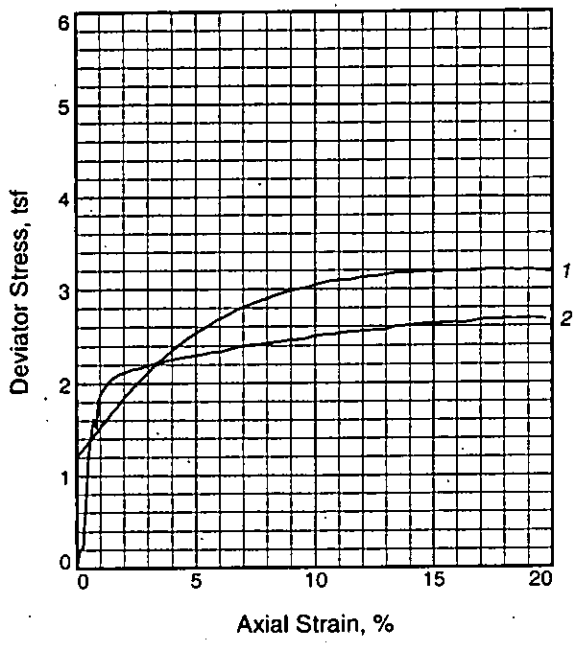
	Total	Effective
C, tsf	0.745	0.360
ϕ, deg	6.9	24.5
Tan(ϕ)	0.12	0.46





Sample No.		1	2
Initial	Water Content,	14.3	14.3
	Dry Density, pcf	114.1	114.6
	Saturation,	77.9	79.0
	Void Ratio	0.5045	0.4976
	Diameter, in.	2.82	2.83
	Height, in.	5.59	5.58
At Test	Water Content,	18.0	17.0
	Dry Density, pcf	114.9	117.1
	Saturation,	100.0	100.0
	Void Ratio	0.4940	0.4663
	Diameter, in.	2.82	2.81
	Height, in.	5.55	5.51
Strain rate, in./min.		0.01	0.01
Back Pressure, tsf		3.31	3.31
Cell Pressure, tsf		4.32	6.34
Fail. Stress, tsf		1.96	2.51
Total Pore Pr., tsf		3.73	5.35
Ult. Stress, tsf		1.96	2.51
Total Pore Pr., tsf		3.73	5.35
$\bar{\sigma}_1$ Failure, tsf		2.55	3.49
$\bar{\sigma}_3$ Failure, tsf		0.59	0.98

Type of Test:
CU with Pore Pressures
Sample Type: 3" press tube
Description: Clayey sand with gravel

LL= 27 **PL=** 16 **PI=** 11
Assumed Specific Gravity= 2.75
Remarks:

Figure _____

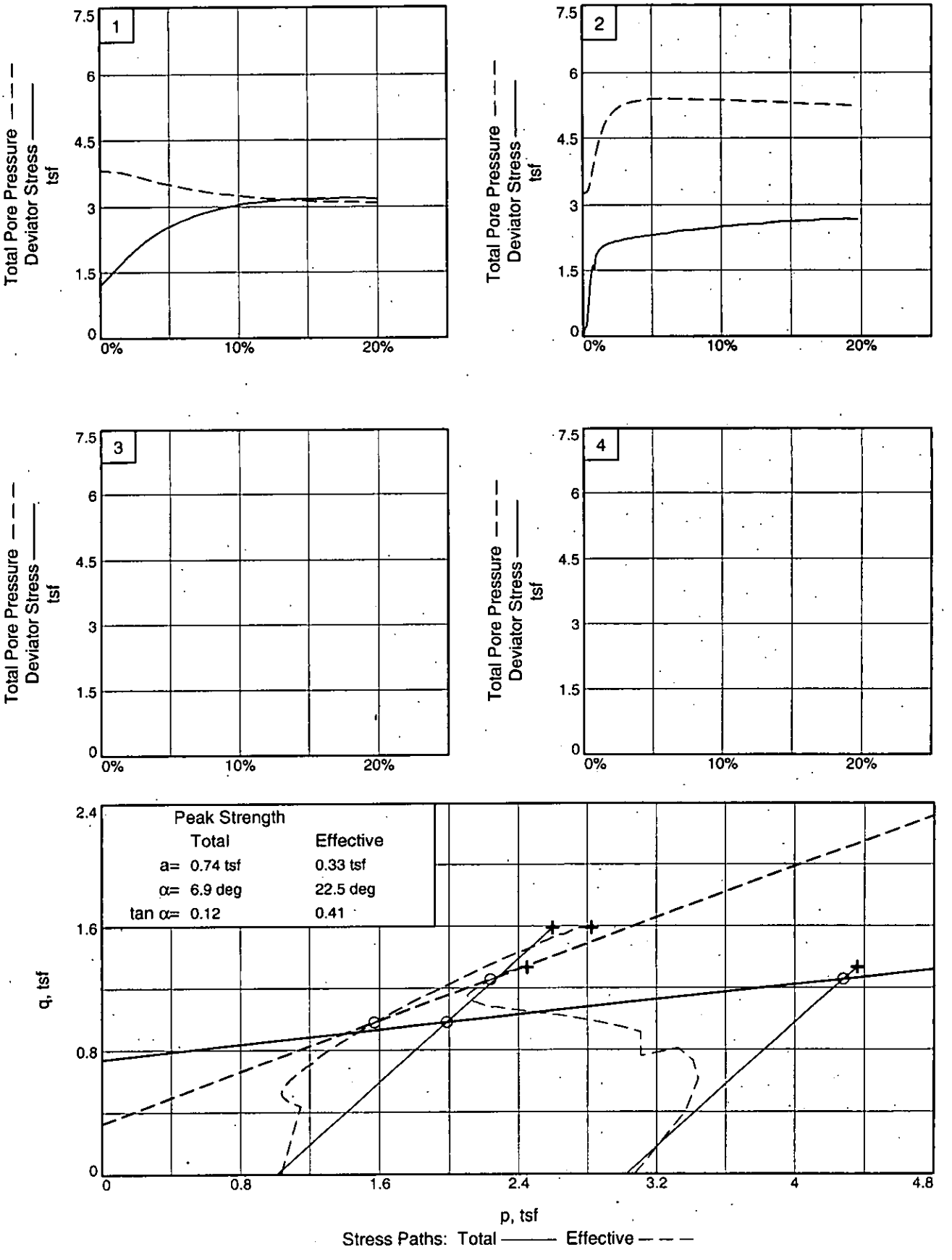
Client: TranSystems, Inc.

Project: SCI-823-0.00

Source of Sample: B-45 **Depth:** 8.0
Sample Number: P-2

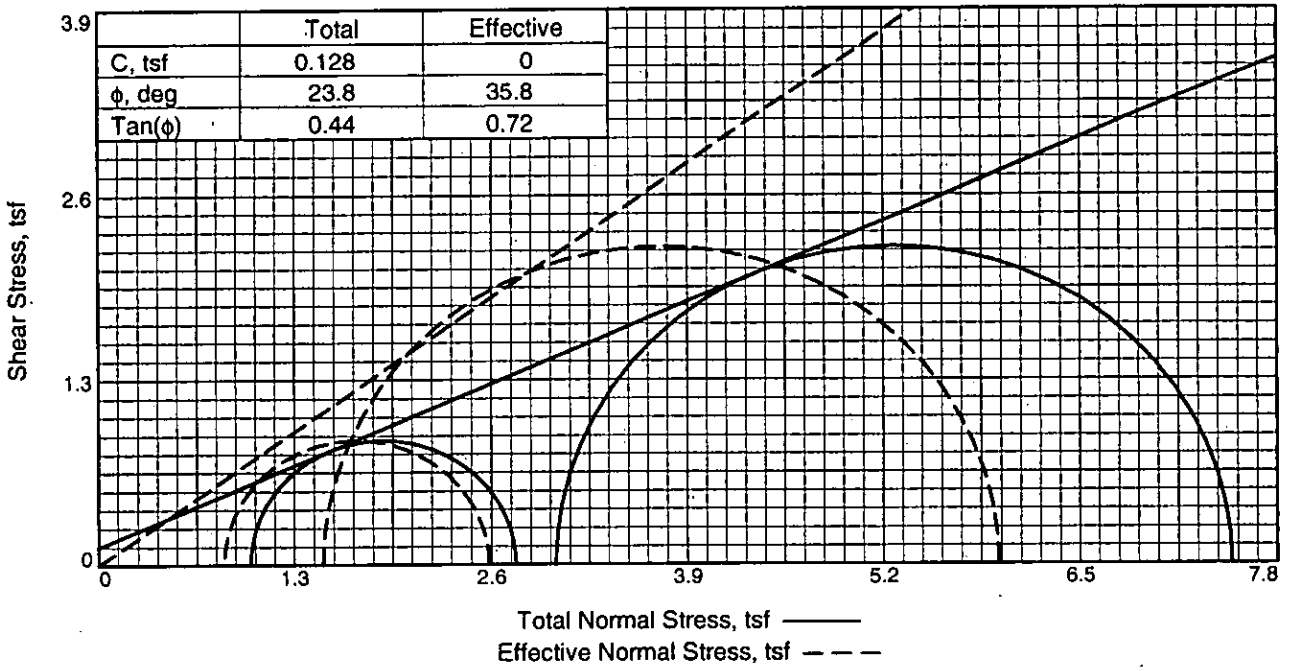
Proj. No.: 0121-3070.03 **Date:** 7/20/07

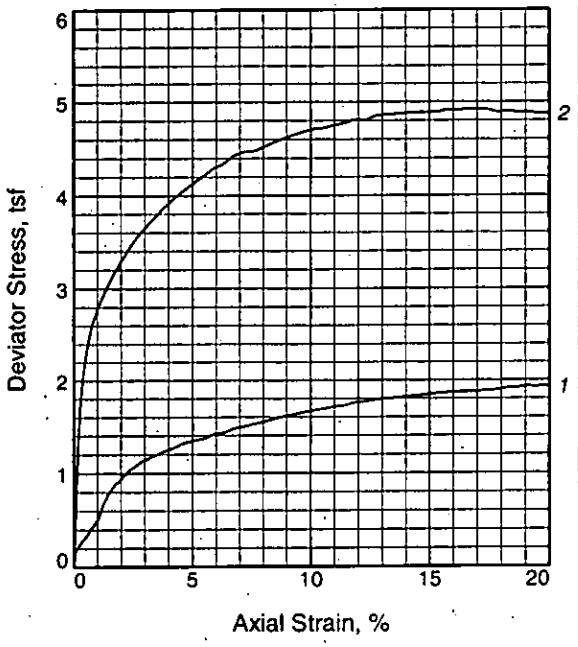
DLZ



Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-45 **Depth:** 8.0 **Sample Number:** P-2
Project No.: 0121-3070.03 **Figure** _____

DLZ, INC.





Sample No.		1	2
Initial	Water Content,	16.7	16.7
	Dry Density, pcf	108.2	110.2
	Saturation,	78.2	82.3
	Void Ratio	0.5861	0.5573
	Diameter, in.	2.86	2.85
	Height, in.	5.61	5.59
At Test	Water Content,	18.9	16.3
	Dry Density, pcf	112.9	118.5
	Saturation,	100.0	100.0
	Void Ratio	0.5208	0.4484
	Diameter, in.	2.80	2.76
	Height, in.	5.58	5.56
Strain rate, in./min.		0.01	0.01
Back Pressure, tsf		3.31	3.31
Cell Pressure, tsf		4.32	6.34
Fail. Stress, tsf		1.75	4.48
Total Pore Pr., tsf		3.49	4.85
Ult. Stress, tsf		1.75	4.48
Total Pore Pr., tsf		3.49	4.85
$\bar{\sigma}_1$ Failure, tsf		2.58	5.96
$\bar{\sigma}_3$ Failure, tsf		0.83	1.49

Type of Test:
CU with Pore Pressures

Sample Type: 3" press tube

Description: Clayey sand

LL= 32 **PL=** 17 **PI=** 15

Assumed Specific Gravity= 2.75

Remarks:

Figure _____

Client: TranSystems, Inc.

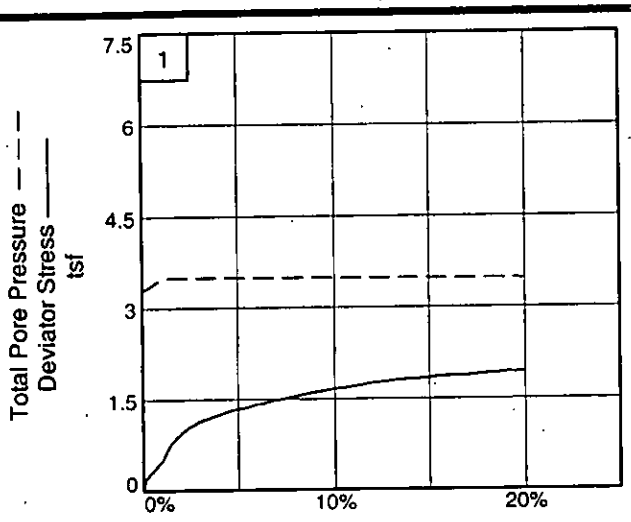
Project: SCI-823-0.00

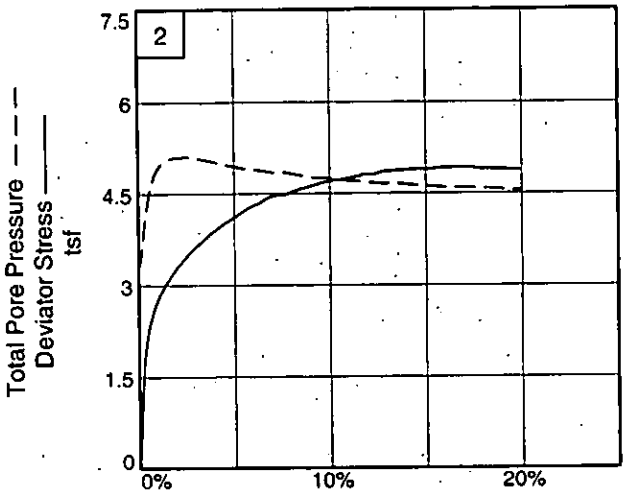
Source of Sample: B-46 **Depth:** 8.0

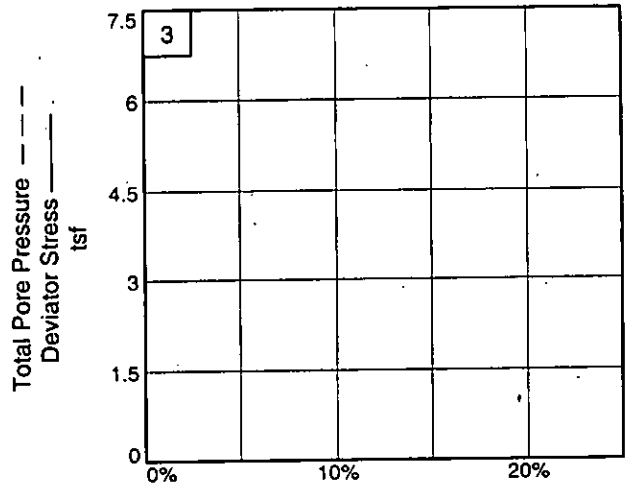
Sample Number: P-2

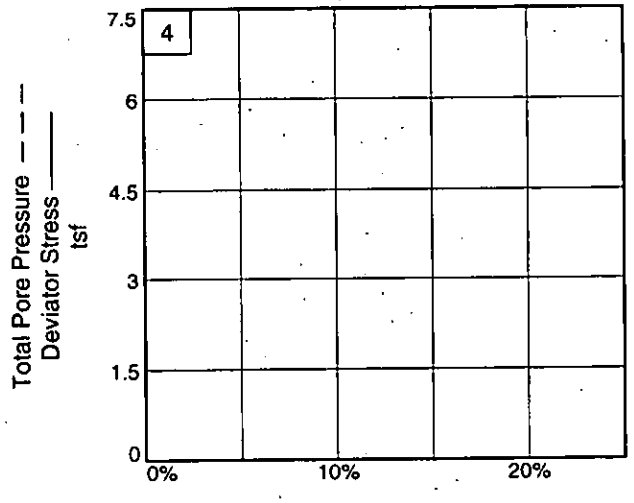
Proj. No.: 0121-3070.03 **Date:** 7/20/07

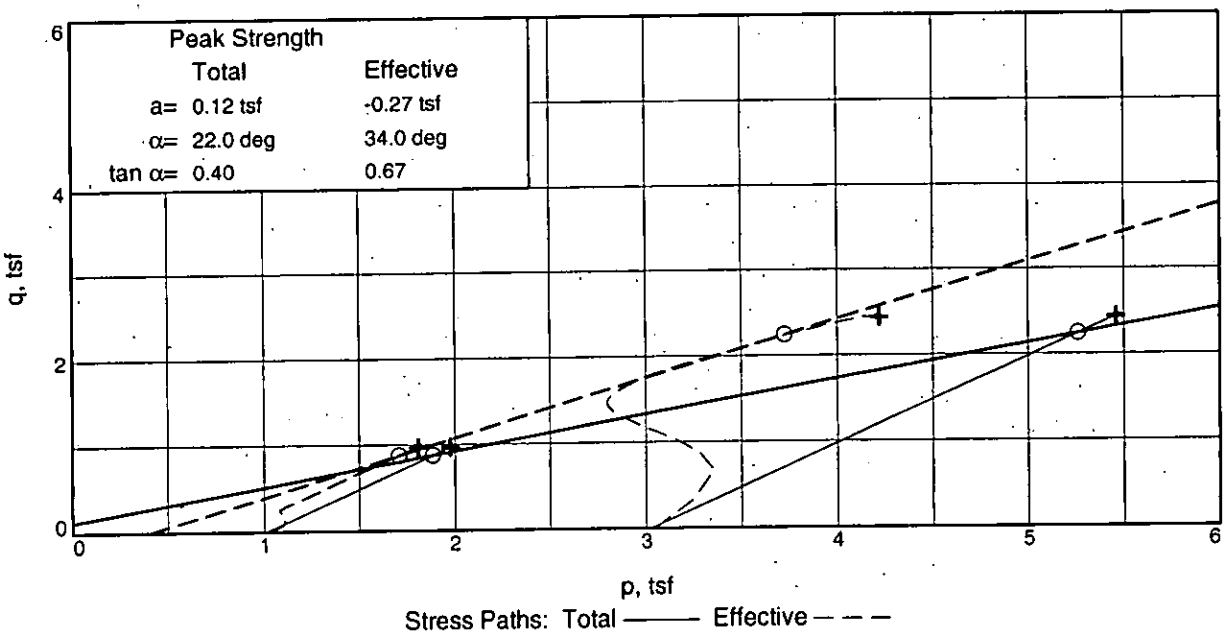
DLZ









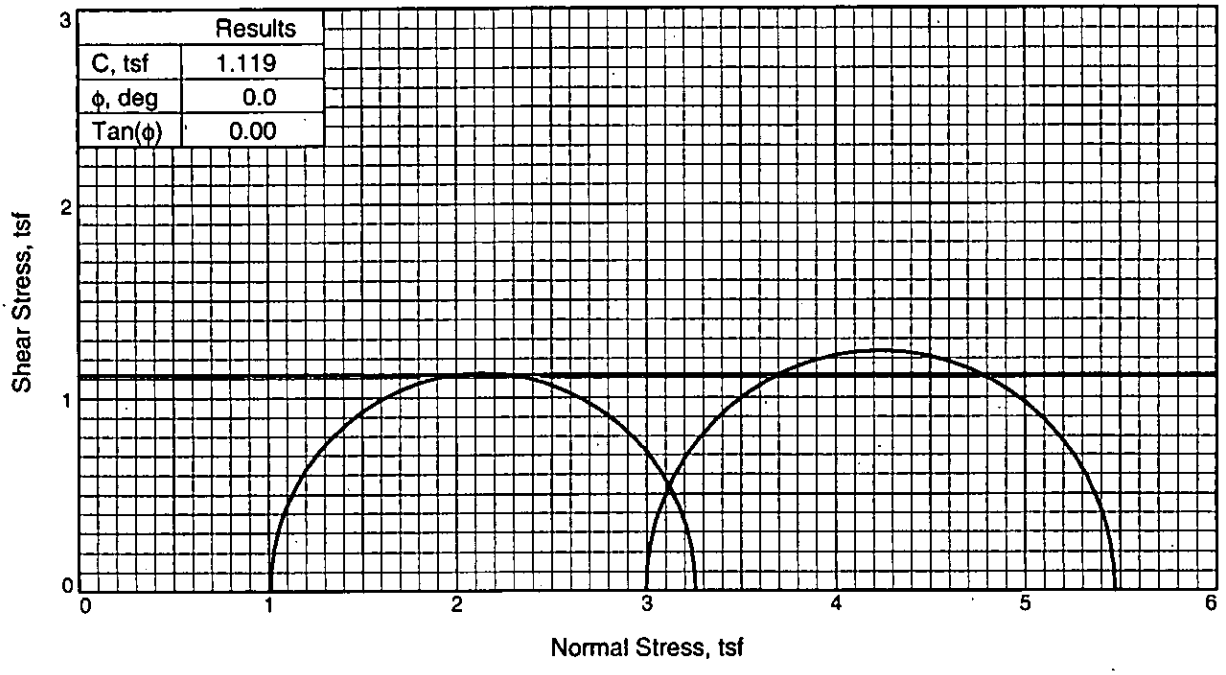


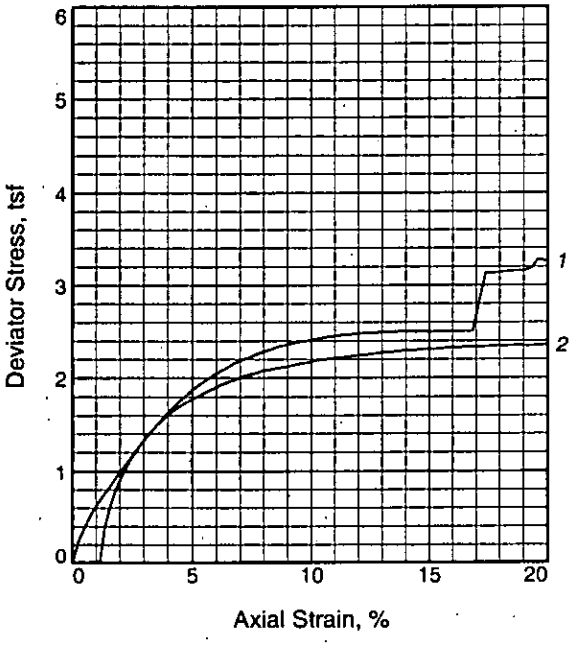
Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-46
Project No.: 0121-3070.03

Depth: 8.0
Figure _____

Sample Number: P-2

DLZ, INC.





Sample No.		1	2
Initial	Water Content,	23.0	24.2
	Dry Density, pcf	97.6	97.8
	Saturation,	83.5	88.1
	Void Ratio	0.7585	0.7561
	Diameter, in.	2.84	2.84
	Height, in.	4.95	5.53
At Test	Water Content,	22.7	22.9
	Dry Density, pcf	97.6	97.8
	Saturation,	82.4	83.1
	Void Ratio	0.7585	0.7561
	Diameter, in.	2.84	2.84
	Height, in.	4.95	5.53
Strain rate, in./min.		0.06	0.06
Back Pressure, tsf		0.00	0.00
Cell Pressure, tsf		3.00	1.01
Fail. Stress, tsf		2.48	2.25
Ult. Stress, tsf		2.48	2.25
σ_1 Failure, tsf		5.47	3.26
σ_3 Failure, tsf		3.00	1.01

Type of Test:
Unconsolidated Undrained
Sample Type: 3 " press tube
Description:

LL= 26 **PL=** 19 **PI=** 7
Assumed Specific Gravity= 2.75
Remarks:

Client: TranSystems, Inc.

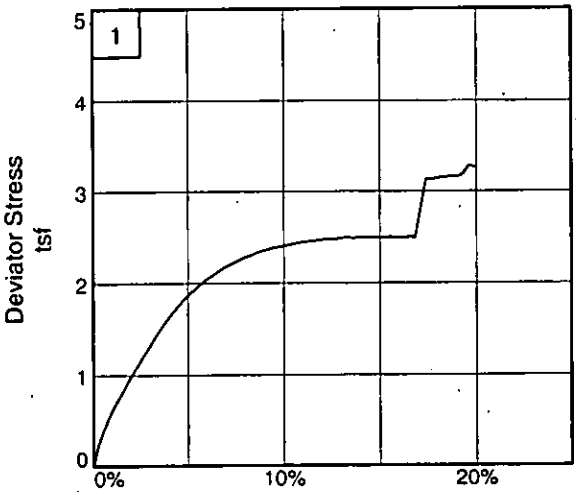
Project: SCI-823-0.00

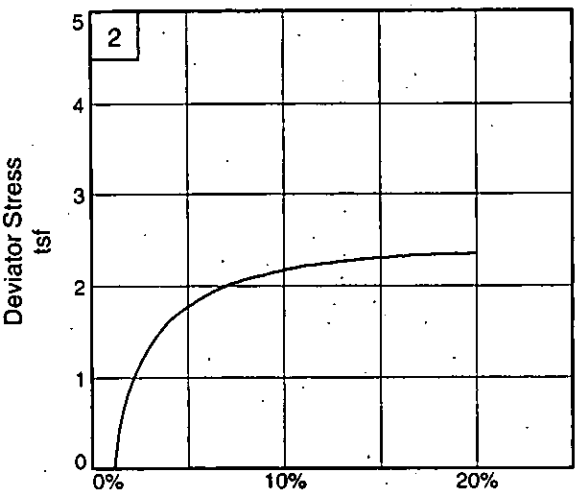
Source of Sample: B-47 **Depth:** 4.0
Sample Number: P-1

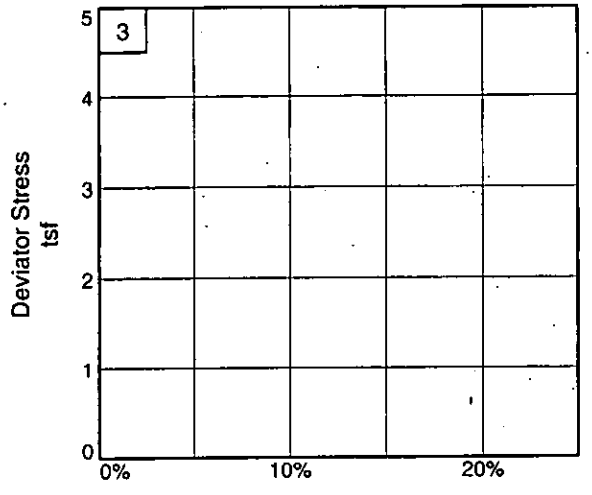
Proj. No.: 0121-3070.03 **Date:** 7/21/07

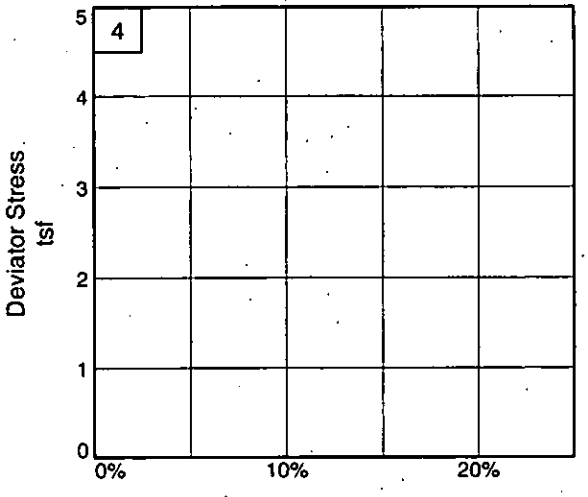
DLZ

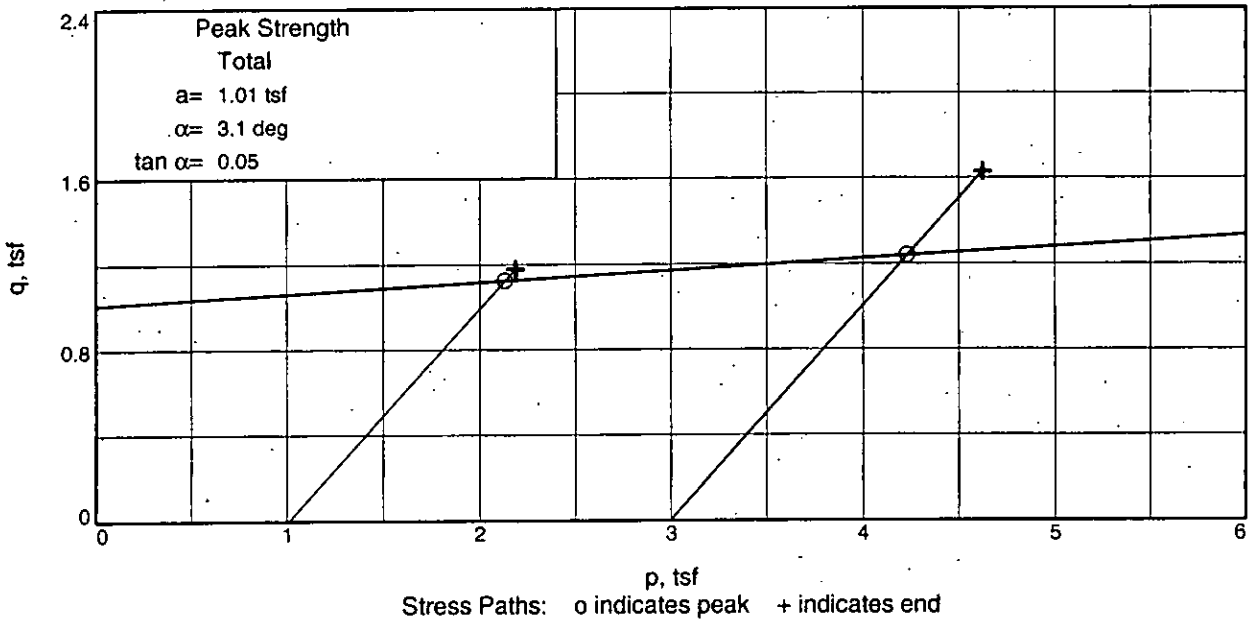
Figure _____







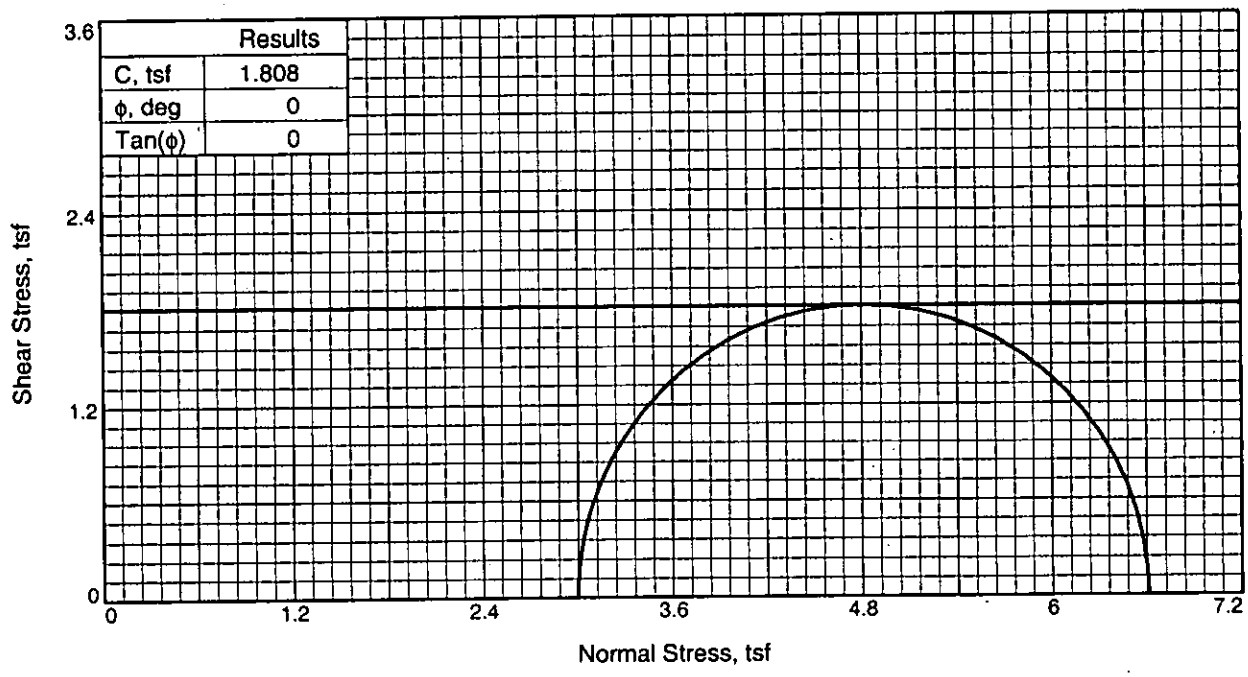


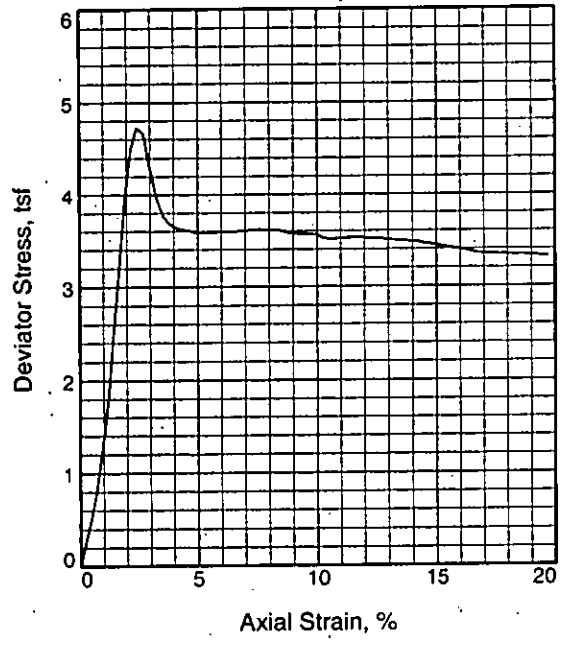


Stress Paths: o indicates peak + indicates end

Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-47 **Depth:** 4.0 **Sample Number:** P-1
Project No.: 0121-3070.03 **Figure** _____

DLZ, INC.





Sample No.		1
Initial	Water Content,	19.8
	Dry Density, pcf	102.7
	Saturation,	81.0
	Void Ratio	0.6713
	Diameter, in.	2.85
	Height, in.	5.03
At Test	Water Content,	18.4
	Dry Density, pcf	102.7
	Saturation,	75.4
	Void Ratio	0.6713
	Diameter, in.	2.85
	Height, in.	5.03
Strain rate, in./min.		0.06
Back Pressure, tsf		0.00
Cell Pressure, tsf		3.00
Fail. Stress, tsf		3.62
Ult. Stress, tsf		3.62
σ_1 Failure, tsf		6.61
σ_3 Failure, tsf		3.00

Type of Test:
Unconsolidated Undrained

Sample Type:

Description: Silty clay

LL= 23 **PL=** 17 **PI=** 6

Assumed Specific Gravity= 2.75

Remarks:

Figure _____

Client: TranSystems, Inc.

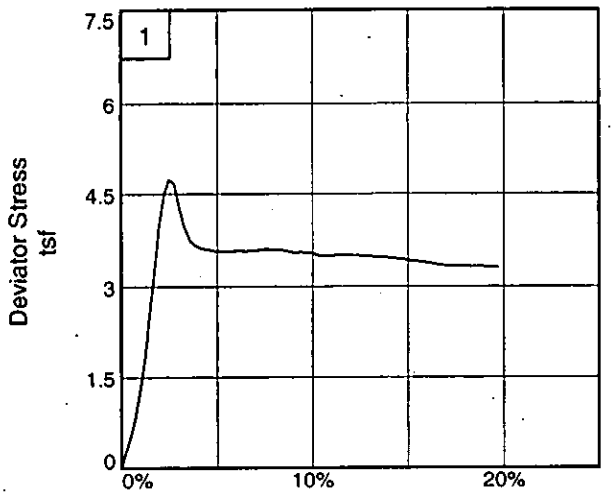
Project: SCI-823-0.00

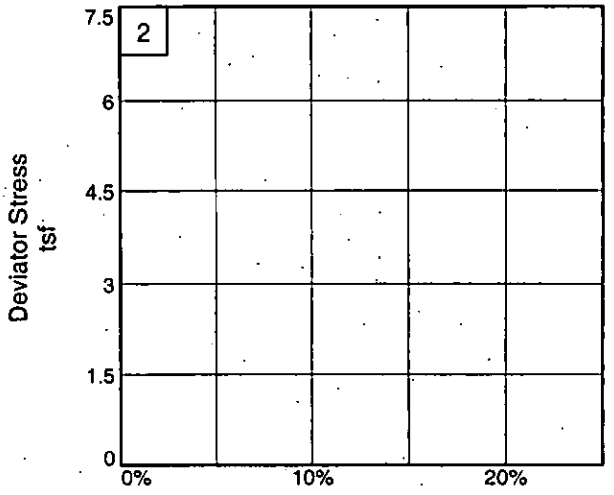
Source of Sample: B-47 **Depth:** 6.0

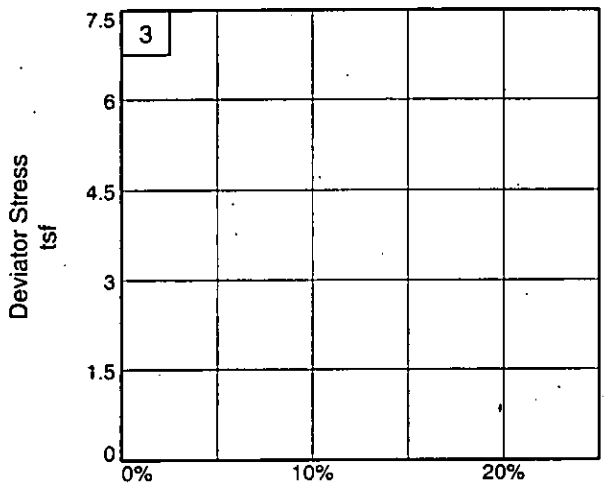
Sample Number: P-2

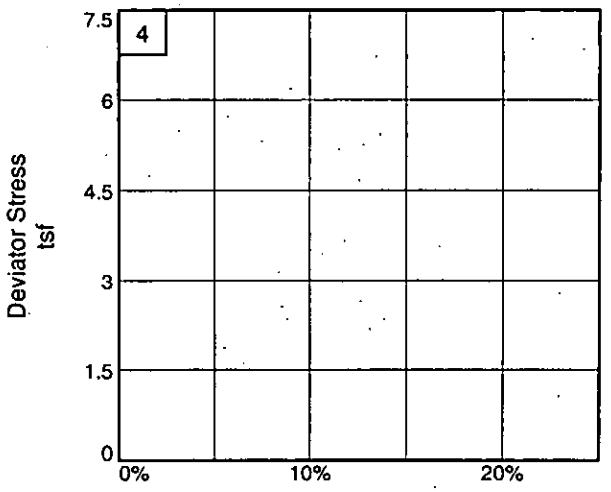
Proj. No.: 0121-3070.03 **Date:** 7/21/07

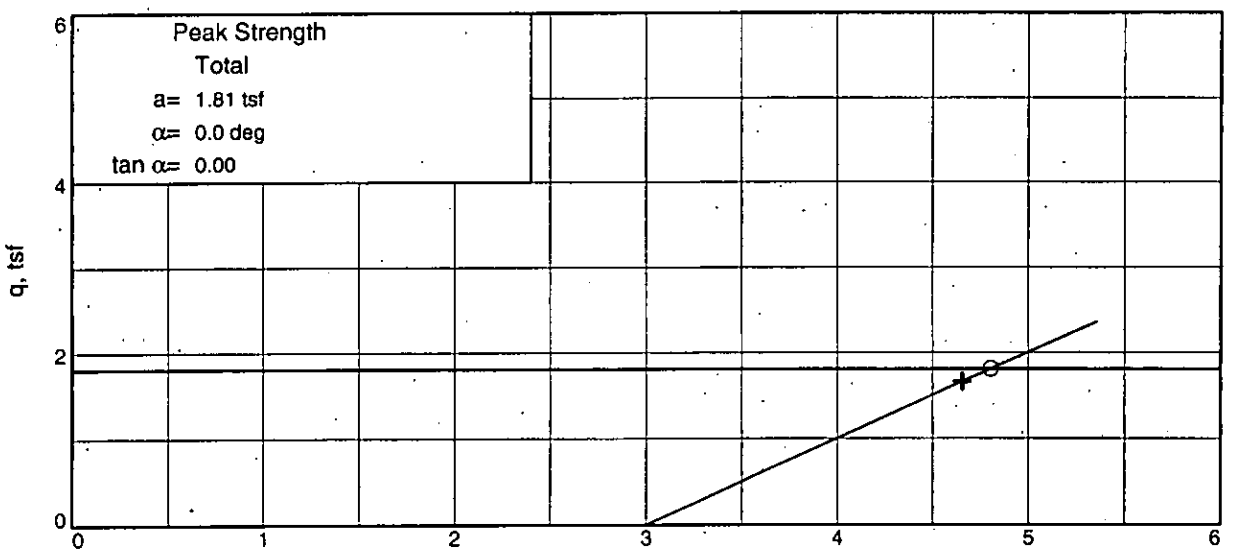
DLZ











Stress Paths: o indicates peak + indicates end

Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-47 **Depth:** 6.0 **Sample Number:** P-2
Project No.: 0121-3070.03 **Figure** _____

DLZ, INC.

Vane Shear Test Report

Project	SCI-823-0.00	Date and Time	6/18/2007 Begin 2:30pm End 3:00pm
Project No.	0121-3070-03	Boring Number	B-47 Depth 6.0
Client	ODOT		
Drill Rig & Crew	CME 850 / D. Wamsley		
Tested By	B Mott		
Weather / Temp.	sunny 96		
Soil Type	SILTY CLAY with sand		

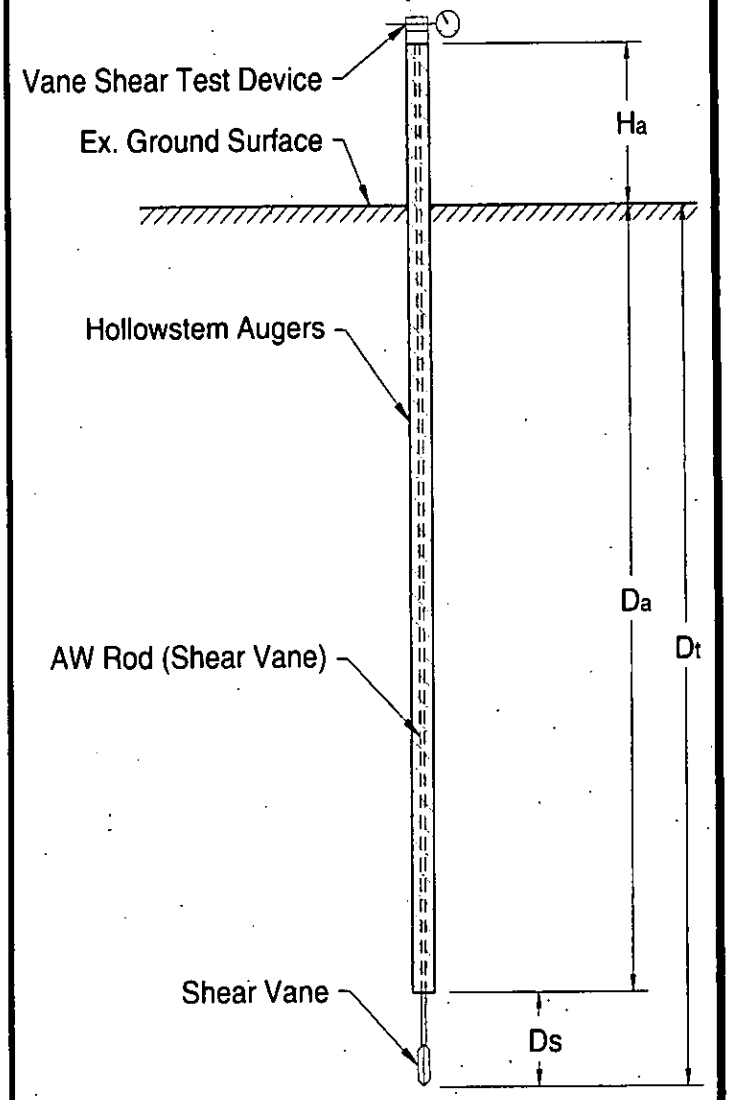
DRILLING

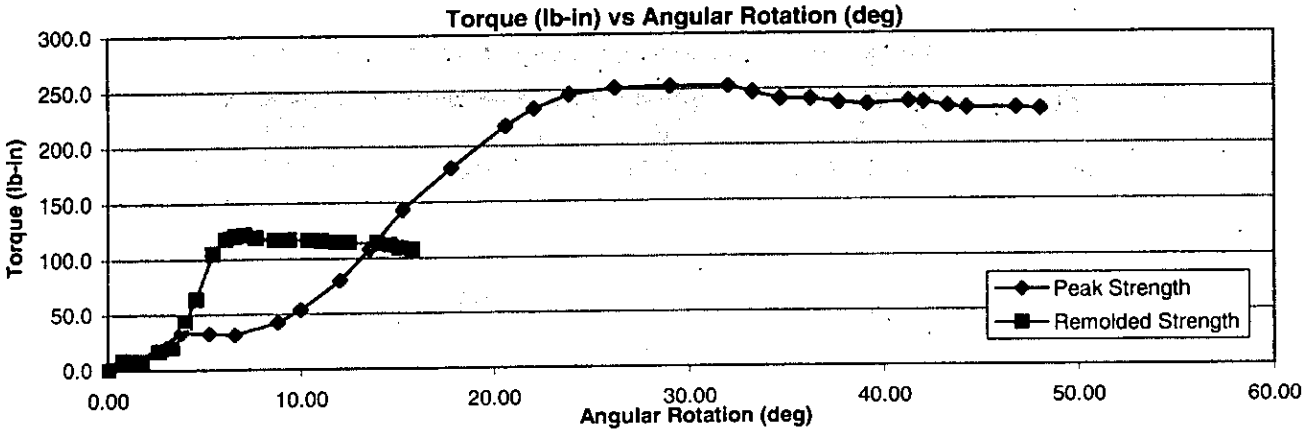
Hollowstem augers to depth	D_a	5
Vane Depth below bottom of augers	D_s	1.25
Augers above ground surface	H_a	7
Depth to vane tip	D_t	6

SHEAR VANE

Vane Used	2.0"	2.5"	3.625"
Vane constant, k (lb-in to psf)	5.17	2.59	0.905
Masurement by	Automatic/torque cell		
Max Torque	253	lb-in	
Max UD Shear Strength	**1306**	**psf**	

Test Setup





Vane Shear Test Report

Read Time	Δ time	Rotation *(degrees)*	Torque *(in-lbs.)*
Peak Strength Test			
14:38:34	0:00:00	0.00	0.0
14:38:42	0:00:08	0.77	7.6
14:38:48	0:00:14	1.35	7.4
14:39:13	0:00:39	3.77	33.6
14:39:28	0:00:54	5.22	32.6
14:39:42	0:01:08	6.57	31.4
14:40:05	0:01:31	8.80	42.4
14:40:17	0:01:43	9.96	53.9
14:40:38	0:02:04	11.99	80.2
14:40:54	0:02:20	13.53	107.9
14:41:12	0:02:38	15.27	143.7
14:41:38	0:03:04	17.79	180.7
14:42:07	0:03:33	20.59	218.2
14:42:22	0:03:48	22.04	233.7
14:42:41	0:04:07	23.88	246.0
14:43:05	0:04:31	26.20	251.3
14:43:34	0:05:00	29.00	252.5
14:44:05	0:05:31	32.00	252.5
14:44:18	0:05:44	33.25	247.0
14:44:33	0:05:59	34.70	241.1
14:44:49	0:06:15	36.25	241.0
14:45:04	0:06:30	37.70	237.7
14:45:19	0:06:45	39.15	236.0
14:45:41	0:07:07	41.28	238.1
14:45:49	0:07:15	42.05	237.6
14:46:02	0:07:28	43.31	233.8
14:46:12	0:07:38	44.27	232.2
14:46:38	0:08:04	46.79	232.0
14:46:51	0:08:17	48.04	230.9

Read Time	Δ time	Rotation *(degrees)*	Torque *(in-lbs.)*
Remolded Strength Test			
14:56:26	0:00:00	0.00	0.0
14:56:34	0:00:08	0.77	8.1
14:56:38	0:00:12	1.16	8.0
14:56:44	0:00:18	1.74	7.9
14:56:53	0:00:27	2.61	16.7
14:57:00	0:00:34	3.29	20.1
14:57:07	0:00:41	3.96	43.2
14:57:13	0:00:47	4.54	64.2
14:57:22	0:00:56	5.41	104.7
14:57:29	0:01:03	6.09	118.0
14:57:34	0:01:08	6.57	121.0
14:57:39	0:01:13	7.06	121.9
14:57:45	0:01:19	7.64	119.2
14:57:55	0:01:29	8.60	117.2
14:58:03	0:01:37	9.38	117.3
14:58:13	0:01:47	10.34	116.8
14:58:20	0:01:54	11.02	116.3
14:58:28	0:02:02	11.79	114.8
14:58:35	0:02:09	12.47	114.4
14:58:50	0:02:24	13.92	114.3
14:58:57	0:02:31	14.60	112.3
14:59:02	0:02:36	15.08	109.3
14:59:09	0:02:43	15.76	107.9

Peak Torque	*252.5498*	(lb-in)
Vane Constant	*5.17*	
Peak Shear Strength	*1306*	*psf*

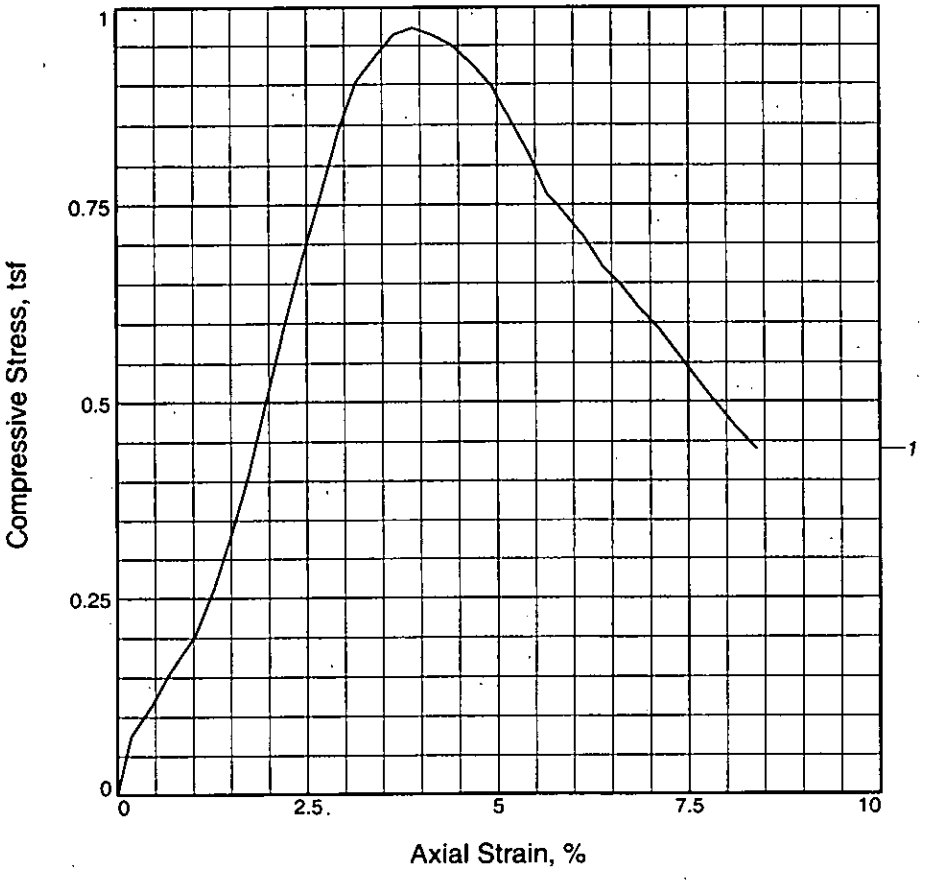
Remolded Torque	*121.93*	(lb-in)
Vane Constant	*5.17*	
Remolded Shear Strength	*630.40*	*psf*
Sensitivity	*2.1*	

DLZ

DLZ Ohio, Inc.

ENGINEERS · ARCHITECTS · SCIENTISTS
PLANNERS · SURVEYORS

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	0.973			
Undrained shear strength, tsf	0.487			
Failure strain,	3.9			
Strain rate, in./min.	0.06			
Water content, %	21.4			
Wet density, pcf	127.8			
Dry density, pcf	105.3			
Saturation, %	93.2			
Void ratio	0.6302			
Specimen diameter, in.	2.83			
Specimen height, in.	5.52			
Height/diameter ratio	1.95			

Description:

LL =	**PL =**	**PI =**	**Assumed GS=** 2.75	**Type:** 3" press tube

Project No.: 0121-3070.03

Date:

Remarks:

Figure _____

Client: TranSystems, Inc.

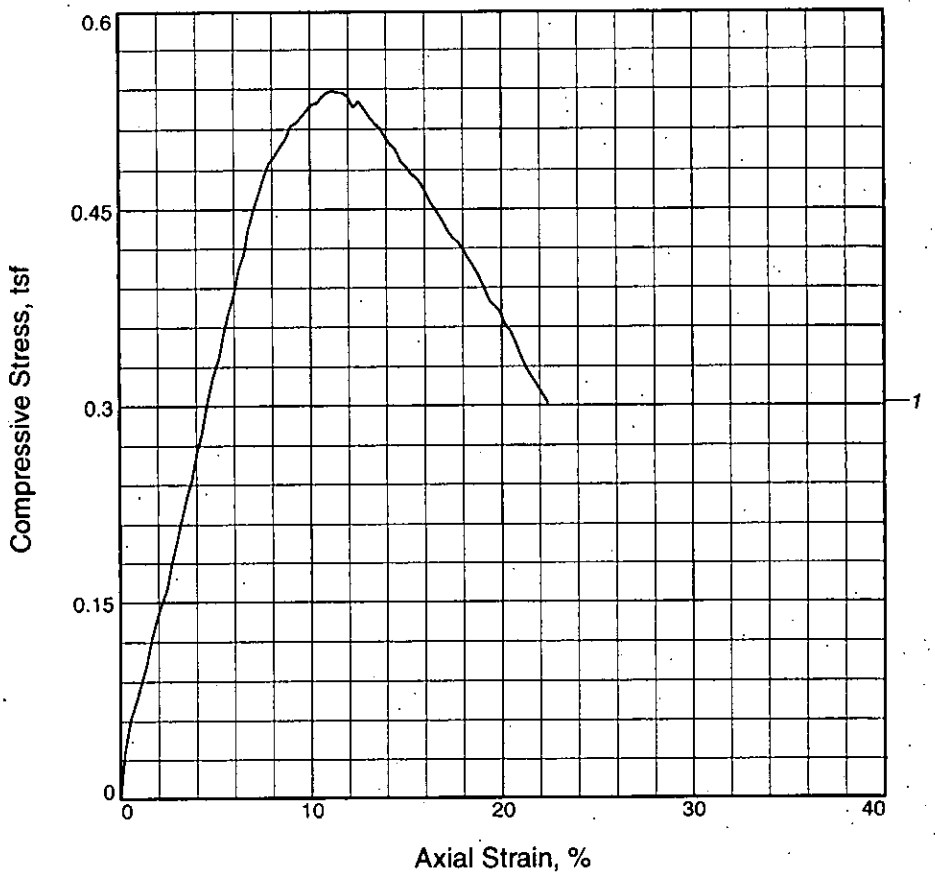
Project: SCI-823-0.00

Source of Sample: B-54 **Depth:** 6.0

Sample Number: 3

DLZ

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	0.535			
Undrained shear strength, tsf	0.267			
Failure strain,	10.6			
Strain rate, in./min.	0.06			
Water content, %	21.7			
Wet density, pcf	127.6			
Dry density, pcf	104.9			
Saturation, %	93.6			
Void ratio	0.6370			
Specimen diameter, in.	2.84			
Specimen height, in.	4.98			
Height/diameter ratio	1.75			

Description:

LL =	**PL =**	**PI =**	**Assumed GS=** 2.75	**Type:** 3" press tube

Project No.: 0121-3070.03

Date:

Remarks:

Figure _____

Client: TranSystems, Inc.

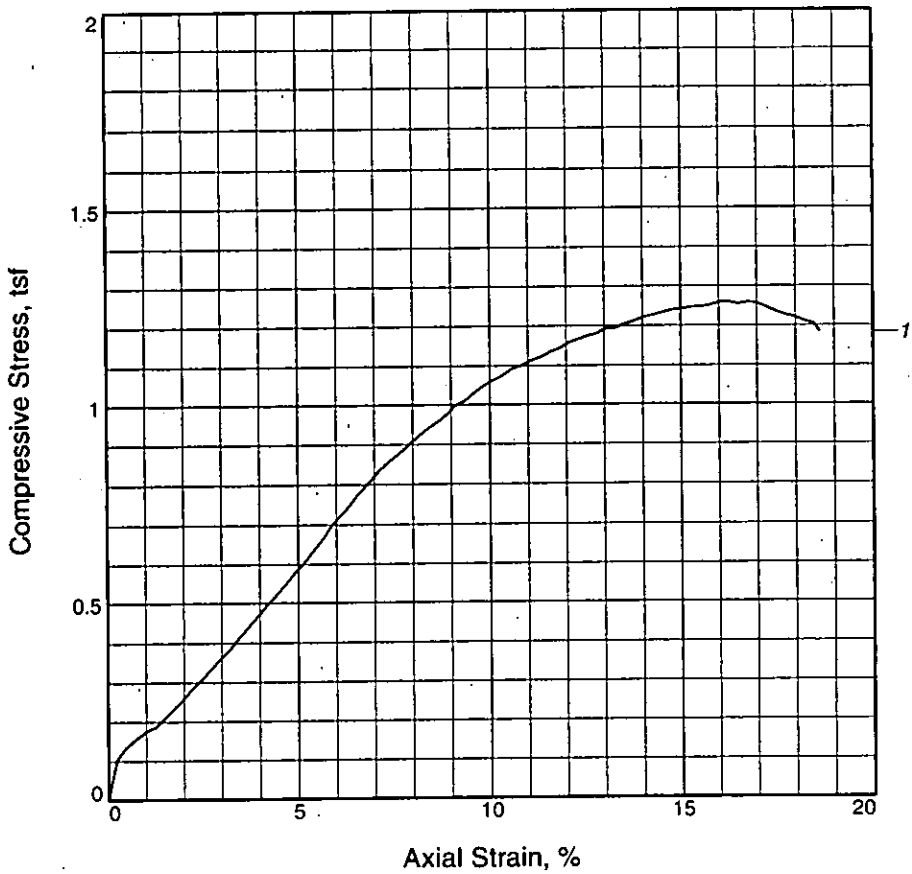
Project: SCI-823-0.00

Source of Sample: B-54 **Depth:** 10

Sample Number: ST-2

DLZ

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, tsf	1.258			
Undrained shear strength, tsf	0.629			
Failure strain,	17.0			
Strain rate, in./min.	0.06			
Water content, %	16.4			
Wet density, pcf	134.1			
Dry density, pcf	115.3			
Saturation, %	91.9			
Void ratio	0.4894			
Specimen diameter, in.	2.83			
Specimen height, in.	5.49			
Height/diameter ratio	1.94			

Description:

LL =	PL =	PI =	Assumed GS= 2.75	Type:

Project No.: 0121-3070.03

Date:

Remarks:

Figure _____

Client: TranSystems, Inc.

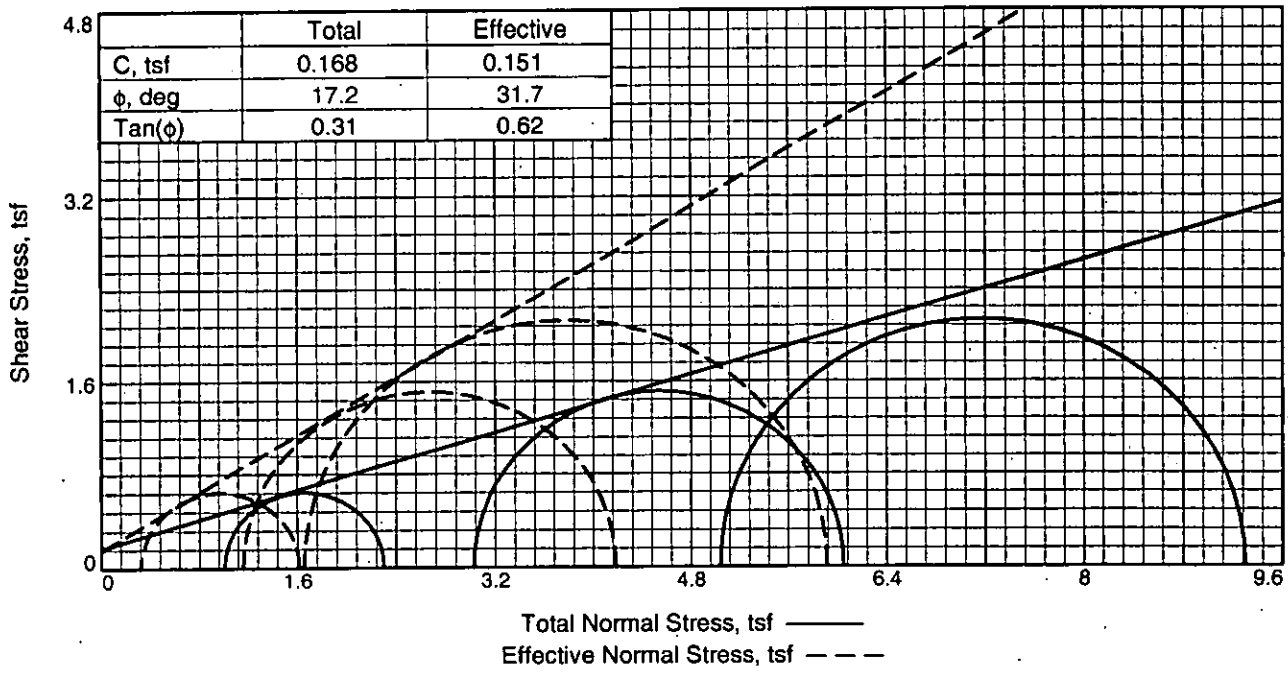
Project: SCI-823-0.00

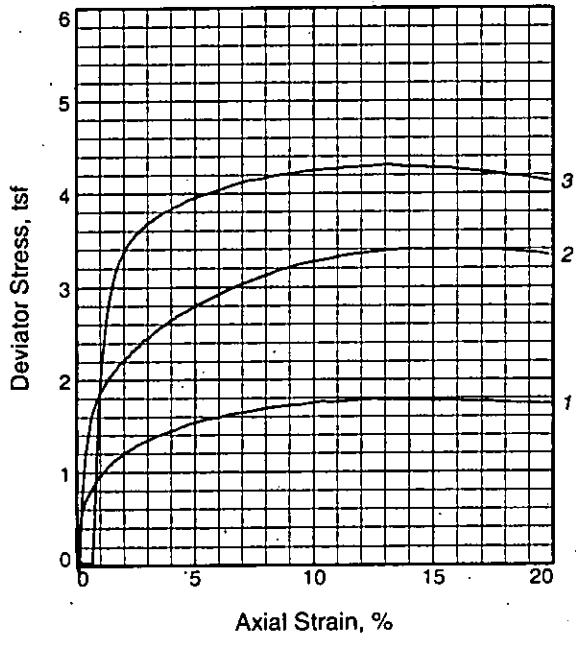
Source of Sample: B-54 **Depth:** 10

Sample Number: ST-2

DLZ

	Total	Effective
C, tsf	0.168	0.151
ϕ, deg	17.2	31.7
Tan(ϕ)	0.31	0.62





Sample No.		1	2	3
Initial	Water Content,	26.5	27.7	28.9
	Dry Density, pcf	98.3	98.1	94.9
	Saturation,	97.8	101.4	98.1
	Void Ratio	0.7457	0.7505	0.8097
	Diameter, in.	2.84	2.83	2.83
	Height, in.	5.46	5.47	5.48
At Test	Water Content,	25.6	22.8	24.5
	Dry Density, pcf	100.8	105.5	102.6
	Saturation,	100.0	100.0	100.0
	Void Ratio	0.7029	0.6274	0.6729
	Diameter, in.	2.80	2.73	2.72
	Height, in.	5.46	5.47	5.48
Strain rate, in./min.		0.01	0.01	0.01
Back Pressure, tsf		3.31	3.31	3.31
Cell Pressure, tsf		4.32	6.34	8.35
Fail. Stress, tsf		1.29	3.02	4.26
Total Pore Pr., tsf		4.00	5.18	6.70
Ult. Stress, tsf		1.32	2.92	4.26
Total Pore Pr., tsf		3.99	5.21	6.70
$\bar{\sigma}_1$ Failure, tsf		1.61	4.18	5.91
$\bar{\sigma}_3$ Failure, tsf		0.32	1.16	1.65

Type of Test:
CU with Pore Pressures
Sample Type: 3" press tube
Description:

LL= 25 **PL=** 18 **PI=** 7
Assumed Specific Gravity= 2.75
Remarks:

Figure _____

Client: TranSystems, Inc.

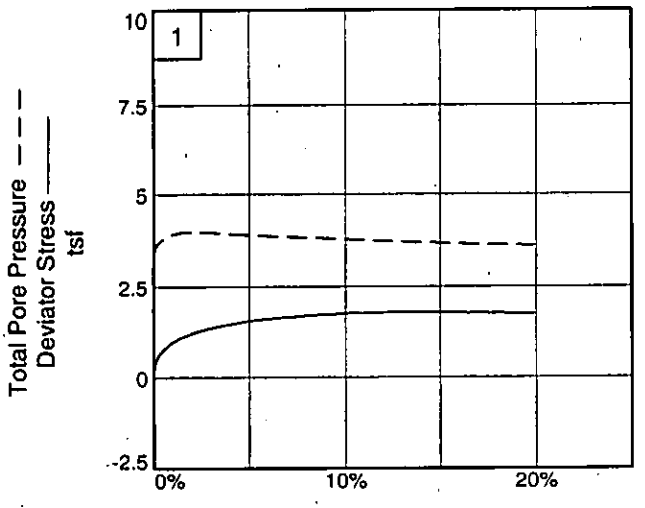
Project: SCI-823-0.00

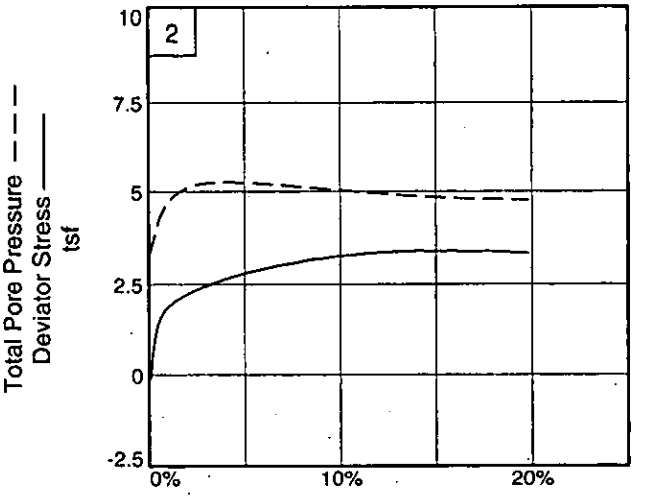
Source of Sample: B-54 **Depth:** 15.0

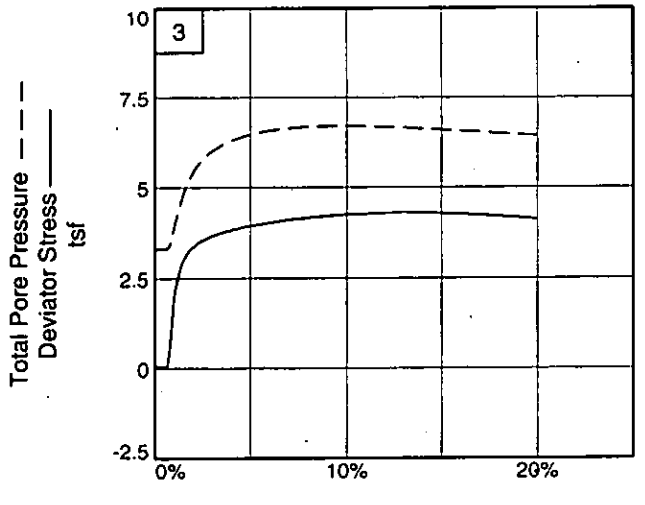
Sample Number: ST3

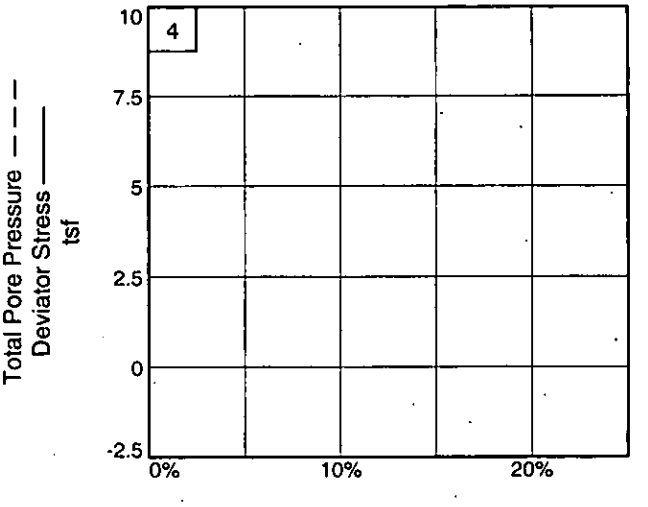
Proj. No.: 0121-3070.03 **Date:** 9/18/07

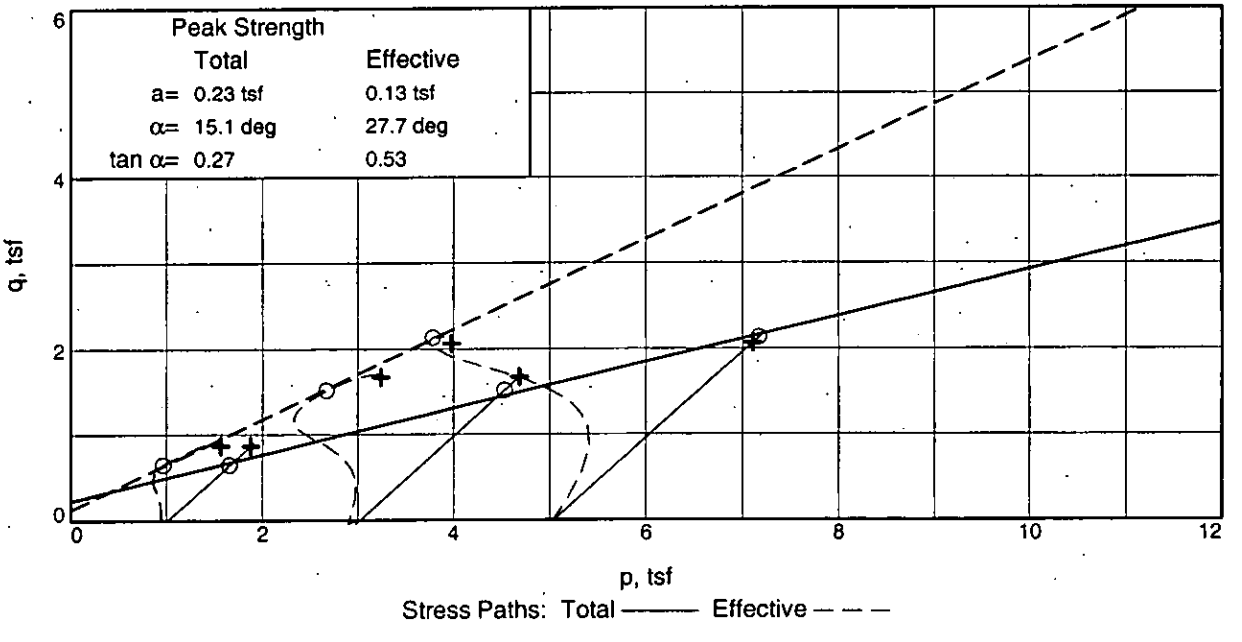
DLZ





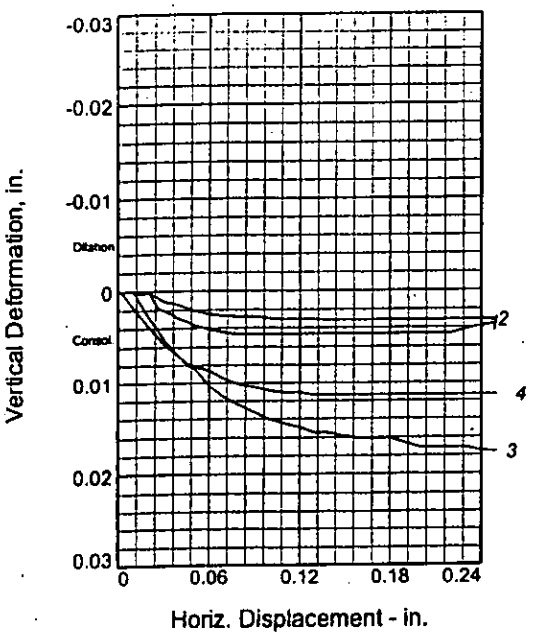


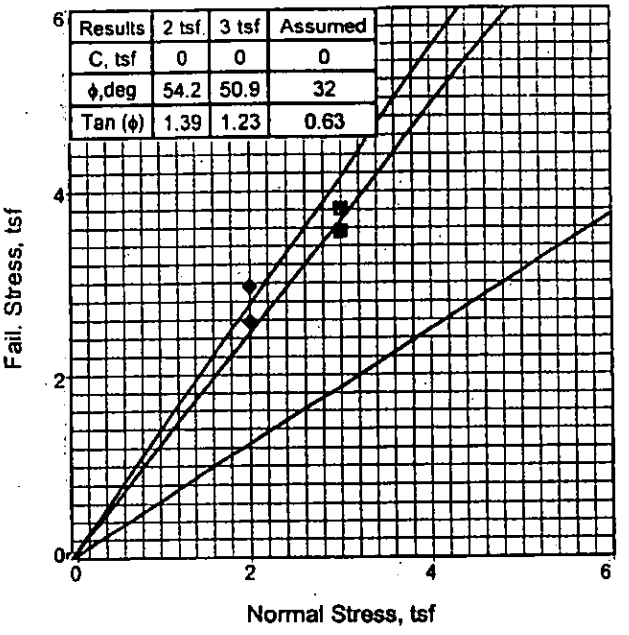


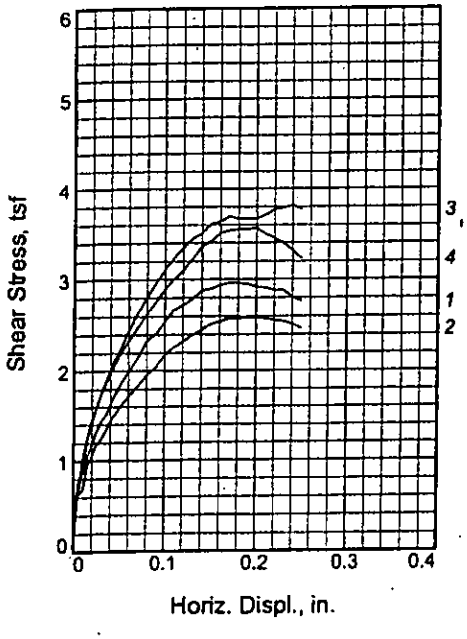


Client: TranSystems, Inc.
Project: SCI-823-0.00
Source of Sample: B-54 **Depth:** 15.0 **Sample Number:** ST3
Project No.: 0121-3070.03 **Figure** _____

DLZ, INC.







Sample No.		1	2	3	4
Initial	Water Content, %	28.7	28.7	28.7	28.7
	Dry Density, pcf	106.4	101.0	98.5	101.4
	Saturation, %	132.3	115.7	108.8	116.8
	Void Ratio	0.5849	0.6691	0.7111	0.6628
	Diameter, in.	2.50	2.50	2.50	2.50
	Height, in.	1.02	1.21	1.27	1.21
At Test	Water Content, %	21.2	21.2	19.4	19.4
	Dry Density, pcf	111.1	104.8	102.5	104.9
	Saturation, %	110.7	94.1	81.2	86.3
	Void Ratio	0.5172	0.6089	0.6451	0.6069
	Diameter, in.	2.50	2.50	2.50	2.50
	Height, in.	0.98	1.16	1.22	1.17
Normal Stress, tsf		2.000	2.000	3.000	3.000
Fail. Stress, tsf		2.963	2.582	3.814	3.564
Displacement, in.		0.17	0.19	0.24	0.20
Ult. Stress, tsf					
Displacement, in.					
Strain rate, in./min.		0.01	0.01	0.01	0.01

Sample Type: Standard Penetration Test
Description: Silty sand

LL= NP **PL=** NP **PI=** NP
Assumed Specific Gravity= 2.7
Remarks: Due to small REC, S-6 & S-7 were combined for testing. Samples were completely saturated and contained "free water". Sample was stired prior to testing, to incorporate excess water.
Figure _____

Client: TranSystems, Inc.

Project: SCI-823-0.00

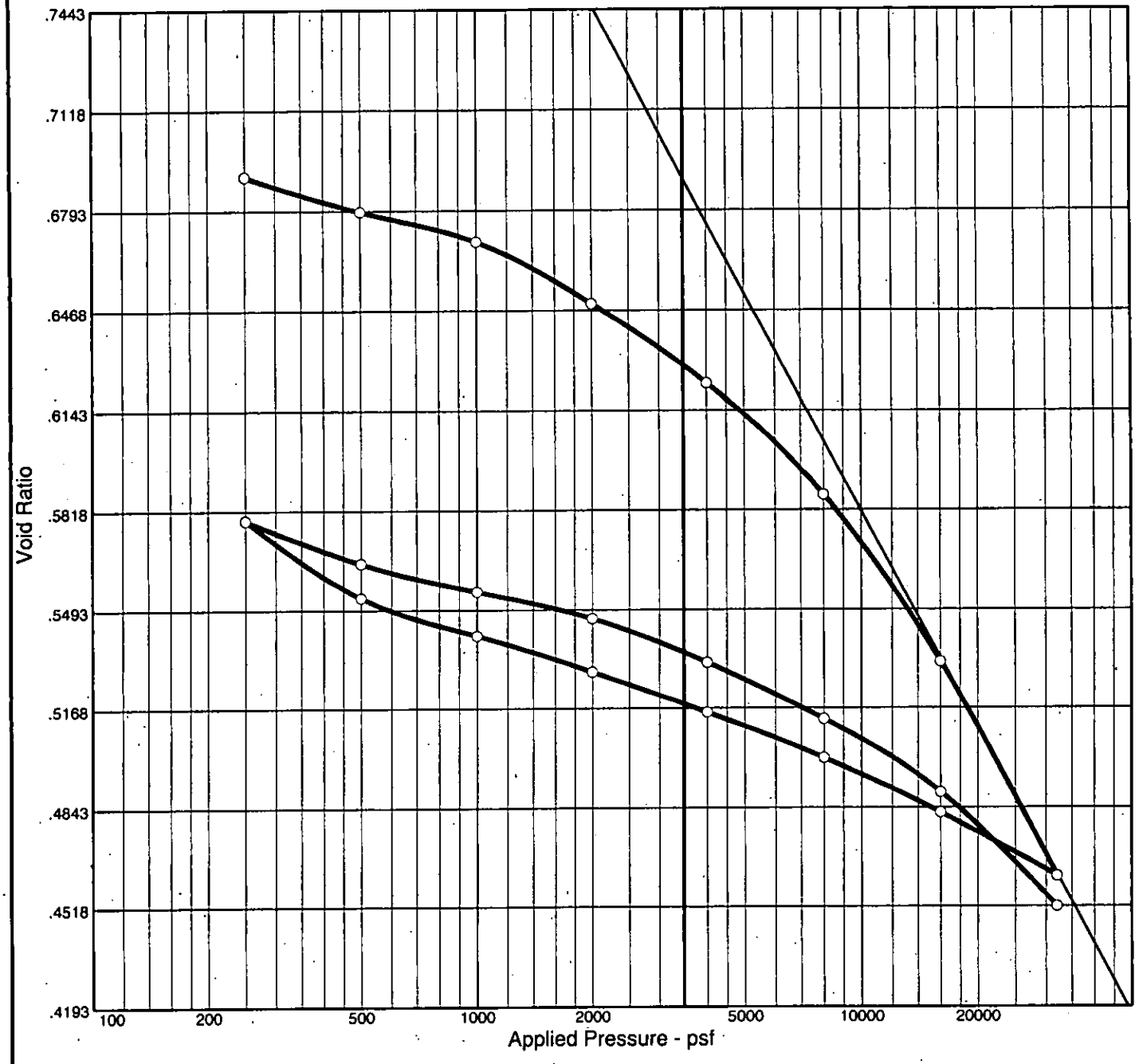
Source of Sample: TR-61 **Depth:** 13.5
Sample Number: 6

Proj. No.: 0121-3070.03 **Date:** 11/7/05

DLZ

Tested By: JN

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
84.9 %	21.9 %	99.2	30	11	2.69			0.694

MATERIAL DESCRIPTION

Silt and Clay (A-6a)

Project No. 0121- **Client:** TranSystems. Inc.

Project: SCI-823-0.00

Source: B-1105A **Sample No.:** ST3 **Elev./Depth:** 12.0

Remarks:

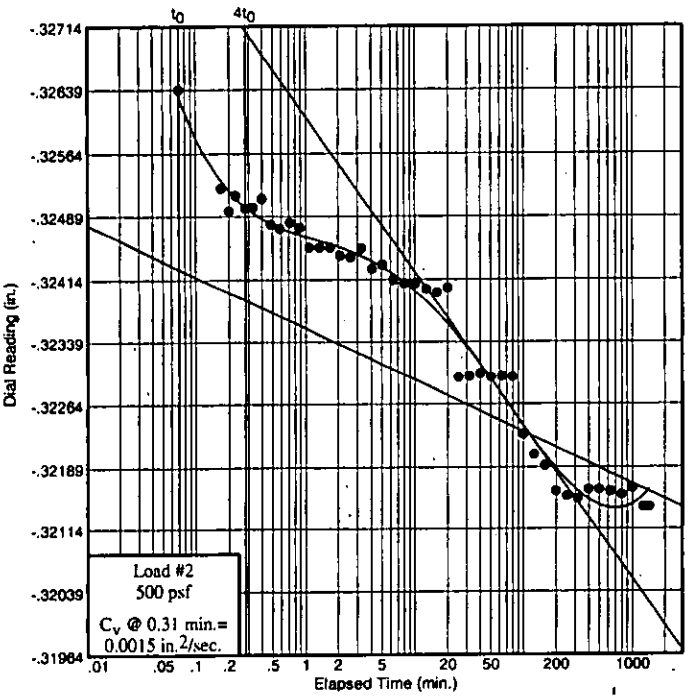
DLZ

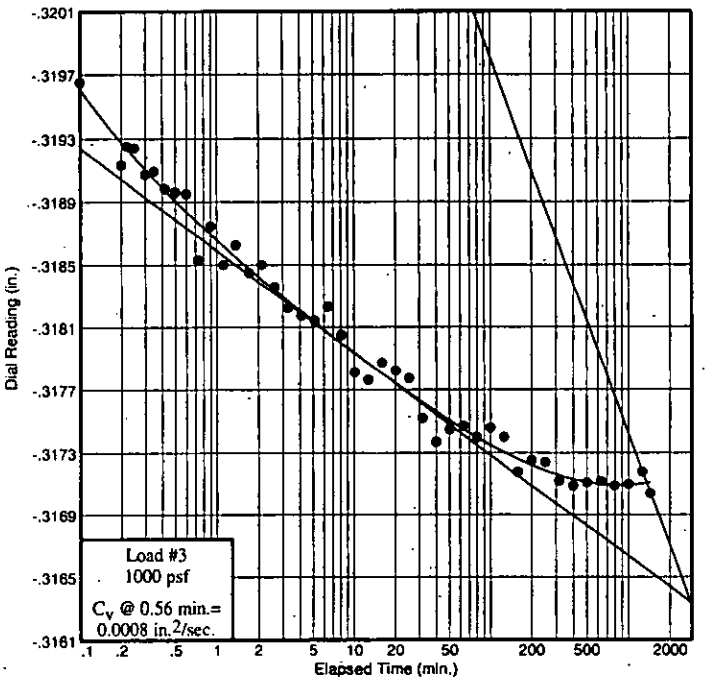
Figure

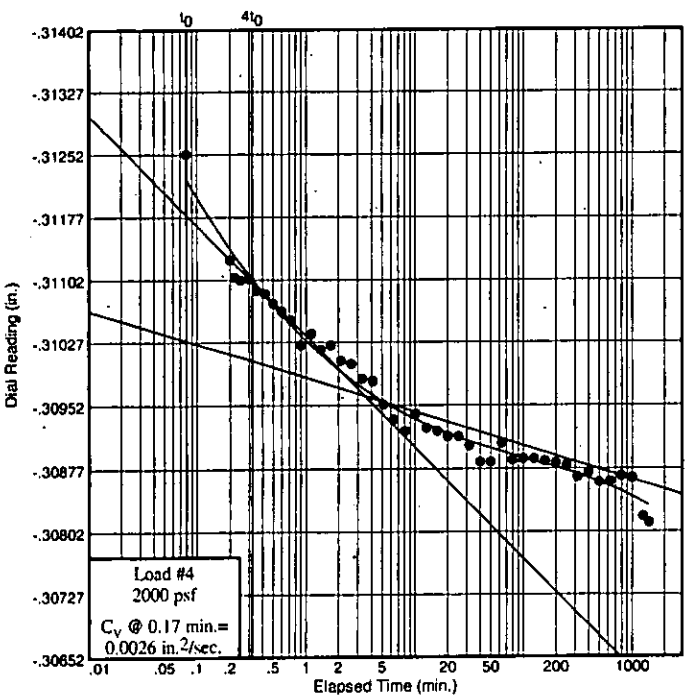
Dial Reading vs. Time

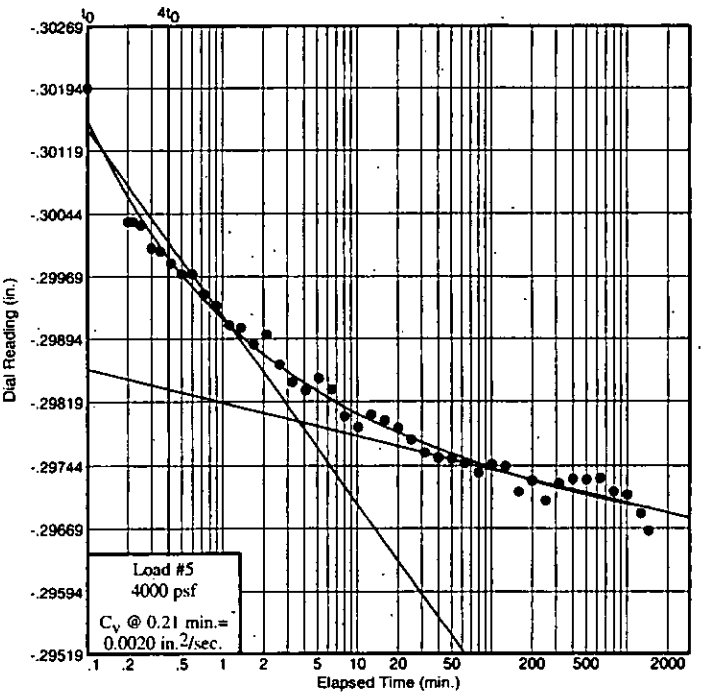
Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-1105A Sample No.: ST3 Elev./Depth: 12.0









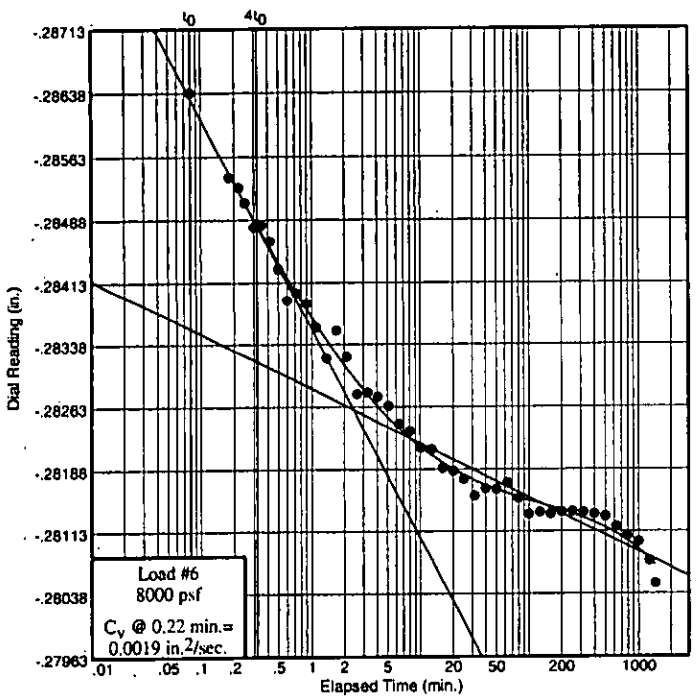
DLZ

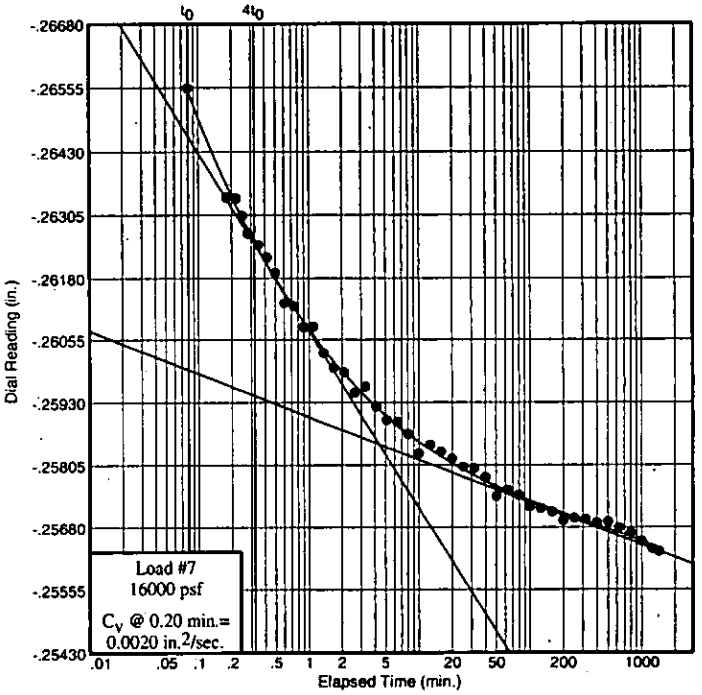
Figure

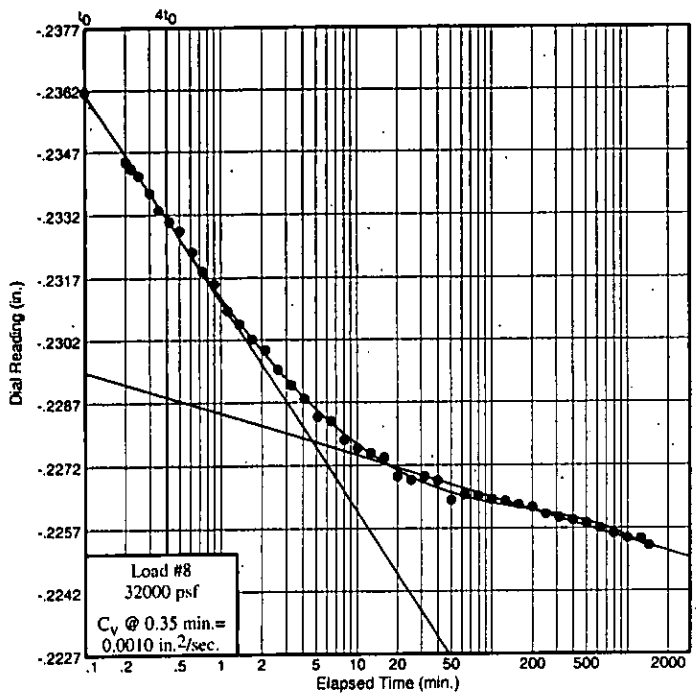
Dial Reading vs. Time

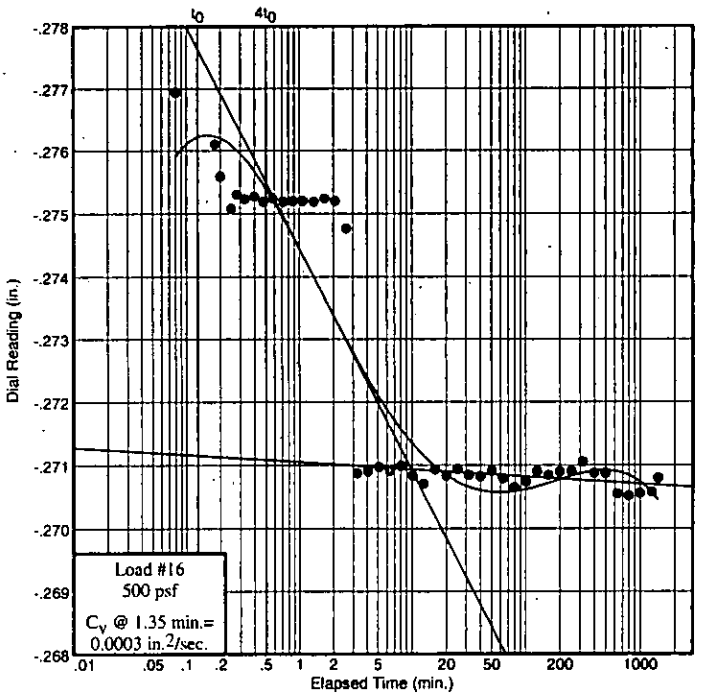
Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-1105A Sample No.: ST3 Elev./Depth: 12.0









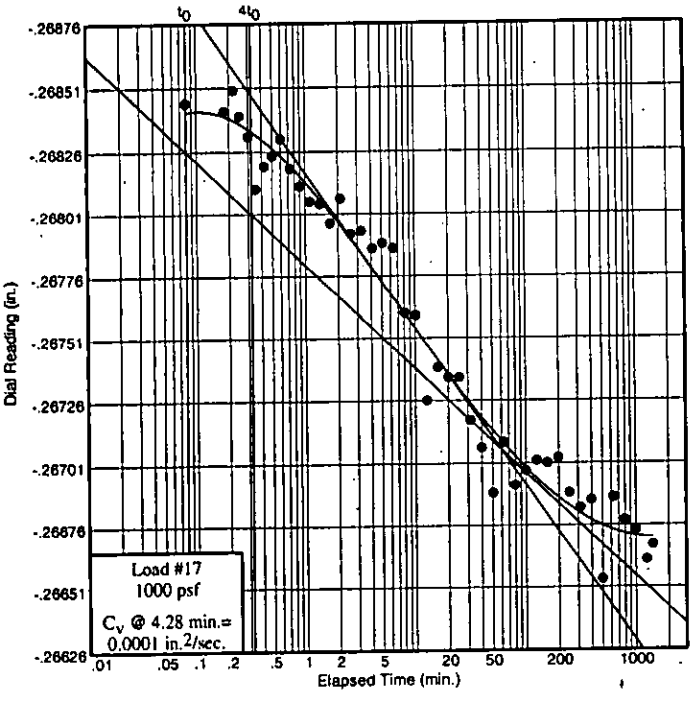
DLZ

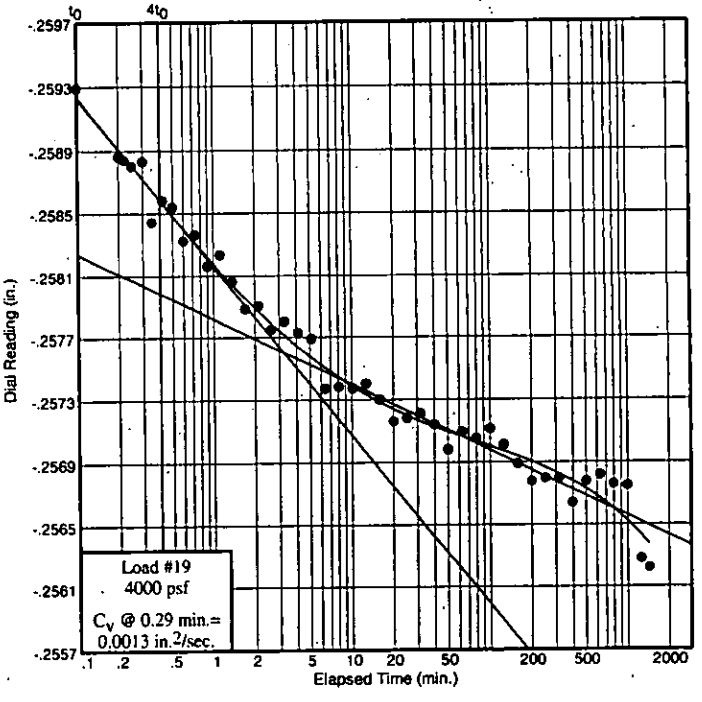
Figure

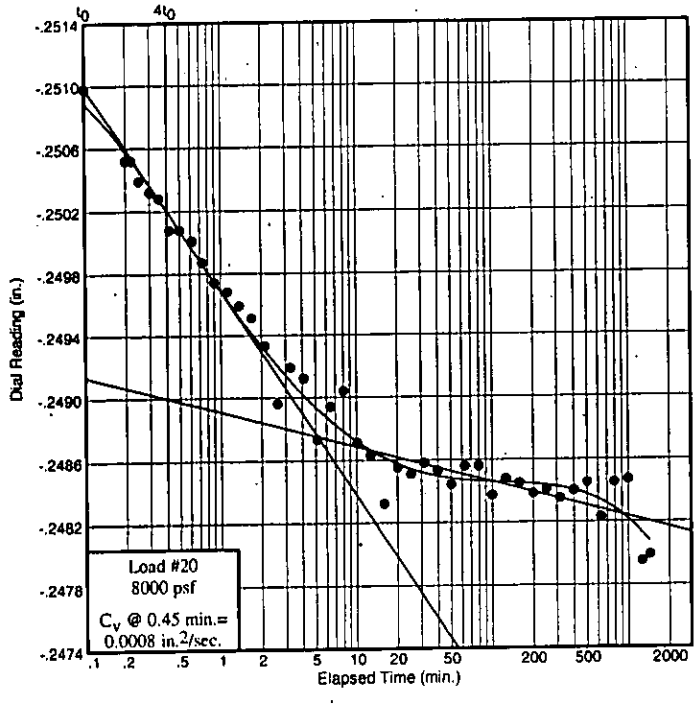
Dial Reading vs. Time

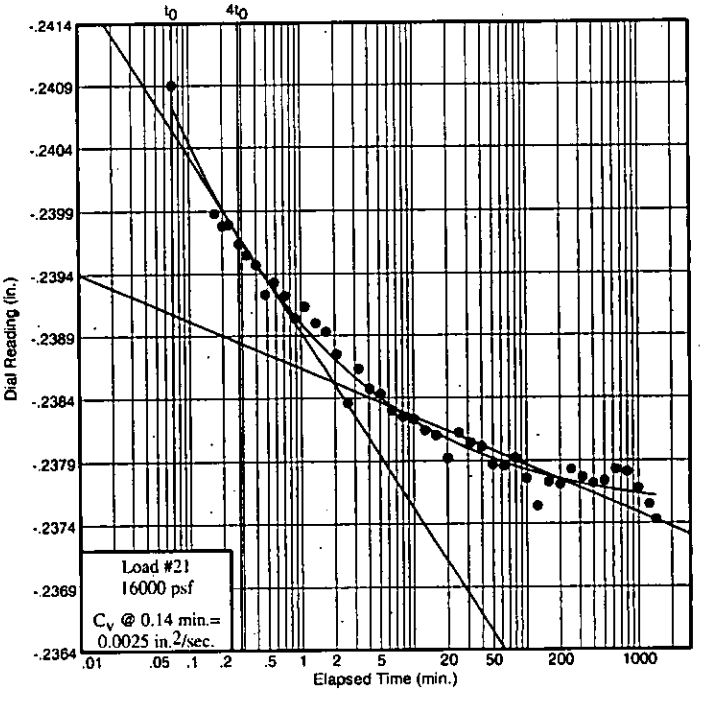
Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-1105A Sample No.: ST3 Elev./Depth: 12.0









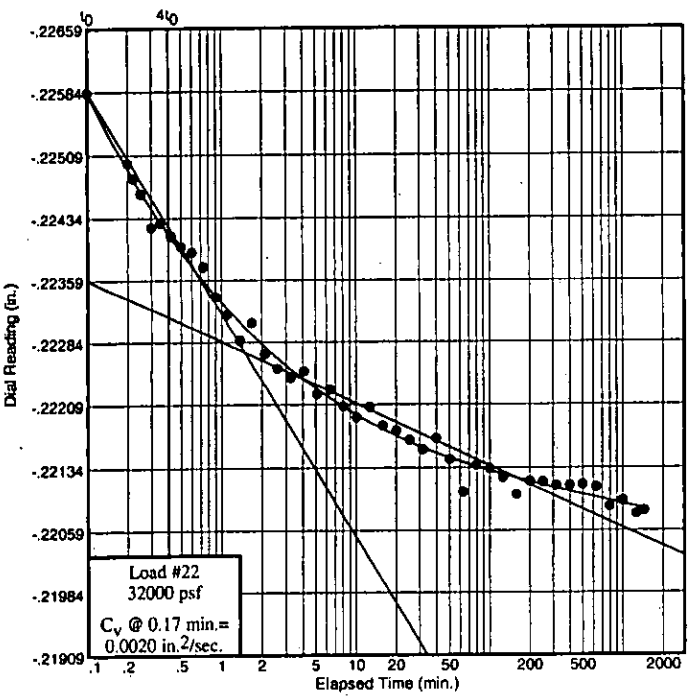
DLZ

Figure

Dial Reading vs. Time

Project No.: 0121-3070.03
Project: SCI-823-0.00

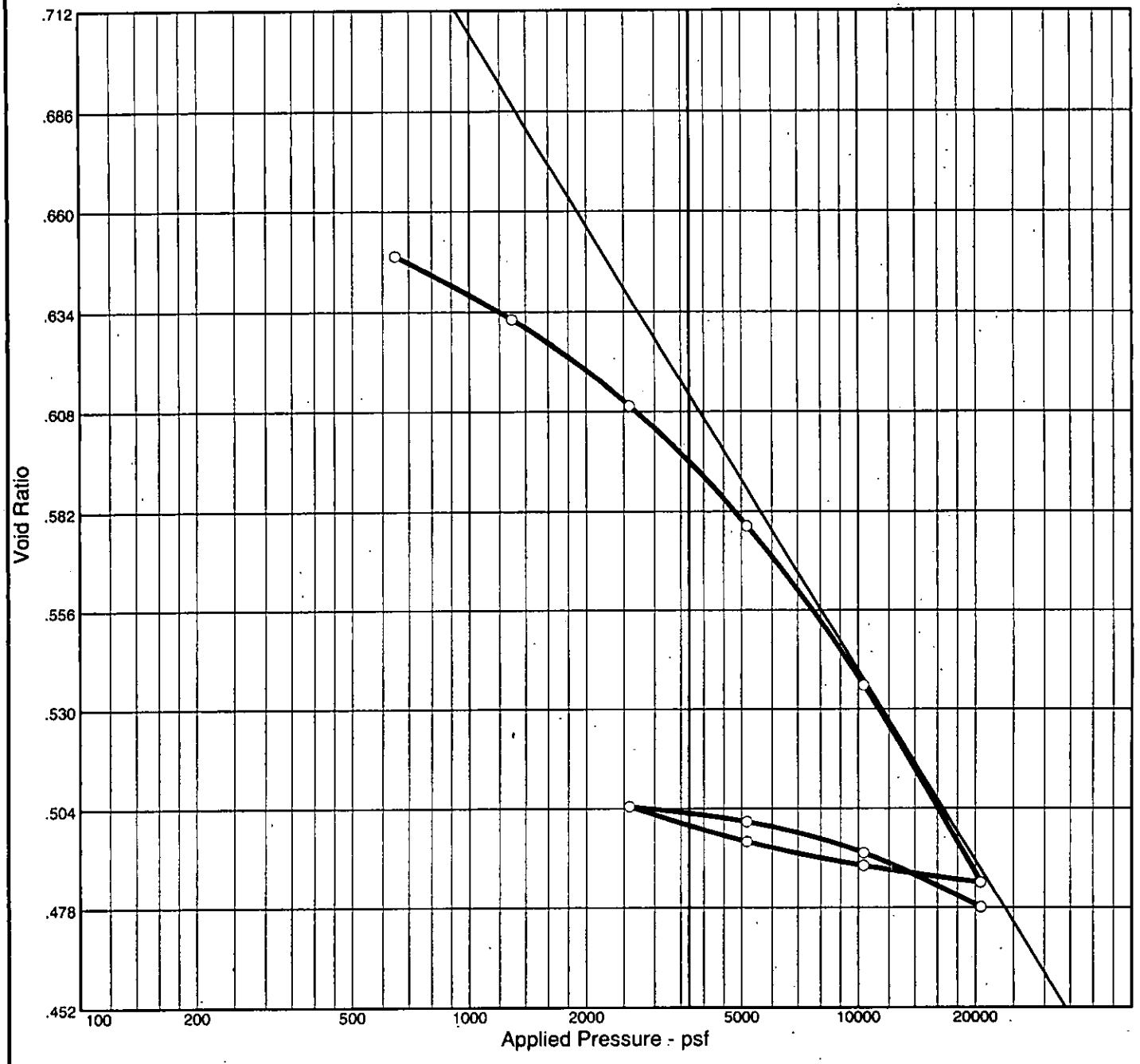
Source: B-1105A Sample No.: ST3 Elev./Depth: 12.0



DLZ

Figure

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
95.5 %	23.0 %	101.0	36	15	2.65	CL	A-6(15)	0.639

MATERIAL DESCRIPTION

Silt and Clay (A-6b)

Project No. 0121- **Client:** TranSystems, Inc.

Project: SCI-823-0.00

Source: B-1108 **Sample No.:** P1 **Elev./Depth:** 10.0

Remarks:

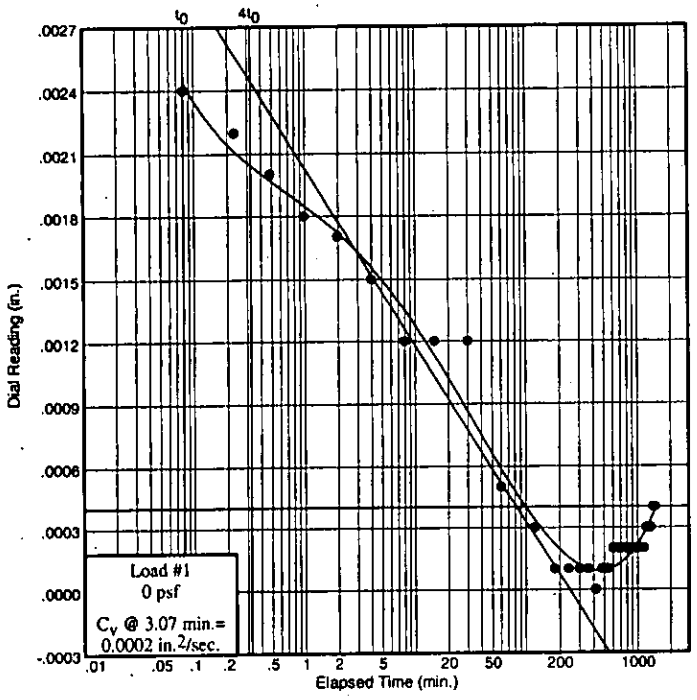
DLZ

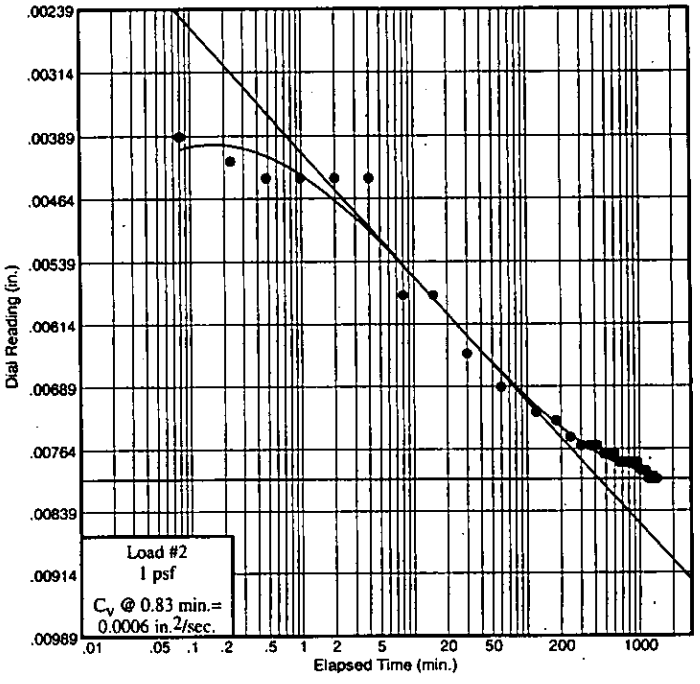
Figure

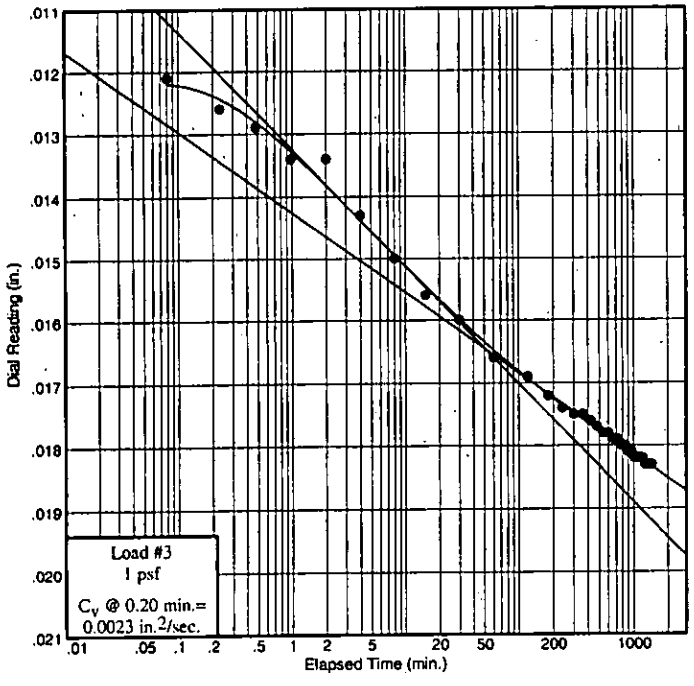
Dial Reading vs. Time

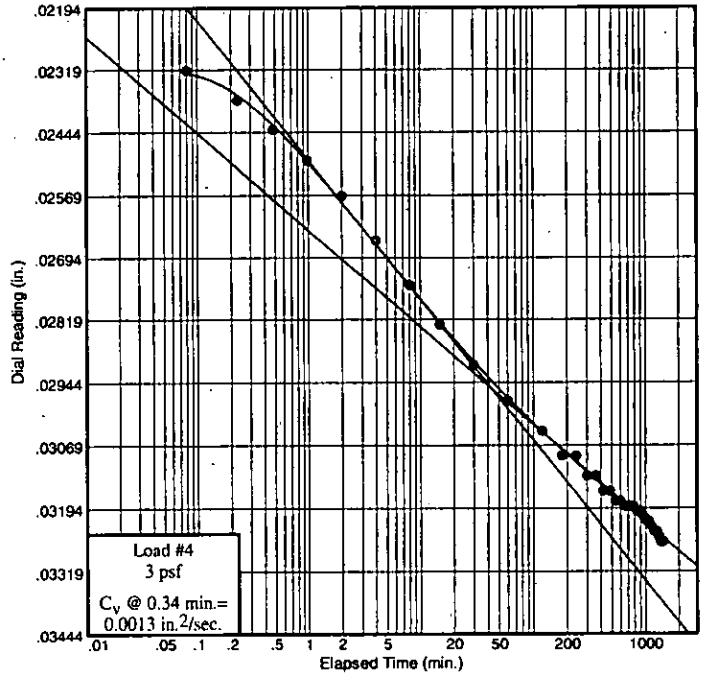
Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-1108 Sample No.: P1 Elev./Depth: 10.0









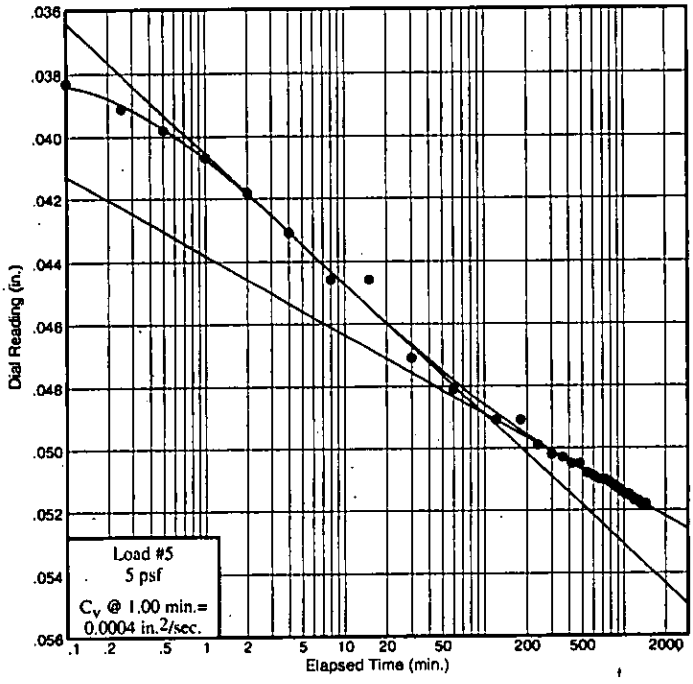
DLZ

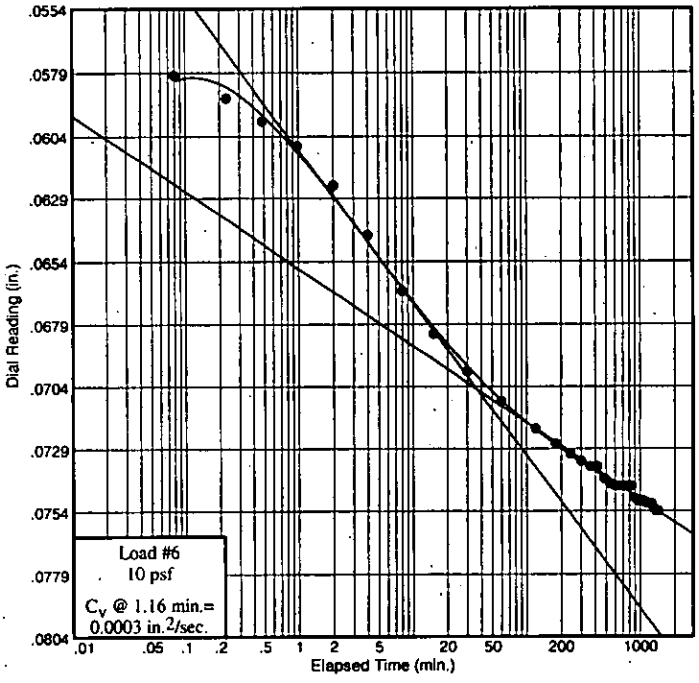
Figure

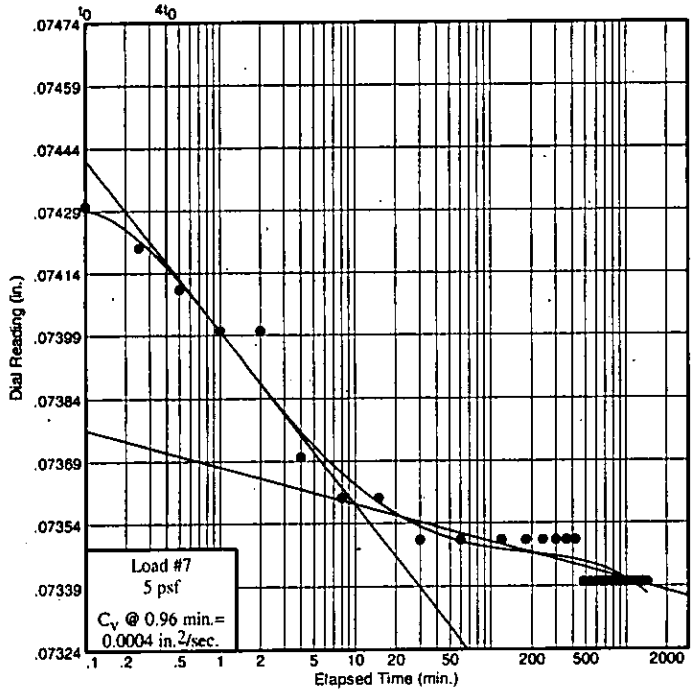
Dial Reading vs. Time

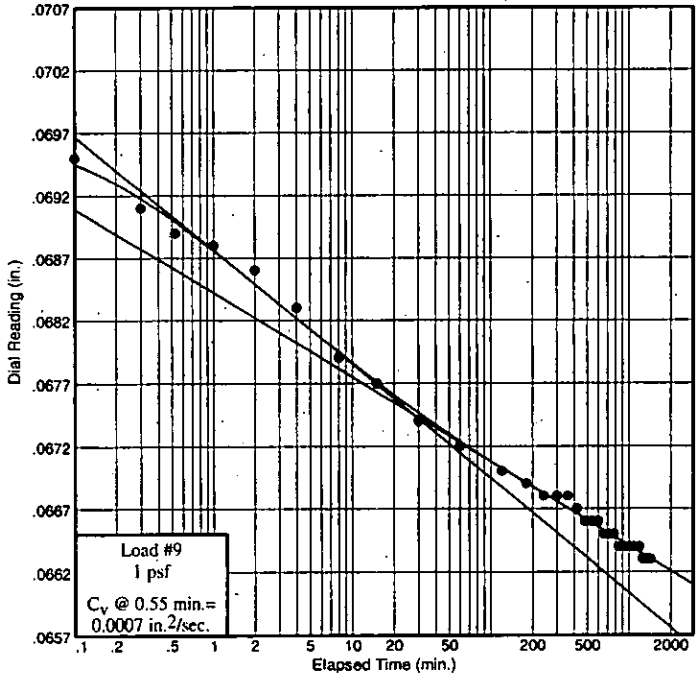
Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-1108 Sample No.: P1 Elev./Depth: 10.0









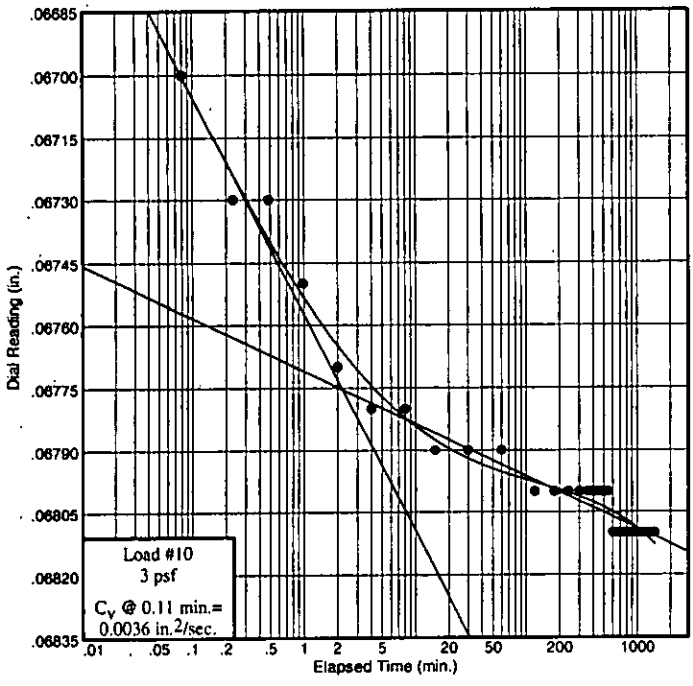
DLZ

Figure

Dial Reading vs. Time

Project No.: 0121-3070.03
Project: SCI-823-0.00

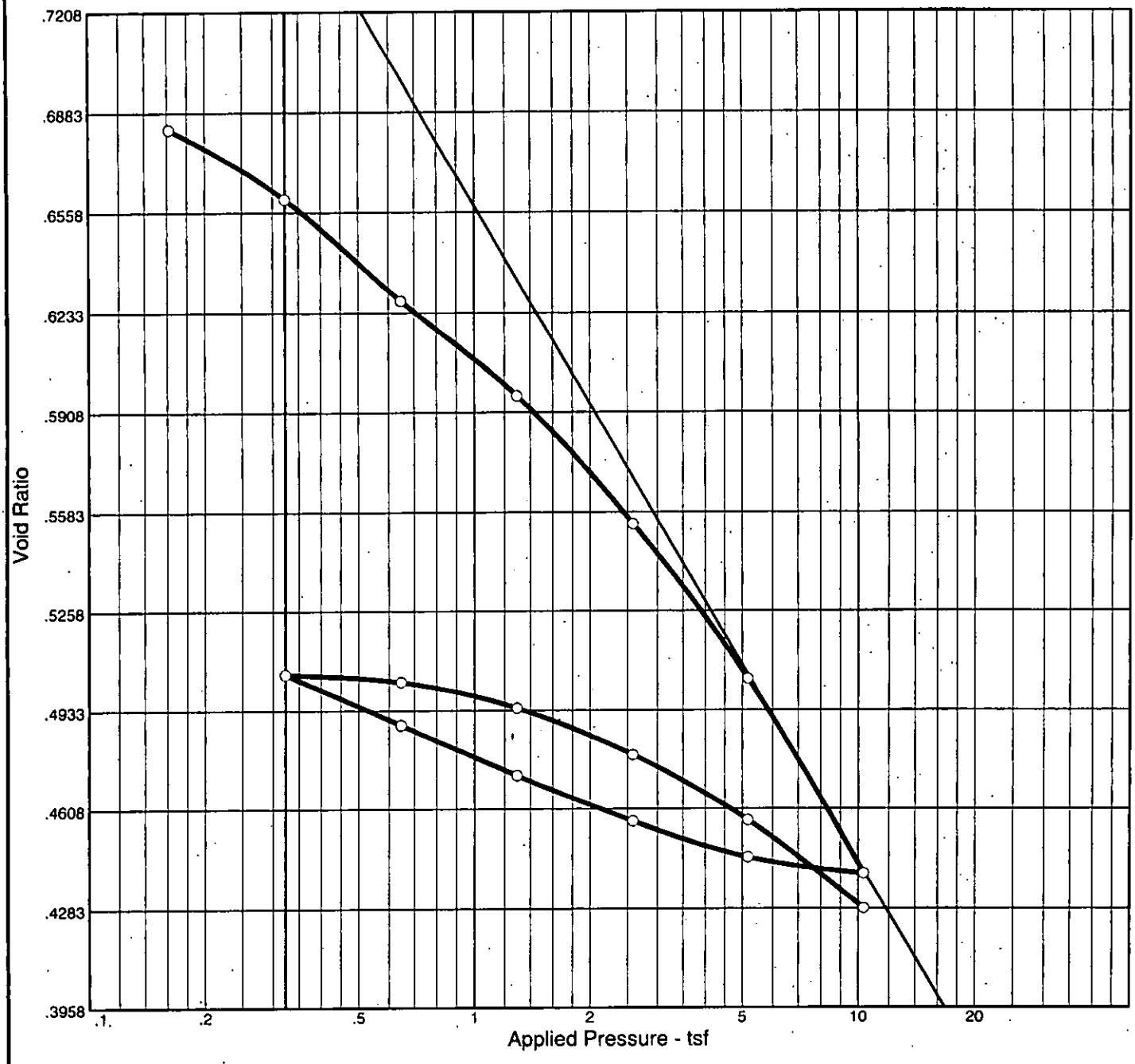
Source: B-1108 Sample No.: P1 Elev./Depth: 10.0



DLZ

Figure

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
104.7 %	29.1 %	95.0	38	19	2.64	CL	A-6(17)	0.734

MATERIAL DESCRIPTION

Silt Clay (A-6b)

Project No. 0121- **Client:** TranSystems, Inc.

Project: SCI-823-0.00

Source: B-1108 **Sample No.:** P3 **Elev./Depth:** 18.0

DLZ

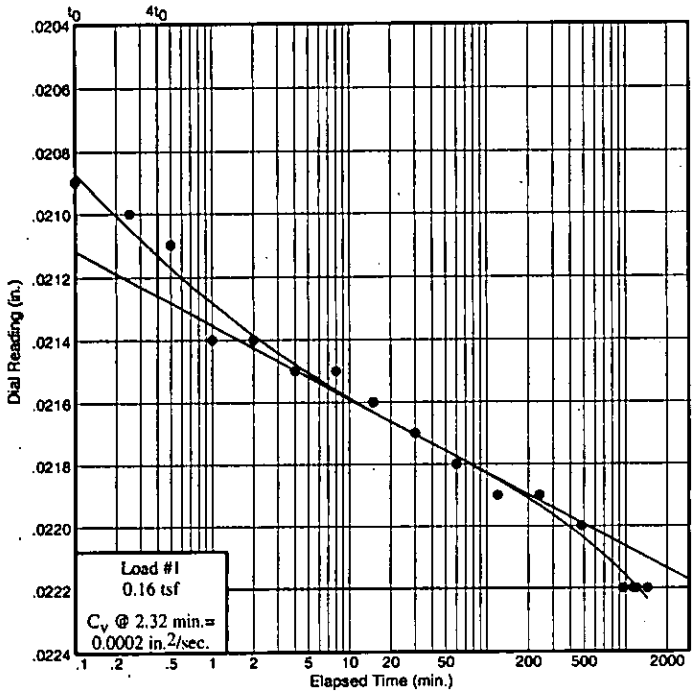
Remarks:

Figure

Dial Reading vs. Time

Project No.: 0121-3070.03
Project: SCI-823-0.00

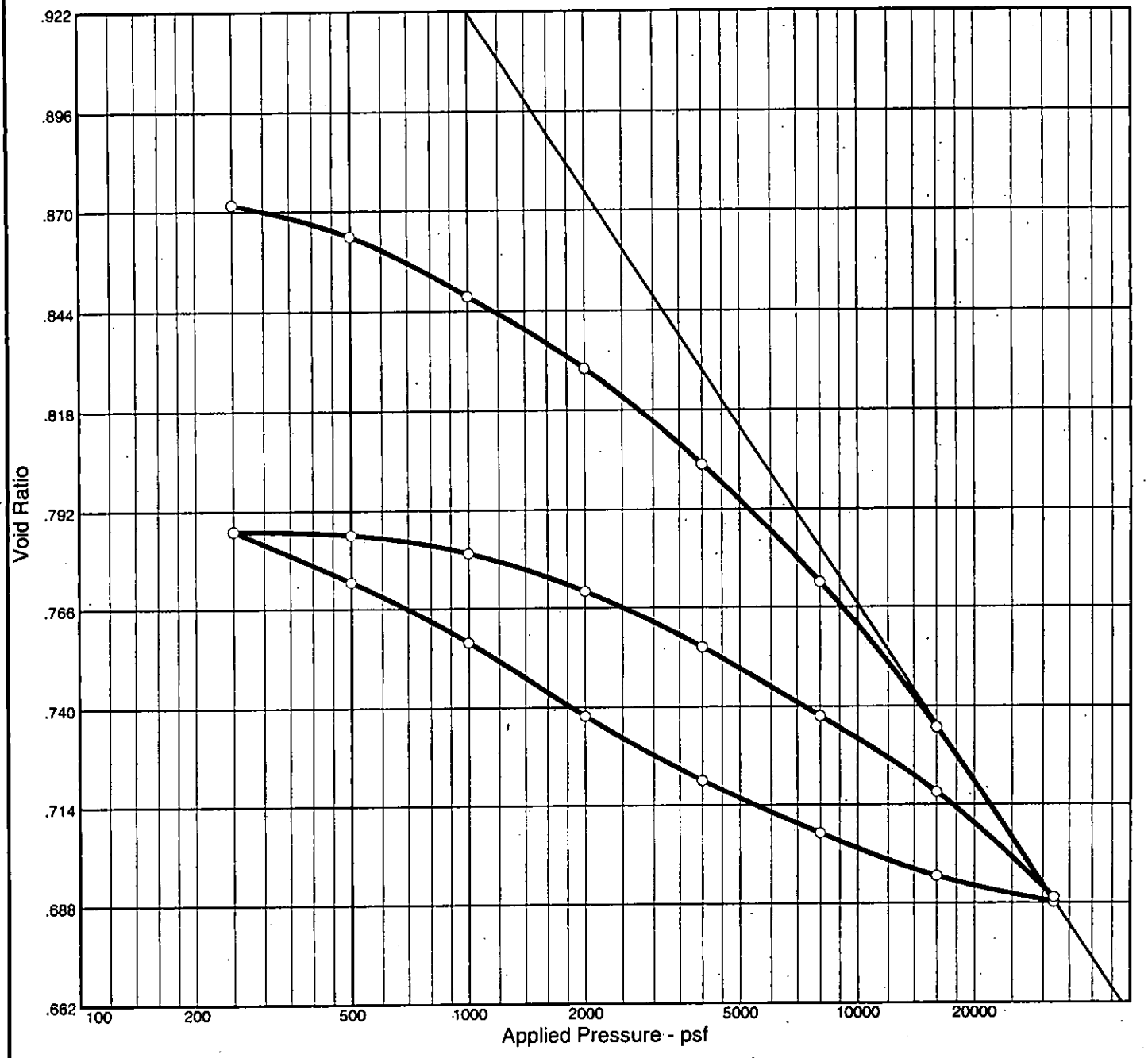
Source: B-1108 Sample No.: P3 Elev./Depth: 18.0



DLZ

Figure

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
95.5 %	30.9 %	90.5	57	33	2.73		A-7-6	0.883

MATERIAL DESCRIPTION

Project No. 0121- **Client:** TranSystems, Inc.

Project: SCI-823-0.00

Source: B-1109A **Elev./Depth:** 8.0

Remarks:

DLZ

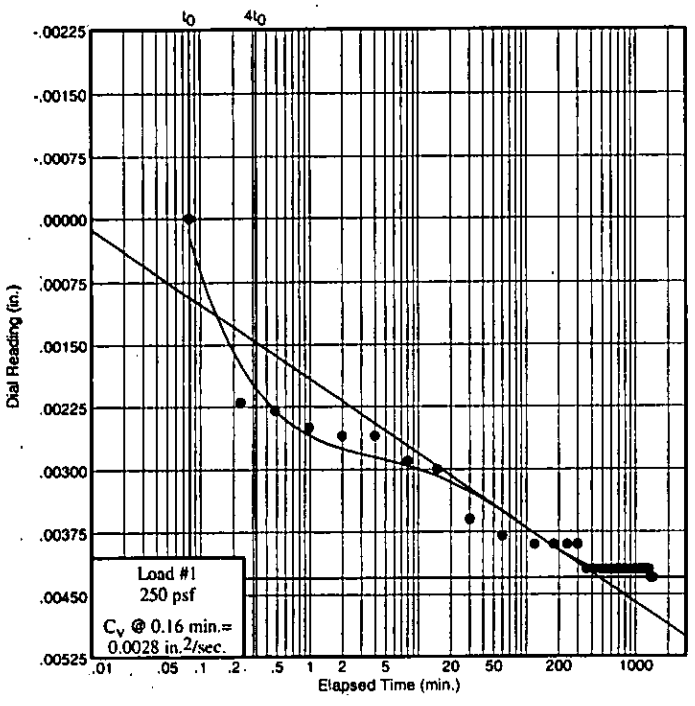
Figure

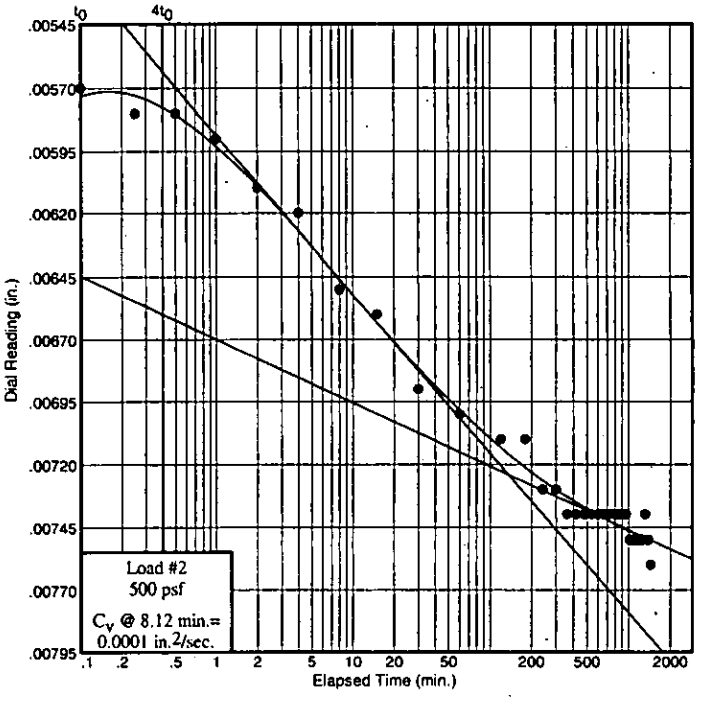
Dial Reading vs. Time

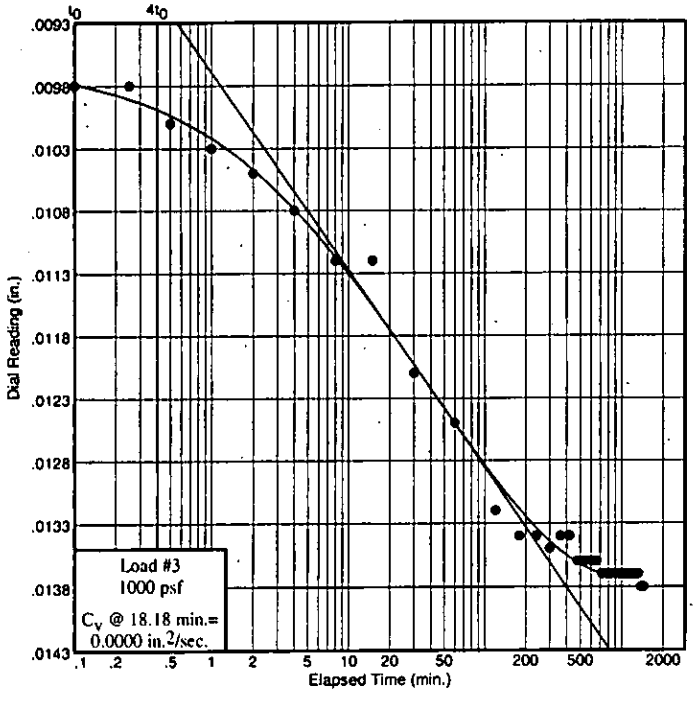
Project No.: 0121-3070.03
Project: SCI-823-0.00

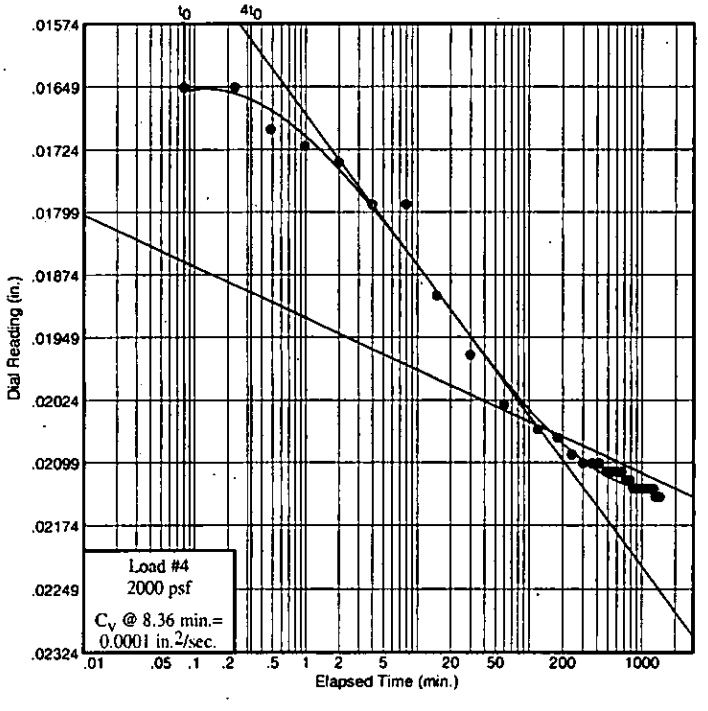
Source: B-1109A

Elev./Depth: 8.0









DLZ

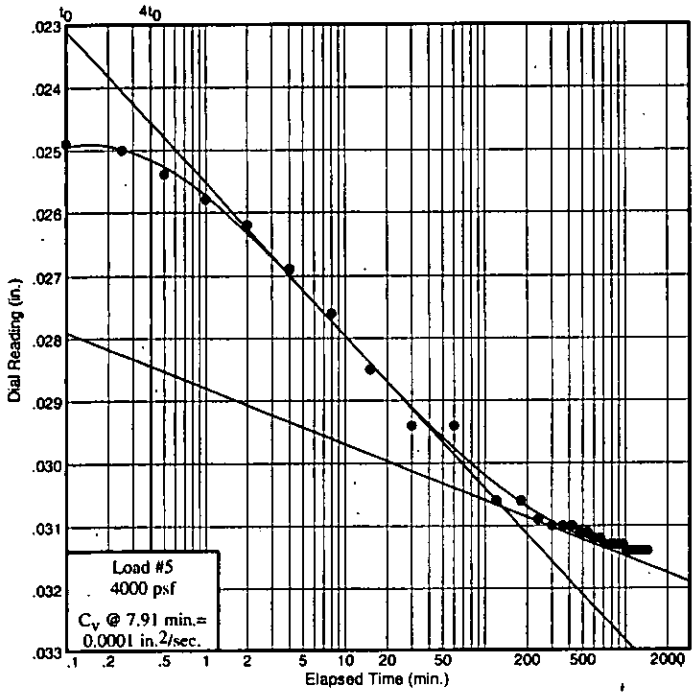
Figure

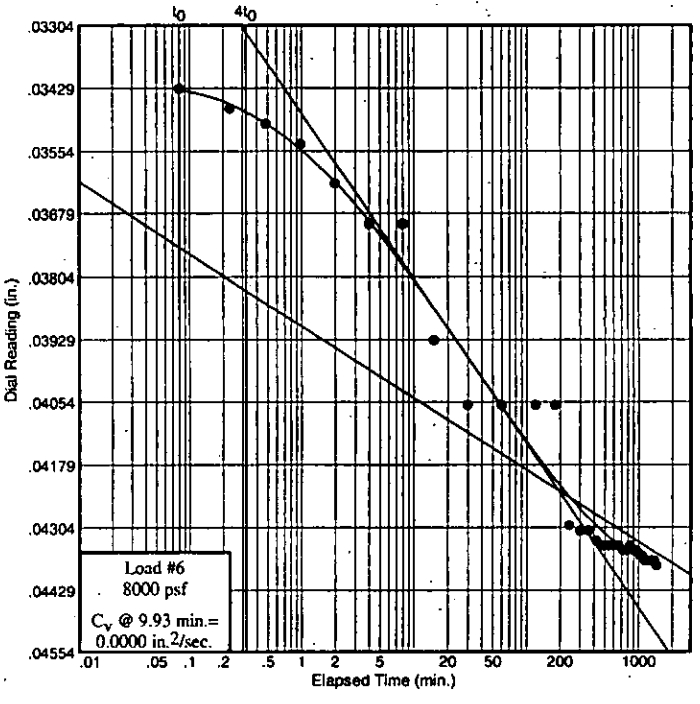
Dial Reading vs. Time

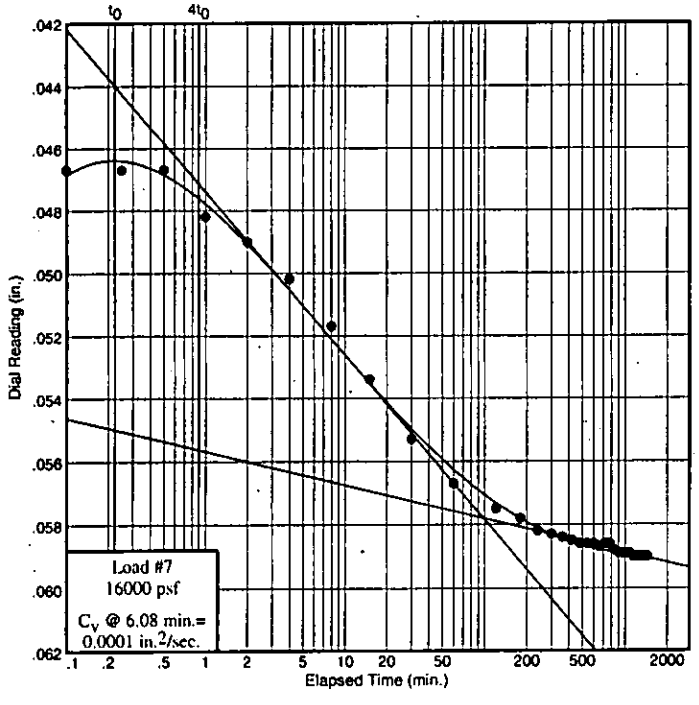
Project No.: 0121-3070.03
Project: SCI-823-0.00

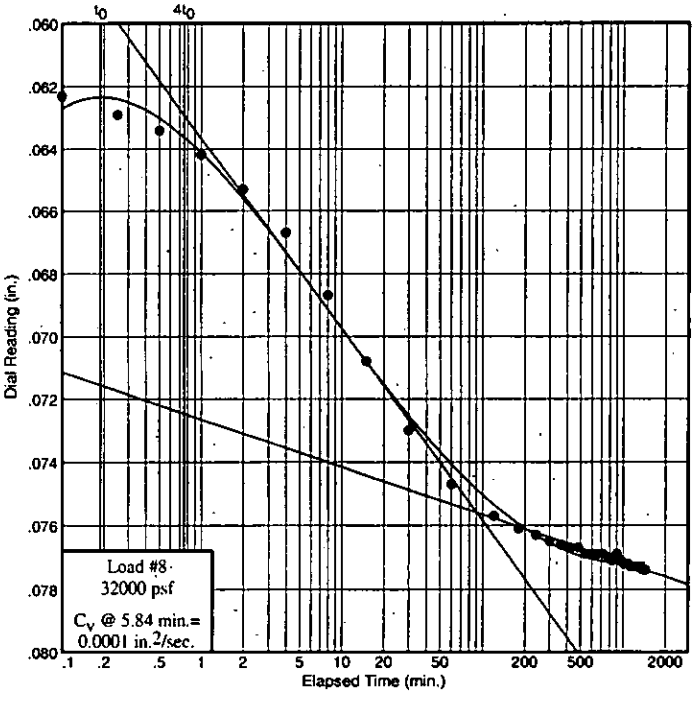
Source: B-1109A

Elev./Depth: 8.0









DLZ

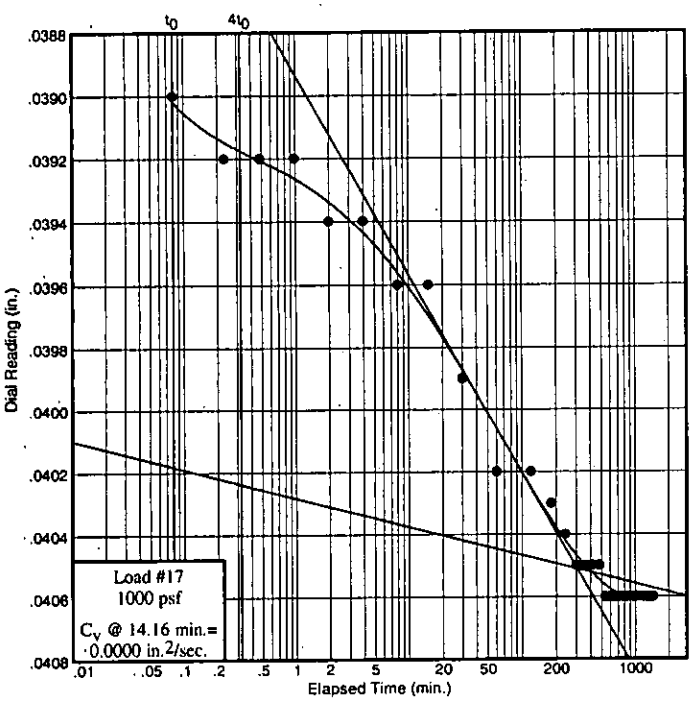
Figure

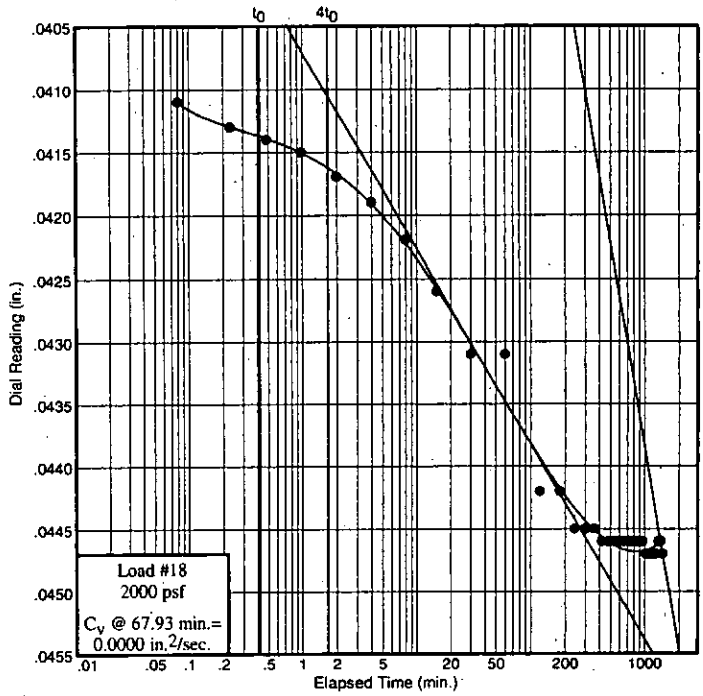
Dial Reading vs. Time

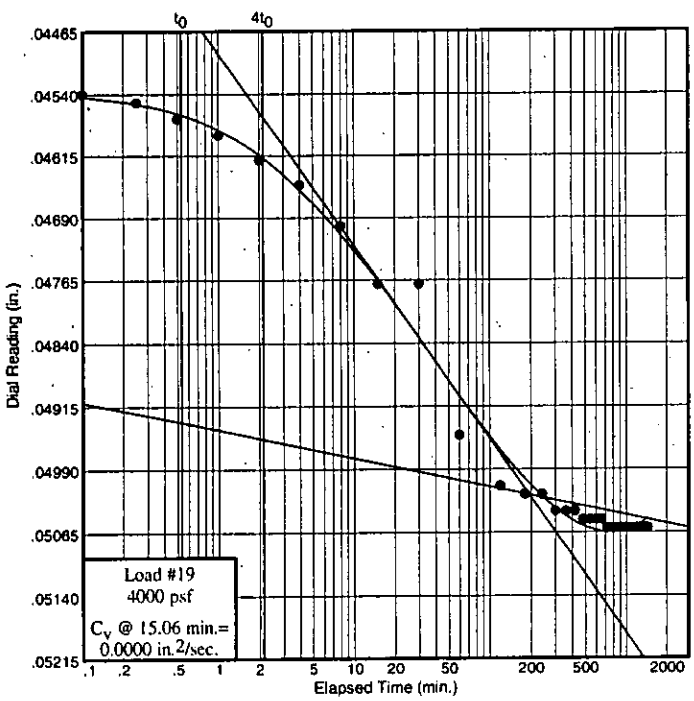
Project No.: 0121-3070.03
Project: SCI-823-0.00

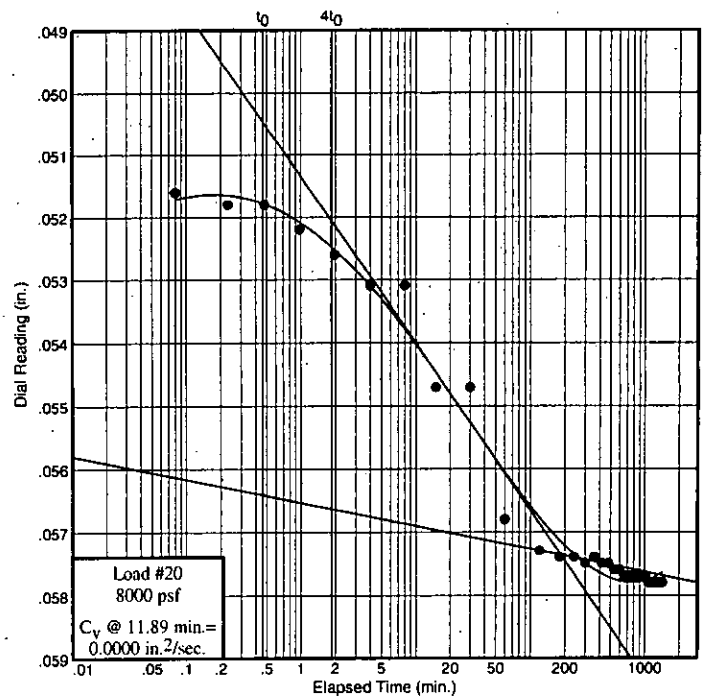
Source: B-1109A

Elev./Depth: 8.0









DLZ

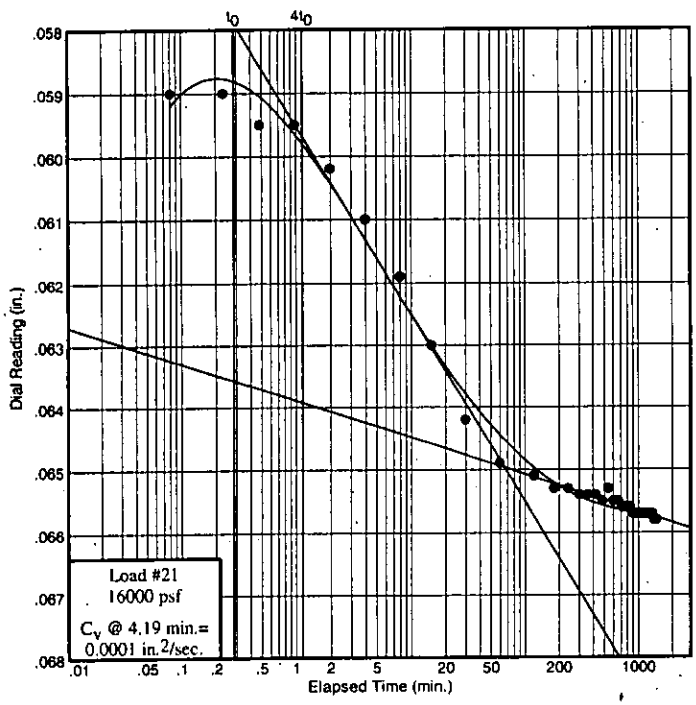
Figure

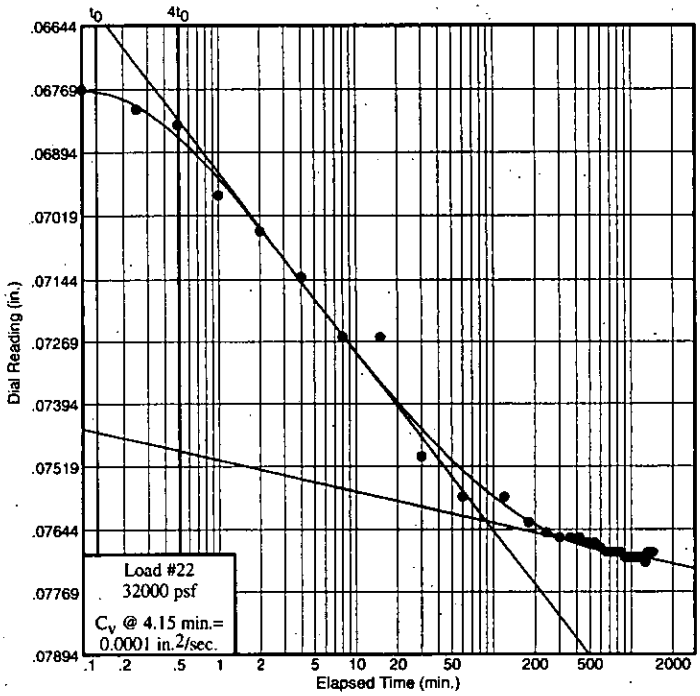
Dial Reading vs. Time

Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-1109A

Elev./Depth: 8.0

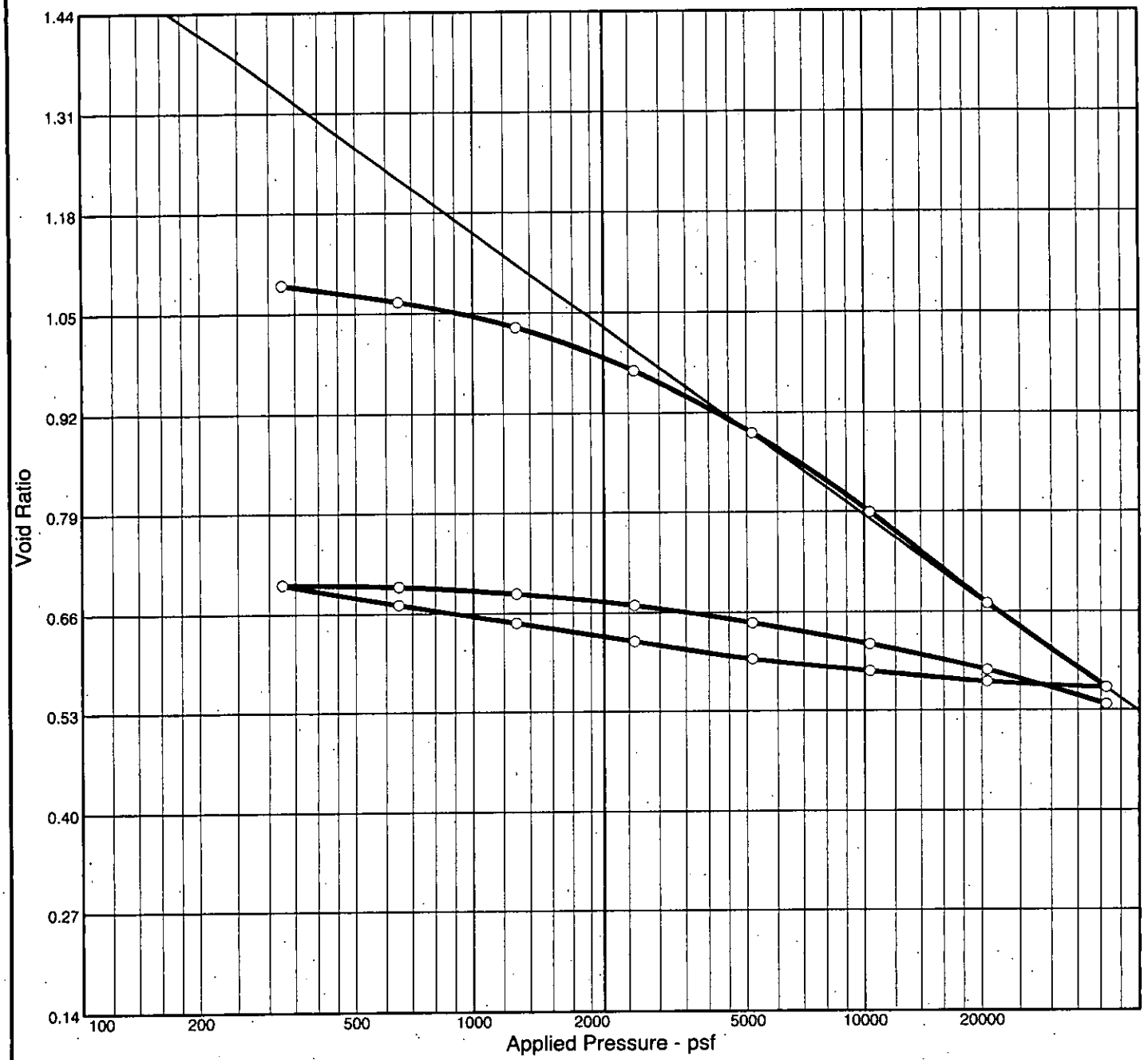




DLZ

Figure

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
82.6 %	34.2 %	79.4	36	15	2.68	CL	A-6(15)	1.108

MATERIAL DESCRIPTION

Silt and Clay (A-6a)

Project No. 0121- **Client:** TranSystems, Inc.

Project: SCI-823-0.00

Source: B-1122A **Sample No.:** ST1 **Elev./Depth:** 12.0

DLZ

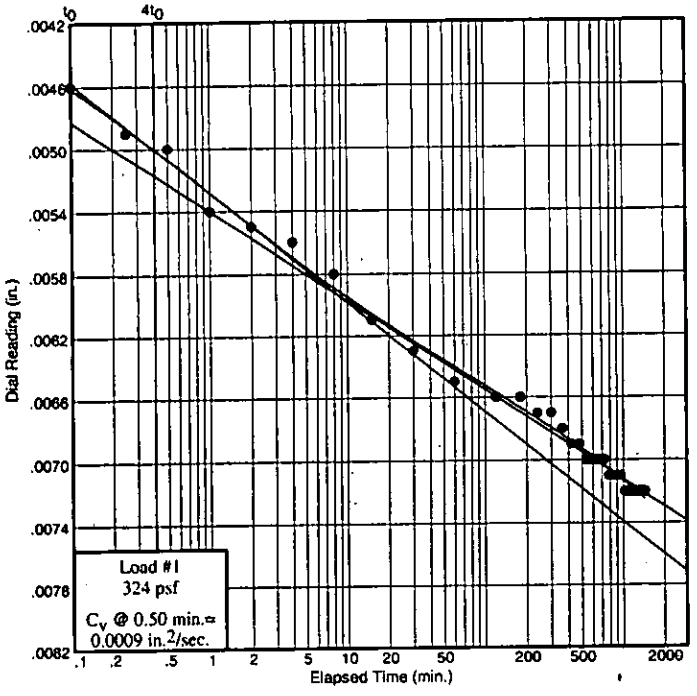
Remarks:

Figure

Dial Reading vs. Time

Project No.: 0121-3070.03
Project: SCI-823-0.00

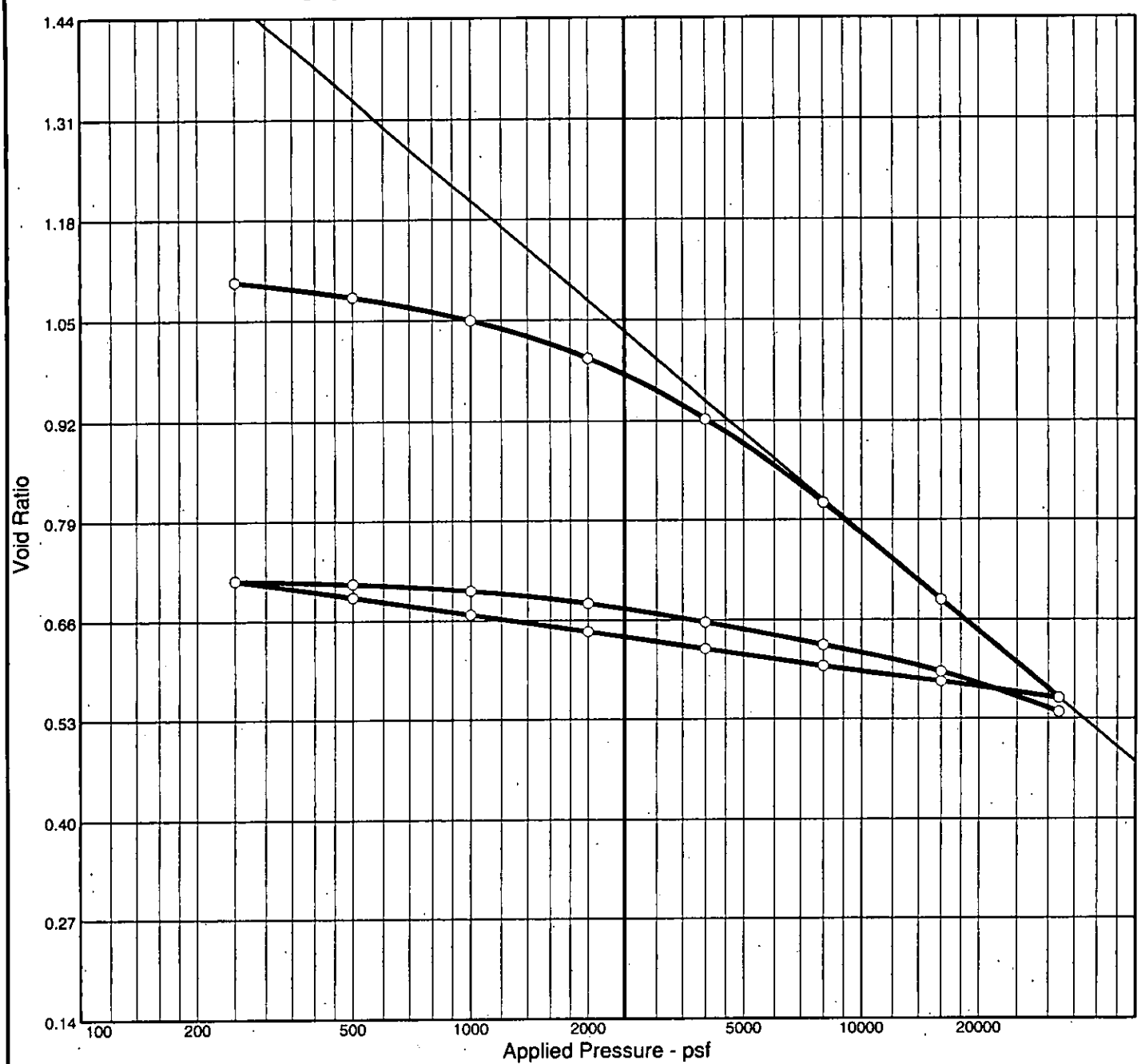
Source: B-1122A Sample No.: ST1 Elev./Depth: 12.0



DLZ

Figure

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
96.5 %	39.9 %	79.4	41	14	2.68	ML	A-7-6(16	1.108

MATERIAL DESCRIPTION

Clay (A-7-6)

Project No. 0121- **Client:** TranSystems. Inc.

Project: SCI-823-0.00

Source: B-1133A **Elev./Depth:** 20.3

DLZ

Remarks:

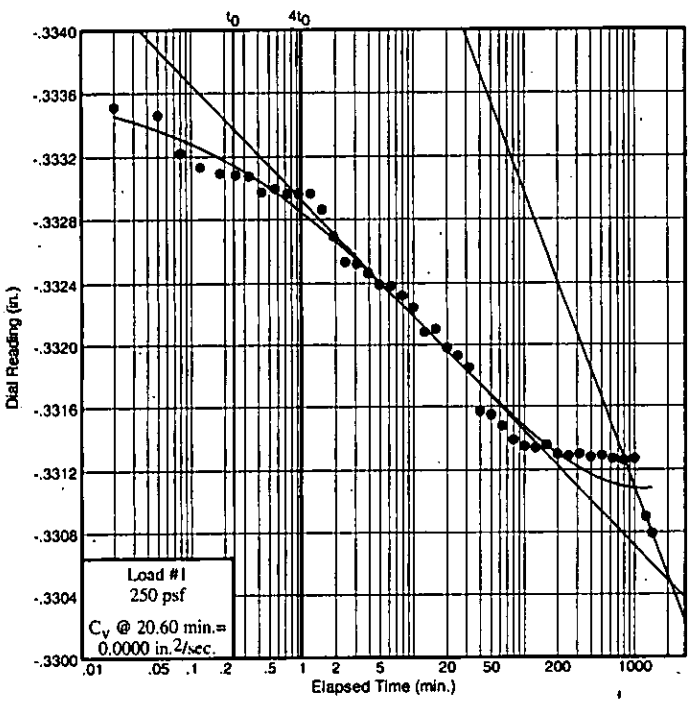
Figure

Dial Reading vs. Time

Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-1133A

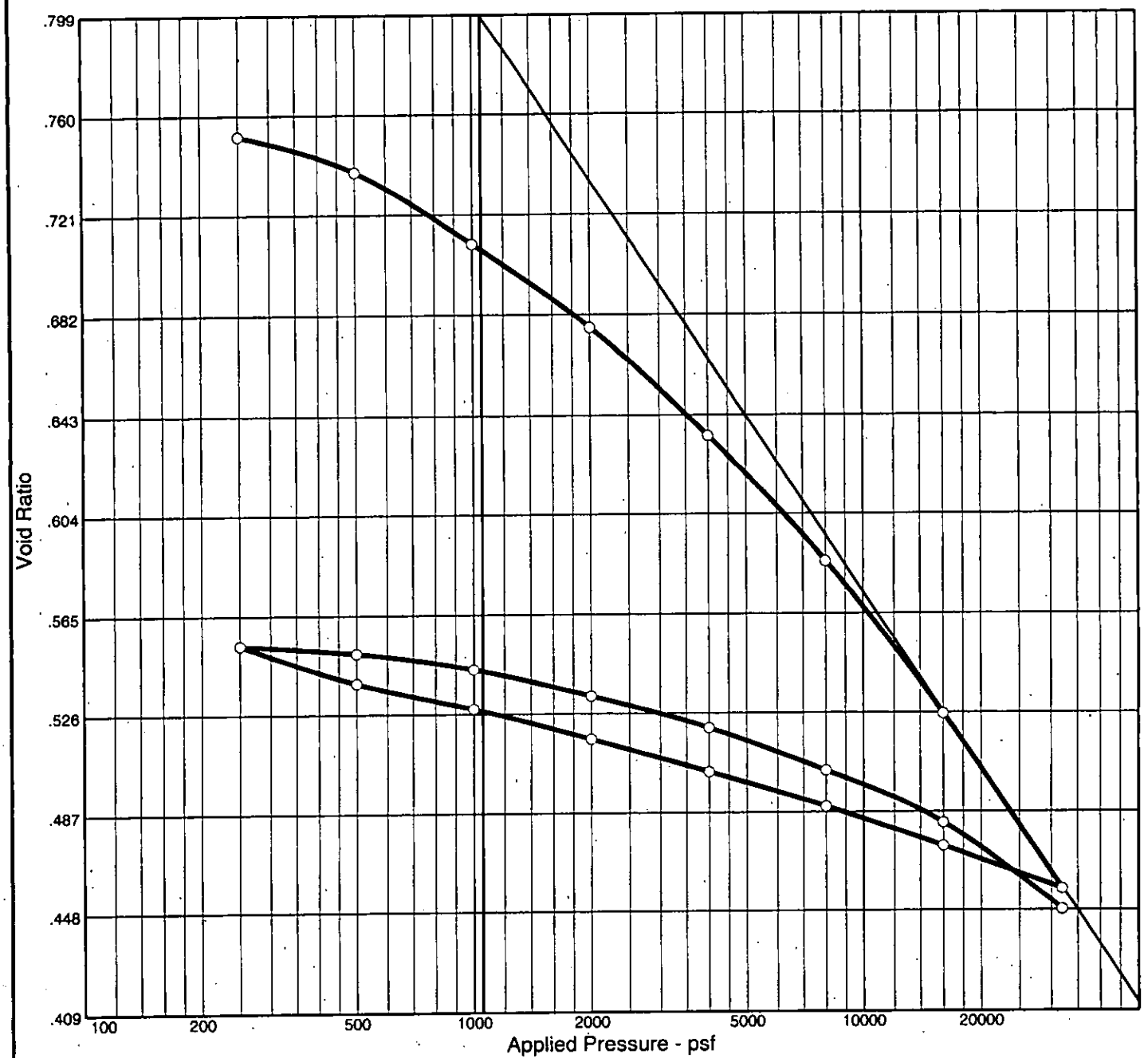
Elev./Depth: 20.3



DLZ

Figure

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
87.1 %	23.7 %	98.3	31	10	2.76	CL	A-4(10)	0.752

MATERIAL DESCRIPTION

Silt (A-4b)

Project No. 0121- **Client:** TranSystems, Inc.

Project: SCI-823-0.00

Source: B-1136A **Sample No.:** ST1 **Elev./Depth:** 6.0

DLZ

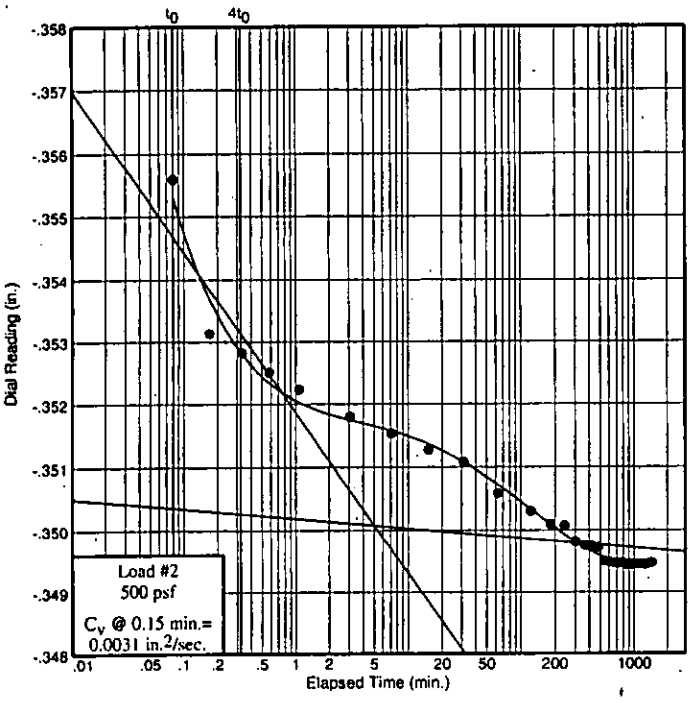
Remarks:

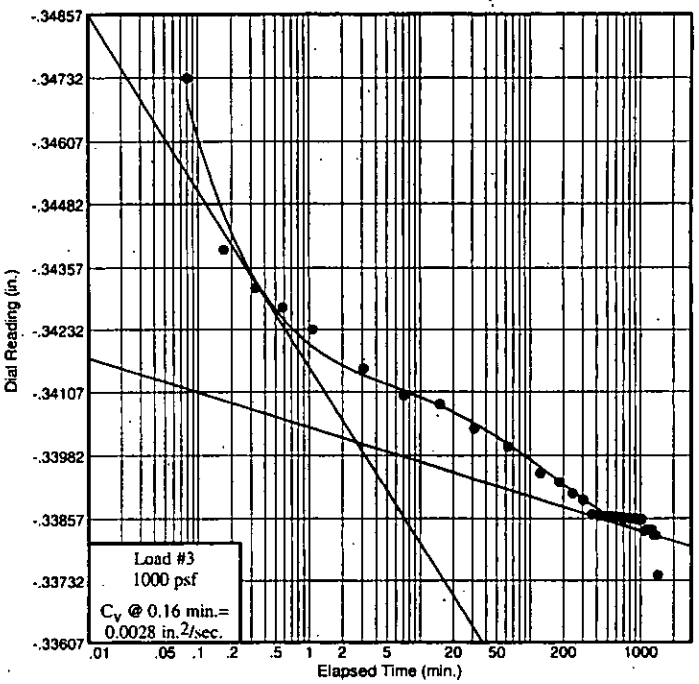
Figure

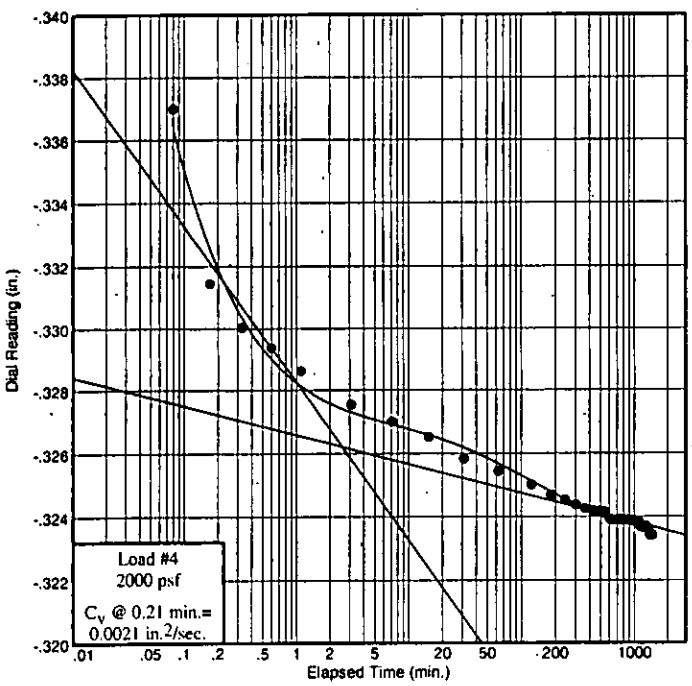
Dial Reading vs. Time

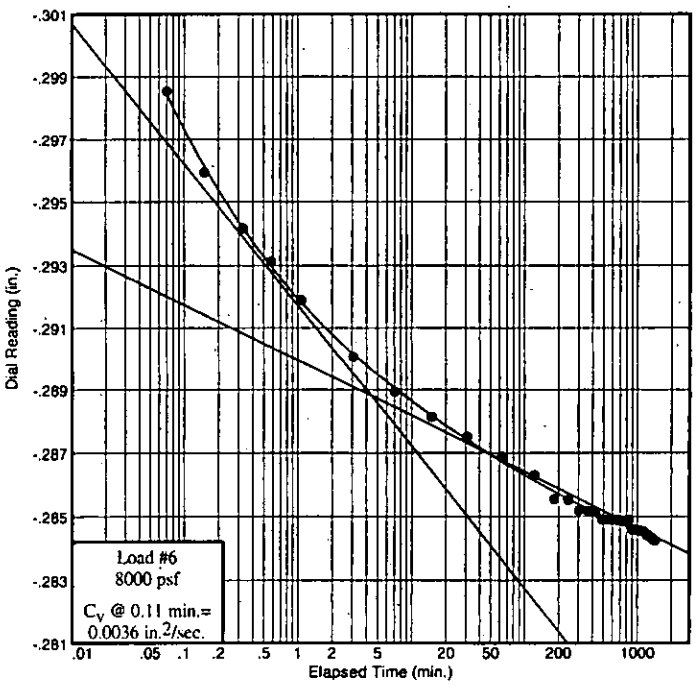
Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-1136A Sample No.: ST1 Elev./Depth: 6.0









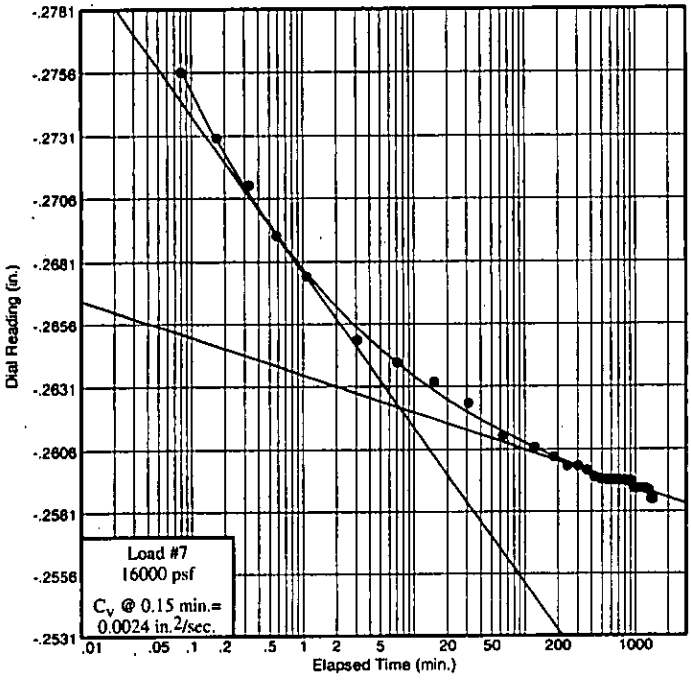
DLZ

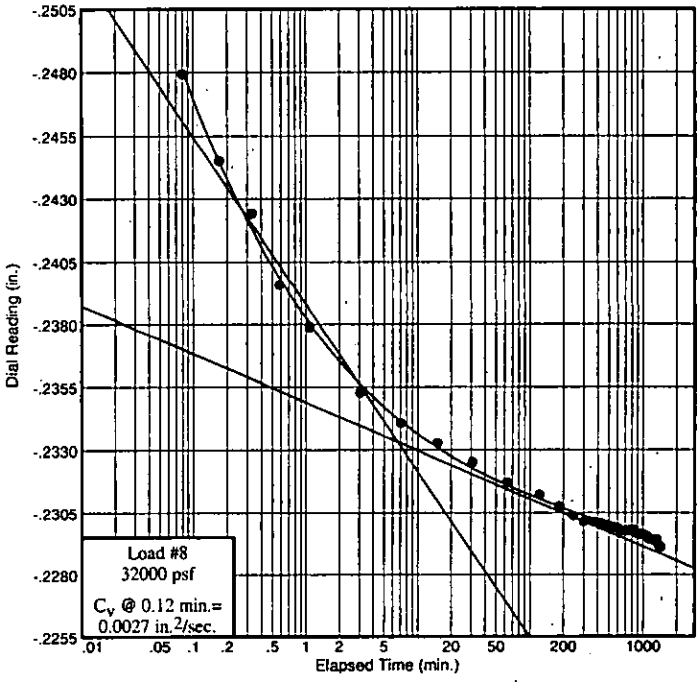
Figure

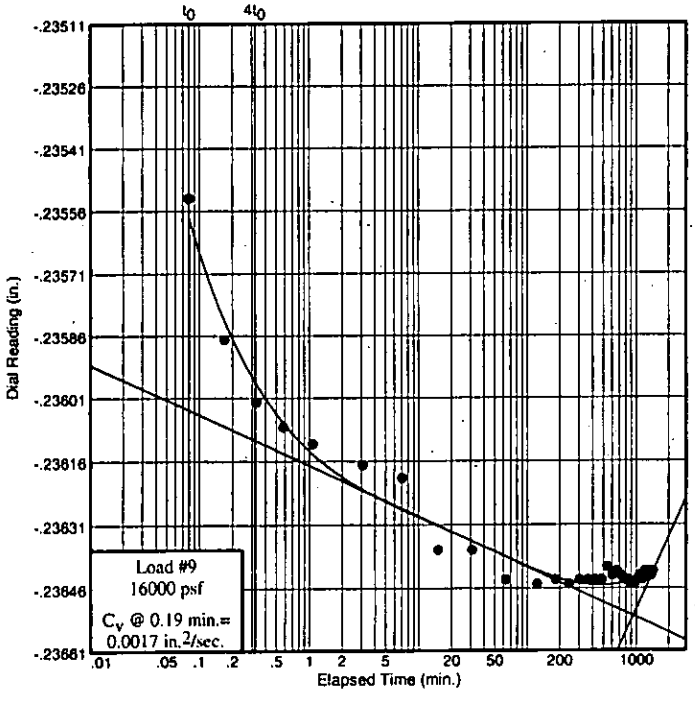
Dial Reading vs. Time

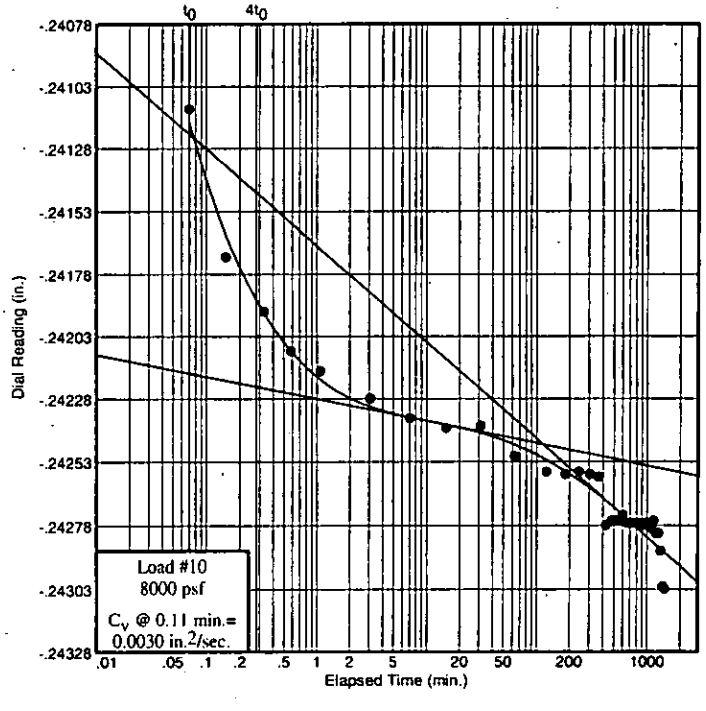
Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-1136A Sample No.: ST1 Elev./Depth: 6.0









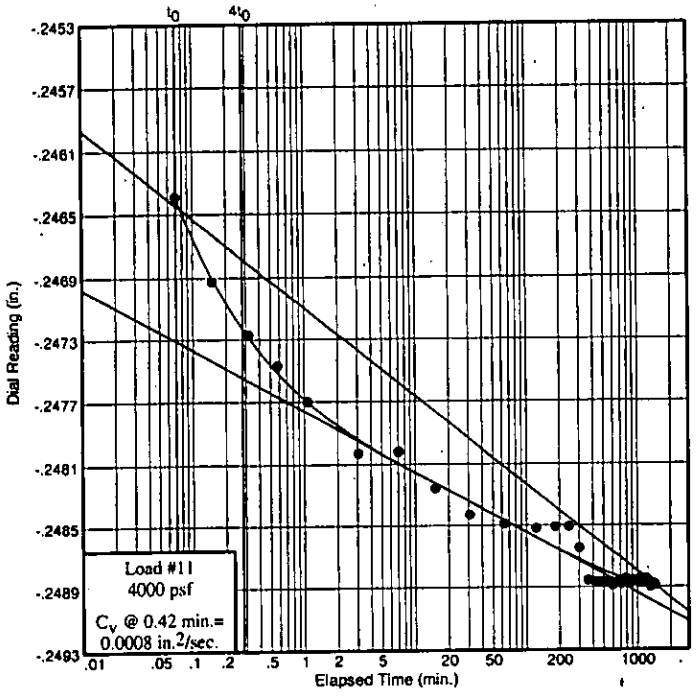
DLZ

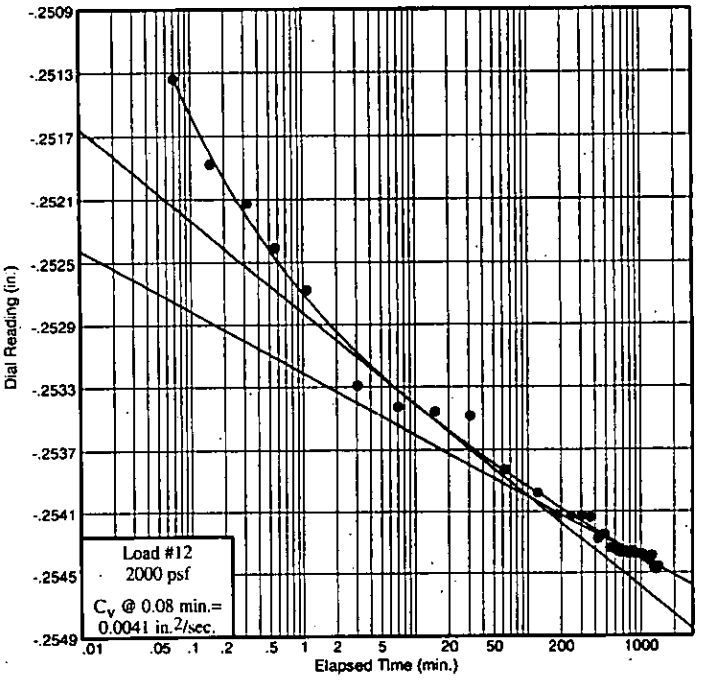
Figure

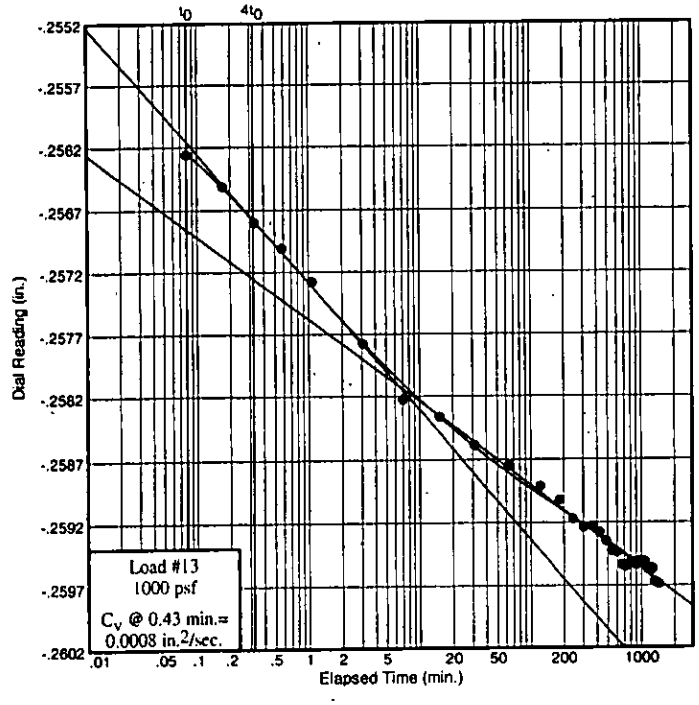
Dial Reading vs. Time

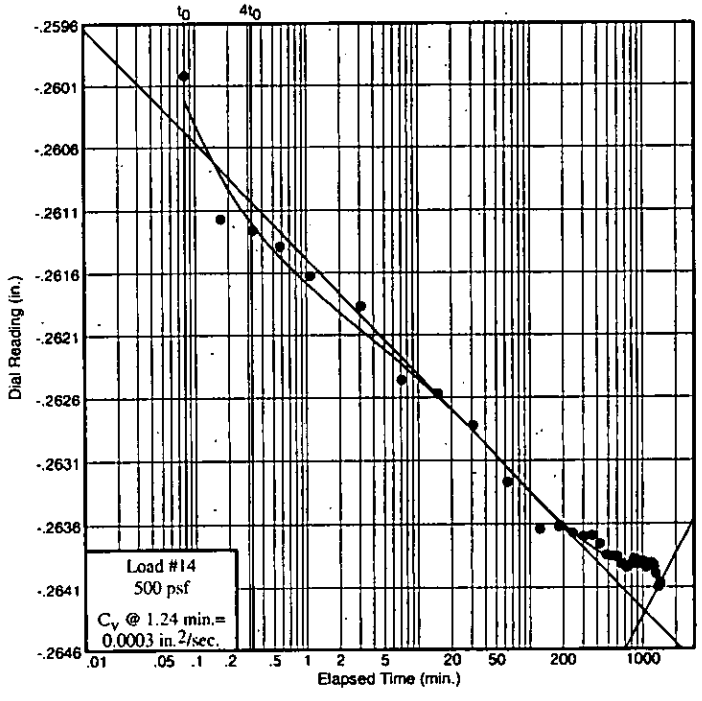
Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-1136A Sample No.: ST1 Elev./Depth: 6.0









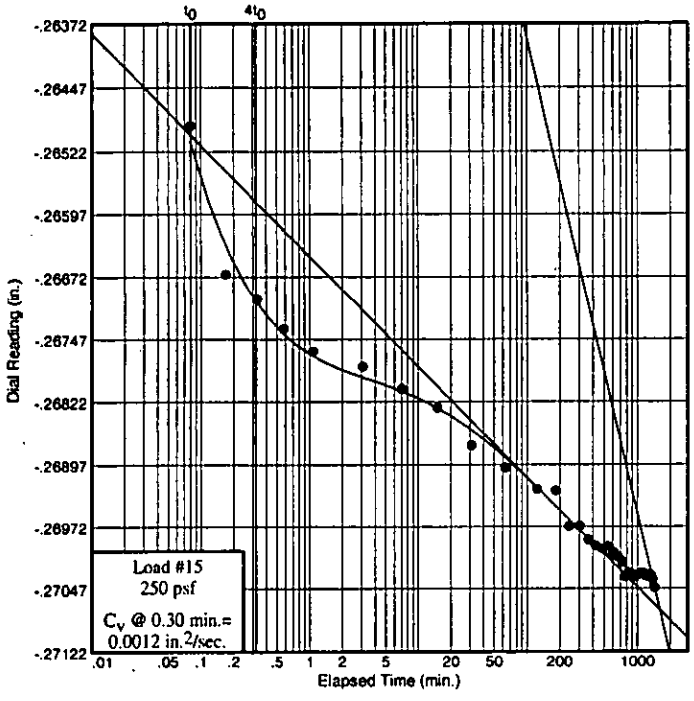
DLZ

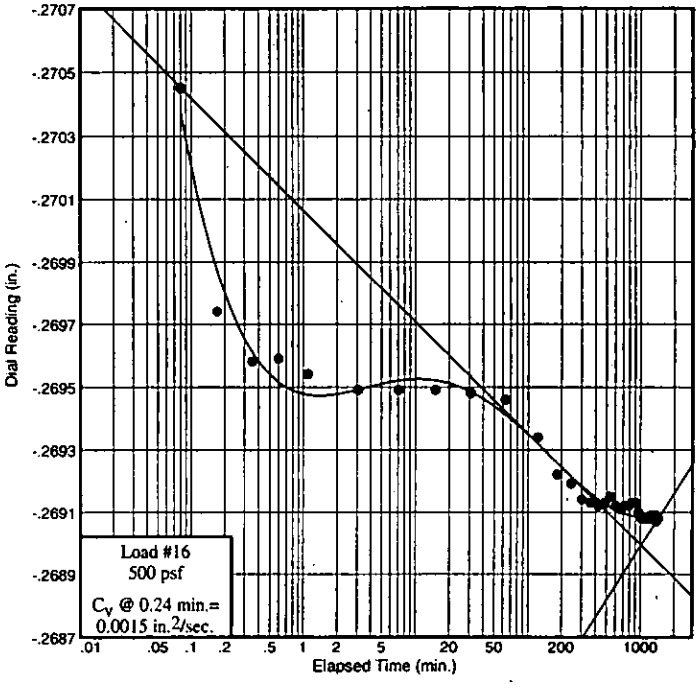
Figure

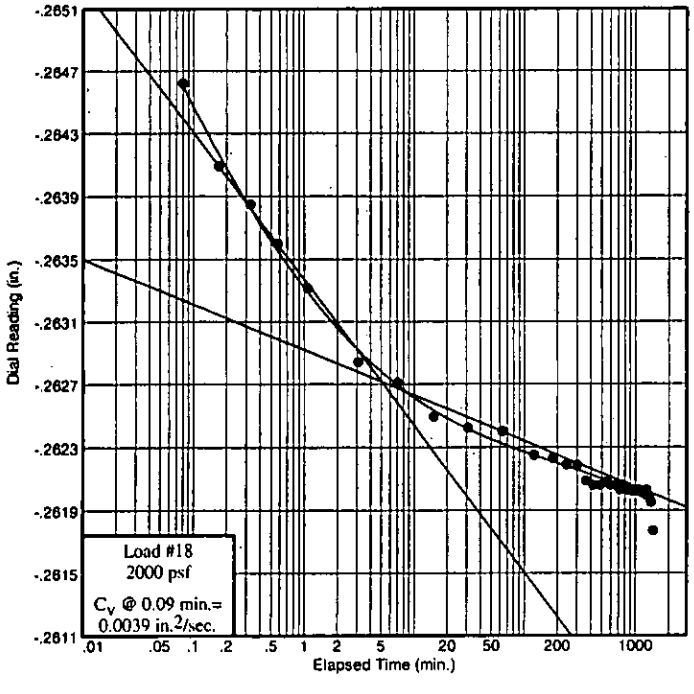
Dial Reading vs. Time

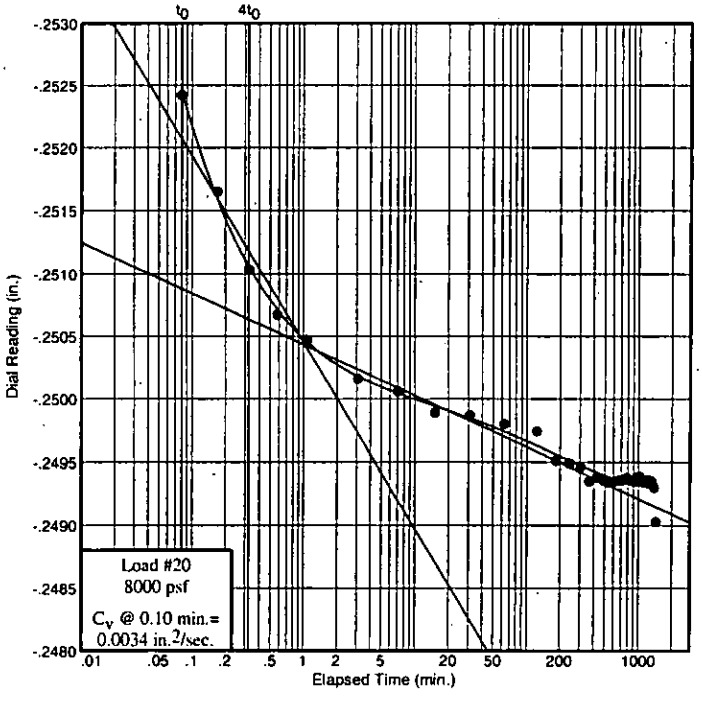
Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-1136A Sample No.: ST1 Elev./Depth: 6.0









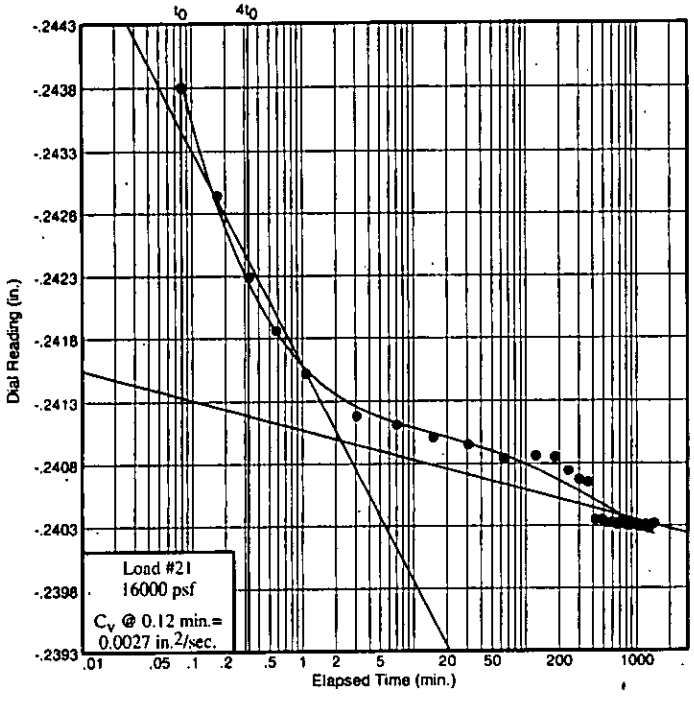
DLZ

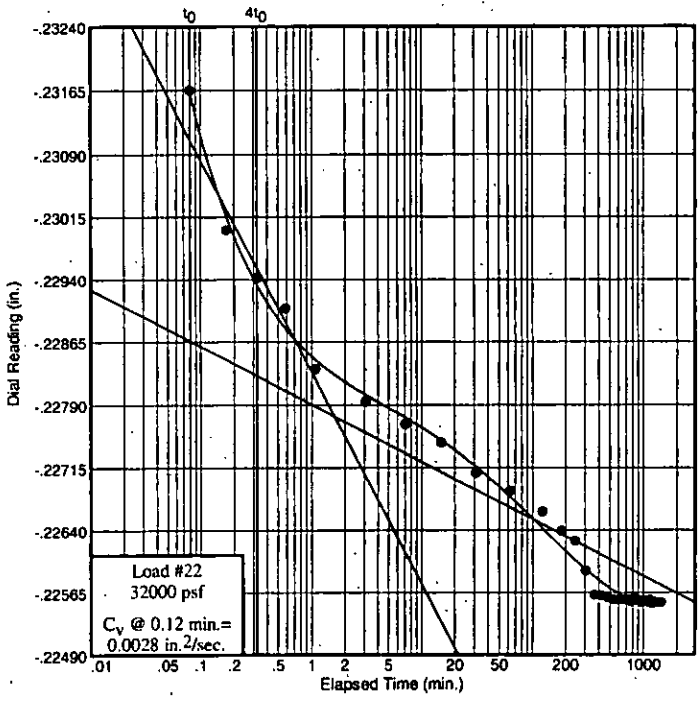
Figure

Dial Reading vs. Time

Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-1136A Sample No.: ST1 Elev./Depth: 6.0

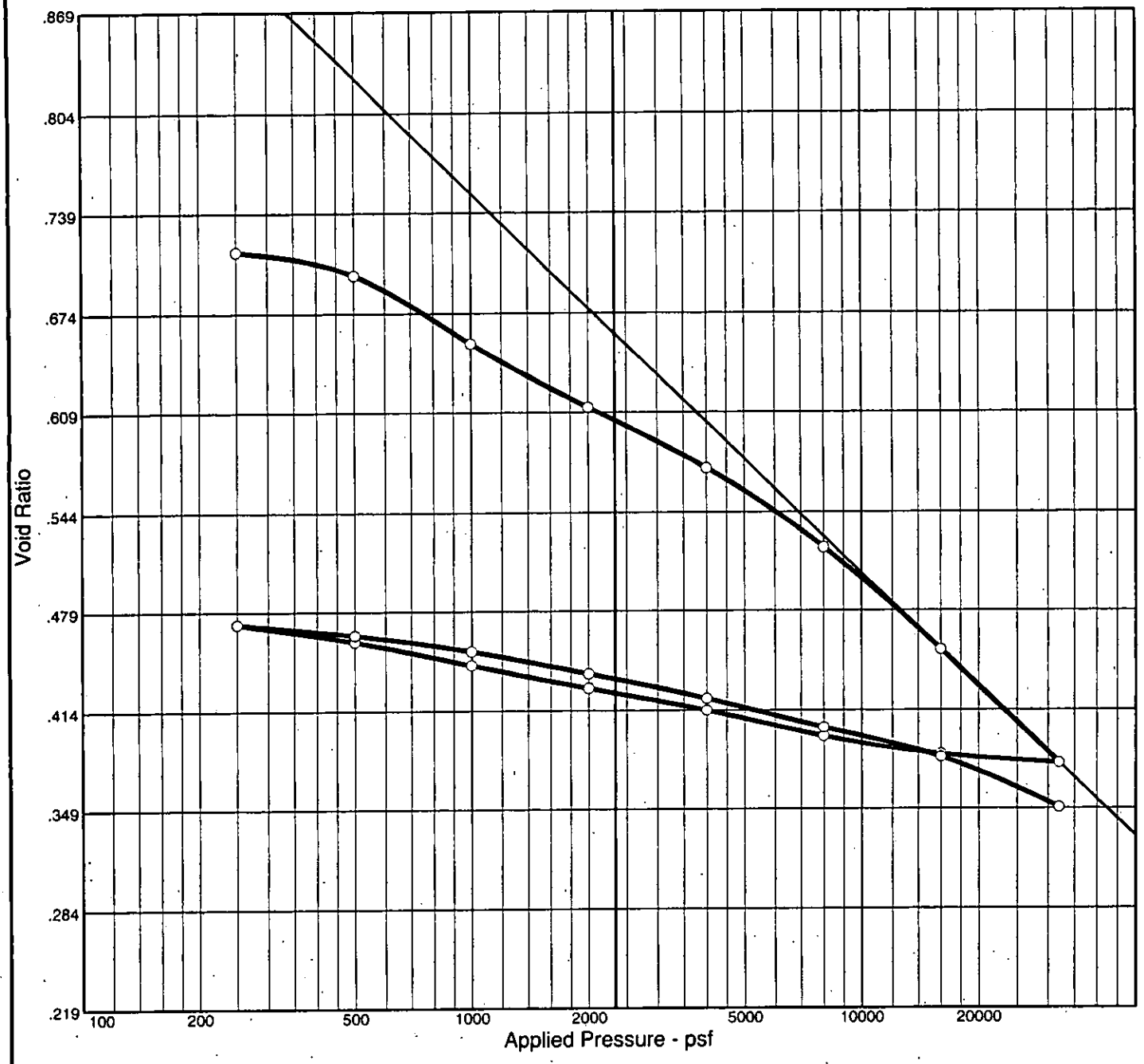




DLZ

Figure

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
96.5 %	25.9 %	97.6	38	18	2.69	CL	A-6(18)	0.721

MATERIAL DESCRIPTION

Silty Clay (A-6b)

Project No. 0121- **Client:** TranSystems, Inc.

Project: SCI-823-0.00

Source: B-1138A **Sample No.:** ST2 **Elev./Depth:** 8.0

DLZ

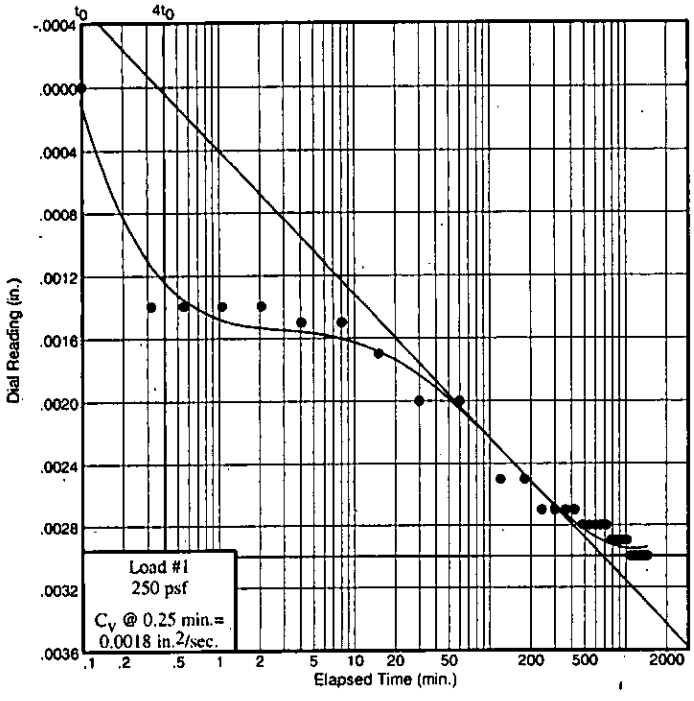
Remarks:

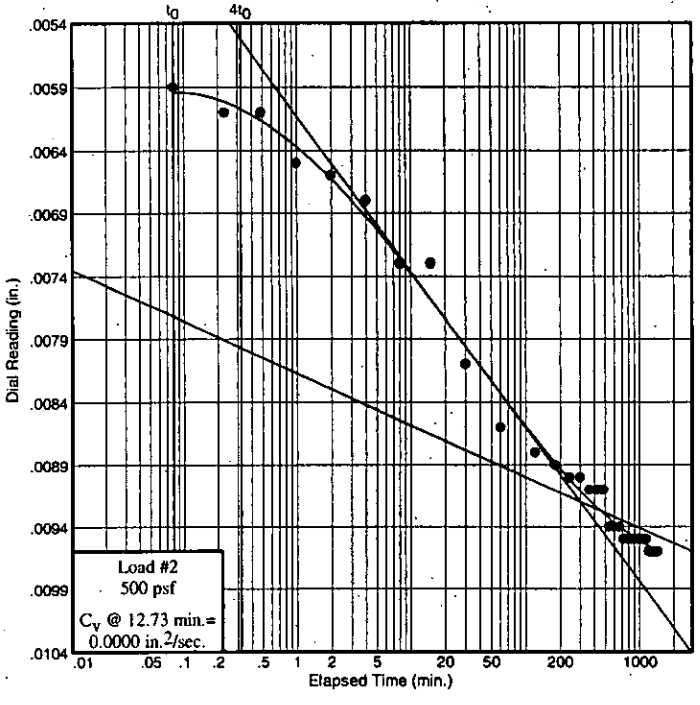
Figure

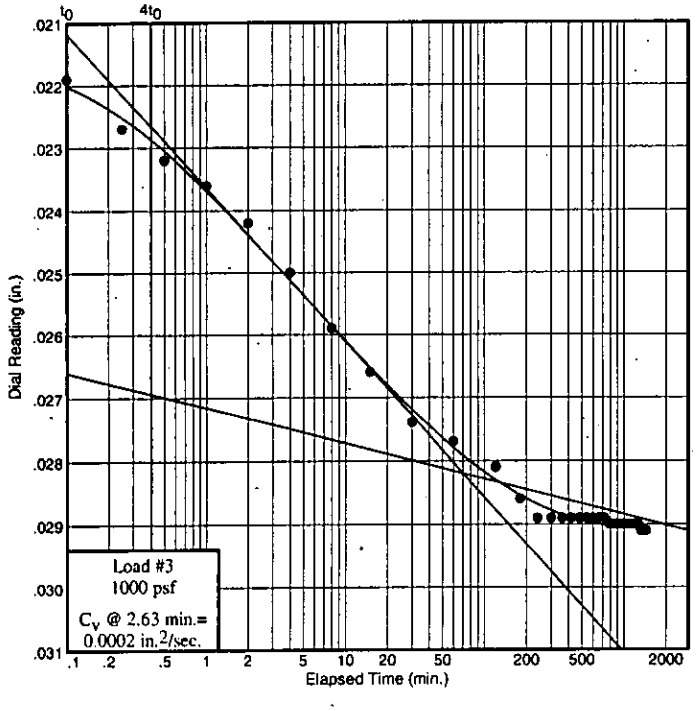
Dial Reading vs. Time

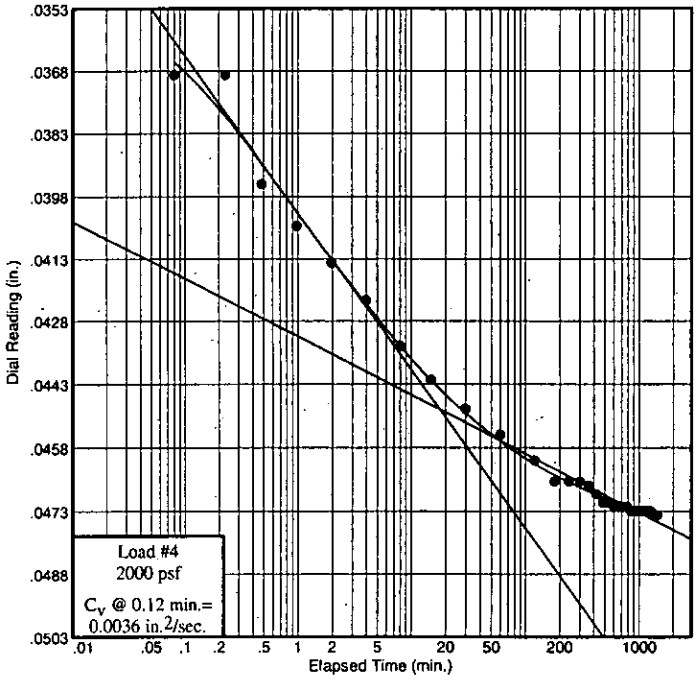
Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-1138A Sample No.: ST2 Elev./Depth: 8.0









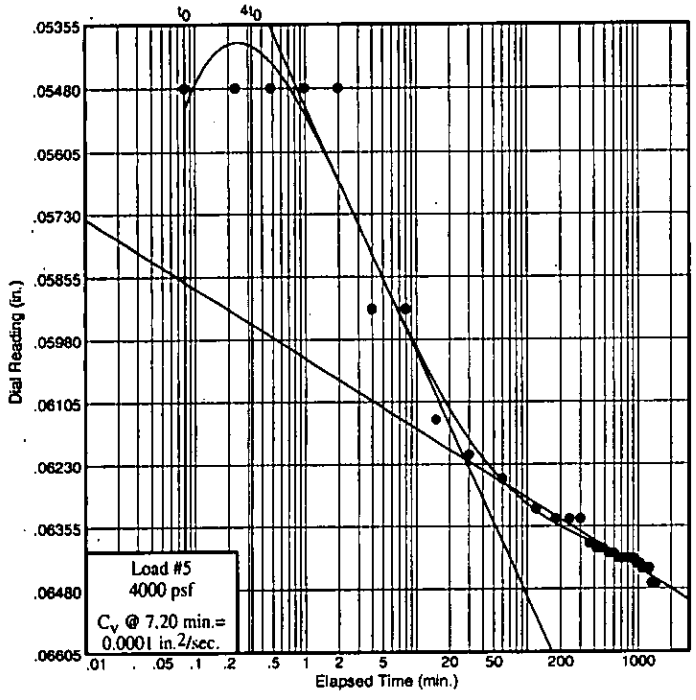
DLZ

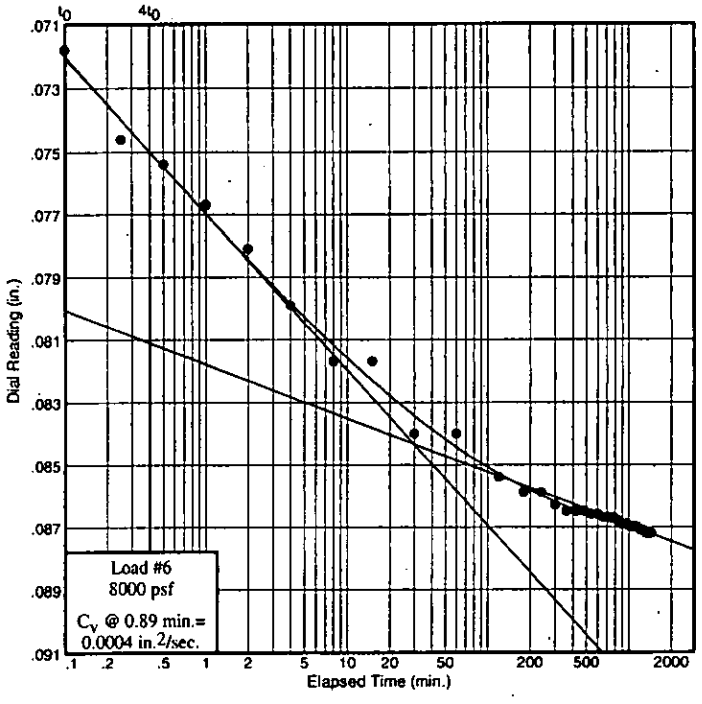
Figure

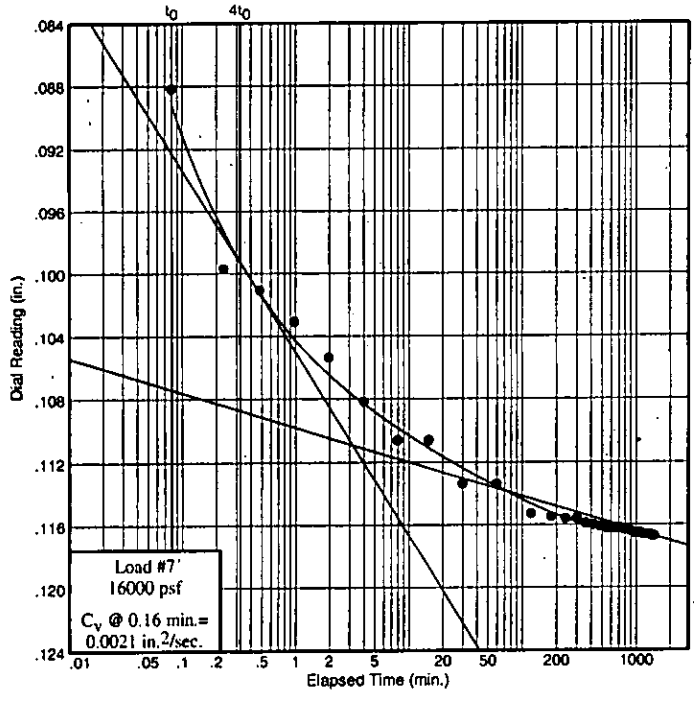
Dial Reading vs. Time

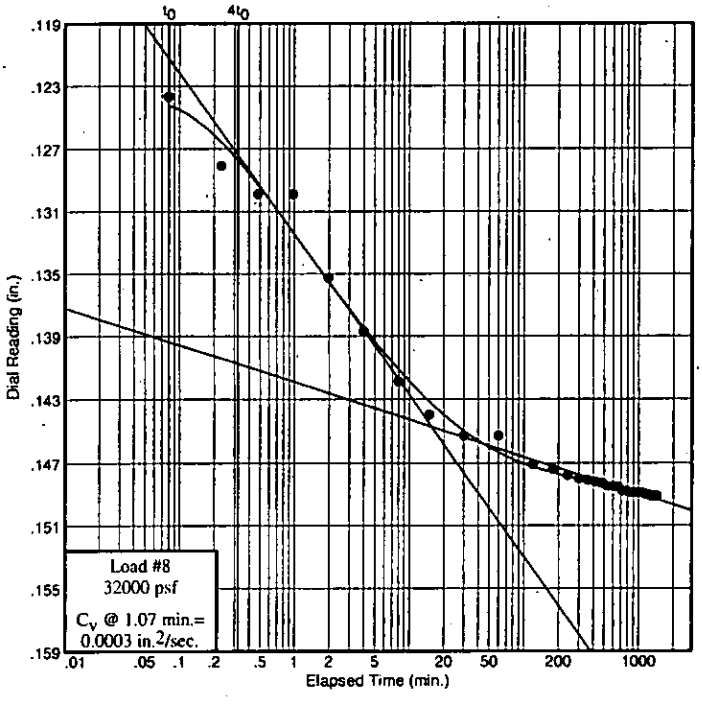
Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-1138A Sample No.: ST2 Elev./Depth: 8.0









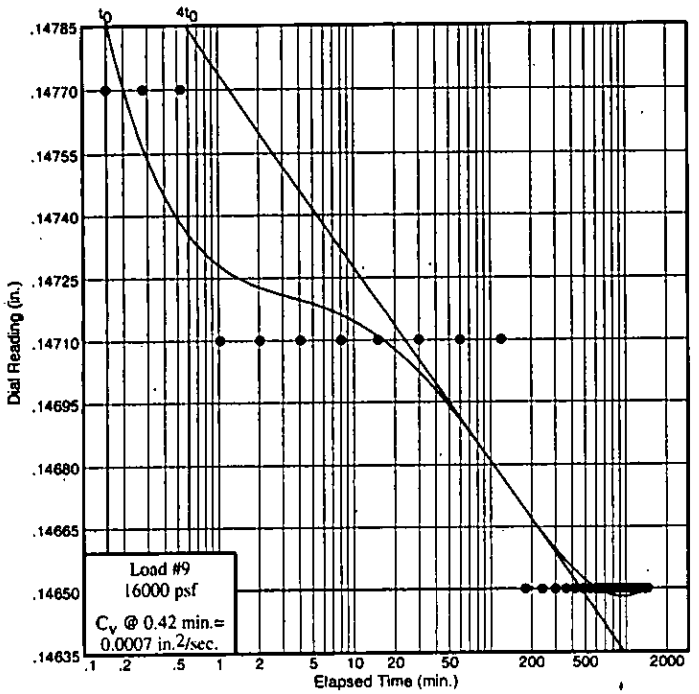
DLZ

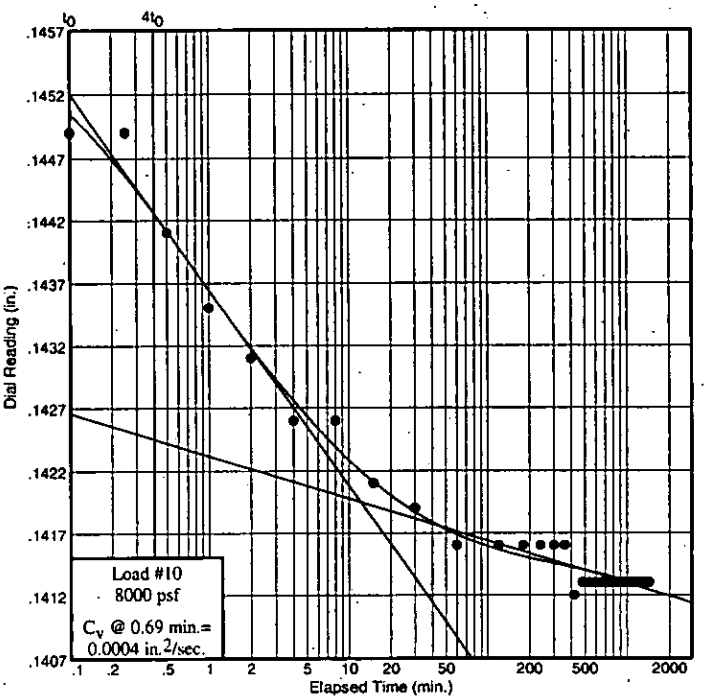
Figure

Dial Reading vs. Time

Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-1138A Sample No.: ST2 Elev./Depth: 8.0

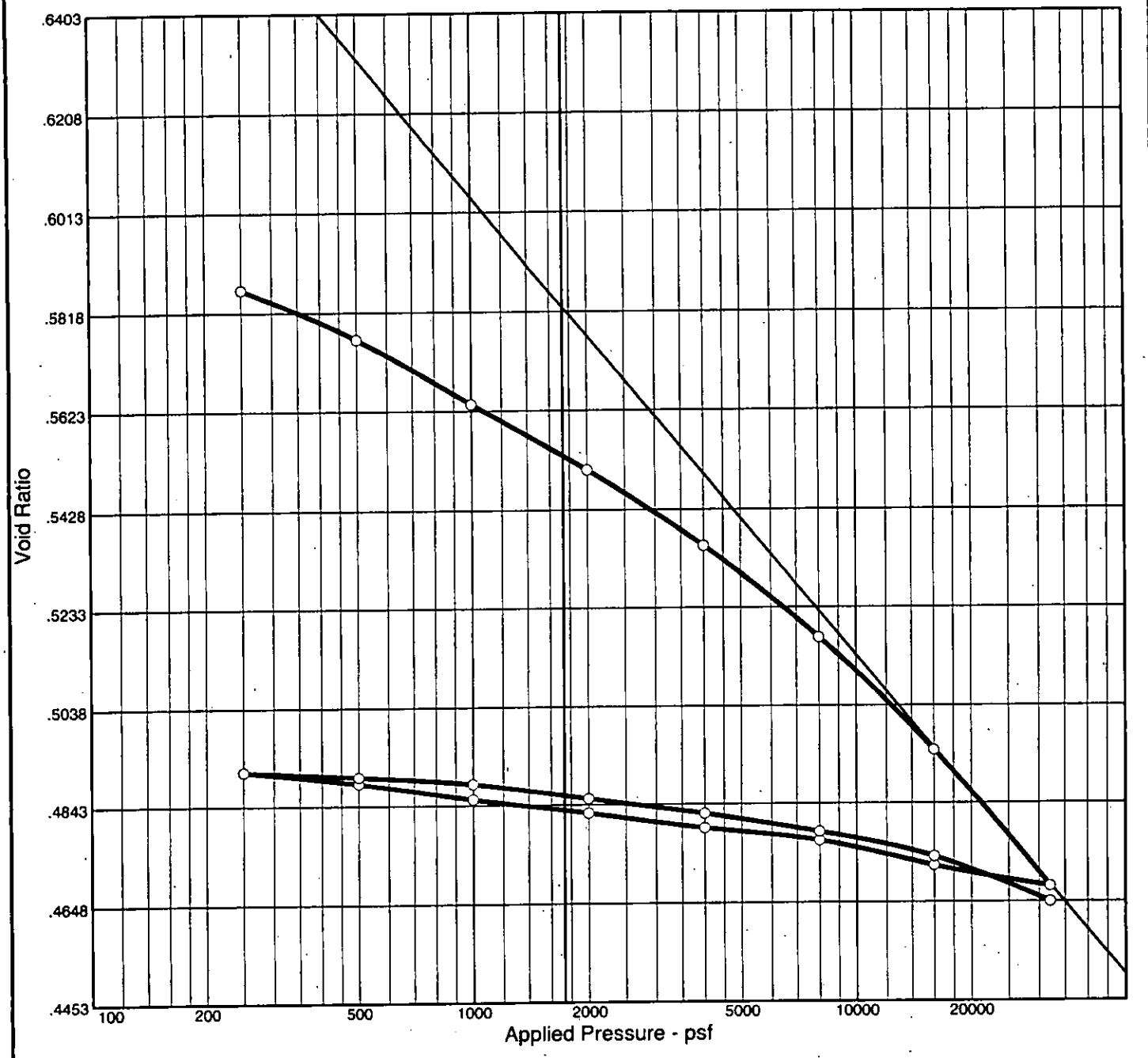




DLZ

Figure

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
87.0 %	20.0 %	105.2	29	18	2.75	CL	A-6(11)	0.632

MATERIAL DESCRIPTION

Project No. 0121- **Client:** TranSystems, Inc.

Project: SCI-823-0.00

Source: B-45 **Sample No.:** P-1 **Elev./Depth:** 5.0

Remarks:

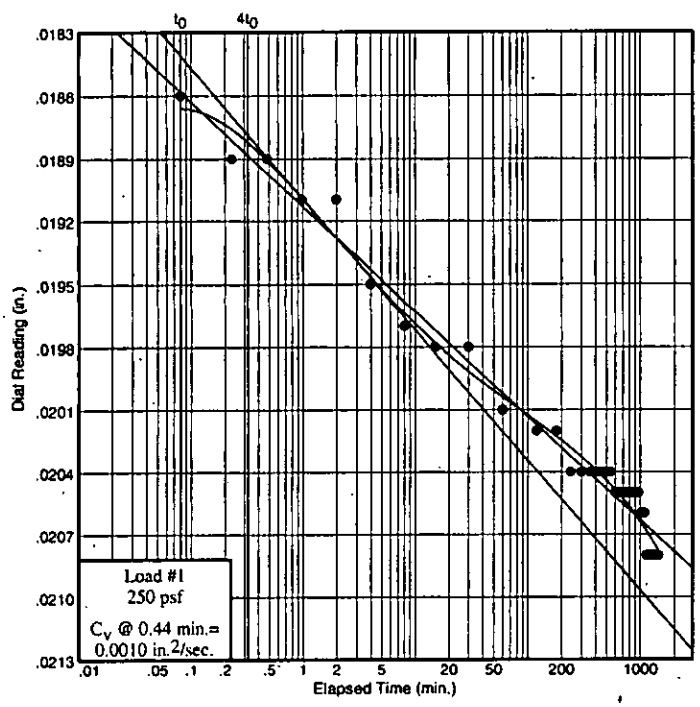
DLZ

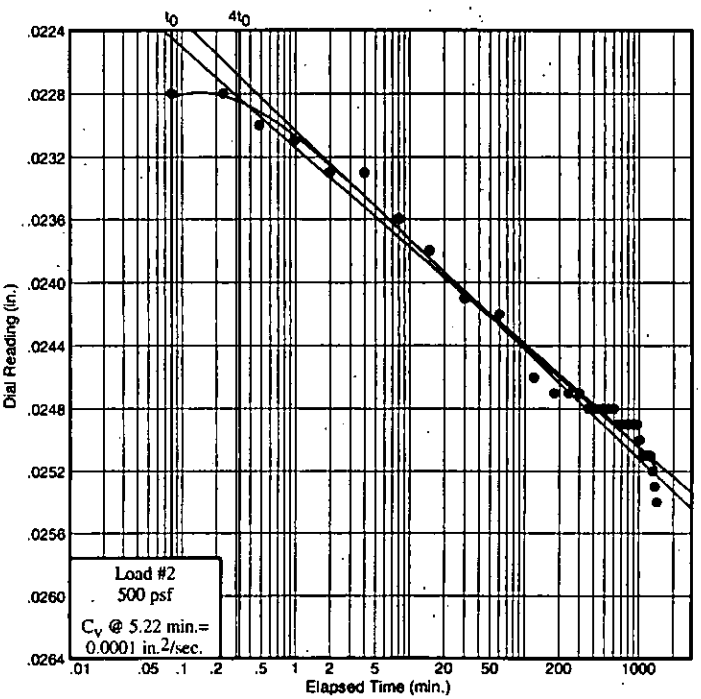
Figure

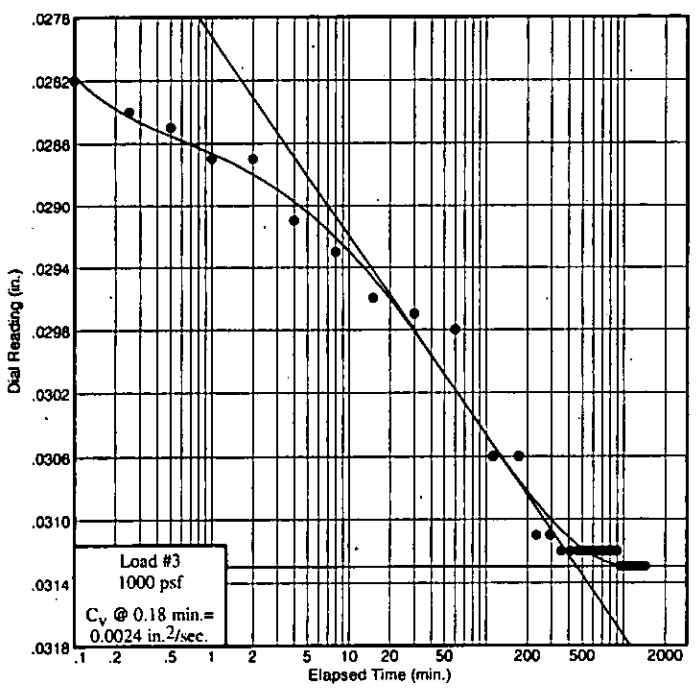
Dial Reading vs. Time

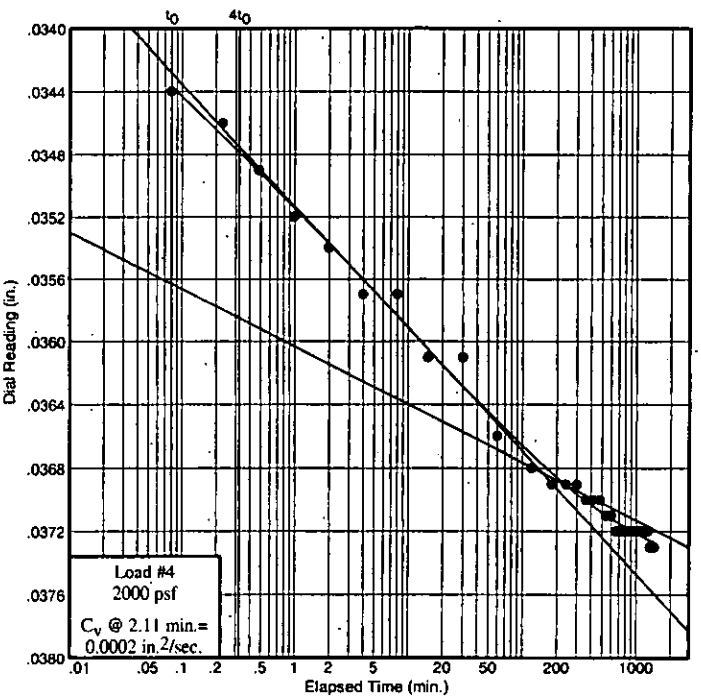
Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-45 Sample No.: P-1 Elev./Depth: 5.0









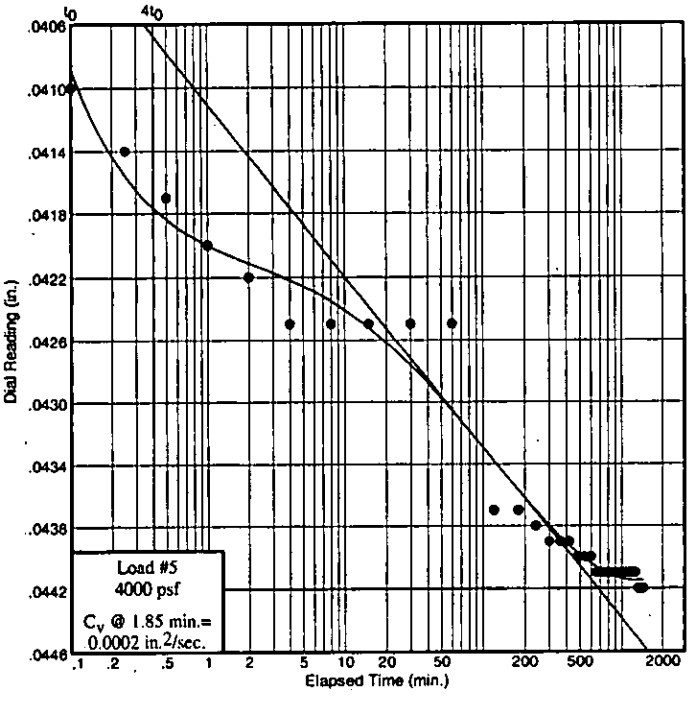
DLZ

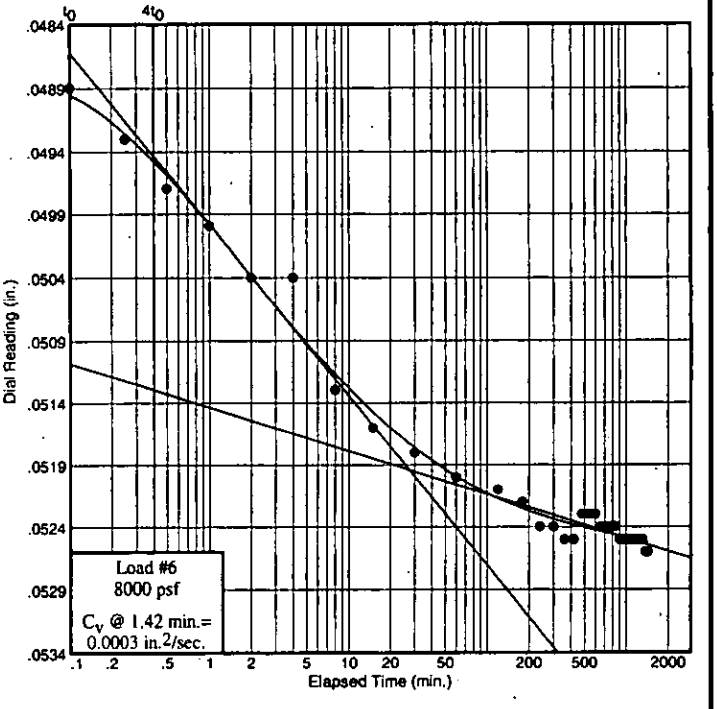
Figure

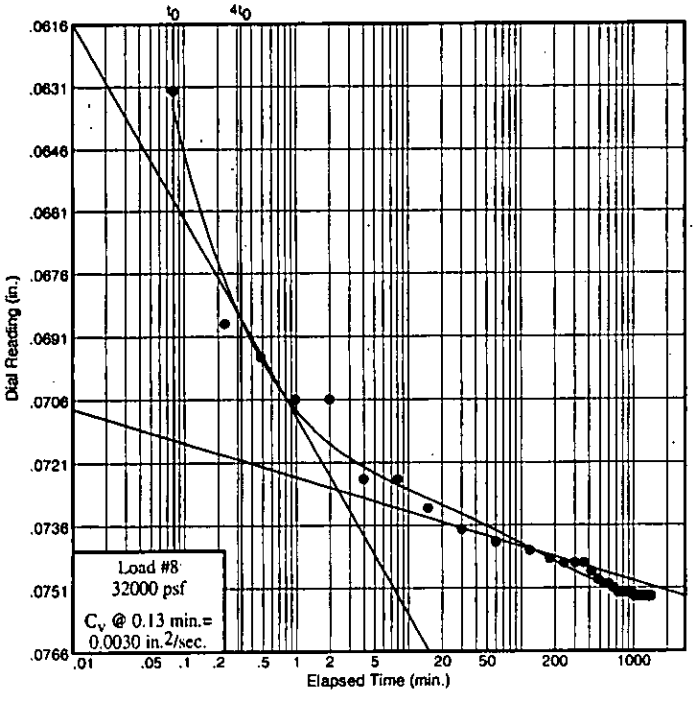
Dial Reading vs. Time

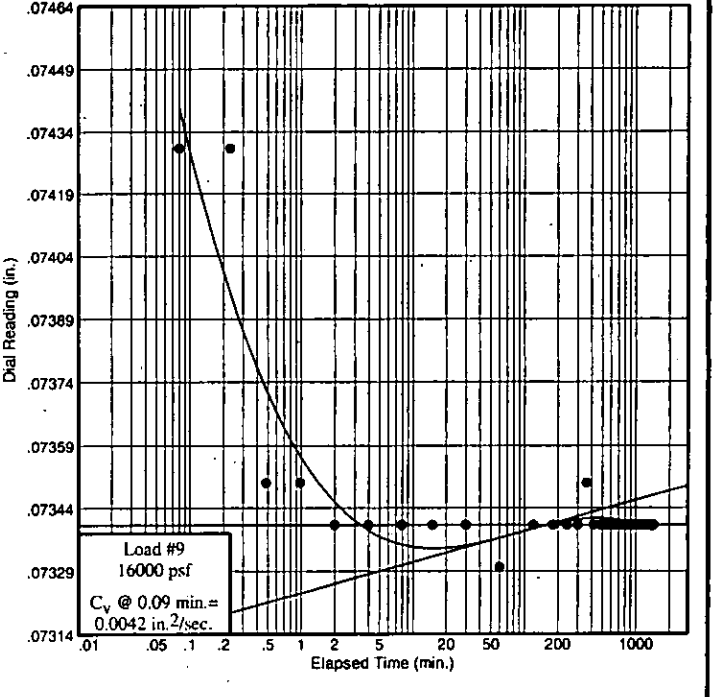
Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-45 Sample No.: P-1 Elev./Depth: 5.0









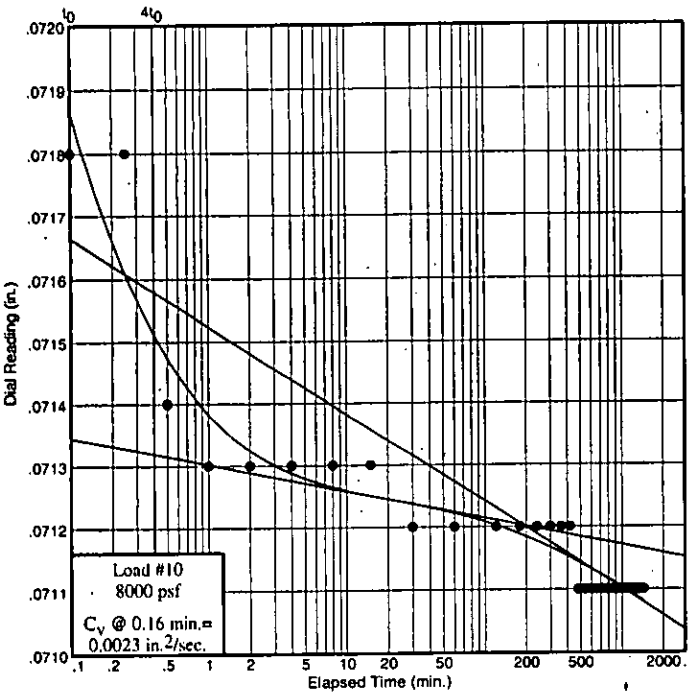
DLZ

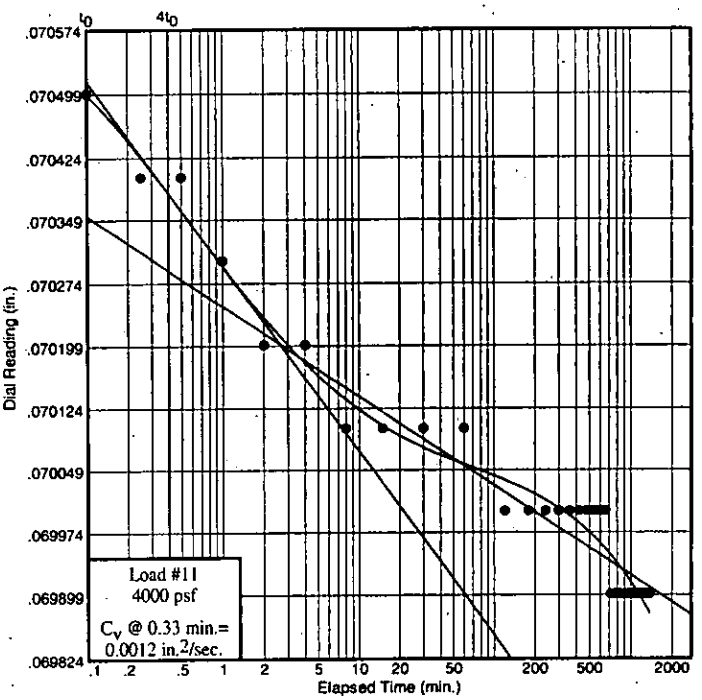
Figure

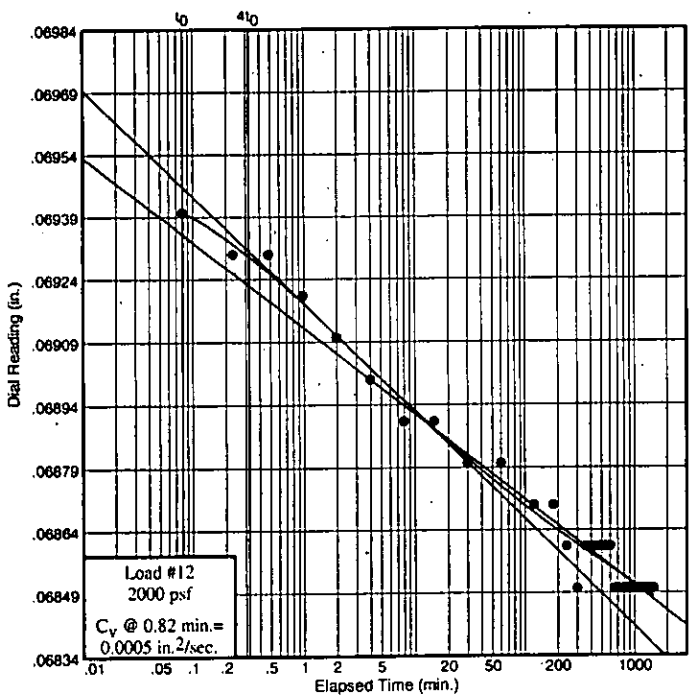
Dial Reading vs. Time

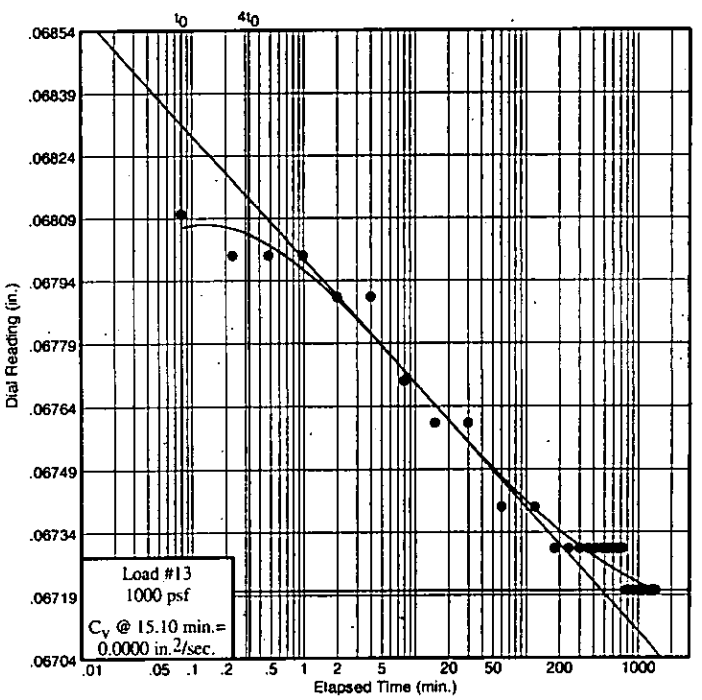
Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-45 Sample No.: P-1 Elev./Depth: 5.0





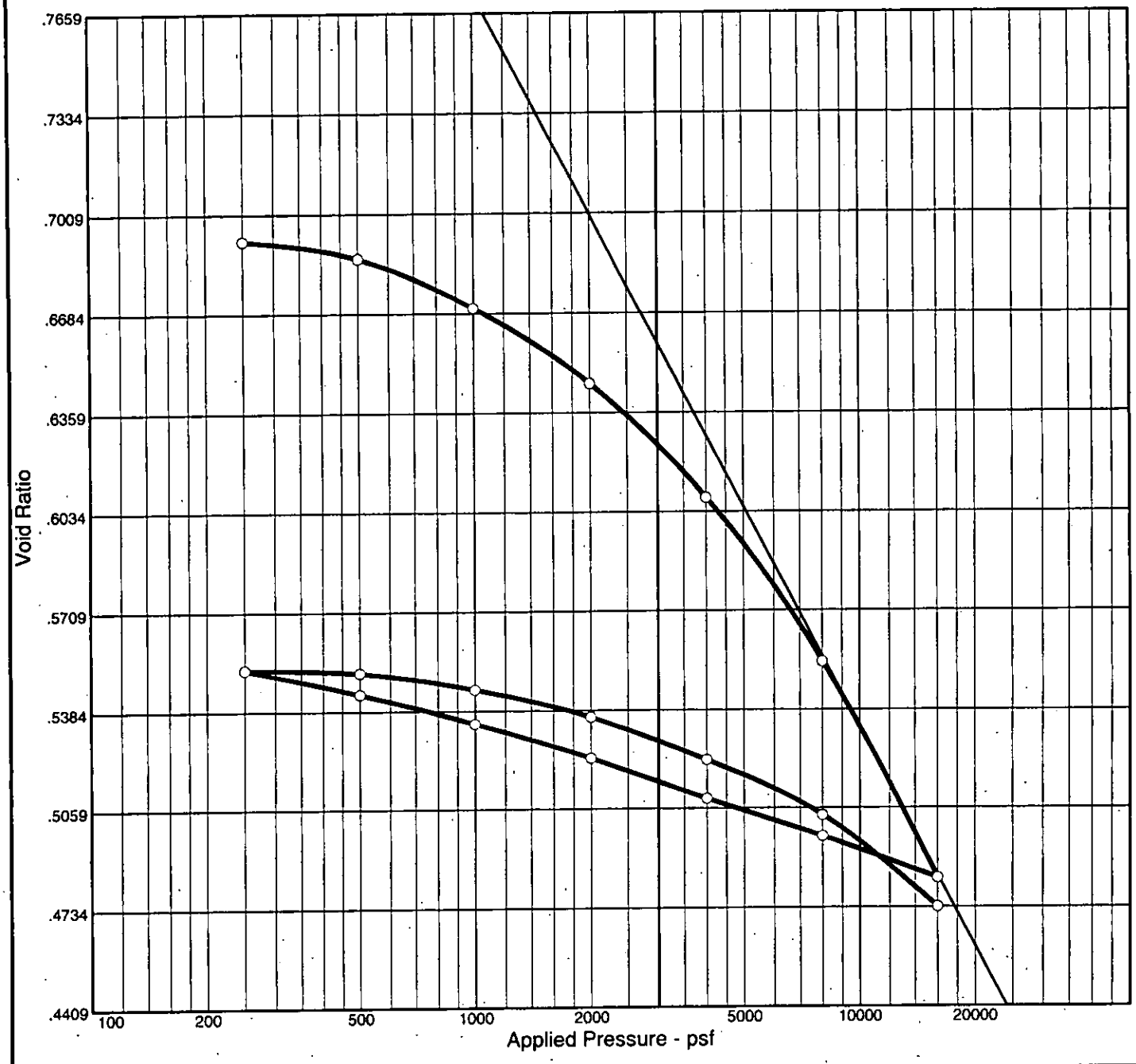




DLZ

Figure

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
90.3 %	23.1 %	100.0	36	18	2.71	CL	A-6(17)	0.692

MATERIAL DESCRIPTION

Lean clay
Specific Gravity= 2.71

Project No. 0121- **Client:** TranSystems. Inc.

Project: SCI-823-0.00

Source: B-46 **Sample No.:** P-1 **Elev./Depth:** 5.0

Remarks:

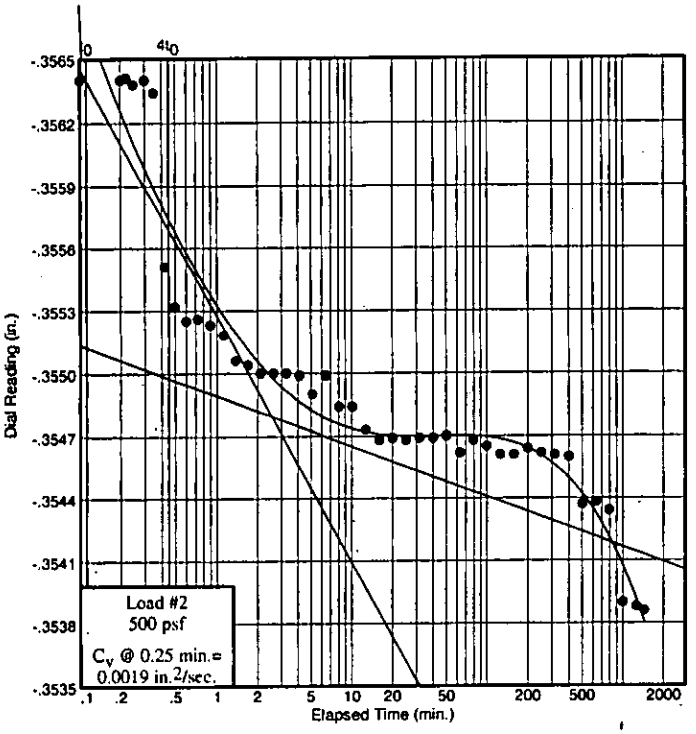
DLZ

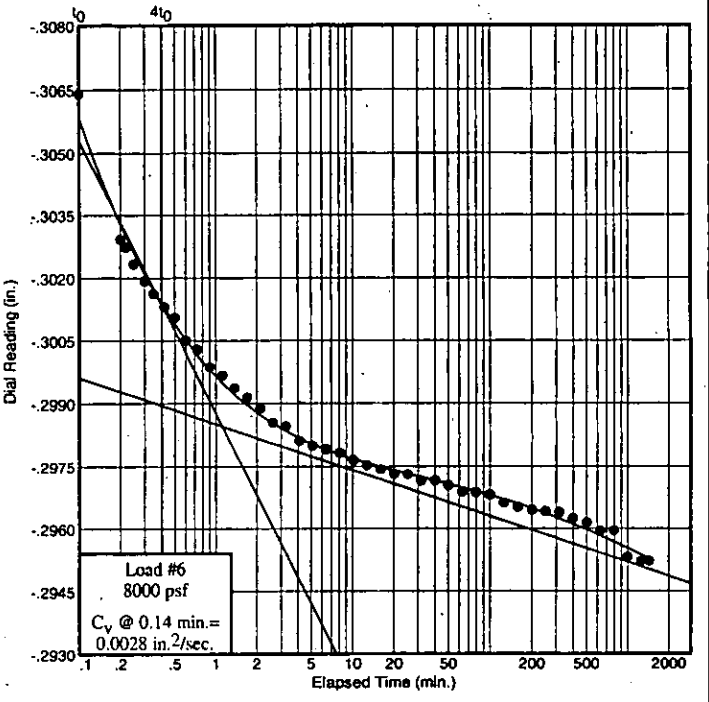
Figure

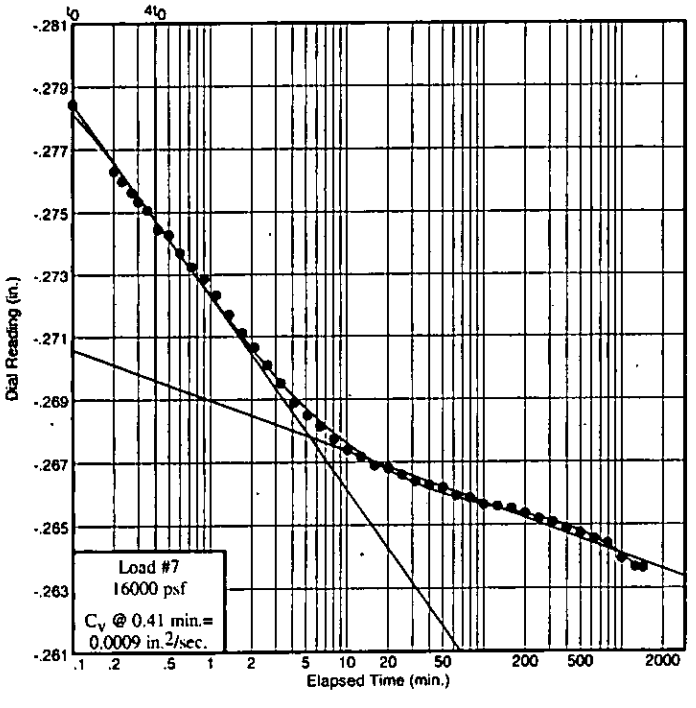
Dial Reading vs. Time

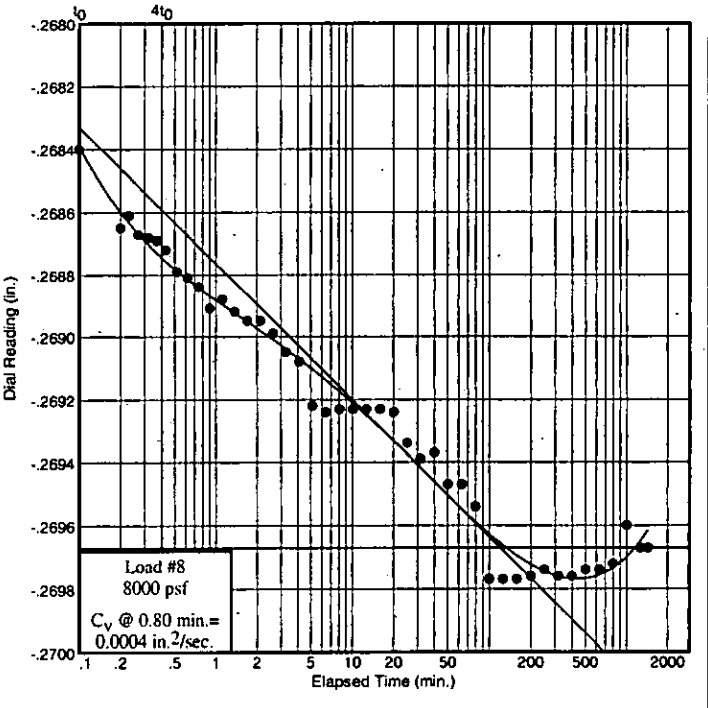
Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-46 Sample No.: P-1 Elev./Depth: 5.0









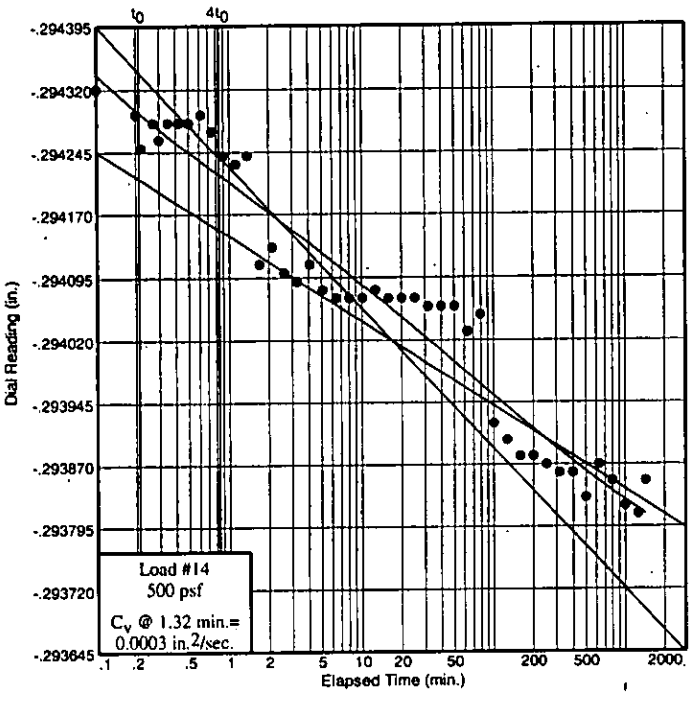
DLZ

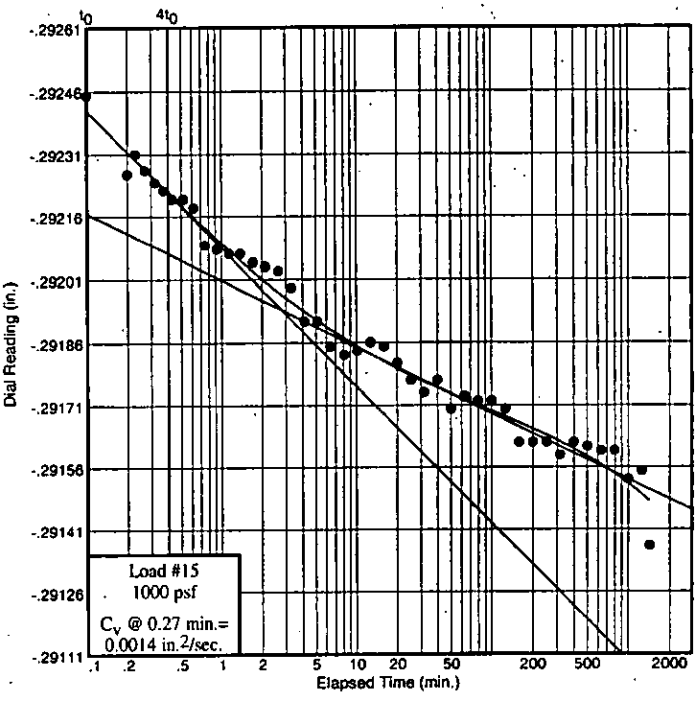
Figure

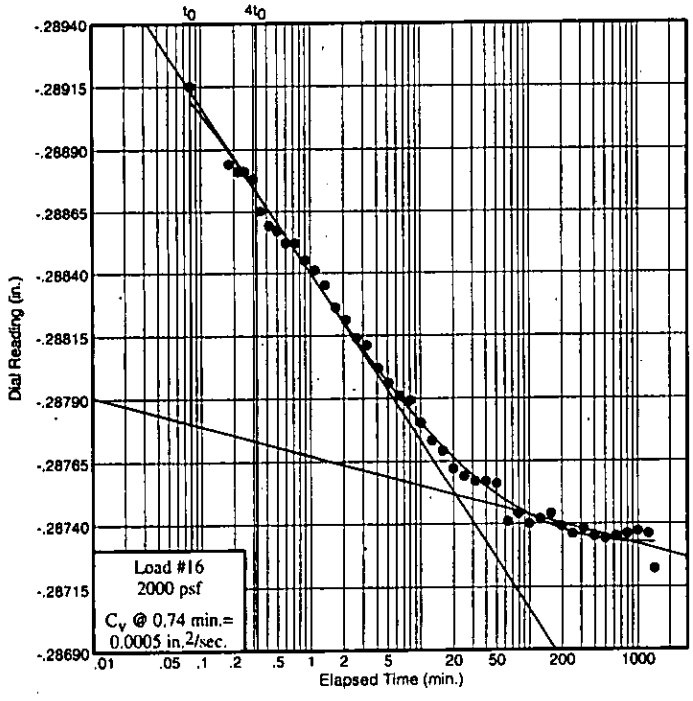
Dial Reading vs. Time

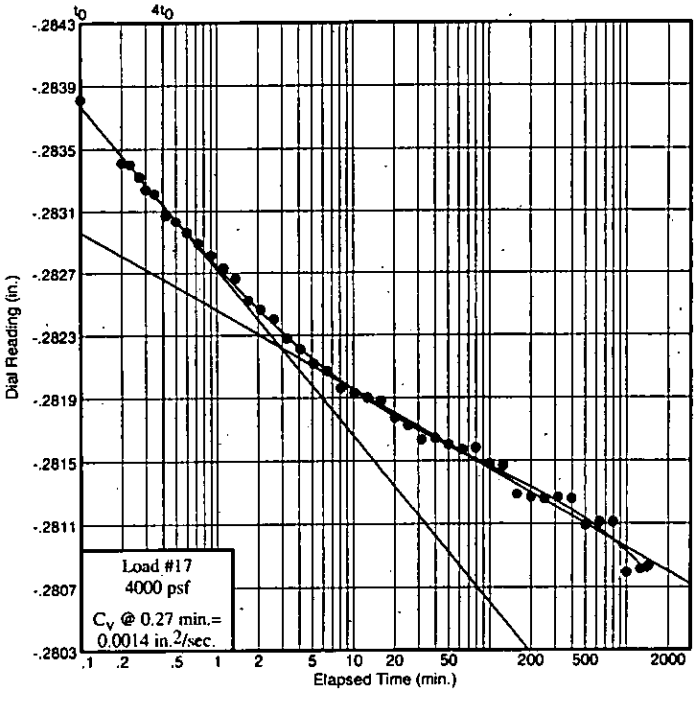
Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-46 Sample No.: P-1 Elev./Depth: 5.0









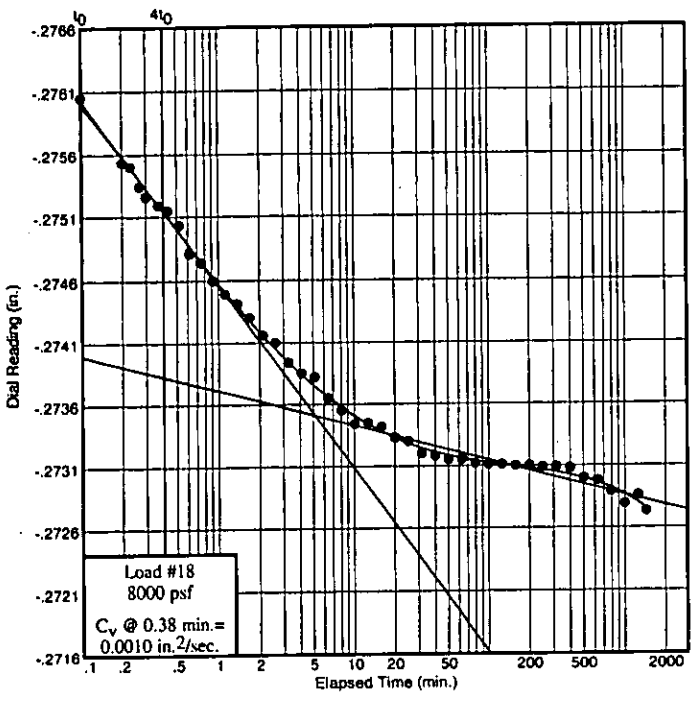
DLZ

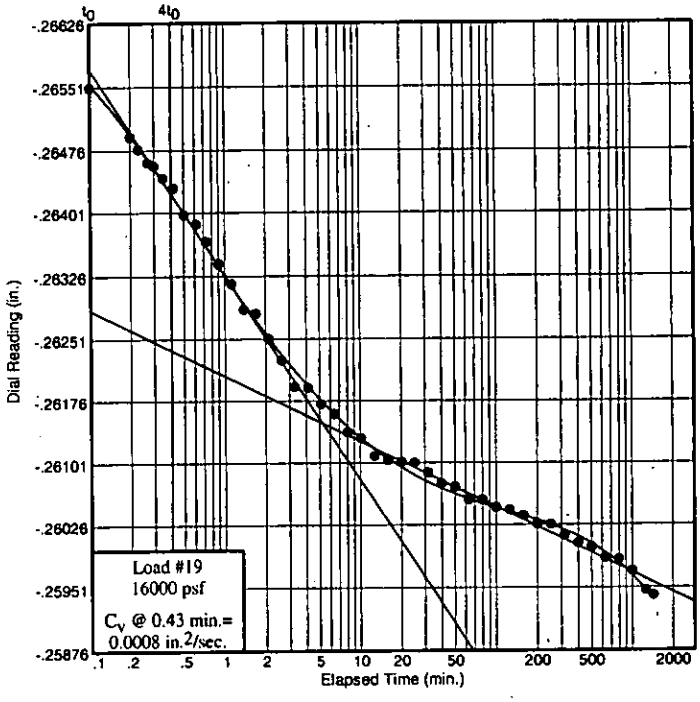
Figure

Dial Reading vs. Time

Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-46 Sample No.: P-1 Elev./Depth: 5.0

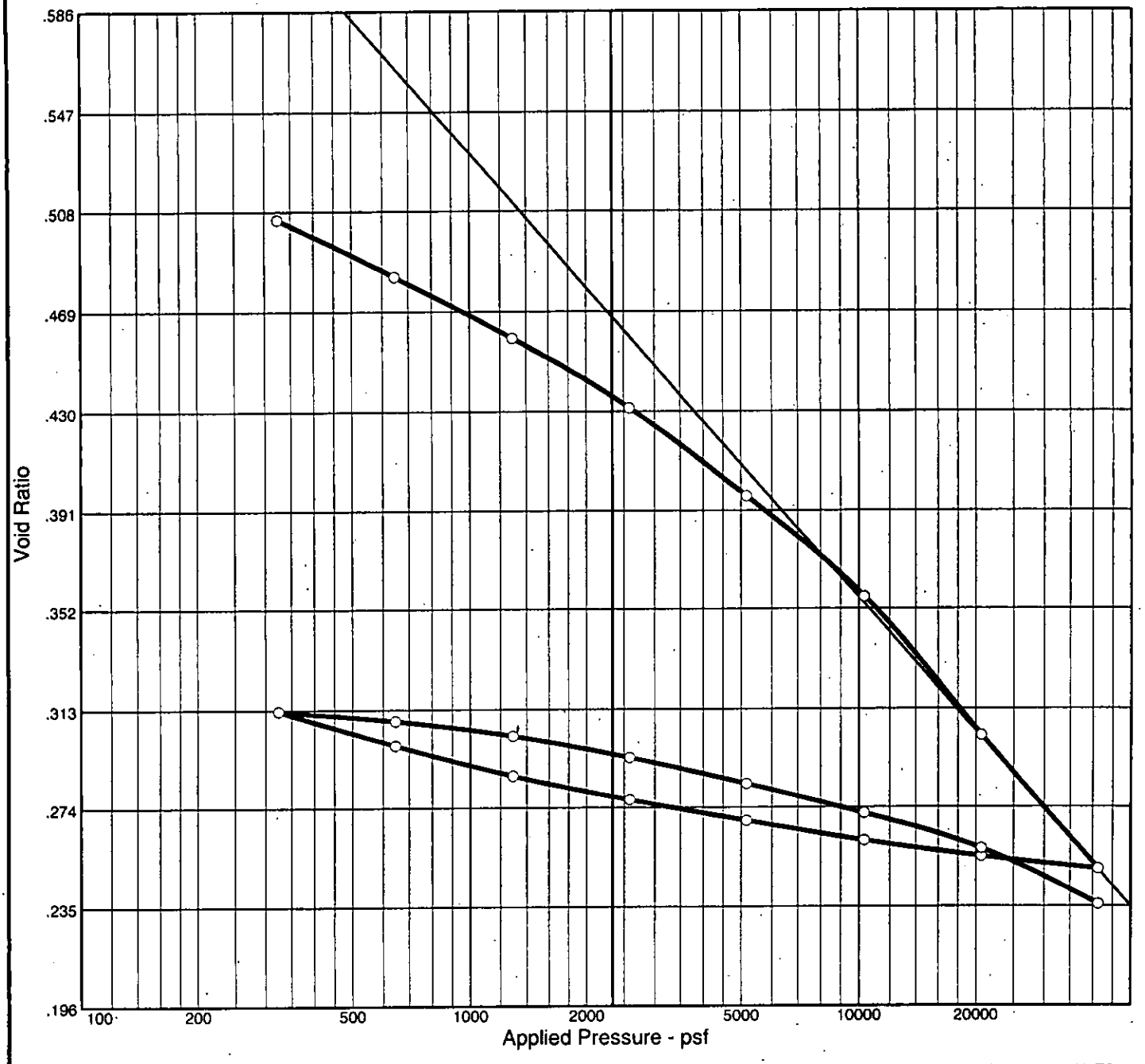




DLZ

Figure

CONSOLIDATION TEST REPORT



Natural		Dry Dens. (pcf)	LL	PI	Sp. Gr.	USCS	AASHTO	Initial Void Ratio
Saturation	Moisture							
87.3 %	20.3 %	103.9	36	15	2.71	CL	A-6(14)	0.629

MATERIAL DESCRIPTION

Silt and Clay (A-6a)

Project No. 0121- **Client:** TranSystems. Inc.

Project: SCI-823-0.00

Source: B-54 **Sample No.:** ST1 **Elev./Depth:** 6.0

DLZ

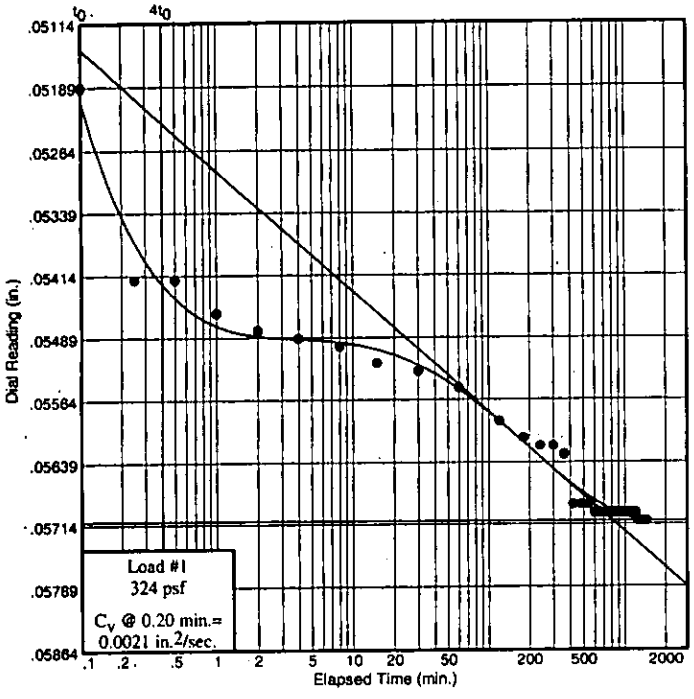
Remarks:

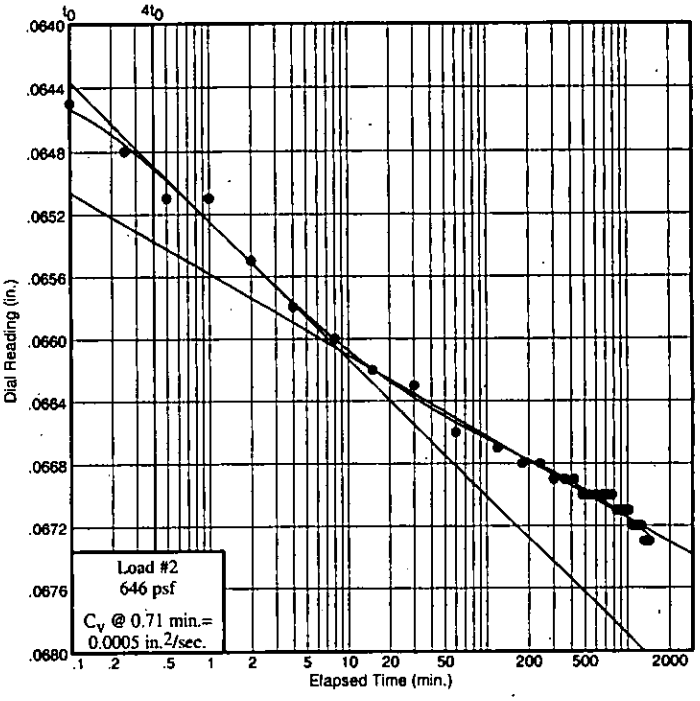
Figure

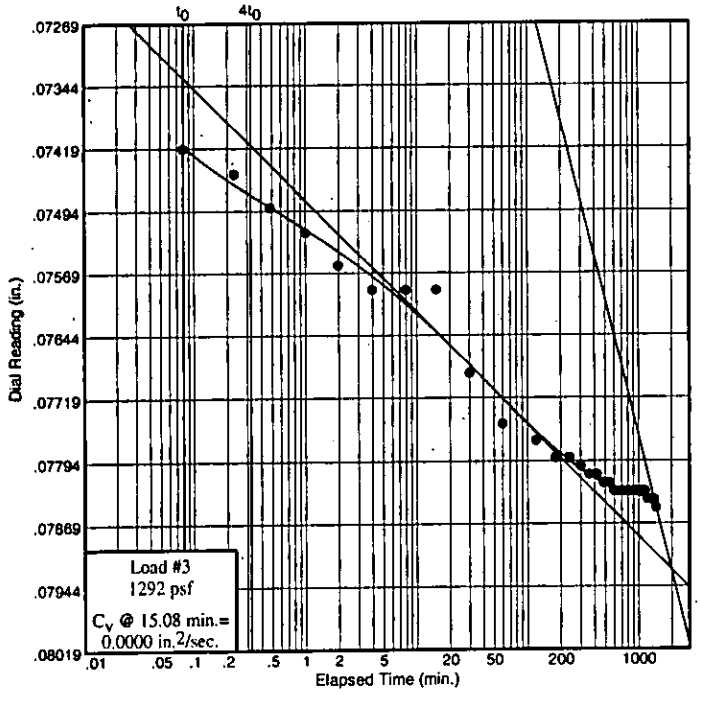
Dial Reading vs. Time

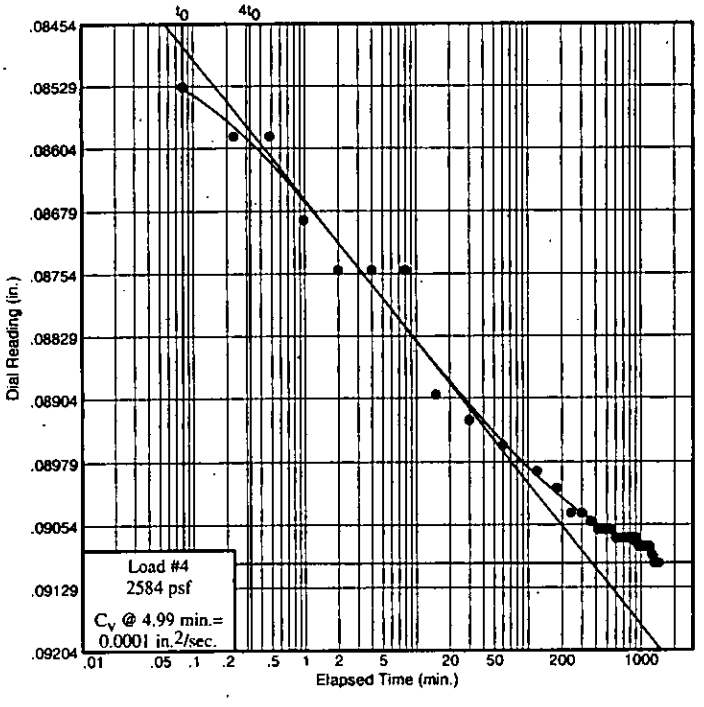
Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-54 Sample No.: ST1 Elev./Depth: 6.0









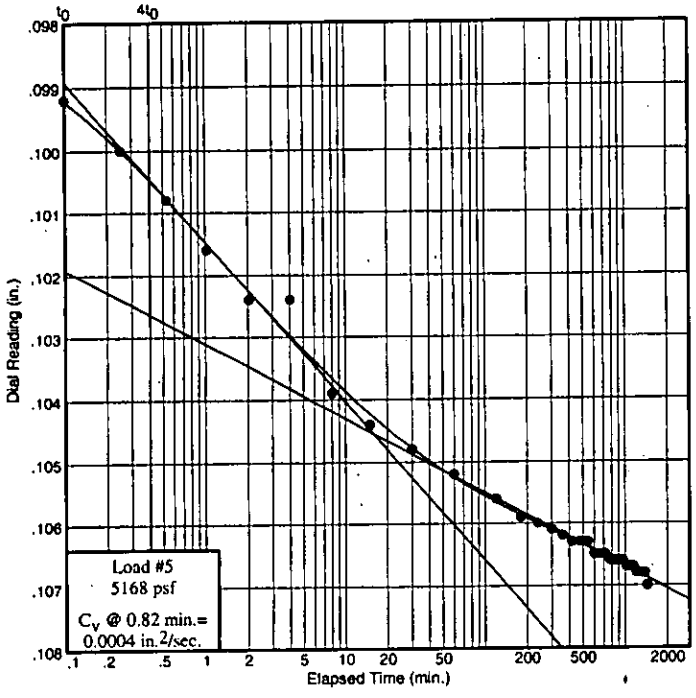
DLZ

Figure

Dial Reading vs. Time

Project No.: 0121-3070.03
Project: SCI-823-0.00

Source: B-54 Sample No.: ST1 Elev./Depth: 6.0



DLZ

Figure

APPENDIX D

DLZ

APPENDIX D

Calculations

DLZ

CLIENT	CH2M Hill	JOB NUMBER	0121-3070.03
PROJECT	SCI-823 Portsmouth Bypass	SHEET NO.	OF
SUBJECT	Summary of Analyses	COMP. BY	DATE
	US 23 / SR 823 Interchange	CHECKED BY	DATE

Summary of Analyses

Along Mainline SR 823 Stationing

Wall No. 1 Station 891+70 — Full Height of MSE Wall = 34.0 ft

Global Stability			Allowable Bearing Capacity			Settlement	
Undrained	FS =	2.6	Undrained	q_{all} =	4,901 psf	δ_{max} =	3 inches
Drained	FS =	2.1	Drained	q_{all} =	8,627 psf	Differential Settlement =	0.4%
Drained Seismic	FS =	1.9				t_{90} =	7 days

Wall No. 2 Station 892+58 — Full Height of MSE Wall = 32.0 ft

Global Stability			Allowable Bearing Capacity			Settlement	
Undrained	FS =	2.0	Undrained	Stg.1 q_{all} =	*3,153 psf	δ_{max} =	5 inches
Drained	FS =	2.2		Stg.2 q_{all} =	*4,284 psf	Differential Settlement =	0.6%
Drained Seismic	FS =	2.0		Stg.3 q_{all} =	*4,761 psf	t_{90} =	18 days
			Drained	q_{all} =	8,181 psf		

** See report text for additional staged construction details*

Embankment Station 892+95 — Full Height of Embankment = 28.0 ft — Using 2H:1V Slopes

Global Stability			Settlement		
Undrained	FS =	2.3	δ_{max} =	5 inches	
Drained	FS =	1.8	t_{90} =	18 days	
Drained Seismic	FS =	1.7			

Embankment Station 895+17 — Full Height of Embankment = 34.5 ft — Using 2H:1V Slopes

Global Stability			Settlement		
Undrained	FS =	2.9	δ_{max} =	1 inch	
Drained	FS =	1.7	t_{90} =	NA	
Drained Seismic	FS =	1.6			

Wall No. 6 Station 895+54 — Full Height of MSE Wall = 43.3 ft

Global Stability			Allowable Bearing Capacity			Settlement	
Undrained	FS =	2.0	Undrained	q_{all} =	NA	δ_{max} =	1 inches
Drained	FS =	1.8	Drained	q_{all} =	6,933 psf	Differential Settlement =	0.1%
Drained Seismic	FS =	1.7				t_{90} =	NA

DLZ

CLIENT	CH2M Hill	JOB NUMBER	0121-3070.03
PROJECT	SCI-823 Portsmouth Bypass	SHEET NO.	OF
SUBJECT	Summary of Analyses	COMP. BY	DATE
	US 23 / SR 823 Interchange	CHECKED BY	DATE

Summary of Analyses

Along Mainline SR 823 Stationing

Wall No. 3 Station 899+07 — Full Height of MSE Wall = 39.4 ft

Global Stability

Undrained	FS =	1.3
Drained	FS =	1.9
Drained Seismic	FS =	1.8

Allowable Bearing Capacity

Undrained	q_{all} =	*1,920 psf
Drained	q_{all} =	6,390 psf

Settlement

δ_{max} =	*9 inches	Preloading
δ_{max} =	*2 inches	MSE Wall

Differential Settlement = 0.1%

t_{90} = 81 days

** See report text for additional details on preloading embankment*

Embankment Station 899+44 — Full Height of Embankment = 35.9 ft — Using 2H:1V Slopes

Global Stability

Undrained	FS =	2.0
Drained	FS =	1.7
Drained Seismic	FS =	1.6

Settlement

δ_{max} = 9 inches

t_{90} = 81 days

US 23 Ramps A & D

Embankment Station 4906+00 / 1906+50 — Full Height of Embankment = 25.3 ft — Using 2H:1V Slopes

Global Stability

Undrained	FS =	3.4
Drained	FS =	2.1
Drained Seismic	FS =	1.9

Settlement

δ_{max} = 7 inches

t_{90} = 79 days

Embankment Station 4911+00 / 1912+00 — Full Height of Embankment = 18.7 ft — Using 2H:1V Slopes

Global Stability

Undrained	FS =	3.2
Drained	FS =	2.0
Drained Seismic	FS =	1.9

Settlement

δ_{max} = 6 inches

t_{90} = 65 days

US 23 Ramp A

Embankment Station 1919+00 — Full Height of Embankment = 6.8 ft — Using 2H:1V Slopes

Global Stability

Undrained	FS =	4.0
Drained	FS =	3.1
Drained Seismic	FS =	2.8

Settlement

δ_{max} = 2 inches

t_{90} = 187 days

DLZ

CLIENT	CH2M Hill	JOB NUMBER	0121-3070.03
PROJECT	SCI-823 Portsmouth Bypass	SHEET NO.	OF
SUBJECT	Summary of Analyses	COMP. BY	DATE
	US 23 / SR 823 Interchange	CHECKED BY	DATE

Summary of Analyses

US 23 Ramp D

Embankment Station 4914+00 — Full Height of Embankment = 9.2 ft — Using 2H:1V Slopes

Global Stability

Undrained	FS =	5.0
Drained	FS =	2.3
Drained Seismic	FS =	2.1

Settlement

δ_{max} = 3 inches

t_{90} = 35 days

US 23 Ramp B

Wall No. 4 Station 2600+75 — Max. Height of MSE Wall = 15.1 ft — Single Wall

Global Stability

Undrained	FS =	4.3
Drained	FS =	2.3
Drained Seismic	FS =	2.2

Allowable Bearing Capacity

Undrained q_{all} = 3,116 psf

Drained q_{all} = 3,533 psf

Settlement

δ_{max} = 3 inches

Differential Settlement = 0.1%

t_{90} = 45 days

Wall No. 4 Station 2604+48 — Max. Height of MSE Wall = 40.5 ft — Double Wall (abutment location)

Global Stability

Undrained	FS =	1.4
Drained	FS =	2.2
Drained Seismic	FS =	2.1

Allowable Bearing Capacity

Undrained Stg.1 q_{all} = *2,287 psf

Stg.2 q_{all} = *3,508 psf

Stg.3 q_{all} = *4,541 psf

Stg.4 q_{all} = *5,293 psf

Drained q_{all} = 7,206 psf

Settlement

δ_{max} = 8 inches

Differential Settlement = 0.3%

t_{90} = 45 days

** See report text for additional staged construction details*

Embankment Station 2609+07 — Full Height of Embankment = 30.8 ft — Using 2H:1V Slopes

Global Stability

Undrained	FS =	2.6
Drained	FS =	1.8
Drained Seismic	FS =	1.6

Settlement

δ_{max} = 8 inches

t_{90} = 106 days

DLZ

CLIENT	CH2M Hill	JOB NUMBER	0121-3070.03
PROJECT	SCI-823 Portsmouth Bypass	SHEET NO.	OF
SUBJECT	Summary of Analyses	COMP. BY	DATE
	US 23 / SR 823 Interchange	CHECKED BY	DATE

Summary of Analyses

US 23 Ramp C

Embankment Station 3894+77 — Full Height of Embankment = 28.3 ft — Using 2H:1V Slopes

Global Stability

Undrained	FS =	2.1
Drained	FS =	1.8
Drained Seismic	FS =	1.7

Settlement

δ_{max} = 13 inches

t_{90} = 422 days

Wall No. 5 Station 3900+32 — Max. Height of MSE Wall = 37.3 ft — Double Wall (abutment location)

Global Stability

Undrained	FS =	1.7
Drained	FS =	2.5
Drained Seismic	FS =	2.4

Allowable Bearing Capacity

Undrained Stg.1 q_{all} = *2,226 psf

Stg.2 q_{all} = *3,432 psf

Stg.3 q_{all} = *4,359 psf

Stg.4 q_{all} = *4,772 psf

Drained q_{all} = 7,125 psf

Settlement

δ_{max} = 8 inches

Differential Settlement = 0.3%

t_{90} = 56 days

** See report text for additional staged construction details*

Wall No. 5 Station 3902+50 — Height of MSE Wall = 21.5 ft — Double Wall

Global Stability

Undrained	FS =	2.4
Drained	FS =	2.7
Drained Seismic	FS =	2.4

Allowable Bearing Capacity

Undrained Stg.1 q_{all} = *2,226 psf

Stg.2 q_{all} = *3,432 psf

Drained q_{all} = 7,125 psf

Settlement

δ_{max} = 4 inches

Differential Settlement = 0.3%

t_{90} = 56 days

** See report text for additional staged construction details*

Fairground Road

MSE Retaining Walls (Walls No. 1 & 2) and Embankment Evaluations

DLZ
ENGINEERS · ARCHITECTS · SCIENTISTS
PLANNERS · SURVEYORS

CLIENT CH2M Hill
PROJECT SCI - 823 Portsmouth Bypass
SUBJECT Fairgrounds Rd. Structures
Wall Properties / Soil Properties

PROJECT NO. 0121-3070.03
SHEET NO. 1 OF 21
COMP. BY SJK DATE 8-13-07
CHECKED BY DAA DATE 8-31-07

Wall No. 1 East Wall - Fairgrounds Rd.

* Assumed Leveling Pad Elevation = 563'

- Ramp C Proposed Gr = 594.5' H = 31.5' (full height)
- S.R. 823 Proposed Gr = 597.0' H = 34.0' (Includes embedment)
- Ramp B Proposed Gr = 596.5' H = 33.5'

Wall No. 2 West Wall - Fairgrounds Rd.

* Assumed Leveling Pad Elevation = 562'

- Ramp C Proposed Gr = 591.0' H = 29.0' full height
- SR 823 Proposed Gr = 594.0' H = 32.0' (Includes embedment)
- Ramp B Proposed Gr = 593.5' H = 31.5'

* For stability analyses

* Wall # 1 profile based upon borings B-47 & B-1146

LP = 563' Bot. of leveling Pad excavation
el. 561.5'
el. 559.2' ▽ A-46/A-6a C = 2350 φ' = 29°
el. 557.2'
A-46 C = 0 φ' = 29°
el. 554.5'
TOP OF ROCK

* Wall # 2 profile based upon borings B-45 & B-1113

LP = 562' Bot of leveling Pad excav.
el. 560.5'
A-6b / A-2-6 C = 1500 φ = 0°
el. 550* ▽ c' = 0 φ' = 29°
el. 548.0'
A-2-4 C = 0 φ = 30°
el. 544.5'
Top of Rock

* from piezometer reading in B-46

DLZ

SUBJECT

Client CH2M Hill
Project SCI-823 Portsmouth Bypass
Item MSE Wall Stability
Wall No. 1, Fairground Road
Full Height MSE wall, based on B-47 & B-1146

JOB NUMBER 0121-3070.03
SHEET NO. 2 OF 21
COMP. BY SJR DATE 8-13-07
CHECKED BY DAA DATE 8-31-07

STABILITY OF MSE WALL

Assumptions:

1 Estimated height of embankment; H=31.0'
2 Sssume bridge is supported on deep foundations
3 Ground water; Dw=0.0'
4 Traffic loading is neglected in resisting forces
5

Wall Properties

H+D = 34 feet
γ_{mse} = 120 pcf
L = 37.4 feet
L factor = 1.10 Length factor-range (0.7 - 1.0)
ϕ = 30 deg Friction Angle of Embankment Fill

Foundational Soil Properties

c = 2350 psf Cohesion
ϕ' = 29 deg Friction angle
ω_T = 240 psf Traffic loading

RESISTANCE AGAINST SLIDING ALONG BASE

Thrust: $P_a = K_a\left[\frac{1}{2}\gamma H^2 + \omega_T H\right]$

where; $K_a = \tan^2(45 - \frac{\phi}{2})$ K_a = 0.33

P_a = 25,582 lbs per foot of wall

Resistance: $P_r = W(\mu)$ (Drained)

where; $\mu = \left(\frac{2}{3}\right)\tan(\phi)$ μ = 0.37

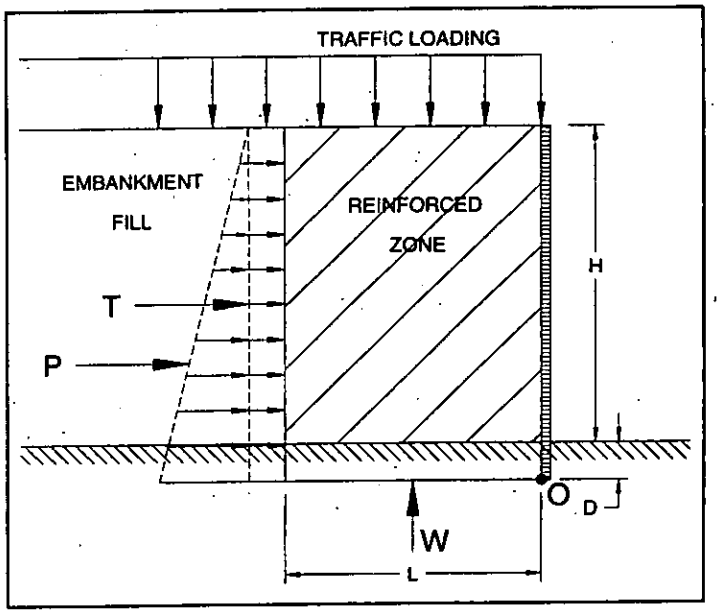
P_r = 56,459 lbs per foot of wall

USE THIS VALUE

$P_r = L(c)$ (Undrained)

P_r = 87,890 lbs per foot of wall

Use Drained Value



	Calculated	Required	
$FS = \frac{P_r}{P_a}$	FS = **2.21**	FS = 1.50	Resistance Against Sliding is **OK**

RESISTANCE AGAINST OVERTURNING

* Summation of Moments about point "O" (base of wall).
* Traffic loading is neglected in resisting forces

$\Sigma M_{resisting}$ = 2,853,470 lb-ft $\quad \Sigma M_{resisting} = \gamma HL\left(\frac{L}{2}\right)$

$\Sigma M_{overturning}$ = 305,184 lb-ft $\quad \Sigma M_{overturning} = K_a\left[\frac{1}{2}\gamma H^2\left(\frac{H}{3}\right) + \omega_T H\left(\frac{H}{2}\right)\right]$

	Calculated	Required	
$FS = \frac{\Sigma M_{resisting}}{\Sigma M_{overturning}}$	FS = **9.35**	FS = 2.00	Resistance Against Overturning is **OK**

DLZ

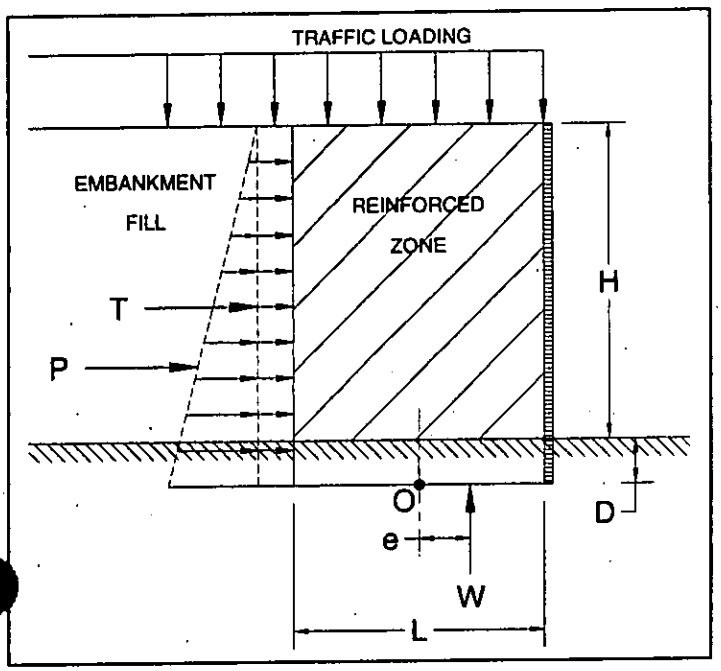
SUBJECT

Client CH2M Hill
Project SCI-823 Portsmouth Bypass
Item MSE Wall Bearing Capacity
Wall No. 1, Fairground Road
Full Height MSE wall, based on B-47 & B-1146

JOB NUMBER 0121-3070.03
SHEET NO. 3 OF 21
COMP. BY SJR DATE 8-13-07
CHECKED BY DAA DATE 8-31-07

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

γ_{EMB}	= 120	pcf	Unit weight	Embankment fill
ϕ'_{EMB}	= 30	deg.	Friction ang.	Embankment fill
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 2350	psf	Cohesion	Foundation soil
ϕ	= 0	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= 29	deg.	Friction ang.	Foundation soil

Loads and Parameters

ω_t	= 240	psf	Traffic loading	
L=B	= 37.4	ft	Length of MSE reinforcement	
L factor	= 1.1		Length factor-range (0.7 - 1.0)	
D	= 3	ft	Embedment depth	
Dw	= 0	ft	Groundwater depth	
H+D	= 34	ft		
H	= 31	ft	Height of wall	
Ka	= 0.33			
Γ Pa	= 11.333	ft	Moment arm	
Γ Wt	= 17	ft	Moment arm	
B'	= 33.62	ft		
γ'	= 57.6	pcf		
W_t	8,976	lb/ft of wall	Weight from traffic	
W_{mse}	= 152,592	lb/ft of wall	Weight from MSE wall	

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 4,806 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 12,252 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 4,901 psf

Factor of Safety = **2.55** **OK**

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 21,567 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 8,627 psf

Factor of Safety = **4.49** **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	27.86
N_q	1.00	N_q	16.44
N_γ	0.00	N_γ	19.34

Eccentricity of Resultant Force

e = 1.89 ft

Kern

e < L/6 = 6.23 ft

DLZ

SUBJECT

Client	CH2M Hill
Project	SCI-823 Portsmouth Bypass
Item	MSE Wall Stability
Wall No. 2, Fairground Road	
Full Height MSE wall, based on B-45 & B-1113	

JOB NUMBER	0121-3070.03
SHEET NO.	4 OF 21
COMP. BY	SAK DATE 8-13-07
CHECKED BY	DAA DATE 8-31-07

STABILITY OF MSE WALL

Assumptions:

1 Estimated height of embankment; H=29.0'
2 Sssume bridge is supported on deep foundations
3 Ground water; Dw=0.0'
4 Traffic loading is neglected in resisting forces
5

Wall Properties

H+D	=	32	feet
γ_{mse}	=	120	pcf
L	=	35.2	feet
L factor	=	1.10	Length factor-range (0.7 - 1.1)
ϕ	=	30	deg Friction Angle of Embankment Fill

Foundational Soil Properties

c	=	1500	psf	Cohesion
ϕ'	=	29	deg	Friction angle
ω_T	=	240	psf	Traffic loading

RESISTANCE AGAINST SLIDING ALONG BASE

Thrust: $P_a = K_a\left[\frac{1}{2}\gamma H^2 + \omega_T H\right]$

where; $K_a = \tan^2(45 - \frac{\phi}{2})$ K_a = 0.33

P_a = 22,810 lbs per foot of wall

Resistance: $P_r = W(\mu)$ (Drained)

where; $\mu = \left(\frac{2}{3}\right)\tan(\phi)$ μ = 0.37

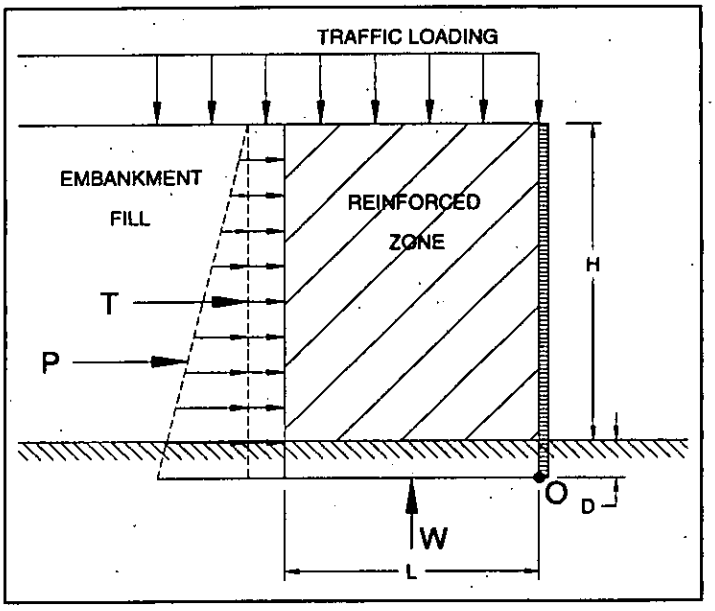
P_r = 50,012 lbs per foot of wall

USE THIS VALUE

$P_r = L(c)$ (Undrained)

P_r = 52,800 lbs per foot of wall

Use Drained Value



	Calculated	Required	
$FS = \frac{P_r}{P_a}$	FS = **2.19**	FS = 1.50	Resistance Against Sliding is **OK**

RESISTANCE AGAINST OVERTURNING

* Summation of Moments about point "O" (base of wall).
* Traffic loading is neglected in resisting forces

$\Sigma M_{resisting}$ = 2,378,957 lb-ft $\quad \Sigma M_{resisting} = \gamma H L\left(\frac{L}{2}\right)$

$\Sigma M_{overturning}$ = 256,819 lb-ft $\quad \Sigma M_{overturning} = K_a\left[\frac{1}{2}\gamma H^2\left(\frac{H}{3}\right) + \omega_T H\left(\frac{H}{2}\right)\right]$

	Calculated	Required	
$FS = \frac{\Sigma M_{resisting}}{\Sigma M_{overturning}}$	FS = **9.26**	FS = 2.00	Resistance Against Overturning is **OK**

DLZ

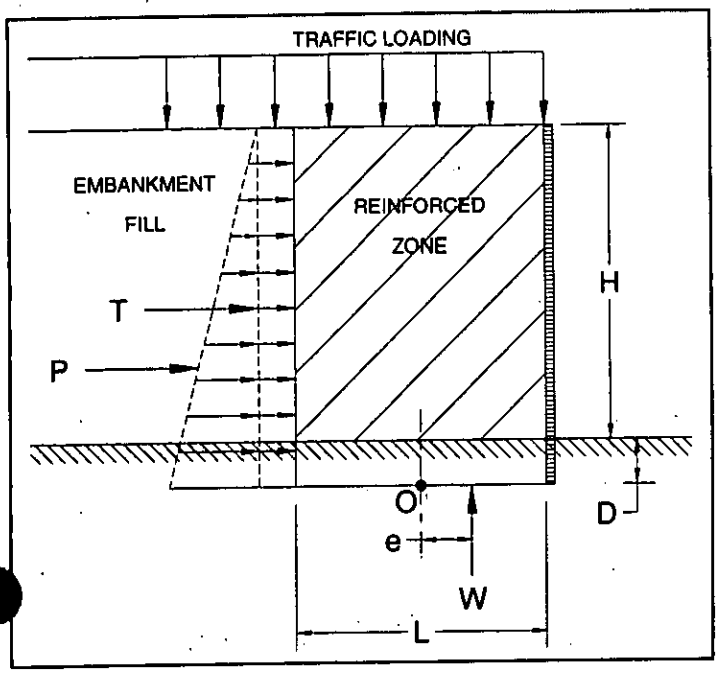
SUBJECT

Client	CH2M Hill
Project	SCI-823 Portsmouth Bypass
Item	MSE Wall Bearing Capacity
Wall No. 2, Fairground Road	
Full Height Wall	

JOB NUMBER	0121-3070.03		
SHEET NO.	5	OF	21
COMP. BY	SAK	DATE	8-13-07
CHECKED BY	DAA	DATE	8-31-07

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

γ_{EMB}	= 120	pcf	Unit weight	Embankment fill
ϕ'_{EMB}	= 30	deg.	Friction ang.	Embankment fill
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 1500	psf	Cohesion	Foundation soil
ϕ	= 0	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= 29	deg.	Friction ang.	Foundation soil

Loads and Parameters

***L based on H+D=32'**

ω_t	= 240	psf	Traffic loading	
L=B	= 35.2	ft	Length of MSE reinforcement	
L factor	= 1.1		Length factor-range (0.7 - 1.1)	
D	= 3	ft	Embedment depth	
Dw	= 0	ft	Groundwater depth	
H+D	= 32	ft		
H	= 29	ft	Height of wall	
Ka	= 0.33			
Γ Pa	= 10.667	ft	Moment arm	
Γ Wt	= 16	ft	Moment arm	
B'	= 31.62	ft		
γ'	= 57.6	pcf		
W_t	8,448	lb/ft of wall	Weight from traffic	
W_{mse}	= 135,168	lb/ft of wall	Weight from MSE wall	

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 4,542 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma B N_\gamma$$

q_{ULT} = 7,883 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 3,153 psf

Factor of Safety = 1.74 **No Good**

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 20,453 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 8,181 psf

Factor of Safety = 4.50 **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	27.86
N_q	1.00	N_q	16.44
N_γ	0.00	N_γ	19.34

Eccentricity of Resultant Force

e = 1.79 ft

Kern

e < L/6 = 5.87 ft

DLZ

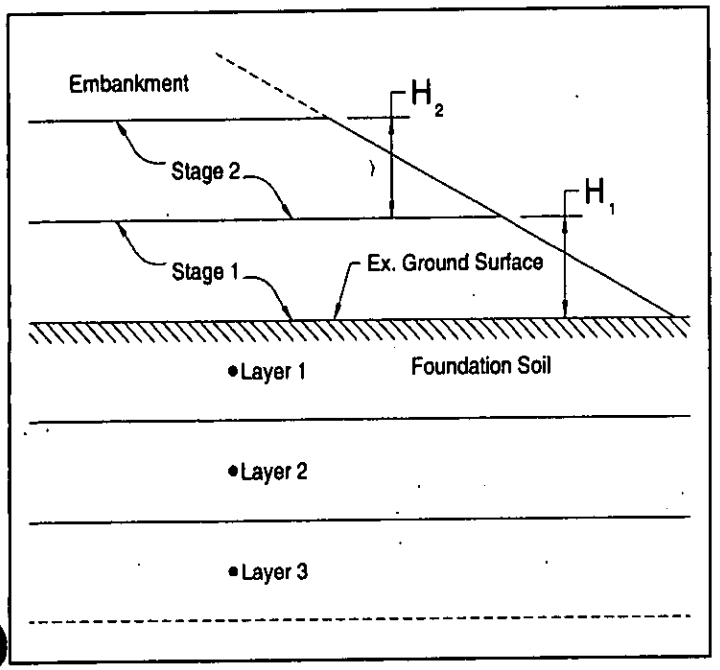
SUBJECT

Client	CH2M Hill	JOB NUMBER	0121-3070.03
Project	SCI-823 Portsmouth Bypass	SHEET NO.	6 OF 21
Item	Undrained Strength Analysis - Staged Const.	COMP. BY	SJK DATE 8-13-07
MSE wall No. 2, Fairground Road		CHECKED BY	DAA DATE 8-30-07

Determine Increase in Undrained Shear Strength Due to Consolidation

Undrained Strength Analysis - Staged Construction

Ref: Ladd, Charles C. (1991). "Stability Evaluation During Staged Construction." *The Twenty-Second Karl Terzaghi Lecture.*, Journal of Geotechnical Engineering, ASCE, 117(4), 540-615



Increase in Undrained Shear Strength from consolidation

$$c_u = c_{ui} + \Delta\sigma' \cdot \tan(\phi_{cu})$$

Where: c_{ui} Initial undrained shear strength, UU or q_u testing

Φ_{cu} Determined from CIU testing

$\Delta\sigma'$ Effective stress increase due to embankment loading

$$\Delta\sigma' = (H_n \cdot \gamma_{emb}) \cdot U$$

Where: U. Average degree of consolidation (%)

H_n Height of Embankment, Stage n (ft)

Embankment Fill

γ_{fill} **120** pcf

Top of leveling pad el. 562.0'

Bot. of excavation el. 560.5

Depths measured from bottom of leveling pad excavation, below MSE retaining wall

Stage 1 Embankment First Stage Embankment Height H_1= **19.0** Average Percent Consolidation U= **90%**

Depth	Soil Type	Initial Undrained Shear Strength, c_{ui} (psf)	$\Delta\sigma'$ (psf)	Φ_{cu} (deg)	Δc_u (psf)	c_u (psf), *After Consolidation*	Percent Increase
0-12.5	A-6b/A-2-6	1500	2052	15.0	550	2050	37%

Stage 2 Embankment Second Stage Embankment Height H_2= **8.0** Average Percent Consolidation U= **90%**

0-12.5	A-6b/A-2-6	2050	864	15.0	232	2282	11%

Stage 3 Embankment Third Stage Embankment Height H_3= **2.0** Average Percent Consolidation U= **0%**

0-12.5	A-6b/A-2-6	2282	0	15.0	0	2282	0%

DLZ

SUBJECT

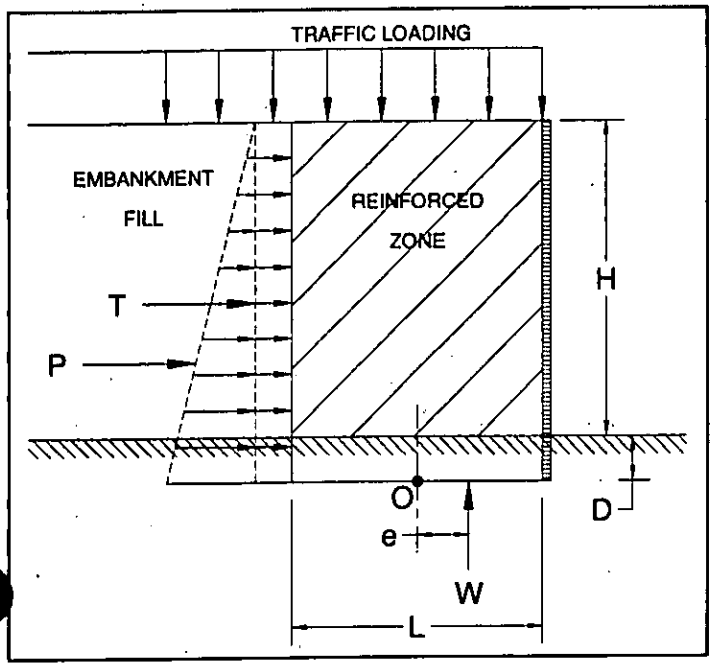
Client	CH2M Hill
Project	SCI-823 Portsmouth Bypass
Item	MSE Wall Bearing Capacity
Wall No. 2, Fairground Road	

JOB NUMBER	0121-3070.03		
SHEET NO.	7	OF	21
COMP. BY	SJK	DATE	8-13-07
CHECKED BY	DAA	DATE	8-30-07

Stage 1, H+D=22', based on B-45 & B-1113

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

γ_{EMB}	= 120	pcf	Unit weight	Embankment fill
ϕ'_{EMB}	= 30	deg.	Friction ang.	Embankment fill
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 1500	psf	Cohesion	Foundation soil
ϕ	= 0	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= 29	deg.	Friction ang.	Foundation soil

Loads and Parameters

***L based on H+D=32'**

ω_t	= 240	psf	Traffic loading	
L=B	= 35.2	ft	Length of MSE reinforcement	
L factor	= 1.1		Length factor-range (0.7 - 1.1)	
D	= 3	ft	Embedment depth	
Dw	= 0	ft	Groundwater depth	
H+D	= 22	ft		
H	= 19	ft	Height of wall	
Ka	= 0.33			
⌜ Pa	= 7.3333	ft	Moment arm	
⌜ Wt	= 11	ft	Moment arm	
B'	= 33.44	ft		
γ'	= 57.6	pcf		
W_t	8,448	lb/ft of wall	Weight from traffic	
W_{mse}	= 92,928	lb/ft of wall	Weight from MSE wall	

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 3,032 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 7,883 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 3,153 psf

Factor of Safety = 2.60 **OK**

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 21,467 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 8,587 psf

Factor of Safety = 7.08 **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	27.86
N_q	1.00	N_q	16.44
N_γ	0.00	N_γ	19.34

Eccentricity of Resultant Force

e = 0.88 ft

Kern

e < L/6 = 5.87 ft

DLZ

SUBJECT

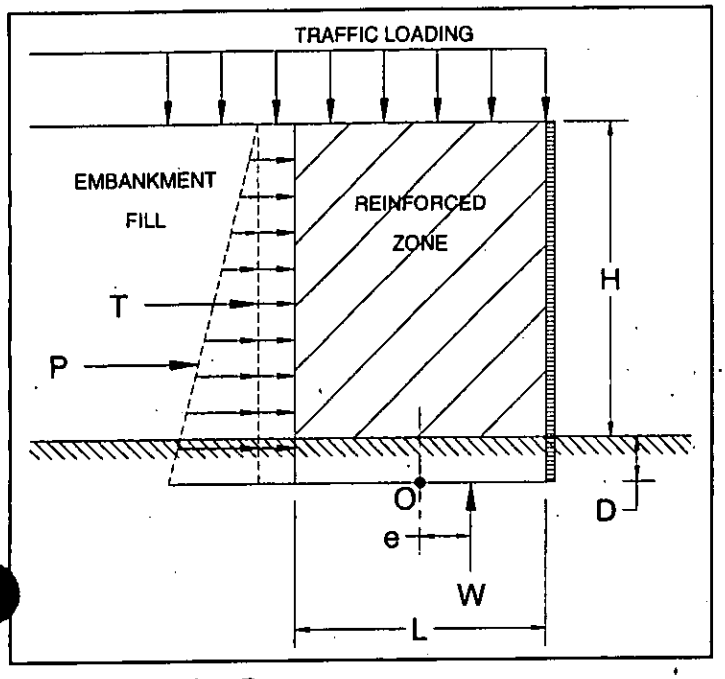
Client	CH2M Hill
Project	SCI-823 Portsmouth Bypass
Item	MSE Wall Bearing Capacity
Wall No. 2, Fairground Road	

JOB NUMBER	0121-3070.03		
SHEET NO.	8	OF	21
COMP. BY	SJR	DATE	8-13-07
CHECKED BY	DAA	DATE	8-31-07

Stage 2, H+D=27'+3'=30', based on B-45 & B-1113

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

γ_{EMB}	= 120	pcf	Unit weight	Embankment fill
ϕ'_{EMB}	= 30	deg.	Friction ang.	Embankment fill
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 2050	psf	Cohesion	Foundation soil
ϕ	= 0	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= 29	deg.	Friction ang.	Foundation soil

Loads and Parameters

***L based on H+D=32'**

ω_t	= 240	psf	Traffic loading
L=B	= 35.2	ft	Length of MSE reinforcement
L factor	= 1.1		Length factor-range (0.7 - 1.1)
D	= 3	ft	Embedment depth
Dw	= 0	ft	Groundwater depth
H+D	= 30	ft	
H	= 27	ft	Height of wall
Ka	= 0.33		
⌜ Pa	= 10	ft	Moment arm
⌜ Wt	= 15	ft	Moment arm
B'	= 32.04	ft	
γ'	= 57.6	pcf	
W_t	8,448	lb/ft of wall	Weight from traffic
W_{mse}	= 126,720	lb/ft of wall	Weight from MSE wall

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 4,219 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma B N_\gamma$$

q_{ULT} = 10,710 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 4,284 psf

Factor of Safety = **2.54** **OK**

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 20,687 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 8,275 psf

Factor of Safety = **4.90** **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	27.86
N_q	1.00	N_q	16.44
N_γ	0.00	N_γ	19.34

Eccentricity of Resultant Force

e = 1.58 ft

Kern

e < L/6 = 5.87 ft

DLZ

SUBJECT

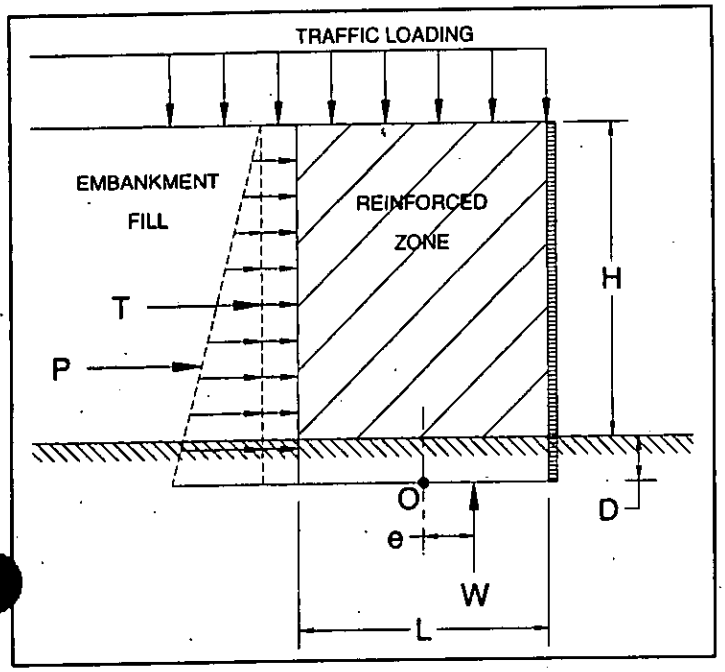
Client	CH2M Hill
Project	SCI-823 Portsmouth Bypass
Item	MSE Wall Bearing Capacity
Wall No. 2, Fairground Road	

Stage 3, H+D=29'+3'=32', based on B-45 & B-1113

JOB NUMBER	0121-3070.03		
SHEET NO.	9	OF	21
COMP. BY	SJR	DATE	8-13-07
CHECKED BY	DAA	DATE	8-31-07

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

γ_{EMB}	= 120	pcf	Unit weight	Embankment fill
ϕ'_{EMB}	= 30	deg.	Friction ang.	Embankment fill
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 2282	psf	Cohesion	Foundation soil
ϕ	= 0	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= 29	deg.	Friction ang.	Foundation soil

Loads and Parameters

***L based on H+D=32'**

ω_t	= 240	psf	Traffic loading	
L=B	= 35.2	ft	Length of MSE reinforcement	
L factor	= 1.1		Length factor-range (0.7 - 1.1)	
D	= 3	ft	Embedment depth	
Dw	= 0	ft	Groundwater depth	
H+D	= 32	ft		
H	= 29	ft	Height of wall	
Ka	= 0.33			
⌜ Pa	= 10.667	ft	Moment arm	
⌜ Wt	= 16	ft	Moment arm	
B'	= 31.62	ft		
γ'	= 57.6	pcf		
W_t	8,448	lb/ft of wall	Weight from traffic	
W_{mse}	= 135,168	lb/ft of wall	Weight from MSE wall	

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 4,542 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 11,902 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 4,761 psf

Factor of Safety = 2.62 **OK**

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 20,453 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 8,181 psf

Factor of Safety = 4.50 **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	27.86
N_q	1.00	N_q	16.44
N_γ	0.00	N_γ	19.34

Eccentricity of Resultant Force

e = 1.79 ft

Kern

e < L/6 = 5.87 ft

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CLIENT CHZM Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Fairgrounds Rd. Structures
Staged Construction Details

PROJECT NO. 0121-3070.03
SHEET NO. 10 OF 21
COMP. BY SJK DATE 8-15-07
CHECKED BY DAA DATE 8-31-07

* Based on bearing capacity calculations, staged construction is required for Wall No. 2
  - Height of 1st Stage; $H_1 = 19.0'$
    - Maximum excess pore pressure; $u_e = 19.0'(120\ pcf) = 2280\ psf = 15.8\ psi$
      * Prior to placing 2nd stage, excess pore pressures should be allowed to dissipate to $U = 90\%$.

$$u_{e_{90}} = (1-0.90)(15.8\ psi) = \underline{1.6\ psi}$$

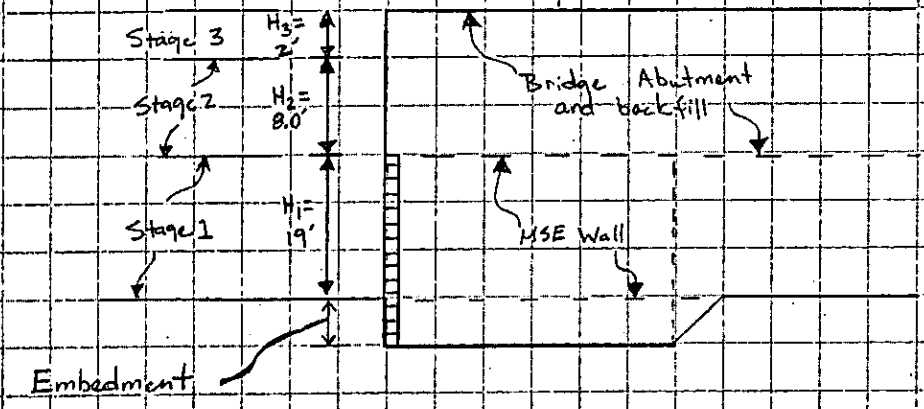
  - Height of 2nd Stage; $H_2 = 8.0'$

$$u_e = 8.0'(120\ pcf) = 960\ psf = 6.7\ psi$$

      * Prior to placing Final (3rd Stage), excess pore pressures should be allowed to dissipate to $U = 90\%$.

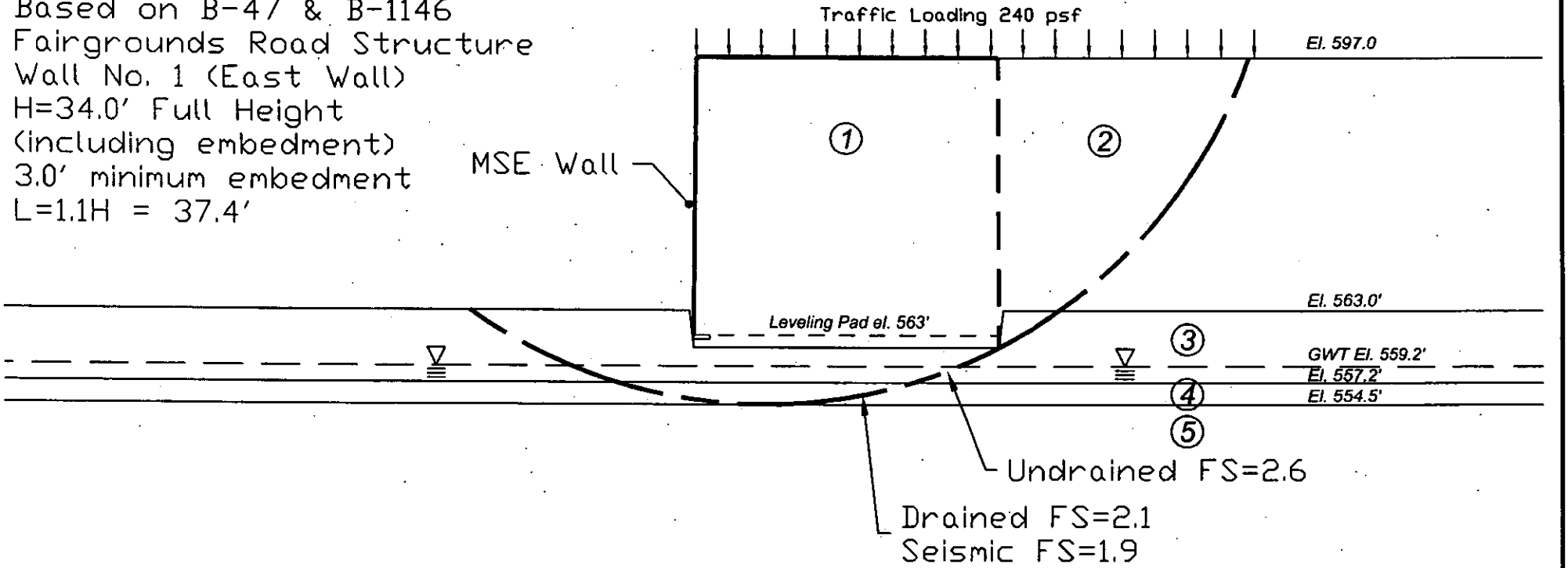
$$u_{e_{90}} = (1-0.90)(6.7\ psi) = \underline{0.7\ psi}$$

Wall No. 2 Only



			Undrained		Drained		
Material	Consistency	Soil Type	c (psf)	ϕ (deg)	c' (psf)	ϕ' (deg)	γ (pcf)
Material 1	Compacted	MSE Fill	0	34	0	34	120
Material 2	Compacted	Emb. Fill	0	30	0	30	120
Material 3	V. Stiff	A-4a/A-6a	2350	0	0	29	120
Material 4	Loose	Silt	0	29	0	29	120
Material 5		Bedrock	10000	45	10000	45	145

Stability Analysis
Based on B-47 & B-1146
Fairgrounds Road Structure
Wall No. 1 (East Wall)
H=34.0' Full Height
(including embedment)
3.0' minimum embedment
L=1.1H = 37.4'



US-23 Interchange
Fairground Road Wall No. 1
Based on Borings B-47 & B-1146

MSE GLOBAL STABILITY ANALYSIS

SCI-823-0.00

PROJECT NO. 0121-3070.03	CALC: SJR	DATE 8/14/07

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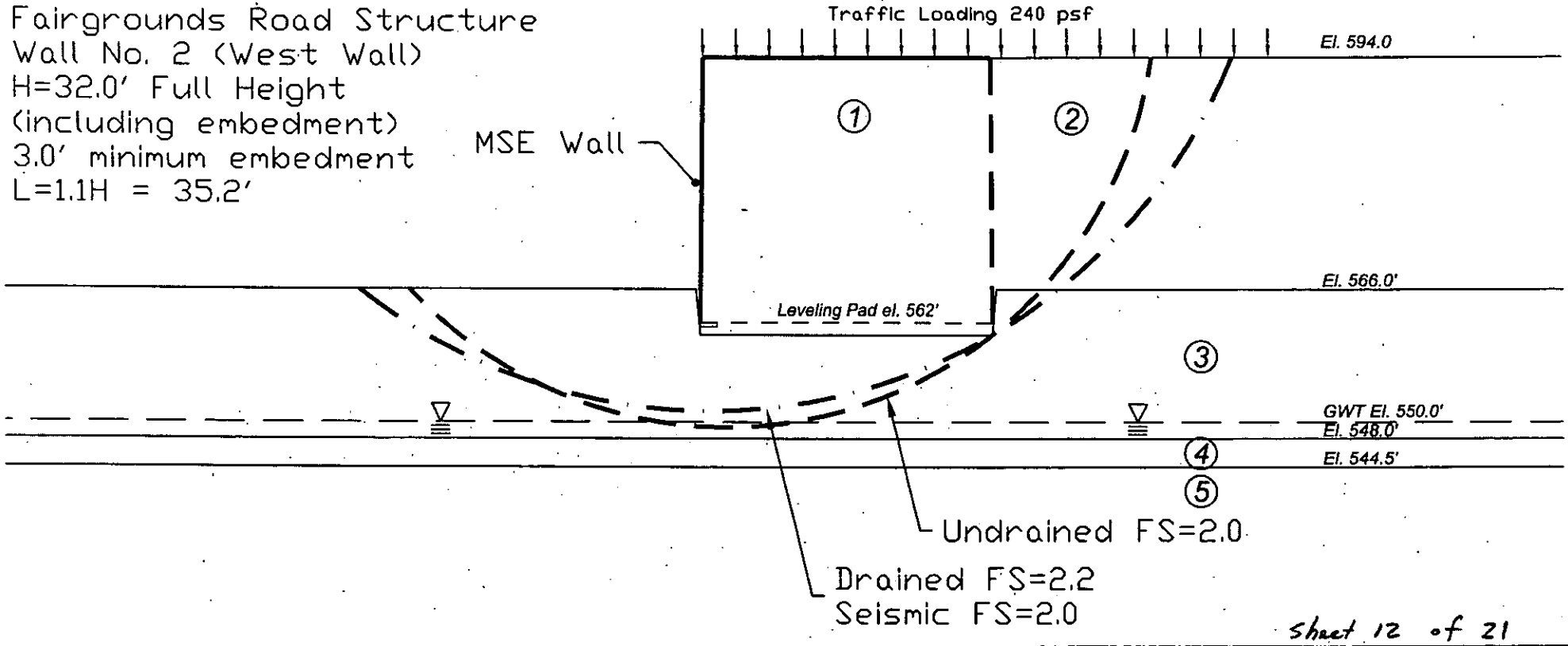
			Undrained		Drained		
Material	Consistency	Soil Type	c (psf)	Φ (deg)	c' (psf)	Φ' (deg)	γ (pcf)
Material 1	Compacted	MSE Fill	0	34	0	34	120
Material 2	Compacted	Emb. Fill	0	30	0	30	120
Material 3	V. Stiff	A-6b/A-2-6	1500	0	0	29	120
Material 4	Loose	A-2-4	0	30	0	30	120
Material 5		Bedrock	10000	45	10000	45	145

Stability Analysis
Based on B-45 & B-1113
Fairgrounds Road Structure
Wall No. 2 (West Wall)
H=32.0' Full Height
(including embedment)
3.0' minimum embedment
L=1.1H = 35.2'



US-23 Interchange
Fairground Road Wall No. 2
Based on Borings B-45 & B-1113

MSE GLOBAL STABILITY ANALYSIS

SCI-823-0.00

PROJECT NO. 0121-3070.03	CALC: SJR	DATE 8/14/07

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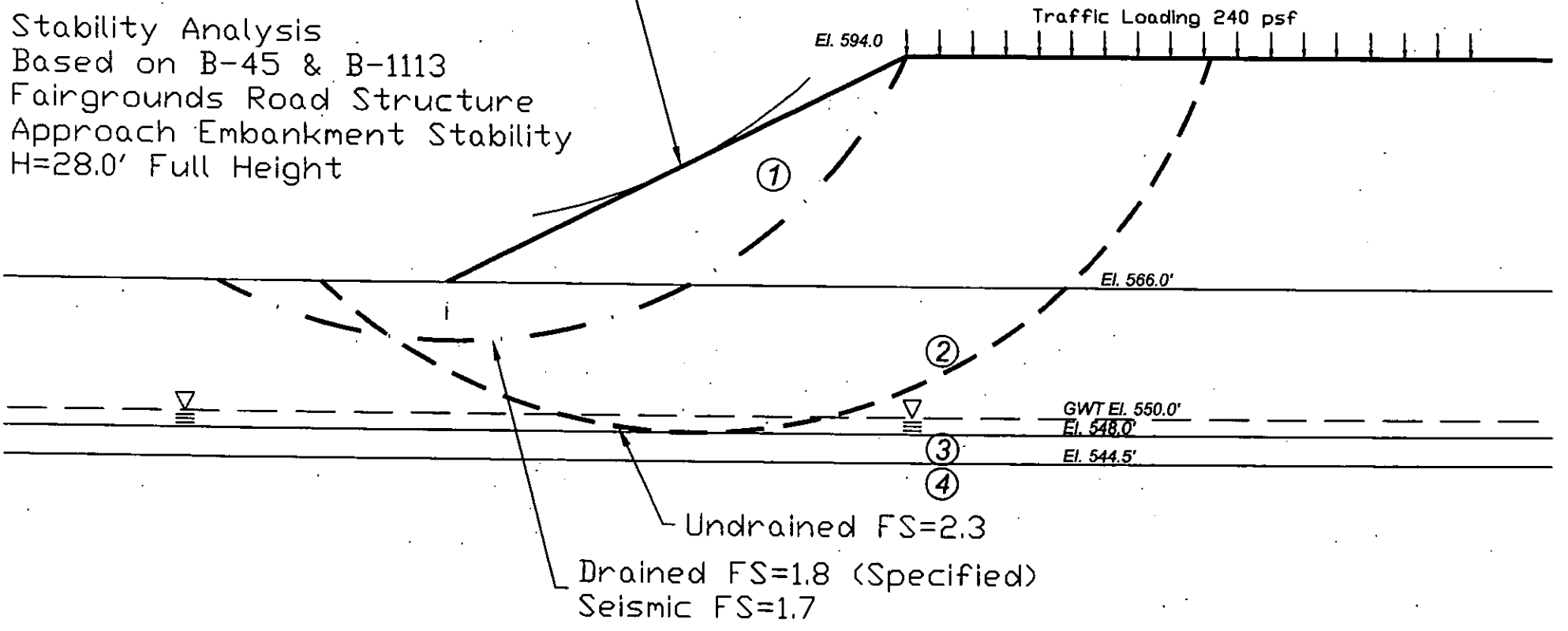
Material	Consistency	Soil Type	Undrained c (psf)	Undrained ϕ (deg)	Drained c' (psf)	Drained ϕ' (deg)	γ (pcf)
Material 1	Compacted	Emb. Fill	0	30	0	30	120
Material 2	V. Stiff	A-6b/A-2-6	1500	0	0	29	120
Material 3	Loose	A-2-4	0	30	0	30	120
Material 4		Bedrock	10000	45	10000	45	145

Drained FS=1.2
Infinite Slope Failure

Stability Analysis
Based on B-45 & B-1113
Fairgrounds Road Structure
Approach Embankment Stability
H=28.0' Full Height



US-23 Interchange
Fairground Road Wall Approach Embankment
Based on Borings B-45 & B-1113

EMBANKMENT STABILITY ANALYSIS

SCI-823-0.00

PROJECT NO. 0121-3070.03	CALC: SJR	DATE 8/14/07

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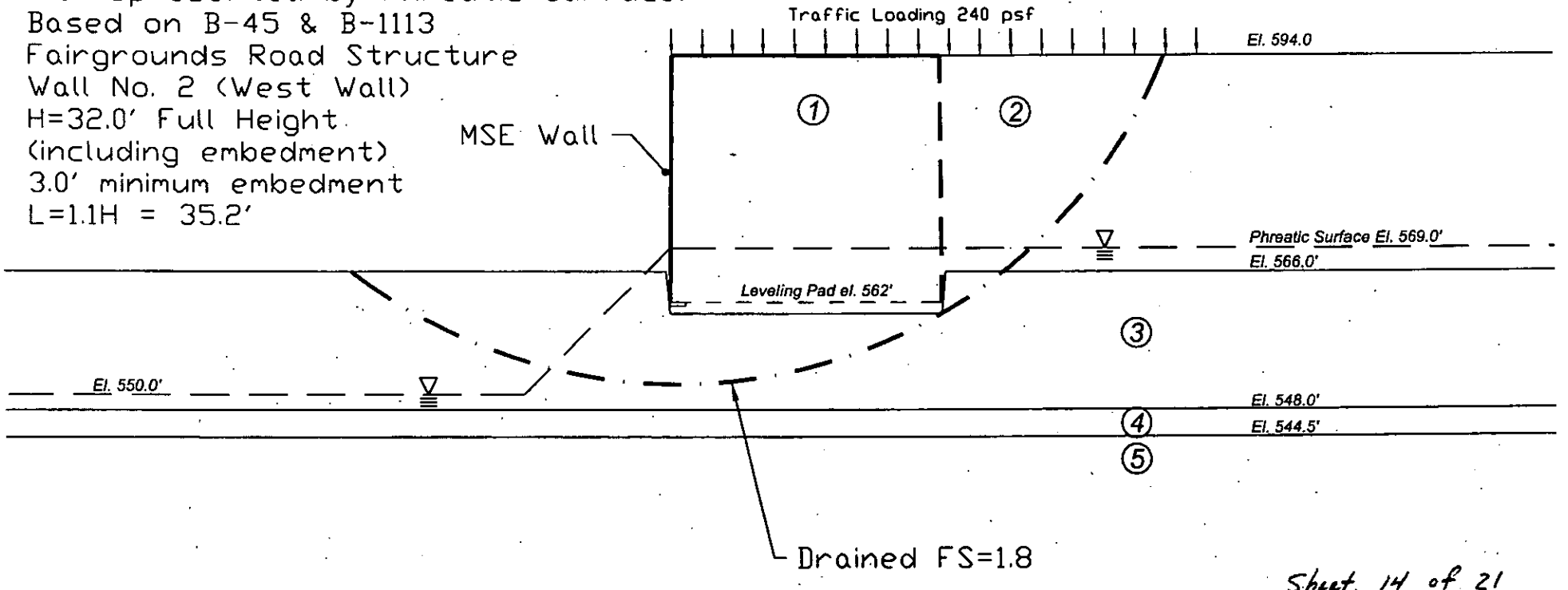
Material	Consistency	Soil Type	Undrained c (psf)	Undrained Φ (deg)	Drained c' (psf)	Drained Φ' (deg)	γ (pcf)
Material 1	Compacted	MSE Fill	0	34	0	34	120
Material 2	Compacted	Emb. Fill	0	30	0	30	120
Material 3	V. Stiff	A-6b/A-2-6	1500	0	0	29	120
Material 4	Loose	A-2-4	0	30	0	30	120
Material 5		Bedrock	10000	45	10000	45	145

EFFECTIVE STRESS ANALYSIS
Determine stability at theoretical
Maximum pore pressure following staged
construction guidelines.
(u_e Represented by Phreatic Surface)
Based on B-45 & B-1113
Fairgrounds Road Structure
Wall No. 2 (West Wall)
H=32.0' Full Height
(including embedment)
3.0' minimum embedment
L=1.1H = 35.2'



US-23 Interchange
Fairground Road Wall No. 2
Based on Borings B-45 & B-1113

MSE GLOBAL STABILITY ANALYSIS

SCI-823-0.00

PROJECT NO. 0121-3070.03	CALC: SJR	DATE 8/15/07

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CLIENT: CH2 M Hill
PROJECT: SCI-823 Portsmouth Bypass
SUBJECT: Fairgrounds Rd Structures
Consolidation / Settlement under MSE wall

PROJECT NO. 0121-3070.03
SHEET NO. 15 OF 21
COMP. BY SJK DATE 8-14-07
CHECKED BY DAA DATE 8-31-07

$H = 597.0 - 567.5' = 29.5'$

• Wall No. 1 East Wall - Fairgrounds Rd

* moisture content from B-47
* N-values from B-47
* Profile based on B-47 and B-1146

~ MSE Wall ~

el. 567.5' Top of Leveling Pad → el. 563.0'

Layer #1 el. 561.5' $\bar{w}\% = 19.3$ } Compacted MSE Fill Assume Incompressible

el. 559.2 ▽ el. 557.2' A-4b / A-6a } $C_c = 0.19$ $e_o = 0.52$ *See Below #1

Layer #2 A-4b $\bar{w}\% = 8.5$

el. 554.5' $\bar{N} = 9$ blows/ft } * See below #2

TOP OF ROCK

#1 * Sample Calculation: $\bar{w} = 19.3\%$, $\overline{LL} = 24.5\%$, $\overline{PL} = 18.0\%$ $\overline{PI} = 6.5$

* Assume soil is normally consolidated
* Assume soil is saturated.

$$e_o = \frac{G_s \cdot w}{100} = \frac{2.70\,(19.3)}{100} = 0.52$$

$$C_c = \frac{w}{100} = \frac{19.3}{100} = 0.19$$

Ref [FHWA NHI-00-045]
"Soils and Foundation Workshop Ref Manual"

#2 * Sample Calculation: Ref [FHWA NHI-00-045]

Average N-value = 9 blows/ft

$\sigma_{ov} = 1290$ psf $N'/N \simeq 1.1 \longrightarrow N' = N(1.1) = 9(1.1) = 9.9$ say 10

$c' \simeq 30$

The computer program EMBANK requires input for C_c and e_o.
To evaluate the settlement of granular layers, we must compute equivalent consolidation parameters from c'.

$$\frac{1}{c'} = \frac{C_c}{1+e_o}$$

Say $e_o = 1.0$ in this case

$$\frac{1}{c'} = \frac{C_c}{1+1.0} \longrightarrow c' = \frac{2.0}{C_c} \qquad \boxed{C_c = \frac{2}{c'}}$$

When $c' = 30 \longrightarrow$ Use $C_c = \frac{2}{30} = 0.07$ when $e_o = 1.0$

* From EMBANK

Total Settlement = 3.3" at $x = 59'$ and = 0.3" at $x = 0'$

Differential Settlement, $DS = \dfrac{(3.3'' - 0.3'')\,1'/12''}{59'-0'} = 0.004$

SJK

Fairground Road Wall No 1

ÚÄÄÄÄÄ ONE DIMENSIONAL SETTLEMENT ANALYSIS/Federal Highway Administration ÄÄÄÄÄ¿
INCREMENT OF STRESSES BENEATH THE END OF FILL CONDITION

Project Name : SCI-823 Client : CH2M Hill
File Name : FRW1 Project Manager : Nix
Date : 8/14/10 Computed by : sjr

Settlement for X-Direction

Embank. slope, x direc. =	59.00 (ft)	Height of fill H =	29.50 (ft)
y direc. =	00.10 (ft)	Unit weight of fill =	120.00 (pcf)
Embankment top width =	273.00 (ft)	p load/unit area =	3540.00 (psf)
Embankment bottom width =	391.00 (ft)	Foundation Elev. =	567.50 (ft)
Ground Surface Elev. =	567.50 (ft)		
Water table Elev. =	559.20 (ft)	Unit weight of Wat. =	62.40 (pcf)

N§.	LAYER TYPE	THICK. (ft)	COEFFICIENT COMP.	RECOMP.	SWELL.	UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO
1	INCOMP.	6.0	-----	-----	-----	120.00	----	----
2	COMP.	4.3	0.190	0.000	0.000	120.00	2.65	0.52
3	COMP.	2.7	0.070	0.000	0.000	120.00	2.65	1.00

N§.	SUBLAYER THICK. (ft)	ELEV. (ft)	SOIL STRESSES INITIAL (psf)	MAX.PAST PRESS. (psf)
1	INCOMP.			
2	4.30	559.35	978.00	978.00
3	2.70	555.85	1188.96	1188.96

Layer	X = 0.00 Stress (psf)	Sett. (in.)	X = 59.00 Stress (psf)	Sett. (in.)	X = 118.00 Stress (psf)	Sett. (in.)	X = 177.00 Stress (psf)	Sett. (in.)
1	INCOMP.	INCOMP.	INCOMP.	INCOMP.				
2	73.58	0.20	1683.33	2.80	1755.80	2.88	1756.07	2.88
3	107.27	0.04	1653.75	0.43	1759.24	0.45	1760.03	0.45
		0.25		3.23		3.33		3.33

Say 0.3 Say 3.3"

Layer	X = 236.00 Stress (psf)	Sett. (in.)	X = 295.00 Stress (psf)	Sett. (in.)
1	INCOMP.	INCOMP.		
2	1756.04	2.88	1755.14	2.88
3	1759.93	0.45	1757.39	0.45
		3.33		3.33

proposed grade = 597.0'
existing grade = 567.5'
Assumed bottom of excavation = 561.5'

ÀÄÄÄÄÄ Hit arrow keys to display next screen. <F8> Print. <F10> Main Menu ÄÄÄÄÄÙ

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CLIENT CHZM Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Fairgrounds Rd. Structures
Consolidation / Settlement under MSE wall

PROJECT NO. 0121-3070.03
SHEET NO. 17 OF 21
COMP. BY SJK DATE 8-15-0
CHECKED BY DAA DATE 8-31-0

H = 594.0 - 565.6 = 28.4'

• Wall No. 2 West Wall - Fairgrounds Rd.

* Profile based on B-46

el. 565.6'

~ MSE Wall ~

Top of Leveling Pad el. 562.0'

el. 560.5'

} Compacted MSE Fill
} Assume Incompressible
} C_c = .24 e_o = .692 from B-46
} equivalent C_c = 0.05
} * See sample calculation, pg 15

550 —

Layer #1 el. 555.1' A-6b

Layer #2 el. 547.6' A-2-6 $\bar{N}$ = 4 N' = 4 C' ≈ 42

TOP OF ROCK

* Assume A-6b layer is normally consolidated. Based upon in-situ moisture content, this would be a prudent assumption.

* From EMBANK

Total settlement = 4.8" @ 56.8' and 0.4" @ 0'

Differential Settlement, $DS = \frac{(4.8" - 0.4")(1/2")}{56.8'} = 0.006$

SJK

Sheet 18 of 21
SJK 8-15-07 DAA 8-31-07

Assumes Normally consolidated Soil

ÚÄÄÄÄÄ ONE DIMENSIONAL SETTLEMENT ANALYSIS/Federal Highway Administration ÄÄÄÄÄ¿

INCREMENT OF STRESSES BENEATH THE END OF FILL CONDITION

Project Name	: SCI-823	Client	: CH2M Hill
File Name	: FRW2	Project Manager	: Nix
Date	: 8/14/10	Computed by	: sjr

Settlement for X-Direction

Embank. slope, x direc.	= 56.80 (ft)	Height of fill H	= 28.40 (ft)
y direc.	= 00.10 (ft)	Unit weight of fill	= 120.00 (pcf)
Embankment top width	= 331.00 (ft)	p load/unit area	= 3408.00 (psf)
Embankment bottom width	= 444.60 (ft)	Foundation Elev.	= 565.60 (ft)
Ground Surface Elev.	= 565.60 (ft)		
Water table Elev.	= 550.00 (ft)	Unit weight of Wat.	= 62.40 (pcf)

N§.	LAYER TYPE	THICK. (ft)	COEFFICIENT COMP.	RECOMP.	SWELL.	UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO
1	INCOMP.	5.1	-----	-----	-----	120.00	----	----
2	COMP.	5.4	0.240	0.040	0.000	120.00	2.65	0.69
3	COMP.	7.5	0.050	0.050	0.050	120.00	2.65	1.00

N§.	SUBLAYER THICK. (ft)	ELEV. (ft)	SOIL STRESSES INITIAL (psf)	MAX.PAST PRESS. (psf)
1	INCOMP.			
2	5.40	557.80	936.00	936.00
3	7.50	551.35	1710.00	1710.00

Layer	X = 0.00 Stress (psf)	Sett. (in.)	X = 28.40 Stress (psf)	Sett. (in.)	X = 56.80 Stress (psf)	Sett. (in.)	X = 85.20 Stress (psf)	Sett. (in.)
1	INCOMP.	INCOMP.	INCOMP.	INCOMP.				
2	70.38	0.29	848.38	2.58	1620.45	4.02	1688.52	4.12
3	131.36	0.07	849.87	0.39	1565.69	0.64	1687.74	0.67
		0.36		2.97		4.65		4.79

Say 0.4"

Say 4.8"

Layer	X = 113.60 Stress (psf)	Sett. (in.)	X = 142.00 Stress (psf)	Sett. (in.)
1	INCOMP.	INCOMP.		
2	1689.74	4.12	1689.95	4.12
3	1694.31	0.67	1695.54	0.67
		4.80		4.80

ÀÄÄÄÄÄ Hit arrow keys to display next screen. <F8> Print. <F10> Main Menu ÄÄÄÄÄÙ

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CLIENT CH2M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Fairgrounds Rd Structures
Time-rate of consolidation

PROJECT NO. 0121-3070.03
SHEET NO. 19 OF 21
COMP. BY SJK DATE 8-15-07
CHECKED BY DAA DATE 8-31-07

Wall No. 1 — East Wall - Fairgrounds Rd.

Based on boring B-47

$\overline{LL} \simeq 25$, $H_v = 4.3'/2$ *Assumes double drainage

$H_v = 2.2'$

*$C_v \simeq 0.65\ ft^2/day$

*Ref {FHWA HI-97-021, figure 9-5, "Subsurface Investigations"}

$$t_{90} = \frac{T_v (H_v)^2}{C_v} = \frac{(0.848)(2.2')^2}{0.65\ ft^2/day} = 6.3 \text{ days} \quad \text{say } 7 \text{ days}$$

Wall No. 2 — West Wall - Fairgrounds Rd.

Based on boring B-45 & B-46

$\overline{LL} \simeq 34$ (B-46) $H_v = 5.4'/2 = 2.7'$ *Assumes double drainage

*$C_v \simeq 0.35\ ft^2/day$

$$t_{90} = \frac{T_v (H_v)^2}{C_v} = \frac{(0.848)(2.7')^2}{0.35\ ft^2/day} = 17.7 \text{ days} \quad \text{say } 18 \text{ days}$$

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CLIENT CH2M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Downdrag Forces on Piles
* Calculation of waiting period

PROJECT NO. 0121-3070.03
SHEET NO. 20 OF 21
COMP. BY SJK DATE 8-15-07
CHECKED BY DAA DATE 8-31-07

MSE Wall No. 1

Total Consolidation Settlement, $\delta_c = 2.8"$

To limit remaining settlements to 0.4" or less,

$\frac{0.4"}{2.8"} = 0.14$ $U_{Req'd} = 1 - 0.14 = 0.86$ Say $U = 90\%$

*From time-rate calculations, $t_{90} = 7$ days

MSE Wall No. 1

Total Consolidation Settlement, $\delta_c = 4.0"$

$\frac{0.4"}{4.0"} = 0.10$ $U_{Req'd} = 1 - 0.10 = 0.90$ $U = 90\%$

*From time-rate calculations, $t_{90} = 18$ days

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CLIENT CH2M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Drilled Shaft - End Bearing & Side Friction, Fairground Road

PROJECT NO. 0121-3070.03
SHEET NO. 21 OF 21
COMP. BY SJR DATE 8-22-07
CHECKED BY DAA DATE 8-31-07

* From testing on rock cores from borings B-45, B-46, B-47
Use lower bound; q_u = 1,971 psi

End bearing: FHWA-IF-99-025 Eq. 11.6 $q_{max}(MPa) = 4.83[q_u(MPa)]^{0.51}$
For RQD between 70-100 percent

q_u = 1,971 psi = 13.6 MPa

$q_{max} = 4.83[13.6\ MPa]^{0.51} = 18.3\ MPa = 2,652\ psi = 382\ ksf$

$q_{allow} = \frac{q_{max}}{F.S.} = \frac{382\ ksf}{3.0} = 127\ ksf$

* However, for this type and quality of Shale with Sandstone, we typically use:
q_a = 40 Ksf (20 tsf)

Side Friction: FHWA-IF-99-025 Eq. 11.24

$$f_{max} = 0.65\ p_a\left[\frac{q_u}{p_a}\right]^{0.5} \le 0.65\ p_a\left[\frac{f_c'}{p_a}\right]^{0.5}$$

f_c' ≥ 4500 psi q_u ≈ 1,971 psi * q_u governs

$$f_{max} = 0.65\,(14.7\ psi)\left[\frac{1,971\ psi}{14.7\ psi}\right]^{0.5} = 110.6\ psi$$

$$f_{allow} = \frac{f_{max}}{F.S.} = \frac{110\ psi}{3.0} = 37\ psi = 5280\ psf$$

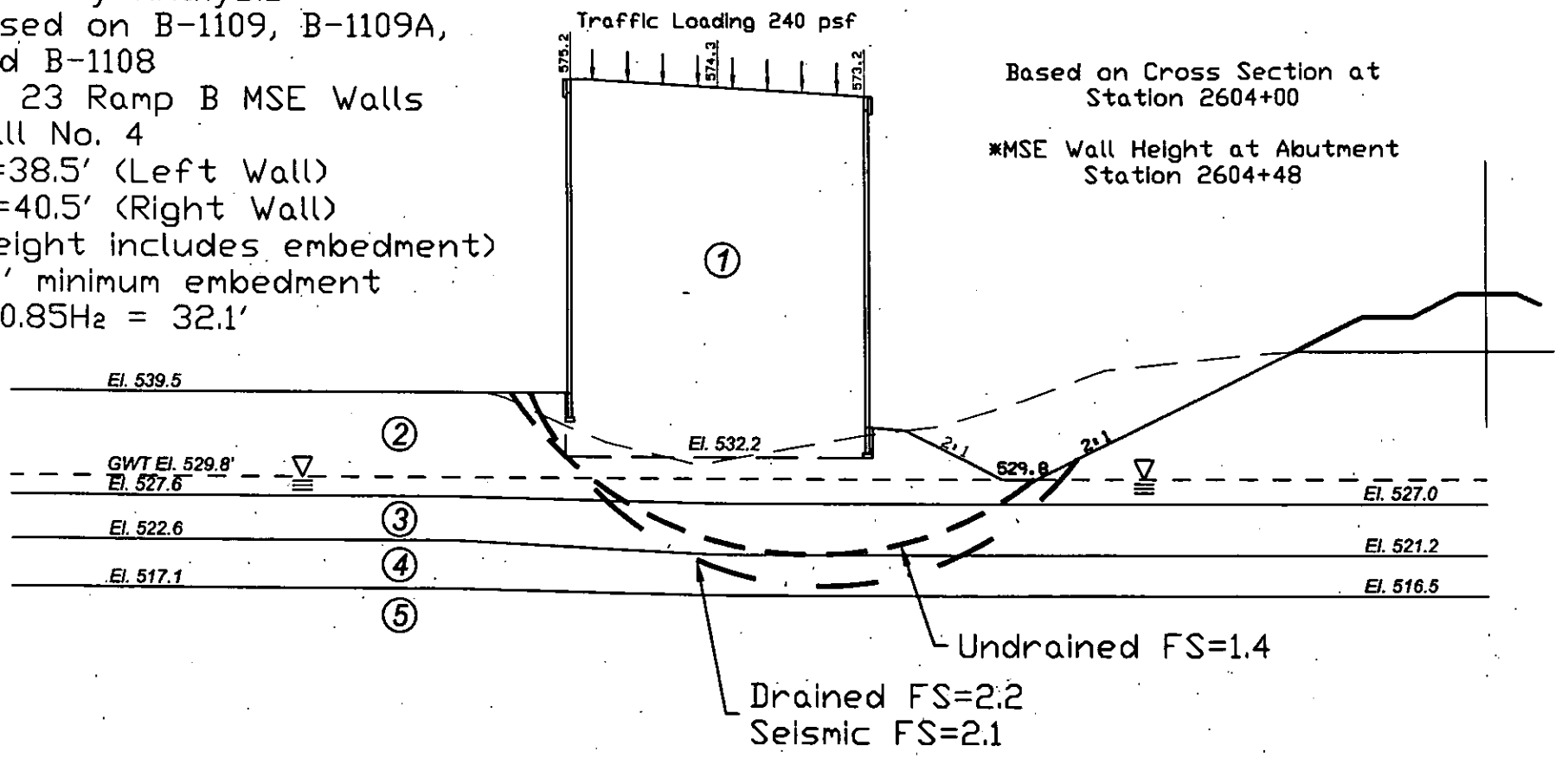
Use f_{allow} = 3,750 psf *Reduction for argillaceous rock

US 23 Ramp B

MSE Wall (Wall No. 4) and Embankment Evaluations

			Undrained		Drained		
Material	Consistency	Soil Type	c (psf)	Φ (deg)	c' (psf)	Φ' (deg)	γ (pcf)
Material 1	Compacted	MSE Fill	0	34	0	34	120
Material 2	Possible Fill	A-4a/A-6a	2000	0	0	29	120
Material 3	Medium Stiff	A-7-6	900	0	0	28	120
Material 4	Loose	A-4a/A-4b	0	29	0	29	120
Material 5		Bedrock	10000	45	10000	45	145

Stability Analysis
Based on B-1109, B-1109A, and B-1108
US 23 Ramp B MSE Walls
Wall No. 4
H_1=38.5' (Left Wall)
H_2=40.5' (Right Wall)
(Height includes embedment)
3.0' minimum embedment
$L=0.85H_2$ = 32.1'



Stability Analyses performed using UTEXAS3 Version 1.201

US-23 Interchange
Ramp B Wall No. 4, Station 2604+48
Based on Borings B-1109, B-1109A, &B-1108

MSE GLOBAL STABILITY ANALYSIS

SCI-823-0.00

PROJECT NO. 0121-3070.03	CALC: SJR	DATE 10/01/07

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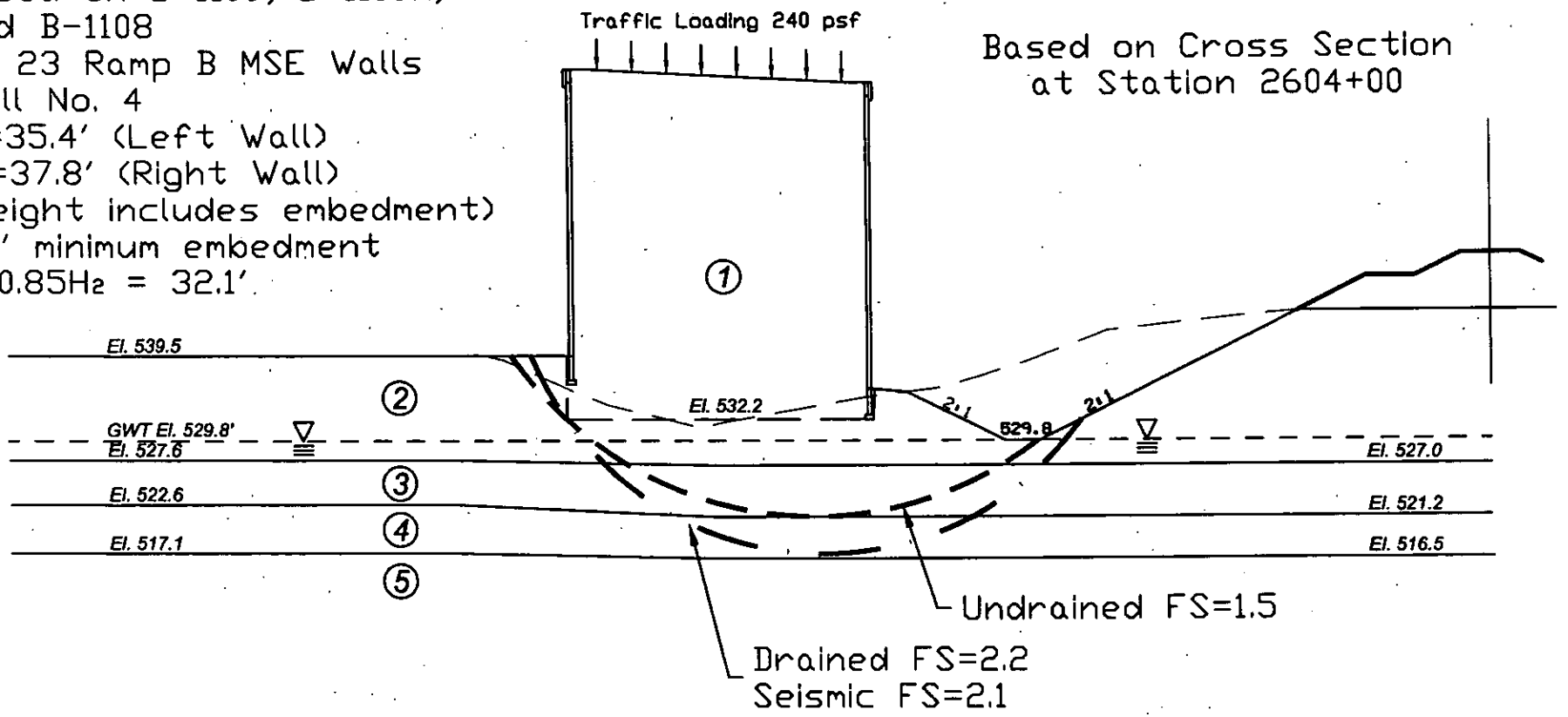
			Undrained		Drained		
Material	Consistency	Soil Type	c (psf)	ϕ (deg)	c' (psf)	ϕ' (deg)	γ (pcf)
Material 1	Compacted	MSE Fill	0	34	0	34	120
Material 2	Possible Fill	A-4a/A-6a	2000	0	0	29	120
Material 3	Medium Stiff	A-7-6	900	0	0	28	120
Material 4	Loose	A-4a/A-4b	0	29	0	29	120
Material 5		Bedrock	10000	45	10000	45	145

Stability Analysis
Based on B-1109, B-1109A, and B-1108
US 23 Ramp B MSE Walls
Wall No. 4
H_1=35.4' (Left Wall)
H_2=37.8' (Right Wall)
(Height includes embedment)
3.0' minimum embedment
$L=0.85H_2$ = 32.1'

Based on Cross Section at Station 2604+00



Stability Analyses performed using UTEXAS3 Version 1.201

US-23 Interchange
Ramp B Wall No. 4, Station 2604+00
Based on Borings B-1109, B-1109A, &B-1108

MSE GLOBAL STABILITY ANALYSIS

SCI-823-0.00

PROJECT NO. 0121-3070.03	CALC: SJR	DATE 9/12/07

M:\proj\0121\3070.03\Interchanges\US 23\embankment stability.dwg, 10/16/2007 11:49:43 AM, Xerox WorkCentre Pro 245 PS

5.4 BACK-TO-BACK WALLS

For walls which are built back-to-back as shown in figure 50, a modified value of backfill thrust influences the external stability calculations. As indicated in figure 50, two cases can be considered.

- For Case I, the overall base width is large enough so that each wall behaves and can be designed independently. In particular, there is no overlapping of the reinforcements. Theoretically, if the distance, D, between the two walls is shorter than:

$$D = H_1 \tan (45° - \varphi/2) \quad (55)$$

then the active wedges at the back of each wall cannot fully spread out and the active thrust is reduced. However, it is assumed that for values of:

$$D > H_1 \tan (45° - \varphi/2) \approx 0.5\, H_1 \quad (56)$$

full active thrust is mobilized.

- For Case II, there is an overlapping of the reinforcements such that the two walls interact. When the overlap, L_R, is greater than $0.3\, H_2$, where H_2 is the shorter of the parallel walls, no active earth thrust from the backfill needs to be considered for external stability calculations. For intermediate geometries between Case I and Case II, the active earth thrust may be linearly interpolated from the full active case to zero. For Case II geometries with overlaps greater than $0.3\, H_2$, L/H ratios for each wall as low as 0.6 may be considered.

  Considering this case, designers might be tempted to use single reinforcements connected to both wall facings. This alternative completely changes the strain patterns in the structure and results in higher reinforcement tensions such that the design method in this manual is no longer applicable. In addition, difficulties in maintaining wall alignment could be encountered during construction, especially when the walls are not in a tangent section.

  Based on a performance review, back-to-back walls with overlapping reinforcements may be designed for static load conditions with a distance between parallel facing as low as L/H = 0.6, where H is the height of each wall, and for conditions where the seismic horizontal accelerations at the foundation level is less than 0.05g. For walls in more seismically active areas (up to 0.19g) a distance of $1.1H_1$ is presently recommended. For walls subjected to significant seismic loading (up to 0.40g) successful performance has been observed when the distance between parallel facings was at least $1.2H_1$.

  Justification of narrower back-to-back distances ($< 1.1H_1$) between faces in seismically active areas require a more detailed analysis be performed to include effects of potential non-uniform distribution of seismic and inertial forces within the wall, as suggested by numerical studies and not provided for in the present design methodology.

DLZ

SUBJECT

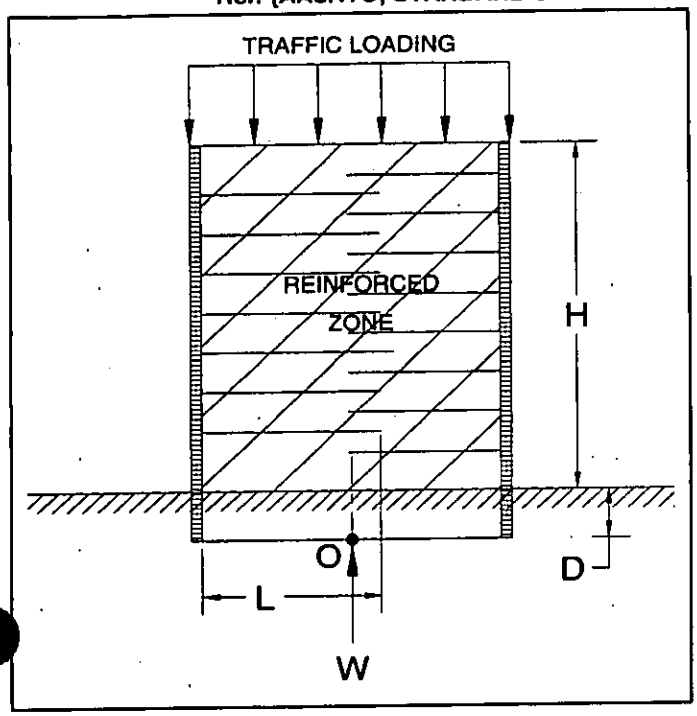
Client	CH2M Hill
Project	SCI-823 Portsmouth Bypass
Item	MSE Wall Bearing Capacity
	Wall No 4, Station 2604+00, BACK-TO-BACK WALLS
	Ka=0.0, for soil reinforcement overlap greater than 0.3*H

JOB NUMBER	0121-3070.03		
SHEET NO.	4	OF	42
COMP. BY	SJK	DATE	10-10-07
CHECKED BY	DAA	DATE	10-17-07

* Full height L is limited by Ramp width.

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

γ_{EMB}	= 120	pcf	Unit weight	Embankment fill
ϕ'_{EMB}	= 30	deg.	Friction ang.	Embankment fill
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 900	psf	Cohesion	Foundation soil
ϕ	= 0	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= 28	deg.	Friction ang.	Foundation soil

Loads and Parameters

ω_t	= 240	psf	Traffic loading
L=B	= 32.13	ft	Length of MSE reinforcement
L factor	= 0.85		Length factor-range (0.7 - 1.0)
D	= 3	ft	Embedment depth
Dw	= 0	ft	Groundwater depth
H+D	= 37.8	ft	
H	= 34.8	ft	Height of wall
Ka	= **0.00**		
Γ Pa	= 12.6	ft	Moment arm
Γ Wt	= 18.9	ft	Moment arm
B'	= 32.13	ft	
γ'	= 57.6	pcf	
W_t	7,711	lb/ft of wall	Weight from traffic
W_{mse}	= 145,742	lb/ft of wall	Weight from MSE wall

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 4,776 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma B N_\gamma$$

q_{ULT} = 4,799 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 1,920 psf

Factor of Safety = 1.00 **No Good**

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma B N_\gamma$$

q_{ULT} = 18,015 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 7,206 psf

Factor of Safety = 3.77 **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	25.80
N_q	1.00	N_q	14.72
N_γ	0.00	N_γ	16.72

Eccentricity of Resultant Force

e = 0.00 ft

Kern

e < L/6 = 5.36 ft

DLZ

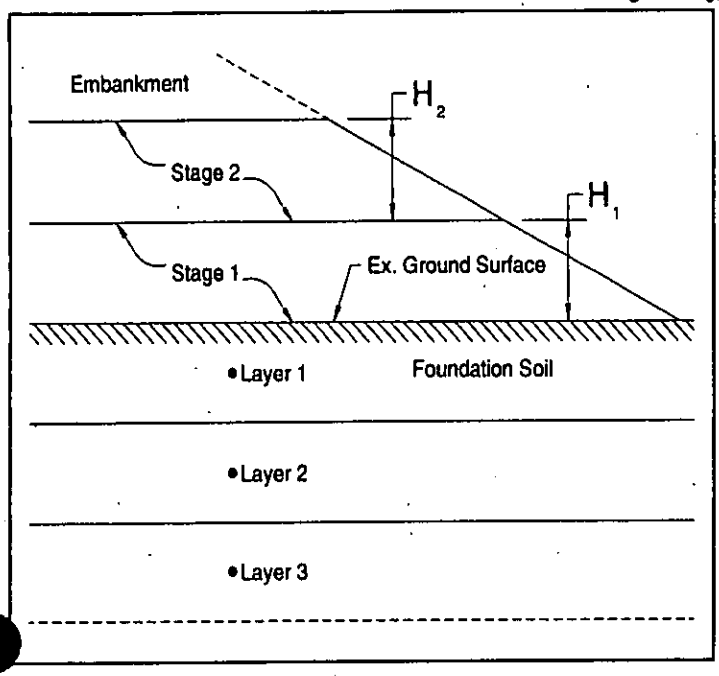
SUBJECT

Client	CH2M Hill	JOB NUMBER	0121-3070.03
Project	SCI-823 Portsmouth Bypass	SHEET NO.	5 OF 42
Item	Undrained Strength Analysis - Staged Const.	COMP. BY	SJK DATE 10-10-07
MSE wall No. 4, US 23 Ramp B, Sta 2604+00		CHECKED BY	DAA DATE 10-17-07

Determine Increase in Undrained Shear Strength Due to Consolidation

Undrained Strength Analysis - Staged Construction

Ref: Ladd, Charles C. (1991). "Stability Evaluation During Staged Construction." *The Twenty-Second Karl Terzaghi Lecture.*, Journal of Geotechnical Engineering, ASCE, 117(4), 540-615



Increase in Undrained Shear Strength from consolidation

$$c_u = c_{ui} + \Delta\sigma' \cdot \tan(\phi_{cu})$$

Where: c_{ui} Initial undrained shear strength, UU or q_u testing

Φ_{cu} Determined from CIU testing

$\Delta\sigma'$ Effective stress increase due to embankment loading

$$\Delta\sigma' = (H_n \cdot \gamma_{emb}) \cdot U$$

Where: U Average degree of consolidation (%)

H_n Height of Embankment, Stage n (ft)

Embankment Fill

γ_{fill} 120 pcf

Depths measured from bottom of leveling pad excavation, below MSE retaining wall

Stage 1 Embankment First Stage Embankment Height H_1= **13.0** Average Percent Consolidation U= **90%**

Depth	Soil Type	Initial Undrained Shear Strength, c_{ui} (psf)	$\Delta\sigma'$ (psf)	Φ_{cu} (deg)	Δc_u (psf)	c_u (psf), *After Consolidation*	Percent Increase
3.0-7.2	A-6a	2000	1404	20.0	511	2511	26%
7.2-14.3	A-7-6	900	1404	21.3	547	1447	61%

Stage 2 Embankment Second Stage Embankment Height H_2= **11.0** Average Percent Consolidation U= **90%**

3.0-7.2	A-6a	2511	1188	20.0	432	2943	17%
7.2-14.3	A-7-6	1447	1188	21.3	463	1910	32%

Stage 3 Embankment Third Stage Embankment Height H_3= **8.0** Average Percent Consolidation U= **90%**

3.0-7.2	A-6a	2943	864	20.0	314	3257	11%
7.2-14.3	A-7-6	1910	864	21.3	337	2247	18%

The fill may be placed up to the finisehd grade after consolidation under the stage 3 embankment/MSE wall

H_4=5.5' For highest wall section at the abutment MSE wall

DLZ
ENGINEERS • ARCHITECTS • SCIENTISTS
PLANNERS • SURVEYORS

CLIENT CH2M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT US 23 Ramp B, MSE Wall No. 4
Staged Construction Details

PROJECT NO. 0121-3070.03
SHEET NO. 6 OF 42
COMP. BY SJK DATE 10-15-07
CHECKED BY DAA DATE 10-17-07

* Based on bearing capacity calculations, staged construction is required for Wall No. 4, Ramp B.

- Height of 1st Stage; $H_1 = 13.0'$
  Max excess pore pressures; $u_e = 13.0'(120\ pcf) = 1560\ psf = 10.8\ psi$
  Prior to placing 2nd stage, u_e should dissipate to U = 90%
  $u_{e_{90}} = (1-.90)(10.8\ psi) = \underline{1.08\ psi}$

- Height of 2nd Stage; $H_2 = 11.0'$
  Max excess pore pressures; $u_e = 11.0'(120\ pcf) = 1320\ psf = 9.2\ psi$
  Prior to placing 3rd Stage, u_e should dissipate to U = 90%
  $u_e = (1-.90)(9.2\ psi) = \underline{0.92\ psi}$

- Height of 3rd Stage; $H_3 = 8.0'$
  Max excess pore pressures; $u_e = 8.0'(120\ pcf) = 960\ psf = 6.7\ psi$
  Prior to placing final stage, u_e should dissipate to U = 80%
  $u_e = (1-.90)(6.7\ psi) = \underline{0.67\ psi}$

Place remaining fill; $H_4 = 5.5'$ $H_{full\ height} = 40.5'$ at abutment

DLZ

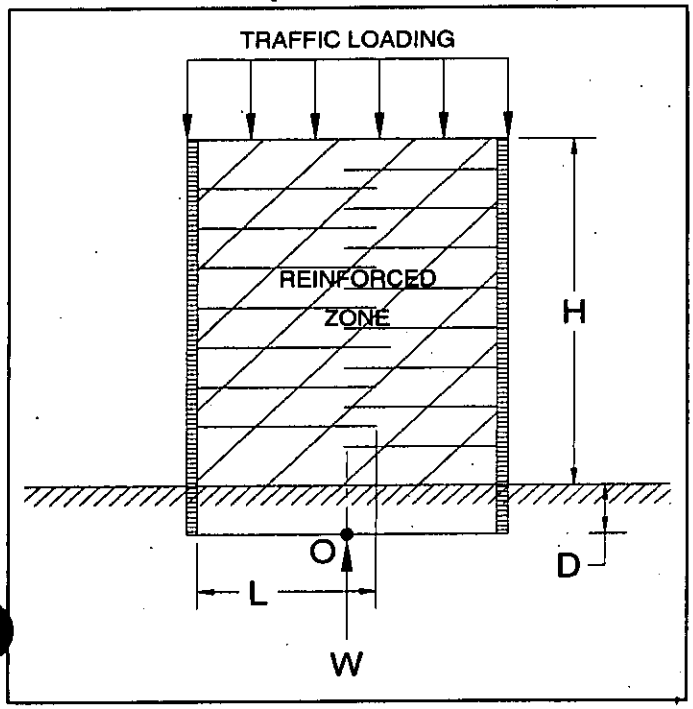
SUBJECT

Client	CH2M Hill	JOB NUMBER	0121-3070.03
Project	SCI-823 Portsmouth Bypass	SHEET NO.	7 OF 42
Item	MSE Wall Bearing Capacity	COMP. BY	SJK DATE 10-10-07
Wall No 4, Station 2604+00, BACK-TO-BACK WALLS		CHECKED BY	DAA DATE 10-17-07

Stage 1 controlled by wall section with Ka=0.33 **STAGE 1**

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

γ_{EMB}	= 120	pcf	Unit weight	Embankment fill
ϕ'_{EMB}	= 30	deg.	Friction ang.	Embankment fill
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 900	psf	Cohesion	Foundation soil
ϕ	= 0	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= 28	deg.	Friction ang.	Foundation soil

Loads and Parameters

ω_t	= 240	psf	Traffic loading	
L=B	= **32.13**	ft	Length of MSE reinforcement	
L factor	= 0.85		Length factor-range (0.7 - 1.0)	
D	= 3	ft	Embedment depth	
Dw	= 0	ft	Groundwater depth	
H+D	= 16	ft		
H	= 13	ft	Height of wall	
Ka	= **0.33**			
Γ Pa	= 5.3333	ft	Moment arm	
Γ Wt	= 8	ft	Moment arm	
B'	= 31.05	ft		
γ'	= 57.6	pcf		
W_t	7,711	lb/ft of wall	Weight from traffic	
W_{mse}	= 61,690	lb/ft of wall	Weight from MSE wall	

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 2,235 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 4,799 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 1,920 psf

Factor of Safety = *2.15 **No Good**

*See multi-layered bearing capacity calculations page 8 of 42

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 17,495 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 6,998 psf

Factor of Safety = **7.83** **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	25.80
N_q	1.00	N_q	14.72
N_γ	0.00	N_γ	16.72

Eccentricity of Resultant Force

e = 0.54 ft

Kern

e < L/6 = 5.36 ft

DLZ

CLIENT	CH2M Hill	JOB NUMBER	0121-3070.03
PROJECT	SCI-823 Portsmouth Bypass	SHEET NO.	8 of 42
SUBJECT	Multi-Layered Bearing Capacity	COMP. BY	SJK Date 10-10-07
	MSE wall No. 4, US 23 Ramp B, Sta 2604+00	CHECKED BY	DAA Date 10-17-07

Bearing Capacity
Stiff Over Soft Clay

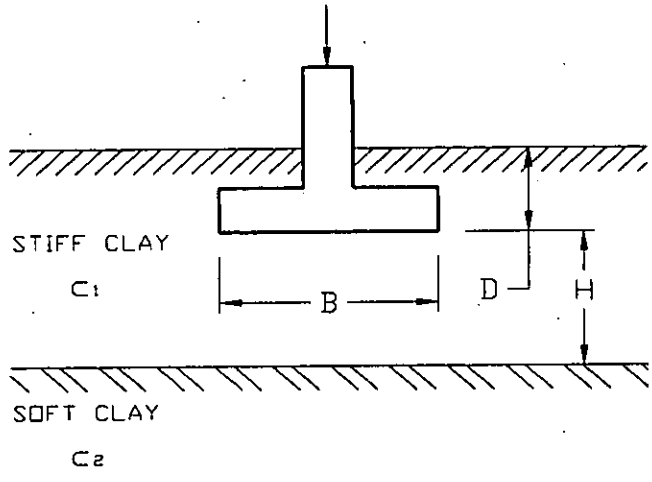
Stage 1

AASHTO, Standard Specifications for Highway Bridges, 17th Ed - 2002

Note:
Used for analysis of ramp B MSE retaining walls.
Stage 1, Using initial undrained strengths

Input

Footing Width (ft)	B	34
Length of Footing (ft)	L	200
Depth below footing to Soil Layer 2	H	4.2
Cohesion of upper soil layer 1	c_1	2000
Cohesion of lower soil layer 2	c_2	900
Bearing Capacity Factors (φ=0)	N_c	5.14
Bearing Capacity Factors (φ=0)	N_q	1.00
Effective overburnden pressure, D*γ	q	360
Factor of Safety	FS	2.5



Shape Factor	s_c	1.03	$s_c = 1 + \left(B/L\right)\left(N_q/N_c\right)$	Eq: 4.4.7.1.1.2-1
Ratio of Cohesion Values	κ	0.45	$\kappa = c_2/c_1$	
Punching Index	β_m	3.46	$\beta_m = BL/[2(B+L)H]$	
Modified Bearing Capacity Factor	N_m	2.68	$N_m = (1/\beta_m + \kappa s_c N_c) \le s_c N_c$	Eq: 4.4.7.1.1.7-2
Ultimate Undrained Bearing Capacity (psf)	q_{ULT}	5,717	$q_{ULT} = c_1 N_m + q$	Eq: 4.4.7.1.1.7-1
Allowable Undrained Bearing Capacity (psf)	q_{ALL}	**2,287**	$q_{ALL} = q_{ULT}/FS$	

Using FS = 2.5 for undrained bearing capacity;

q_{all} = 2,287 psf > 2,235 = σ_v for Stage 1 = 16'

Stage 1 = 16' - 3' (embedment) = 13'
Treat 13' as consolidating stress.

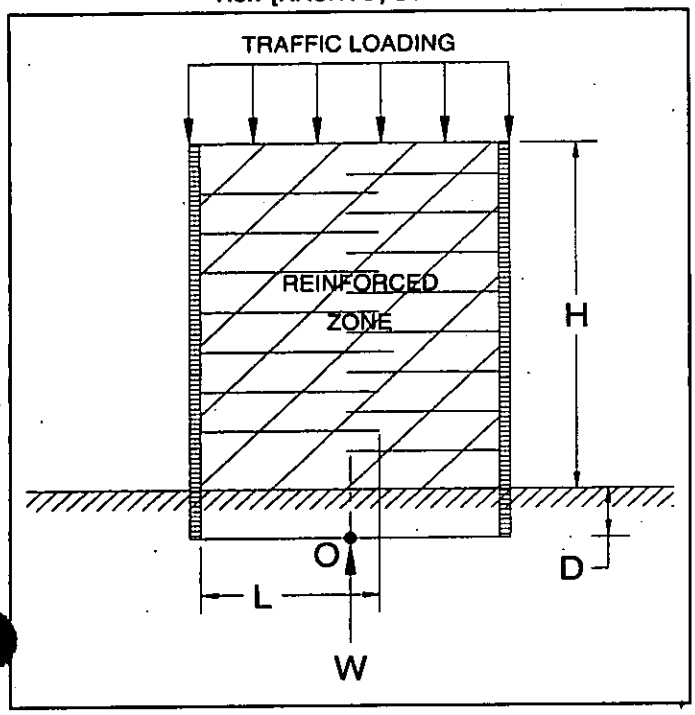
DLZ

SUBJECT

Client	CH2M Hill	JOB NUMBER	0121-3070.03
Project	SCI-823 Portsmouth Bypass	SHEET NO.	9 OF 42
Item	MSE Wall Bearing Capacity	COMP. BY	SJK DATE 10-10-07
Wall No 4, Station 2604+00, BACK-TO-BACK WALLS		CHECKED BY	DAA DATE 10-17-07
Ka=0.0, for soil reinforcement overlap greater than 0.3*H		STAGE 2	

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

γ_{EMB}	= 120	pcf	Unit weight	Embankment fill
ϕ'_{EMB}	= 30	deg.	Friction ang.	Embankment fill
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 1447	psf	Cohesion	Foundation soil
ϕ	= 0	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= 28	deg.	Friction ang.	Foundation soil

Loads and Parameters

ω_t	= 240	psf	Traffic loading	
L=B	= 32.13	ft	Length of MSE reinforcement	
L factor	= 0.85		Length factor-range (0.7 - 1.0)	
D	= 3	ft	Embedment depth	
Dw	= 0	ft	Groundwater depth	
H+D	= 27	ft		
H	= 24	ft	Height of wall	
Ka	= **0.00**			
Γ Pa	= 9	ft	Moment arm	
Γ Wt	= 13.5	ft	Moment arm	
B'	= 32.13	ft		
γ'	= 57.6	pcf		
W_t	7,711	lb/ft of wall	Weight from traffic	
W_{mse}	= 104,101	lb/ft of wall	Weight from MSE wall	

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 3,480 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 7,610 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 3,044 psf

Factor of Safety = 2.19 * **No Good**

* See multi-layered bearing capacity calculations page 10 of 42

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 18,015 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 7,206 psf

Factor of Safety = **5.18** **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	25.80
N_q	1.00	N_q	14.72
N_γ	0.00	N_γ	16.72

Eccentricity of Resultant Force

e = 0.00 ft

Kern

e < L/6 = 5.36 ft

DLZ

CLIENT	CH2M Hill	JOB NUMBER	0121-3070.03
PROJECT	SCI-823 Portsmouth Bypass	SHEET NO.	10 of 42
SUBJECT	Multi-Layered Bearing Capacity	COMP. BY	SJK Date 10-10-07
MSE wall No. 4, US 23 Ramp B, Sta 2604+00		CHECKED BY	DAA Date 10-17-07

Bearing Capacity
Stiff Over Soft Clay

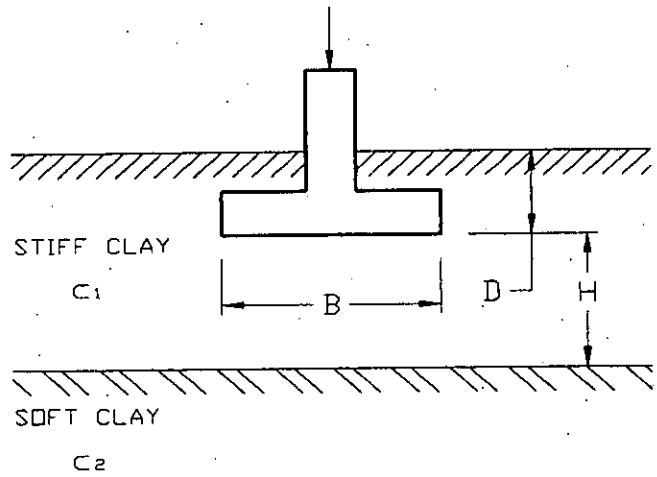
Stage 2

AASHTO, Standard Specifications for Highway Bridges, 17th Ed - 2002

Note:
Used for analysis of ramp B MSE retaining walls.
Stage 2, Using undrained strengths after consolidation under stage 1

Input

Footing Width (ft)	B	34
Length of Footing (ft)	L	200
Depth below footing to Soil Layer 2	H	4.2
Cohesion of upper soil layer 1	c_1	2511
Cohesion of lower soil layer 2	c_2	1447
Bearing Capacity Factors (φ=0)	N_c	5.14
Bearing Capacity Factors (φ=0)	N_q	1.00
Effective overburnden pressure, D*γ	q	360
Factor of Safety	FS	2.5



Shape Factor	s_c	1.03	$s_c = 1 + \left(B/L\right)\left(N_q/N_c\right)$	Eq: 4.4.7.1.1.2-1
Ratio of Cohesion Values	κ	0.57626	$\kappa = c_2/c_1$	
Punching Index	β_m	3.46	$\beta_m = BL/[2(B+L)H]$	
Modified Bearing Capacity Factor	N_m	3.35	$N_m = (1/\beta_m + \kappa s_c N_c) \le s_c N_c$	Eq: 4.4.7.1.1.7-2
Ultimate Undrained Bearing Capacity (psf)	q_{ULT}	8,769	$q_{ULT} = c_1 N_m + q$	Eq: 4.4.7.1.1.7-1
Allowable Undrained Bearing Capacity (psf)	q_{ALL}	**3,508**	$q_{ALL} = q_{ULT}/FS$	

Using FS = 2.5 for undrained bearing capacity;

q_{all} = 3,508 > 3,480 = σ_v for Stage 2 = 24'

Stage 2; H_2 = 24 - 13 = 11'

DLZ

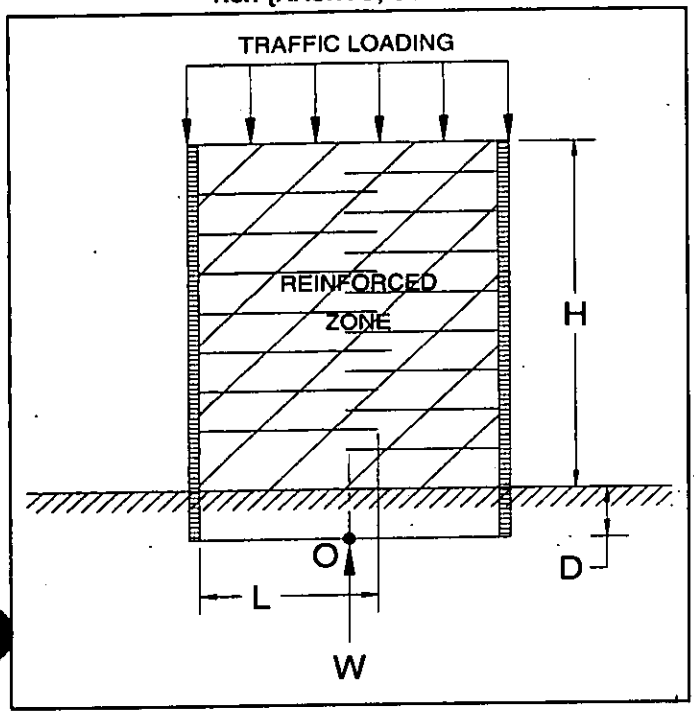
SUBJECT

Client	CH2M Hill
Project	SCI-823 Portsmouth Bypass
Item	MSE Wall Bearing Capacity
Wall No 4, Station 2604+00, BACK-TO-BACK WALLS	
Ka=0.0, for soil reinforcement overlap greater than 0.3*H	

JOB NUMBER 0121-3070.03
SHEET NO. 11 OF 42
COMP. BY SAK DATE 10-10-07
CHECKED BY DAA DATE 10-17-07
STAGE 3

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

γ_{EMB}	= 120	pcf	Unit weight	Embankment fill
ϕ'_{EMB}	= 30	deg.	Friction ang.	Embankment fill
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 1910	psf	Cohesion	Foundation soil
ϕ	= 0	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= 28	deg.	Friction ang.	Foundation soil

Loads and Parameters

ω_t	= 240	psf	Traffic loading
L=B	= 32.13	ft	Length of MSE reinforcement
L factor	= 0.85		Length factor-range (0.7 - 1.0)
D	= 3	ft	Embedment depth
Dw	= 0	ft	Groundwater depth
H+D	= 35	ft	
H	= 32	ft	Height of wall
Ka	= 0.00		
Γ Pa	= 11.667	ft	Moment arm
Γ Wt	= 17.5	ft	Moment arm
B'	= 32.13	ft	
γ'	= 57.6	pcf	
W_t	7,711	lb/ft of wall	Weight from traffic
W_{mse}	= 134,946	lb/ft of wall	Weight from MSE wall

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 4,440 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 9,990 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 3,996 psf

Factor of Safety = 2.25* **No Good**

* See multi-layered bearing capacity calculations page 12 of 42

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 18,015 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 7,206 psf

Factor of Safety = **4.06** **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	25.80
N_q	1.00	N_q	14.72
N_γ	0.00	N_γ	16.72

Eccentricity of Resultant Force

e = 0.00 ft

Kern

e < L/6 = 5.36 ft

DLZ

CLIENT	CH2M Hill		JOB NUMBER	0121-3070.03	
PROJECT	SCI-823 Portsmouth Bypass		SHEET NO.	12	of 42
SUBJECT	Multi-Layered Bearing Capacity		COMP. BY	SJK	Date 10-10-07
MSE wall No. 4, US 23 Ramp B, Sta 2604+00			CHECKED BY	DAA	Date 10-17-07

Bearing Capacity
Stiff Over Soft Clay

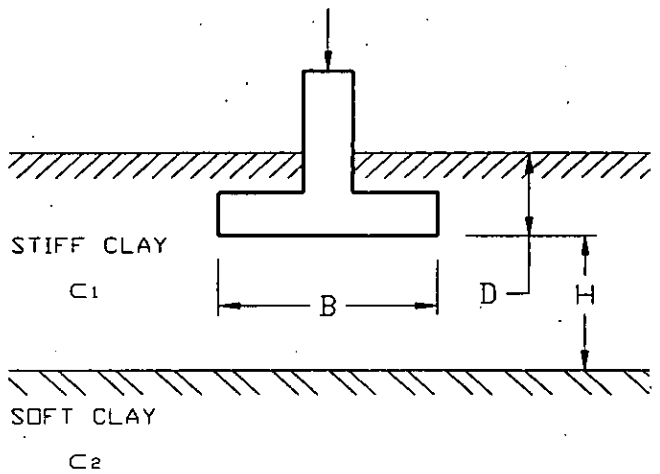
Stage 3

AASHTO, Standard Specifications for Highway Bridges, 17th Ed - 2002

Note:
Used for analysis of ramp B MSE retaining walls.
Stage 3, Using undrained strengths after consolidation under stage 2

Input

Footing Width (ft)	B	34
Length of Footing (ft)	L	200
Depth below footing to Soil Layer 2	H	4.2
Cohesion of upper soil layer 1	c_1	2943
Cohesion of lower soil layer 2	c_2	1910
Bearing Capacity Factors (φ=0)	N_c	5.14
Bearing Capacity Factors (φ=0)	N_q	1.00
Effective overburnden pressure, D*γ	q	360
Factor of Safety	FS	2.5



Shape Factor	s_c	1.03	$s_c = 1 + \left(B/L\right)\left(N_q/N_c\right)$	Eq: 4.4.7.1.1.2-1
Ratio of Cohesion Values	κ	0.649	$\kappa = c_2/c_1$	
Punching Index	β_m	3.46	$\beta_m = BL/[2(B+L)H]$	
Modified Bearing Capacity Factor	N_m	3.74	$N_m = (1/\beta_m + \kappa s_c N_c) \le s_c N_c$	Eq: 4.4.7.1.1.7-2
Ultimate Undrained Bearing Capacity (psf)	q_{ULT}	11,353	$q_{ULT} = c_1 N_m + q$	Eq: 4.4.7.1.1.7-1
Allowable Undrained Bearing Capacity (psf)	q_{ALL}	**4,541**	$q_{ALL} = q_{ULT}/FS$	

Using FS = 2.5 for undrained bearing capacity;
q_{all} = 4,541 psf > 4,440 psf = σ_v for Stage 2 = 32'

Stage 3; $H_3 = 32' - 24' = 8'$

DLZ

CLIENT	CH2M Hill	JOB NUMBER	0121-3070.03
PROJECT	SCI-823 Portsmouth Bypass	SHEET NO.	13 of 42
SUBJECT	Multi-Layered Bearing Capacity	COMP. BY	SJR Date 10-10-07
	MSE wall No. 4, US 23 Ramp B, Sta 2604+00	CHECKED BY	DAA Date 10-17-07

Bearing Capacity
Stiff Over Soft Clay

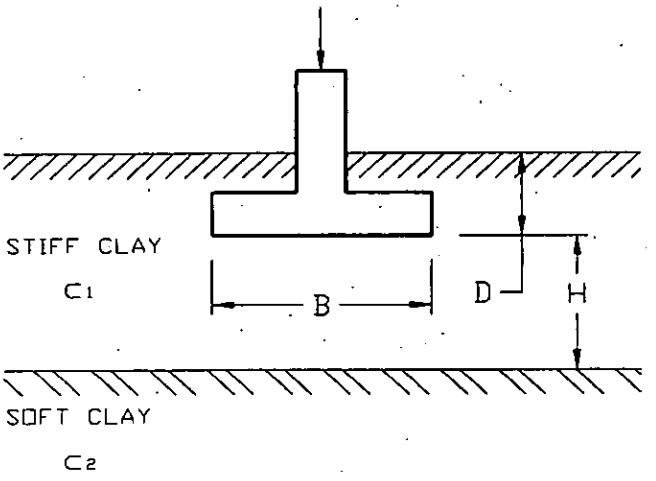
Stage 4

AASHTO, Standard Specifications for Highway Bridges, 17th Ed - 2002

Note:
Used for analysis of ramp B MSE retaining walls.
Stage 4, Using undrained strengths after consolidation under stage 3

Input

Footing Width (ft)	B	34
Length of Footing (ft)	L	200
Depth below footing to Soil Layer 2	H	4.2
Cohesion of upper soil layer 1	c_1	3257
Cohesion of lower soil layer 2	c_2	2247
Bearing Capacity Factors (φ=0)	N_c	5.14
Bearing Capacity Factors (φ=0)	N_q	1.00
Effective overburnden pressure, D*γ	q	360
Factor of Safety	FS	2.5



Shape Factor	s_c	1.03	$s_c = 1 + (B/L)(N_q/N_c)$	Eq: 4.4.7.1.1.2-1
Ratio of Cohesion Values	κ	0.6899	$\kappa = c_2/c_1$	
Punching Index	β_m	3.46	$\beta_m = BL/[2(B+L)H]$	
Modified Bearing Capacity Factor	N_m	3.95	$N_m = (1/\beta_m + \kappa s_c N_c) \le s_c N_c$	Eq: 4.4.7.1.1.7-2
Ultimate Undrained Bearing Capacity (psf)	q_{ULT}	13,233	$q_{ULT} = c_1 N_m + q$	Eq: 4.4.7.1.1.7-1
Allowable Undrained Bearing Capacity (psf)	q_{ALL}	**5,293**	$q_{ALL} = q_{ULT}/FS$	

Prior to placing remaining fill, $q_{all} = 5,293$ psf

DLZ

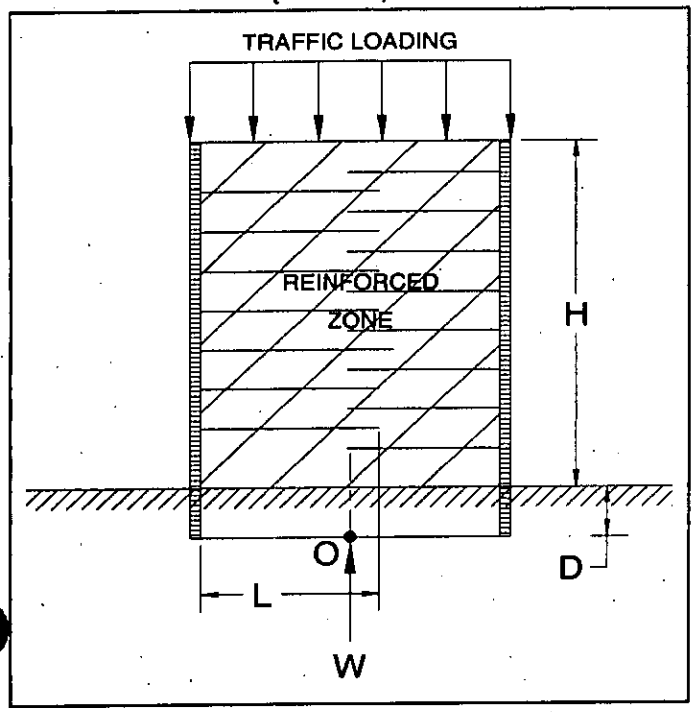
SUBJECT

Client	CH2M Hill	JOB NUMBER	0121-3070.03
Project	SCI-823 Portsmouth Bypass	SHEET NO.	14 OF 42
Item	MSE Wall Bearing Capacity	COMP. BY	SJK DATE 10-10-07
Wall No 4, Station 2604+00, BACK-TO-BACK WALLS		CHECKED BY	DAA DATE 10-17-07

Ka=0.0, for soil reinforcement overlap greater than 0.3*H ABUTMENT WALL - Full Height

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

γ_{EMB}	= 120	pcf	Unit weight	Reinforced Zone
ϕ'_{EMB}	= 34	deg.	Friction ang.	Reinforced Zone
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 900	psf	Cohesion	Foundation soil
ϕ	= 0	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= 28	deg.	Friction ang.	Foundation soil

Loads and Parameters

ω_t	= 240	psf	Traffic loading
L=B	= **32.13**	ft	Length of MSE reinforcement
L factor	= 0.85		Length factor-range (0.7 - 1.0)
D	= 3	ft	Embedment depth
Dw	= 0	ft	Groundwater depth
H+D	= 40.5	ft	
H	= 37.5	ft	Height of wall
Ka	= **0.00**		
⌜ Pa	= 13.5	ft	Moment arm
⌜ Wt	= 20.25	ft	Moment arm
B'	= 32.13	ft	
γ'	= 57.6	pcf	
W_t	7,711	lb/ft of wall	Weight from traffic
W_{mse}	= 156,152	lb/ft of wall	Weight from MSE wall

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 5,100 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 4,799 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 1,920 psf

Factor of Safety = **0.94** **No Good**

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 18,015 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 7,206 psf

Factor of Safety = **3.53** **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	25.80
N_q	1.00	N_q	14.72
N_γ	0.00	N_γ	16.72

Eccentricity of Resultant Force

e = 0.00 ft

Kern

e < L/6 = 5.36 ft

DLZ

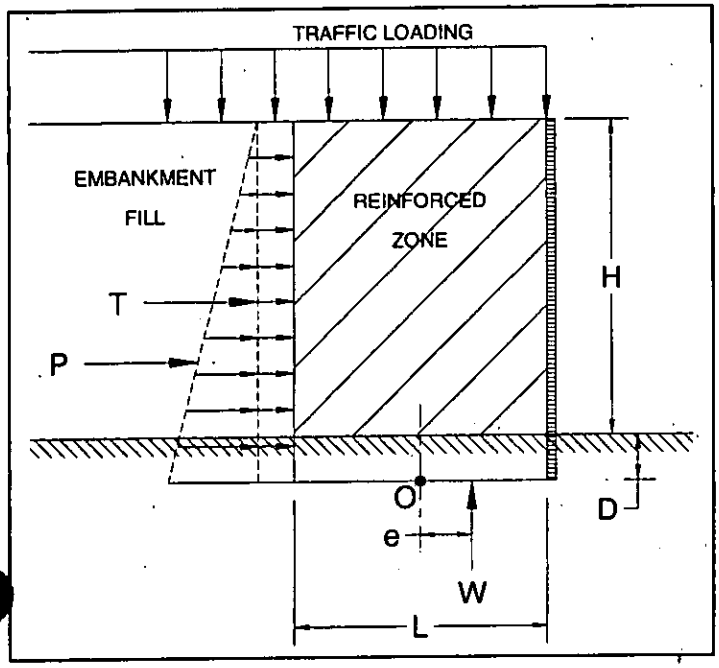
SUBJECT

Client	CH2M Hill	JOB NUMBER	0121-3070.03
Project	SCI-823 Portsmouth Bypass	SHEET NO.	15 OF 42
Item	MSE Wall Bearing Capacity	COMP. BY	SJK DATE 10-10-07
Wall No 4, Station 2602+00, DOUBLE WALL		CHECKED BY	DAA DATE 10-17-07

Use strength values from weaker (lower) soil layer *Maximum wall height with full Ka, H=20'

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

γ_{EMB}	= 120	pcf	Unit weight	Embankment fill
ϕ'_{EMB}	= 30	deg.	Friction ang.	Embankment fill
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 900	psf	Cohesion	Foundation soil
ϕ	= 0	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= 28	deg.	Friction ang.	Foundation soil

Loads and Parameters

ω_t	= 240	psf	Traffic loading	
L=B	= 20	ft	Length of MSE reinforcement	
L factor	= 1		Length factor-range (0.7 - 1.0)	
D	= 3	ft	Embedment depth	
Dw	= 0	ft	Groundwater depth	
H+D	= 20	ft		
H	= 17	ft	Height of wall	
Ka	= 0.33			
Γ Pa	= 6.6667	ft	Moment arm	
Γ Wt	= 10	ft	Moment arm	
B'	= 17.40	ft		
γ'	= 57.6	pcf		
W_t	4,800	lb/ft of wall	Weight from traffic	
W_{mse}	= 48,000	lb/ft of wall	Weight from MSE wall	

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 3,034 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 4,799 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 1,920 psf

Factor of Safety = **1.58** **No Good**

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 10,922 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 4,369 psf

Factor of Safety = **3.60** **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	25.80
N_q	1.00	N_q	14.72
N_γ	0.00	N_γ	16.72

Eccentricity of Resultant Force

e = 1.30 ft

Kern

e < L/6 = 3.33 ft

DLZ

SUBJECT

Client	CH2M Hill
Project	SCI-823 Portsmouth Bypass
Item	MSE Wall Stability
Wall No 4, Station 2602+00, Double Wall	

JOB NUMBER 0121-3070.03
SHEET NO. 16 OF 42
COMP. BY SAK DATE 10-10-07
CHECKED BY DAA DATE 10-17-07

*Maximum wall height with full Ka, H=20.0'

STABILITY OF MSE WALL

Assumptions:

1 Estimated height of embankment; H=17.0'
2 Analysis of double wall, but not reduction in Ka.
3 Ground water; Dw=0.0'
4 Traffic loading is neglected in resisting forces
5 For stability use strength values of upper soil layer

Wall Properties

H+D = 20 feet
γ_{mse} = 120 pcf
L = 20 feet
L factor = 1.00 Length factor-range (0.7 - 1.0)
ϕ = 30 deg Friction Angle of Embankment Fill

Foundational Soil Properties

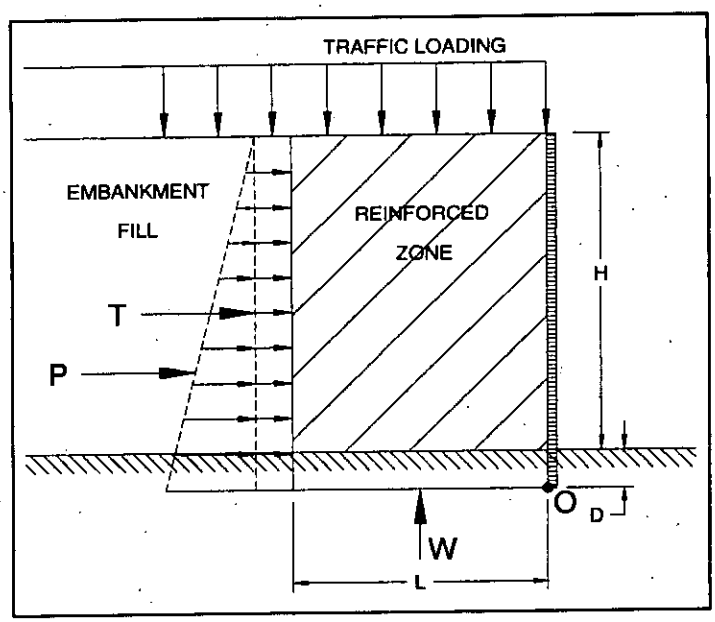
c = 2000 psf Cohesion
ϕ' = 29 deg Friction angle
ω_T = 240 psf Traffic loading

RESISTANCE AGAINST SLIDING ALONG BASE

Thrust: $P_a = K_a\left[\frac{1}{2}\gamma H^2 + \omega_T H\right]$

where; $K_a = \tan^2(45 - \frac{\phi}{2})$ K_a = 0.33

P_a = 9,504 lbs per foot of wall



Resistance: $P_r = W(\mu)$ (Drained)

where; $\mu = \left(\frac{2}{3}\right)\tan(\phi)$ μ = 0.37

P_r = 17,760 lbs per foot of wall

USE THIS VALUE

$P_r = L(c)$ (Undrained)

P_r = 40,000 lbs per foot of wall

Use Drained Value

	Calculated	Required	
$FS = \frac{P_r}{P_a}$	FS = **1.87**	FS = 1.50	Resistance Against Sliding is **OK**

RESISTANCE AGAINST OVERTURNING

* Summation of Moments about point "O" (base of wall).
* Traffic loading is neglected in resisting forces

$\Sigma M_{resisting}$ = 480,000 lb-ft $\quad \Sigma M_{resisting} = \gamma H L\left(\frac{L}{2}\right)$

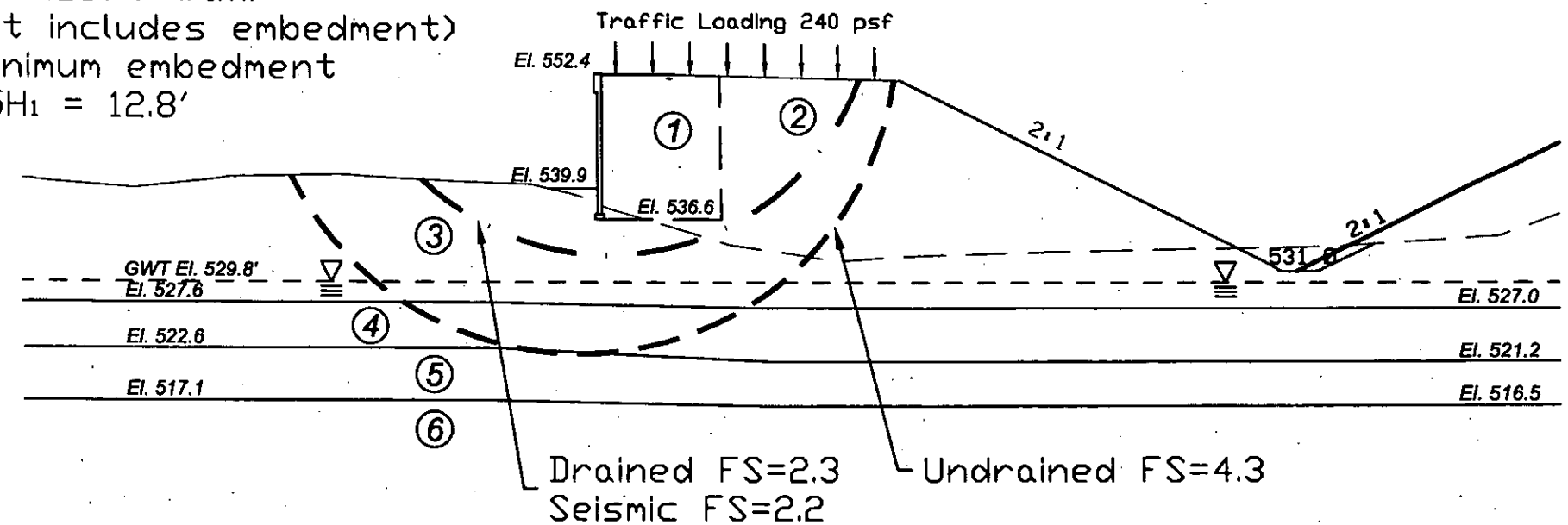
$\Sigma M_{overturning}$ = 68,640 lb-ft $\quad \Sigma M_{overturning} = K_a\left[\frac{1}{2}\gamma H^2\left(\frac{H}{3}\right) + \omega_T H\left(\frac{H}{2}\right)\right]$

	Calculated	Required	
$FS = \frac{\Sigma M_{resisting}}{\Sigma M_{overturning}}$	FS = **6.99**	FS = 2.00	Resistance Against Overturning is **OK**

Material	Consistency	Soil Type	Undrained c (psf)	Undrained ϕ (deg)	Drained c' (psf)	Drained ϕ' (deg)	γ (pcf)
Material 1	Compacted	MSE Fill	0	34	0	34	120
Material 2	Compacted	Embank Fill	0	30	0	30	120
Material 3	Possible Fill	A-4a/A-6a	2000	0	0	29	120
Material 4	Medium Stiff	A-7-6	900	0	0	28	120
Material 5	Loose	A-4a/A-4b	0	29	0	29	120
Material 6		Bedrock	10000	45	10000	45	145

Stability Analysis
Based on B-1109, B-1109A, and B-1108
US 23 Ramp B MSE Wall
Wall No. 4
H_1=15.1' (Left Wall)
(Height includes embedment)
3.0' minimum embedment
L=0.85H_1 = 12.8'

Based on Cross Section at Station 2600+75



US-23 Interchange
Ramp B Wall No. 4, Station 2600+75
Based on Borings B-1109, B-1109A, &B-1108

MSE GLOBAL STABILITY ANALYSIS

SCI-823-0.00

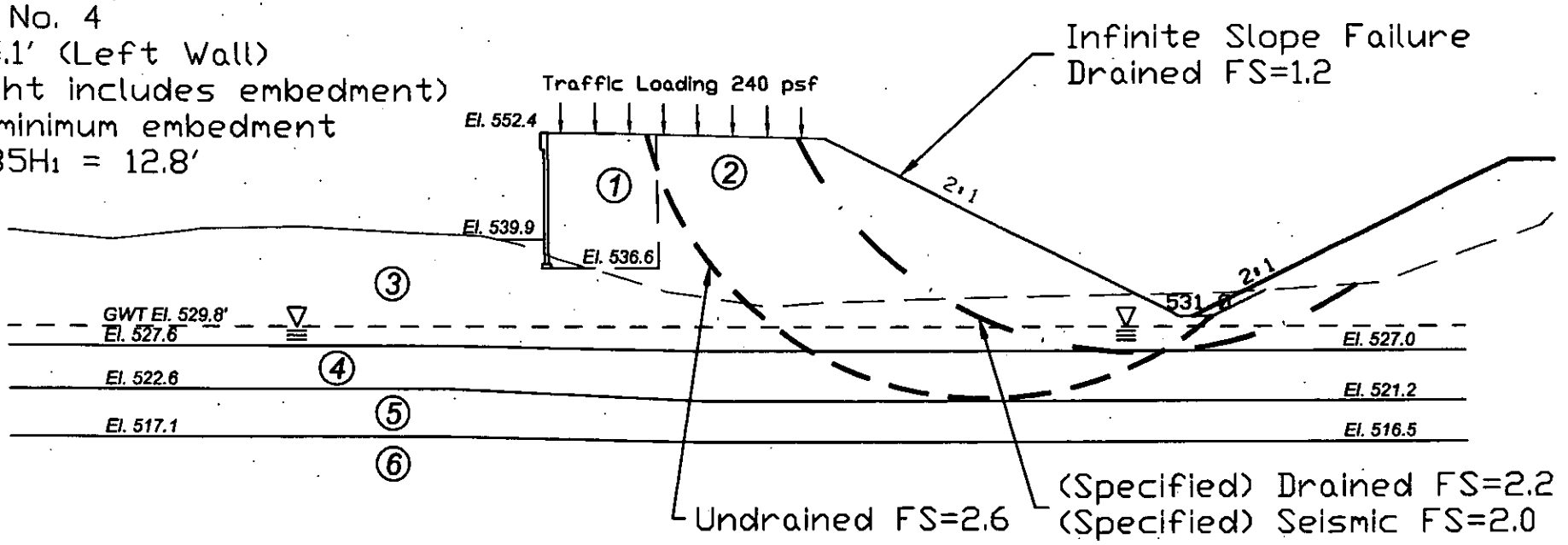
PROJECT NO. 0121-3070.03	CALC. SJR	DATE 9/14/07

Stability Analyses performed using UTEXAS3 Version 1.201

Material	Consistency	Soil Type	Undrained c (psf)	Undrained ϕ (deg)	Drained c' (psf)	Drained ϕ' (deg)	γ (pcf)
Material 1	Compacted	MSE Fill	0	34	0	34	120
Material 2	Compacted	Embank Fill	0	30	0	30	120
Material 3	Possible Fill	A-4a/A-6a	2000	0	0	29	120
Material 4	Medium Stiff	A-7-6	900	0	0	28	120
Material 5	Loose	A-4a/A-4b	0	29	0	29	120
Material 6		Bedrock	10000	45	10000	45	145

Stability Analysis
Based on B-1109, B-1109A,
and B-1108
US 23 Ramp B MSE Walls
Wall No. 4
H_1=15.1' (Left Wall)
(Height includes embedment)
3.0' minimum embedment
$L=0.85H_1$ = 12.8'

Based on Cross Section
at Station 2600+75



Stability Analyses performed using UTEXAS3 Version 1.201

US-23 Interchange
Ramp B Wall No. 4, Station 2600+75
Based on Borings B-1109, B-1109A, &B-1108

MSE GLOBAL STABILITY ANALYSIS

SCI-823-0.00

PROJECT NO. 0121-3070.03	CALC. SJR	DATE 9/14/07

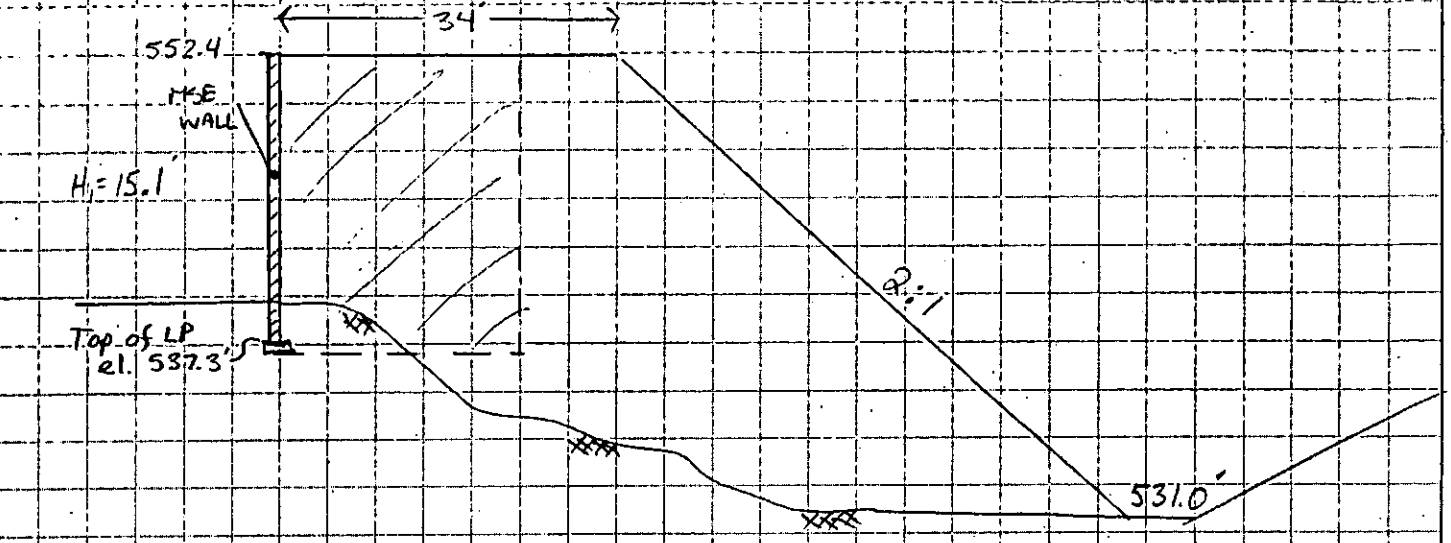
DLZ
ENGINEERS • ARCHITECTS • SCIENTISTS
PLANNERS • SURVEYORS

CLIENT CH2 M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT MSE Wall Stability

PROJECT NO. 0121-3070.03
SHEET NO. 19 OF 42
COMP. BY SAK DATE 10-10-07
CHECKED BY DAA DATE 10-17-07

Highest Single Wall Section

At Station 2600+75 el. = 552.4'



+ Nearest boring B-1107, However, use profile and strengths based upon B-1109, B-1109A and, B-1108. (More Critical)

DLZ

SUBJECT

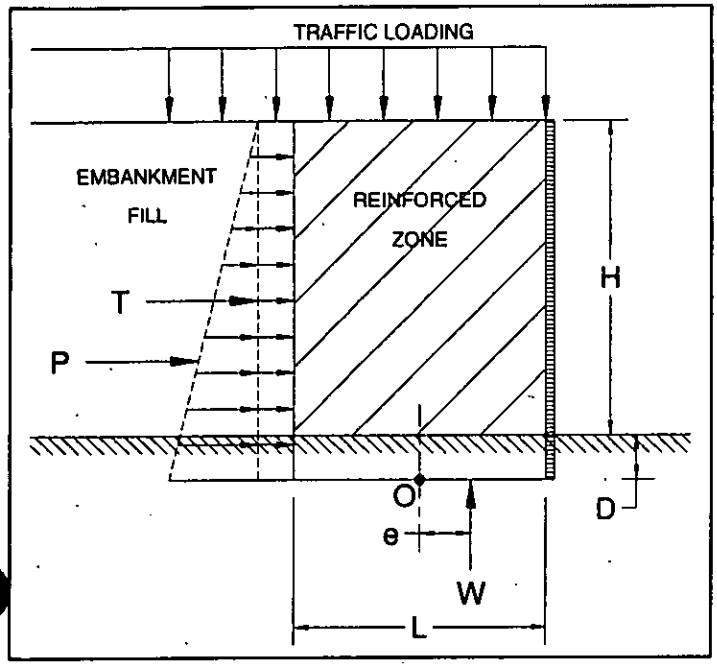
Client	CH2M Hill
Project	SCI-823 Portsmouth Bypass
Item	MSE Wall Bearing Capacity
Wall No 4, Station 2600+75, SINGLE WALL	

Use strength values from weaker (lower) soil layer

JOB NUMBER	0121-3070.03
SHEET NO.	20 OF 42
COMP. BY	SAK DATE 10-10-07
CHECKED BY	DAA DATE 10-17-07

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

γ_{EMB}	= 120	pcf	Unit weight	Embankment fill
ϕ'_{EMB}	= 30	deg.	Friction ang.	Embankment fill
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 900	psf	Cohesion	Foundation soil
ϕ	= 0	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= 28	deg.	Friction ang.	Foundation soil

Loads and Parameters

ω_t	= 240	psf	Traffic loading
L=B	= 15.1	ft	Length of MSE reinforcement
L factor	= 1		Length factor-range (0.7 - 1.0)
D	= 3	ft	Embedment depth
Dw	= 0	ft	Groundwater depth
H+D	= 15.1	ft	
H	= 12.1	ft	Height of wall
Ka	= 0.33		
Γ Pa	= 5.0333	ft	Moment arm
Γ Wt	= 7.55	ft	Moment arm
B'	= 13.06	ft	
γ'	= 57.6	pcf	
W_t	3,624	lb/ft of wall	Weight from traffic
W_{mse}	= 27,361	lb/ft of wall	Weight from MSE wall

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 2,373 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 4,799 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 1,920 psf

Factor of Safety = 2.02* **No Good**

*See multi-layer bearing capacity calculations See page 21 of 42

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 8,832 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 3,533 psf

Factor of Safety = 3.72 **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	25.80
N_q	1.00	N_q	14.72
N_γ	0.00	N_γ	16.72

Eccentricity of Resultant Force

e = 1.02 ft

Kern

e < L/6 = 2.52 ft

DLZ

CLIENT	CH2M Hill	JOB NUMBER	0121-3070.03
PROJECT	SCI-823 Portsmouth Bypass	SHEET NO.	21 of 42
SUBJECT	Multi-Layered Bearing Capacity	COMP. BY	Date 10-10-07
MSE wall No. 4, US 23 Ramp B, Sta 2600+75		CHECKED BY	Date 10-17-07

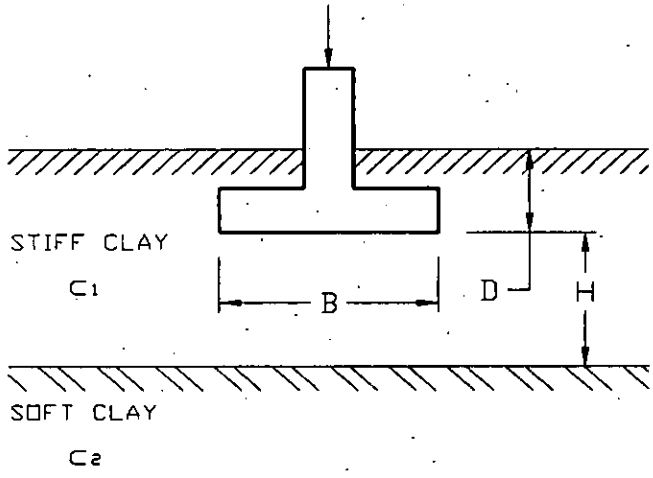
Bearing Capacity
Stiff Over Soft Clay

AASHTO, Standard Specifications for Highway Bridges, 17th Ed - 2002

Note:
Used for analysis of ramp B MSE retaining walls.
Using initial undrained strengths

Input

Footing Width (ft)	B	15.1
Length of Footing (ft)	L	200
Depth below footing to Soil Layer 2	H	9.6
Cohesion of upper soil layer 1	c_1	2000
Cohesion of lower soil layer 2	c_2	900
Bearing Capacity Factors (φ=0)	N_c	5.14
Bearing Capacity Factors (φ=0)	N_q	1.00
Effective overburnden pressure, D*γ	q	360
Factor of Safety	FS	2.5



Shape Factor	s_c	1.01	$s_c = 1 + \left(B/L\right)\left(N_q/N_c\right)$	Eq: 4.4.7.1.1.2-1
Ratio of Cohesion Values	κ	0.45	$\kappa = c_2/c_1$	
Punching Index	β_m	0.73	$\beta_m = BL/[2(B+L)H]$	
Modified Bearing Capacity Factor	N_m	3.71	$N_m = (1/\beta_m + \kappa s_c N_c) \le s_c N_c$	Eq: 4.4.7.1.1.7-2
Ultimate Undrained Bearing Capacity (psf)	q_{ULT}	7,789	$q_{ULT} = c_1 N_m + q$	Eq: 4.4.7.1.1.7-1
Allowable Undrained Bearing Capacity (psf)	q_{ALL}	**3,116**	$q_{ALL} = q_{ULT}/FS$	

Using a FS of 2.5 ;

q_{all} = 3,116 psf > 2,373 = σ_v for 15.1' MSE Wall

Undrained Bearing Capacity ⟶ OK

DLZ

SUBJECT

Client	CH2M Hill	JOB NUMBER	0121-3070.03
Project	SCI-823 Portsmouth Bypass	SHEET NO.	22 OF 42
Item	MSE Wall Stability	COMP. BY	SJH DATE 10-10-07
Wall No 4, Station 2600+75, SINGLE WALL		CHECKED BY	DAA DATE 10-17-07

STABILITY OF MSE WALL

Assumptions:

1 Estimated height of embankment; H=12.1'
2 Analysis of single wall with 2:1 slopes
3 Ground water; Dw=0.0'
4 Traffic loading is neglected in resisting forces
5 For stability use strength values of upper soil layer

Wall Properties				Foundational Soil Properties			
H+D	=	15.1	feet	c	=	2000	psf Cohesion
γ_{mse}	=	120	pcf	ϕ'	=	29	deg Friction angle
L	=	15.1	feet	ω_T	=	240	psf Traffic loading
L factor	=	1.00		Length factor-range (0.7 - 1.0)			
ϕ	=	30	deg	Friction Angle of Embankment Fill			

RESISTANCE AGAINST SLIDING ALONG BASE

Thrust: $P_a = K_a\left[\frac{1}{2}\gamma H^2 + \omega_T H\right]$

where; $K_a = \tan^2(45 - \frac{\phi}{2})$ K_a = 0.33

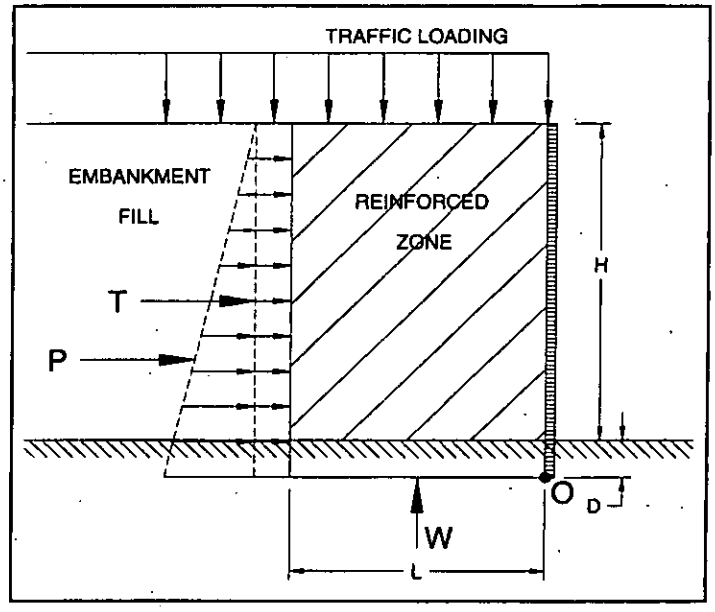
P_a = 5,711 lbs per foot of wall

Resistance: $P_r = W(\mu)$ (Drained)

where; $\mu = \left(\frac{2}{3}\right)\tan(\phi)$ μ = 0.37

P_r = 10,124 lbs per foot of wall

USE THIS VALUE



$P_r = L(c)$ (Undrained)

P_r = 30,200 lbs per foot of wall

Use Drained Value

$FS = \frac{P_r}{P_a}$

Calculated	Required	Resistance Against Sliding is
FS = **1.77**	FS = 1.50	**OK**

RESISTANCE AGAINST OVERTURNING

* Summation of Moments about point "O" (base of wall).
* Traffic loading is neglected in resisting forces

$\Sigma M_{resisting}$ = 206,577 lb-ft $\quad \Sigma M_{resisting} = \gamma H L\left(\frac{L}{2}\right)$

$\Sigma M_{overturning}$ = 31,753 lb-ft $\quad \Sigma M_{overturning} = K_a\left[\frac{1}{2}\gamma H^2\left(\frac{H}{3}\right) + \omega_T H\left(\frac{H}{2}\right)\right]$

$FS = \frac{\Sigma M_{resisting}}{\Sigma M_{overturning}}$

Calculated	Required	Resistance Against Overturning is
FS = **6.51**	FS = 2.00	**OK**

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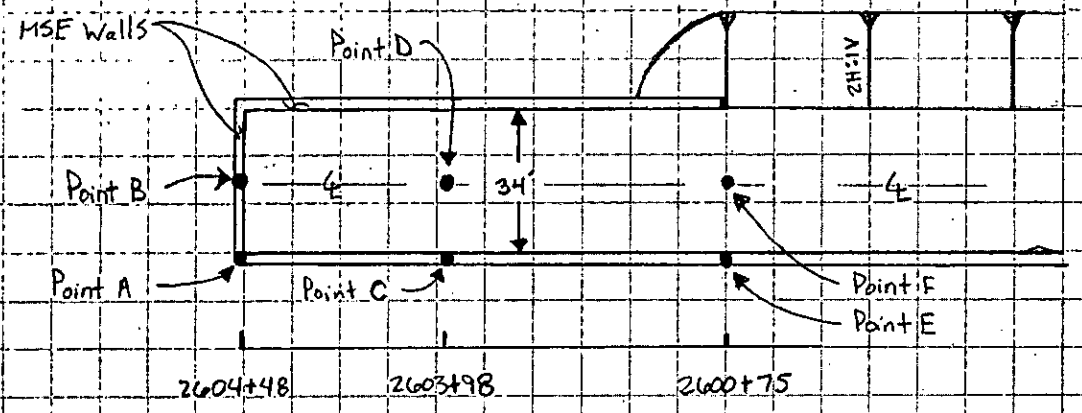
CLIENT CH2M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Consolidation Results
Settlement - Ramp B MSE Walls

PROJECT NO. 0121-3070.03
SHEET NO. 23 OF 42
COMP. BY SJK DATE 10-11-07
CHECKED BY DAA DATE 10-17-07

Plan View - Ramp B



- At abutment location: Sta. 2604+48

Point A, δ = 3.8" (at wall face / corner)
Point B, δ = 5.6" (at abutment wall centerline)

- 50' from abutment location: Sta. 2603+98

Point C, δ = 5.6" (at wall face)
Point D, δ = 8.4" (at ramp centerline)

- At station 2600+75

Point E, δ = 1.5" (at wall face)
Point F, δ = 2.6" (at ramp centerline)

Differential Settlement measured at wall face, between pt A and pt C

$$DS = \frac{(5.6" - 3.8")\left(\frac{1'}{12"}\right)}{50'} = 0.003 = 0.3\% < 1.0\% \checkmark \boxed{OK}$$

Differential Settlement measured at wall face, between pt C and pt E

$$DS = \frac{(5.6" - 1.5")\left(\frac{1'}{12"}\right)}{323'} = 0.001 = 0.1\% < 1.0\% \checkmark \boxed{OK}$$

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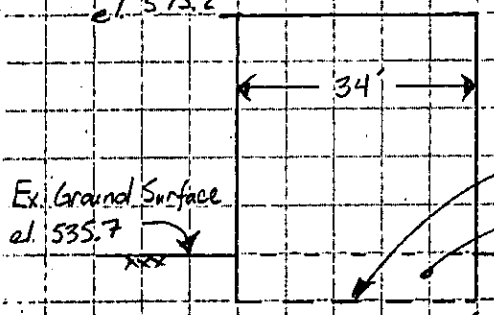
CLIENT CH2M Hill | PROJECT NO. 0121-3070.03
PROJECT SCI-823 Portsmouth Bypass | SHEET NO. 24 OF 42
SUBJECT Consolidation Parameters | COMP. BY SJK DATE 10-10-07
Settlement - Ramp B, Station 2604+48 | CHECKED BY DAA DATE 10-17-07

Evaluate Settlement at Station 2604+48; End Ramp B MSE Wall
Profile based upon borings B-1109, B-1109A, and B-1108

Cross Section View at Sta. 2604+48 - Abutment Location

$H = 575.2 - 535.7' = 39.5'$
(Above existing ground surface)

Assume Groundwater Table = 529.8'



Possible Fill A-4a/A-6a el. 527.0'	γ=120 pcf C_c=.17 C_r=.03 e_o=.639 P_c=3700 psf	• Consolidation Testing from B-1108 Sample P-1, 10.0' - A-6a/A-6b sample
Med. Stiff A-7-6/A-6b el. 521.2'	γ=120 pcf C_c=.21 C_r=.05 e_o=.734 $P_c = P_o$ Assume Norm. Consol.	• Consolidation Testing from B-1108 Sample P-3, 18.0' - A-6b sample
Loose A-4a/A-4b el. 516.5'	γ=120 pcf $\bar{N}$=4 $\bar{N}$=4 C'=25	• *Estimated from FHWA-00-045 "Soils and Foundations Workshop"

* The computer program EMBANK requires inputs for C_c, C_r, and e_o. To evaluate the settlement of cohesionless layers we must calculate equivalent consolidation parameters from C'.

$$\frac{1}{C'} = \frac{C_c}{1+e_o}$$ Say e_o = 1.0 in this case

$$\frac{1}{C'} = \frac{C_c}{1+1.0} \rightarrow \boxed{C' = \frac{2.0}{C_c}}$$

When $C' = 25$, $C_c = \frac{2.0}{25} = 0.08$

* At Station 2603+98, Use $H = 572.3 - 535.7 = 36.6'$

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CLIENT CH2M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Consolidation Parameters
Settlement - Ramp B, Station 2600+75

PROJECT NO. 0121-3070.03
SHEET NO. 25 OF 42
COMP. BY SJK DATE 10-10-07
CHECKED BY DAA DATE 10-17-07

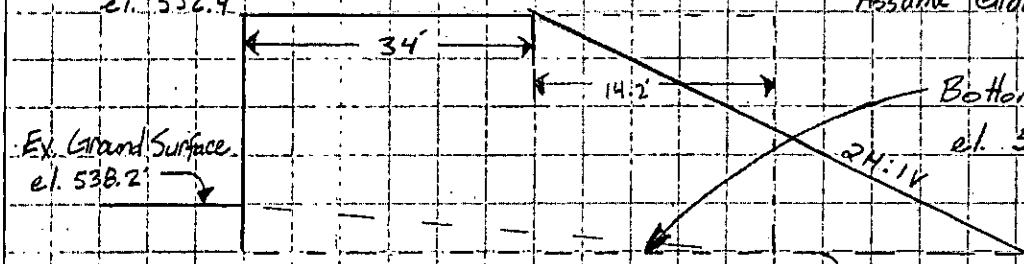
Evaluate Settlement at Station 2600+75 ; Ramp B MSE Wall Profile based upon borings B-1109, B-1109A, and B-1108.

Cross Section View at Sta 2600+75

* Transition from Single to back-to-back MSE Walls.

H = 552.4 - 538.2 = 14.2'

Assume Groundwater Table = 529.8'



Possible Fill A-4a/A-6a el. 527.6'	γ=120 pcf e_o=.639	C_c=.17 C_r=.03 P_c=3700 psf	Consolidation Testing from B-1108 Sample P-1, 10.0' - A-6a/A-6b sample
Med. Stiff A-7-6/A-6b el. 522.6'	γ=120 pcf e_o=.734	C_c=.21 C_r=.05 $P_c \cong P_o$ Assume Norm. Consol.	Consolidation Testing from B-1108 Sample P-3, 18.0' - A-6b sample
Loose A-4a/A-4b el. 516.5'	γ=120 pcf $\bar{N}$ = 4 $\bar{N}$ = 4	ϕ' = 25	*Estimated from FHWA-00-045 "Soils and Foundations Workshop"

*See Sample Calculation pg 24 of 42

* C_c = 0.08

Ramp B 2604+48 Abutment MSE Wall back-to-back

SJK 10-10-07
DHA 10-17-07

ÚÄÄÄÄÄ ONE DIMENSIONAL SETTLEMENT ANALYSIS/Federal Highway Administration ÄÄÄÄÄ¿
INCREMENT OF STRESSES BENEATH THE END OF FILL CONDITION

Project Name	: SCI-823	Client	: CH2M Hill
File Name	: RB1	Project Manager	: Nix
Date	: 10/11/07	Computed by	: sjr

Settlement for X-Direction

Embank. slope, x direc.	= 0.10 (ft)	Height of fill H	= 39.50 (ft)
y direc.	= 0.10 (ft)	Unit weight of fill	= 120.00 (pcf)
Embankment top width	= 34.00 (ft)	p load/unit area	= 4740.00 (psf)
Embankment bottom width	= 34.20 (ft)	Foundation Elev.	= 535.70 (ft)
Ground Surface Elev.	= 535.70 (ft)		
Water table Elev.	= 529.80 (ft)	Unit weight of Wat.	= 62.40 (pcf)

N§.	LAYER TYPE	THICK. (ft)	COEFFICIENT COMP.	RECOMP.	SWELL.	UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO
1	INCOMP.	4.5	-----	-----	-----	120.00	----	----
2	COMP.	4.2	0.170	0.030	0.000	120.00	2.65	0.63
3	COMP.	5.8	0.210	0.050	0.000	120.00	2.65	0.73
4	COMP.	4.7	0.080	0.080	0.000	120.00	2.65	1.00

N§.	SUBLAYER THICK. (ft)	ELEV. (ft)	SOIL STRESSES INITIAL (psf)	MAX.PAST PRESS. (psf)
1	INCOMP.			
2	4.20	529.10	748.32	3700.00
3	5.80	524.10	1036.32	1036.32
4	4.70	518.85	1338.72	1338.72

Layer	X = 0.10 Stress (psf)	Sett. (in.)	X = 3.50 Stress (psf)	Sett. (in.)	X = 6.90 Stress (psf)	Sett. (in.)	X = 10.30 Stress (psf)	Sett. (in.)
1	INCOMP.	INCOMP.	INCOMP.	INCOMP.				
2	1204.52	0.39	1872.13	0.50	2183.41	0.55	2294.48	0.57
3	1180.61	2.79	1595.19	3.42	1896.95	3.82	2072.42	4.03
4	1147.13	0.61	1430.59	0.71	1665.89	0.79	1831.19	0.84
		3.78		4.64		5.16		5.44

Pt. A

Layer	X = 13.70 Stress (psf)	Sett. (in.)	X = 17.10 Stress (psf)	Sett. (in.)
1	INCOMP.	INCOMP.		
2	2333.53	0.57	2343.40	0.57
3	2157.71	4.13	2182.78	4.16
4	1925.76	0.87	1956.18	0.88
		5.57		5.61

Pt. B

Ramp B 2603+98 MSE Wall back-to-back

SJK 10-10-07
DAA 10-17-07

ÚÄÄÄÄÄ ONE DIMENSIONAL SETTLEMENT ANALYSIS/Federal Highway Administration ÄÄÄÄÄ¿
INCREMENT OF STRESSES BENEATH THE END OF FILL CONDITION

Project Name	: SCI-823	Client	: CH2M Hill
File Name	: RB1	Project Manager	: Nix
Date	: 10/11/07	Computed by	: sjr

Settlement for X-Direction

Embank. slope, x direc. =	0.10 (ft)	Height of fill H =	36.60 (ft)
y direc. =	0.10 (ft)	Unit weight of fill =	120.00 (pcf)
Embankment top width =	34.00 (ft)	p load/unit area =	4392.00 (psf)
Embankment bottom width =	34.20 (ft)	Foundation Elev. =	535.70 (ft)
Ground Surface Elev. =	535.70 (ft)		
Water table Elev. =	529.80 (ft)	Unit weight of Wat. =	62.40 (pcf)

N§.	LAYER TYPE	THICK. (ft)	COEFFICIENT COMP.	RECOMP.	SWELL.	UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO
1	INCOMP.	4.5	-----	-----	-----	120.00	----	----
2	COMP.	4.2	0.170	0.030	0.000	120.00	2.65	0.63
3	COMP.	5.8	0.210	0.050	0.000	120.00	2.65	0.73
4	COMP.	4.7	0.080	0.080	0.000	120.00	2.65	1.00

N§.	SUBLAYER THICK. (ft)	ELEV. (ft)	SOIL STRESSES INITIAL (psf)	MAX.PAST PRESS. (psf)
1	INCOMP.			
2	4.20	529.10	748.32	3700.00
3	5.80	524.10	1036.32	1036.32
4	4.70	518.85	1338.72	1338.72

Y = 50.0

Layer	X = Stress (psf)	0.10 Sett. (in.)	X = Stress (psf)	3.50 Sett. (in.)	X = Stress (psf)	6.90 Sett. (in.)	X = Stress (psf)	10.30 Sett. (in.)
1	INCOMP.	INCOMP.	INCOMP.	INCOMP.				
2	2210.04	0.55	3433.80	0.92	4005.41	1.22	4209.76	1.31
3	2172.41	4.15	2935.61	4.93	3491.34	5.41	3814.65	5.66
4	2108.14	0.93	2630.60	1.06	3064.33	1.17	3369.09	1.23
		------		------		------		------
	Pt. C	5.63		6.92		7.79		8.21

Layer	X = Stress (psf)	13.70 Sett. (in.)	X = Stress (psf)	17.10 Sett. (in.)
1	INCOMP.	INCOMP.		
2	4281.68	1.34	4299.86	1.35
3	3971.87	5.78	4018.10	5.81
4	3543.46	1.27	3599.55	1.28
		------		------
		8.39	Pt. D	8.45

Ramp B 2600+75 MSE Wall Single Wall

SJR 10-10-07
DAA 10-17-07

ÚÄÄÄÄÄ ONE DIMENSIONAL SETTLEMENT ANALYSIS/Federal Highway Administration ÄÄÄÄÄ¿
INCREMENT OF STRESSES BENEATH THE END OF FILL CONDITION

Project Name : SCI-823 Client : CH2M Hill
File Name : RB1 Project Manager : Nix
Date : 10/11/07 Computed by : sjr

Settlement for X-Direction

Embank. slope, x direc. = 0.10 (ft) Height of fill H = 14.20 (ft)
y direc. = 0.10 (ft) Unit weight of fill = 120.00 (pcf)
Embankment top width = 34.00 (ft) p load/unit area = 1704.00 (psf)
Embankment bottom width = 34.20 (ft) Foundation Elev. = 535.70 (ft)
Ground Surface Elev. = 538.20 (ft)
Water table Elev. = 529.80 (ft) Unit weight of Wat. = 62.40 (pcf)

N§.	LAYER TYPE	THICK. (ft)	COEFFICIENT COMP.	RECOMP.	SWELL.	UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO
1	INCOMP.	2.6	-----	-----	-----	120.00	----	----
2	COMP.	8.0	0.170	0.030	0.000	120.00	2.65	0.63
3	COMP.	5.0	0.210	0.050	0.000	120.00	2.65	0.73
4	COMP.	6.1	0.080	0.080	0.000	120.00	2.65	1.00

N§.	SUBLAYER THICK. (ft)	ELEV. (ft)	SOIL STRESSES INITIAL (psf)	MAX. PAST PRESS. (psf)
1	INCOMP.			
2	8.00	531.60	792.00	3700.00
3	5.00	525.10	1278.72	1278.48
4	6.10	519.55	1598.40	1598.26

Layer	X = 0.10 Stress (psf)	Sett. (in.)	X = 3.50 Stress (psf)	Sett. (in.)	X = 6.90 Stress (psf)	Sett. (in.)	X = 10.30 Stress (psf)	Sett. (in.)
1	INCOMP.	INCOMP.	INCOMP.	INCOMP.				
2	439.08	0.34	761.01	0.52	837.67	0.55	854.61	0.56
3	426.25	0.91	588.32	1.20	700.66	1.38	761.97	1.48
4	414.25	0.29	520.98	0.36	608.70	0.41	669.38	0.44
		------		------		------		------
	P+.E	1.54		2.07		2.35		2.49

Layer	X = 13.70 Stress (psf)	Sett. (in.)	X = 17.10 Stress (psf)	Sett. (in.)
1	INCOMP.	INCOMP.		
2	859.40	0.56	860.51	0.56
3	790.33	1.52	798.46	1.54
4	703.60	0.46	714.52	0.47
		------		------
		2.55		2.57 P+.F

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CLIENT CH2M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Time - rate of consolidation & Downdrag on piles - Ramp B

PROJECT NO. 0121-3070.03
SHEET NO. 29 OF 42
COMP. BY SJK DATE 10-10-07
CHECKED BY DAA DATE 10-17-07

Rear Abutment Location

* Station 2604+48 Profile based upon boring B-1109

el. 531.2 — Bottom of Excavation

A-4a/A-6a $\overline{LL} \simeq 29$

el. 527.6 — $C_v \simeq 0.5$ ft²/day

A-7-6 $\overline{LL} \simeq 46$

el. 522.6 — $C_v \simeq 0.25$ ft²/day

A-4a/A-4b Assume Free-Draining

el. 517.1 — TOP OF ROCK

Assume double drainage

$H_v = (531.2 - 522.6)/2 = 4.3'$

Use "weighted" C_v value;

$$C_v = \frac{(3.6')(0.5\ ft^2/day) + (5.0')(0.25\ ft^2/day)}{8.6'}$$

$C_v = 0.35$ ft²/day

Time to U = 90%;

$$T_{90} = \frac{T_v \cdot H_v^2}{C_v} = \frac{0.848\ (4.3')^2}{0.35\ ft^2/day} = 45 \text{ days}$$

* Downdrag at Rear Abutment

To prevent downdrag forces from reducing the allowable capacity of the piles, the remaining settlement should be limited to 0.4 inches or less prior to driving piles.

Settlement at the ℄ of abutment wall, $\delta = 5.6"$

Of the 5.6", 4.7" is consolidation settlement.

$\left(1 - \frac{0.4"}{4.7"}\right) = 0.91$ OR $U = 91\%$

Prior to driving piles, $U = 91\%$ * Say $U = 90\%$

DLZ

Time Rate of Consolication of Foundation Soils with Wick Drians

US 23 Ramp B **Station** **2598+23 to 2604+48**

Reference: FHWA-RD-86-168

SAK 10-10-07
DAA 10-17-07

Wick Drain Spacing **5.0** feet Use $\eta = 10$

t (days)	T_R	T_V	U_R	U_V	U_C	δ(inches)	d_e	c_v	H_v	δ_{max}
0	0.0000	0.0000	0.00	0.00	0.0	0.0	5.25	0.35	4.3	4.7
5	0.0635	0.0946	0.29	0.35	53.4	2.5				
10	0.1270	0.1893	0.49	0.51	75.1	3.5				
15	0.1905	0.2839	0.63	0.62	86.1	4.0				
20	0.2540	0.3786	0.74	0.69	91.8	4.3				
25	0.3175	0.4732	0.81	0.74	95.0	4.5				
30	0.3810	0.5679	0.86	0.78	96.9	4.6				
35	0.4444	0.6625	0.89	0.83	98.1	4.6				
40	0.5079	0.7572	0.91	0.87	98.8	4.6				
45	0.5714	0.8518	0.93	0.90	99.3	4.7				

Assumes a Triangular Grid Layout

DLZ

Time Rate of Consolication of Foundation Soils with Wick Drians
US 23 Ramp B Station 2598+23 to 2604+48
Reference: FHWA-RD-86-168

Wick Drain Spacing **7.0** feet Use $\eta = 10$

t (days)	T_R	T_V	U_R	U_V	U_C	δ (inches)	d_e	c_v	H_v	δ_{max}
0	0.0000	0.0000	0.00	0.00	0.0	0.0	7.35	**0.35**	**4.3**	**4.7**
5	0.0324	0.0946	0.17	0.35	45.5	2.1				
10	0.0648	0.1893	0.29	0.51	65.7	3.1				
15	0.0972	0.2839	0.40	0.62	77.3	3.6				
20	0.1296	0.3786	0.49	0.69	84.3	4.0				
25	0.1620	0.4732	0.57	0.74	88.9	4.2				
30	0.1944	0.5679	0.64	0.78	92.2	4.3				
35	0.2268	0.6625	0.70	0.83	94.7	4.5				
40	0.2592	0.7572	0.74	0.87	96.6	4.5				
45	0.2915	0.8518	0.78	0.90	97.8	4.6				
50	0.3239	0.9465	0.82	0.91	98.3	4.6				
55	0.3563	1.0411	0.84	0.88	98.1	4.6				
60	0.3887	1.1357	0.86	0.78	97.0	4.6				

Assumes a Triangular Grid Layout

DLZ

Time Rate of Consolication of Foundation Soils with Wick Drians
US 23 Ramp B **Station** **2598+23 to 2604+48**
Reference: FHWA-RD-86-168

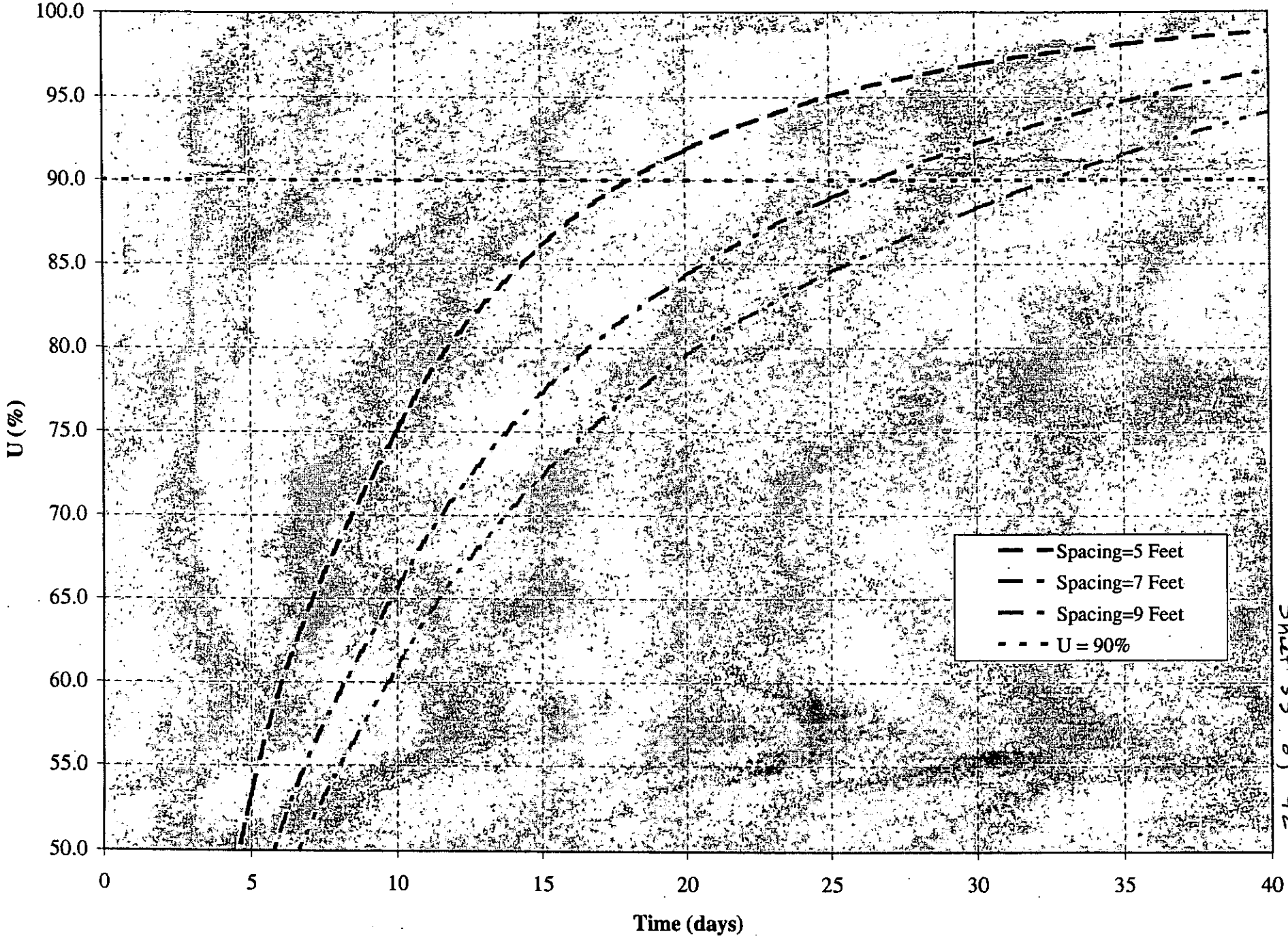
Wick Drain Spacing **9.0** feet Use $\eta = 10$

t (days)	T_R	T_V	U_R	U_V	U_C	δ(inches)	d_e	c_v	H_v	δ_{max}
0	0.0000	0.0000	0.00	0.00	0.0	0.0	9.45	0.35	4.3	4.7
5	0.0196	0.0946	0.11	0.35	41.9	2.0				
10	0.0392	0.1893	0.20	0.51	60.9	2.9				
15	0.0588	0.2839	0.27	0.62	72.4	3.4				
20	0.0784	0.3786	0.34	0.69	79.6	3.7				
25	0.0980	0.4732	0.40	0.74	84.5	4.0				
30	0.1176	0.5679	0.46	0.78	88.3	4.2				
35	0.1372	0.6625	0.51	0.83	91.5	4.3				
40	0.1568	0.7572	0.56	0.87	94.1	4.4				
45	0.1764	0.8518	0.60	0.90	96.0	4.5				
50	0.1960	0.9465	0.64	0.91	96.8	4.5				
55	0.2156	1.0411	0.68	0.88	96.1	4.5				
60	0.2352	1.1357	0.71	0.78	93.6	4.4				
65	0.2548	1.2304	0.74	0.58	89.1	4.2				

Assumes a Triangular Grid Layout

DLZ

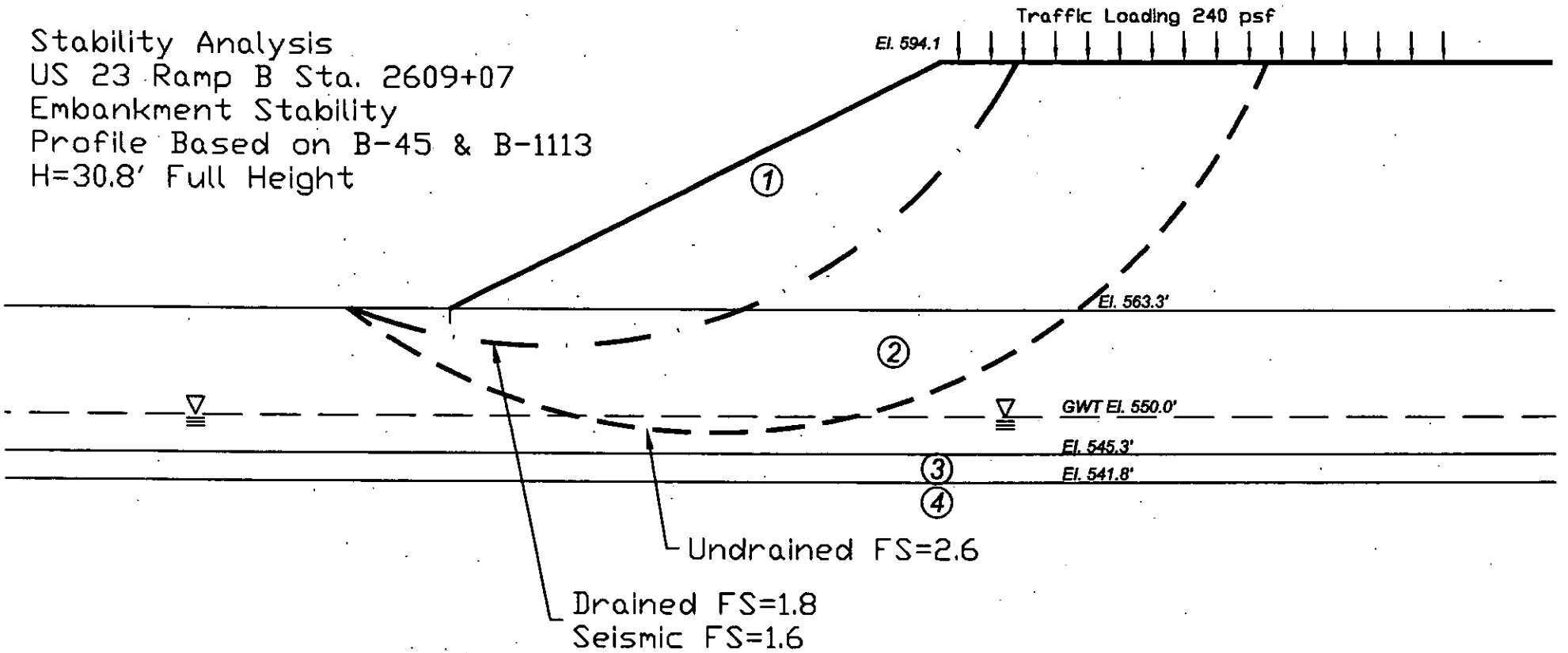
Percent Consolidation vs Time Using Prefabricated Vertical "Wick" Drains
US-23 Interchange, Ramp B (Wall No 4)



Sheet 33 of 42

			Undrained		Drained		
Material	Consistency	Soil Type	c (psf)	ϕ (deg)	c' (psf)	ϕ' (deg)	γ (pcf)
Material 1	Compacted	Emb. Fill	2000	0	300	28	120
Material 2	V. Stiff	A-6b/A-2-6	1500	0	0	29	120
Material 3	Loose	A-2-4	0	30	0	30	120
Material 4		Bedrock	10000	45	10000	45	145

Stability Analysis
US 23 Ramp B Sta. 2609+07
Embankment Stability
Profile Based on B-45 & B-1113
H=30.8' Full Height



Stability Analyses performed using UTEXAS3 Version 1.201

US-23 Interchange
Ramp B Embankment, Station 2609+07
Profile Based on B-45 and B-1113

MSE GLOBAL STABILITY ANALYSIS

SCI-823-0.00

PROJECT NO. 0121-3070.03	CALC: SJR	DATE 9/14/07

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CLIENT CH2M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Consolidation Parameters
Settlement - Ramp B, Station 2609+07

PROJECT NO. 0121-3070.03
SHEET NO. 35 OF 42
COMP. BY SJK DATE 10-11-07
CHECKED BY DAA DATE 10-17-07

Evaluate Settlement at station 2609+07, using 2H:1V Slopes
Profile based upon boring B-45 and B-1113

el. 594.1
Embankment Fill
γ = 120 pcf

*Assume groundwater table = 550.0'

el. 568.3'

A-6b/A-2-6 el. 545.3'
γ = 120 pcf C_c = .09 C_r = .01
e_o = .632 $P_c \approx P_o$

Consolidation Testing from B-45
Sample P-1, 5.0' - A-6b sample

el. 541.8'
γ = 120 pcf $\bar{N} \approx 4$
$\bar{N}$ = 4 C' = 25

Estimated from FHWA-00-045
"Soils and Foundations Workshop"

* See Sample Calculation pg 24 of 42
C_c = 0.08

Ramp B 2609+07 Spill through slopes

SJR 10-10-07
DAA 10-17-07

ÚÄÄÄÄÄ ONE DIMENSIONAL SETTLEMENT ANALYSIS/Federal Highway Administration ÄÄÄÄÄ¿
INCREMENT OF STRESSES BENEATH THE END OF FILL CONDITION

Project Name	: SCI-823	Client	: CH2M Hill
File Name	: RBS.emb	Project Manager	: Nix
Date	: 10/11/07	Computed by	: sjr

Settlement for X-Direction

Embank. slope, x direc. =	61.60 (ft)	Height of fill H =	30.80 (ft)
y direc. =	61.60 (ft)	Unit weight of fill =	120.00 (pcf)
Embankment top width =	40.00 (ft)	p load/unit area =	3696.00 (psf)
Embankment bottom width =	163.20 (ft)	Foundation Elev. =	563.30 (ft)
Ground Surface Elev. =	563.30 (ft)		
Water table Elev. =	550.00 (ft)	Unit weight of Wat. =	62.40 (pcf)

N§.	LAYER TYPE	THICK. (ft)	COEFFICIENT COMP.	RECOMP.	SWELL.	UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO
1	COMP.	18.0	0.090	0.010	0.000	120.00	2.65	0.63
2	COMP.	3.5	0.080	0.080	0.000	120.00	2.65	1.00

N§.	SUBLAYER THICK. (ft)	ELEV. (ft)	SOIL STRESSES INITIAL (psf)	MAX.PAST PRESS. (psf)
1	18.00	554.30	1080.00	1080.00
2	3.50	543.55	1967.52	1967.52

Layer	X = Stress (psf)	0.00 Sett. (in.)	X = Stress (psf)	16.32 Sett. (in.)	X = Stress (psf)	32.64 Sett. (in.)	X = Stress (psf)	48.96 Sett. (in.)
1	161.55	0.72	987.55	3.36	1947.19	5.34	2880.17	6.73
2	343.85	0.12	1024.86	0.31	1877.60	0.49	2659.62	0.62
		0.84		3.67		5.83		7.35

Layer	X = Stress (psf)	65.28 Sett. (in.)
1	3471.90	7.45
2	3132.20	0.69
		8.15

ÀÄÄÄÄÄ Hit arrow keys to display next screen. <F8> Print. <F10> Main Menu ÄÄÄÄÄÙ

Ramp B 2609+57 Spill through slopes SJK 10-10-07
DAA 10-17-07

ÚÄÄÄÄÄ ONE DIMENSIONAL SETTLEMENT ANALYSIS/Federal Highway Administration ÄÄÄÄÄ¿
INCREMENT OF STRESSES BENEATH THE END OF FILL CONDITION

Project Name	: SCI-823	Client	: CH2M Hill
File Name	: RBS.emb	Project Manager	: Nix
Date	: 10/11/07	Computed by	: sjr

Settlement for X-Direction

Embank. slope, x direc. =	61.60 (ft)	Height of fill H =	30.80 (ft)
y direc. =	61.60 (ft)	Unit weight of fill =	120.00 (pcf)
Embankment top width =	40.00 (ft)	p load/unit area =	3696.00 (psf)
Embankment bottom width =	163.20 (ft)	Foundation Elev. =	563.30 (ft)
Ground Surface Elev. =	563.30 (ft)		
Water table Elev. =	550.00 (ft)	Unit weight of Wat. =	62.40 (pcf)

N§.	LAYER TYPE	THICK. (ft)	COEFFICIENT COMP.	RECOMP.	SWELL.	UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO
1	COMP.	18.0	0.090	0.010	0.000	120.00	2.65	0.63
2	COMP.	3.5	0.080	0.080	0.000	120.00	2.65	1.00

N§.	SUBLAYER THICK. (ft)	ELEV. (ft)	SOIL STRESSES INITIAL (psf)	MAX.PAST PRESS. (psf)
1	18.00	554.30	1080.00	1080.00
2	3.50	543.55	1967.52	1967.52

Layer	X = 0.00 Stress (psf)	Sett. (in.)	X = 16.32 Stress (psf)	Sett. (in.)	X = 32.64 Stress (psf)	Sett. (in.)	X = 48.96 Stress (psf)	Sett. (in.)
1	162.95	0.73	990.79	3.37	1956.07	5.35	2915.84	6.78
2	356.61	0.12	1051.81	0.31	1938.74	0.50	2803.87	0.65
		0.85		3.68		5.85		7.42

Layer	X = 65.28 Stress (psf)	Sett. (in.)
1	3609.61	7.61
2	3396.62	0.73
		8.34

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CLIENT CHZM Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Time-rate of Consolidation
Downdrag on piles - Ramp B

PROJECT NO. 0121-3070.03
SHEET NO. 38 OF 42
COMP. BY SJH DATE 10-10-07
CHECKED BY DAA DATE 10-17-07

Forward Abutment Location
Station 2609+07 Profile based upon borings B-45 & B-1113

el. 563.3' Ex. Ground Surface
A-66/A-2-6 $\bar{LL} \approx 26$
$C_v \approx 0.65$ ft²/day
el. 545.3'
A-2-4 Assume Free Draining
el. 541.8'
TOP OF ROCK

Assume Double Drainage
$H_v = (563.3 - 545.3)/2 = 9$ ft.
Use $C_v = 0.65$ ft²/day

* Time to U = 90%

$$t_{90} = \frac{T_v H_v^2}{C_v} = \frac{0.848\,(9')^2}{0.65\ ft^2/day} = 106 \text{ days}$$

* Downdrag at Forward Abutment

To prevent downdrag forces from reducing the allowable capacity of the piles, the remaining settlement should be limited to 0.4 inches or less prior to driving piles.

Settlement at ℄ of forward abutment, $\bar{\delta} = 8.2"$
Of the 8.2", 7.5" is consolidation settlement

$$\left(1 - \frac{0.4}{7.5}\right) = 0.95 \quad OR \quad U = 95\%$$

Prior to driving piles, U = 95%

* Time to U = 95%

for U = 95%, $T_v = 1.15$

$$t_{95} = \frac{1.15\,(9')^2}{0.65\ ft^2/day} = 143 \text{ days}$$

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Time Rate of Consolication of Foundation Soils with Wick Drians

US 23 Ramp B **Station** **2609+07**

Reference: FHWA-RD-86-168

SJK 10-10-07
DAA 10-17-07

Wick Drain Spacing **5.0** feet Use $\eta = 10$

t (days)	T_R	T_V	U_R	U_V	U_C	δ(inches)	d_e	c_v	H_v	δ_{max}
0	0.0000	0.0000	0.00	0.00	0.0	0.0	5.25	0.65	9	7.5
5	0.1179	0.0401	0.46	0.21	57.3	4.3				
10	0.2358	0.0802	0.71	0.31	80.1	6.0				
15	0.3537	0.1204	0.84	0.40	90.4	6.8				
20	0.4717	0.1605	0.90	0.47	94.8	7.1				
25	0.5896	0.2006	0.93	0.53	96.9	7.3				
30	0.7075	0.2407	0.96	0.58	98.3	7.4				
35	0.8254	0.2809	0.98	0.62	99.3	7.4				
40	0.9433	0.3210	0.99	0.65	99.7	7.5				
45	1.0612	0.3611	0.96	0.68	98.8	7.4				

Assumes a Triangular Grid Layout

DLZ

Time Rate of Consolication of Foundation Soils with Wick Drians
US 23 Ramp B **Station** **2609+07**
Reference: FHWA-RD-86-168

Wick Drain Spacing **7.0** feet Use $\eta = 10$

t (days)	T_R	T_V	U_R	U_V	U_C	δ(inches)	d_e	c_v	H_v	δ_{max}
0	0.0000	0.0000	0.00	0.00	0.0	0.0	7.35	0.65	9	7.5
5	0.0602	0.0401	0.28	0.21	42.5	3.2				
10	0.1203	0.0802	0.47	0.31	63.4	4.8				
15	0.1805	0.1204	0.61	0.40	76.7	5.8				
20	0.2406	0.1605	0.72	0.47	85.1	6.4				
25	0.3008	0.2006	0.79	0.53	90.3	6.8				
30	0.3610	0.2407	0.84	0.58	93.5	7.0				
35	0.4211	0.2809	0.88	0.62	95.5	7.2				
40	0.4813	0.3210	0.91	0.65	96.7	7.3				
45	0.5414	0.3611	0.92	0.68	97.5	7.3				
50	0.6016	0.4012	0.94	0.70	98.1	7.4				
55	0.6618	0.4414	0.95	0.72	98.6	7.4				
60	0.7219	0.4815	0.96	0.74	99.0	7.4				

Assumes a Triangular Grid Layout

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Time Rate of Consolication of Foundation Soils with Wick Drians
US 23 Ramp B **Station** **2609+07**
Reference: FHWA-RD-86-168

Wick Drain Spacing **9.0** feet Use η = 10

t (days)	T_R	T_V	U_R	U_V	U_C	δ(inches)	d_e	c_v	H_v	δ_{max}
0	0.0000	0.0000	0.00	0.00	0.0	0.0	9.45	0.65	9	7.5
5	0.0364	0.0401	0.18	0.21	35.3	2.6				
10	0.0728	0.0802	0.32	0.31	53.2	4.0				
15	0.1092	0.1204	0.44	0.40	66.1	5.0				
20	0.1456	0.1605	0.53	0.47	75.3	5.7				
25	0.1820	0.2006	0.62	0.53	81.9	6.1				
30	0.2184	0.2407	0.68	0.58	86.6	6.5				
35	0.2548	0.2809	0.74	0.62	90.0	6.7				
40	0.2911	0.3210	0.78	0.65	92.4	6.9				
45	0.3275	0.3611	0.82	0.68	94.2	7.1				
50	0.3639	0.4012	0.85	0.70	95.5	7.2				
55	0.4003	0.4414	0.87	0.72	96.4	7.2				
60	0.4367	0.4815	0.89	0.74	97.1	7.3				
65	0.4731	0.5216	0.90	0.76	97.7	7.3				

Assumes a Triangular Grid Layout

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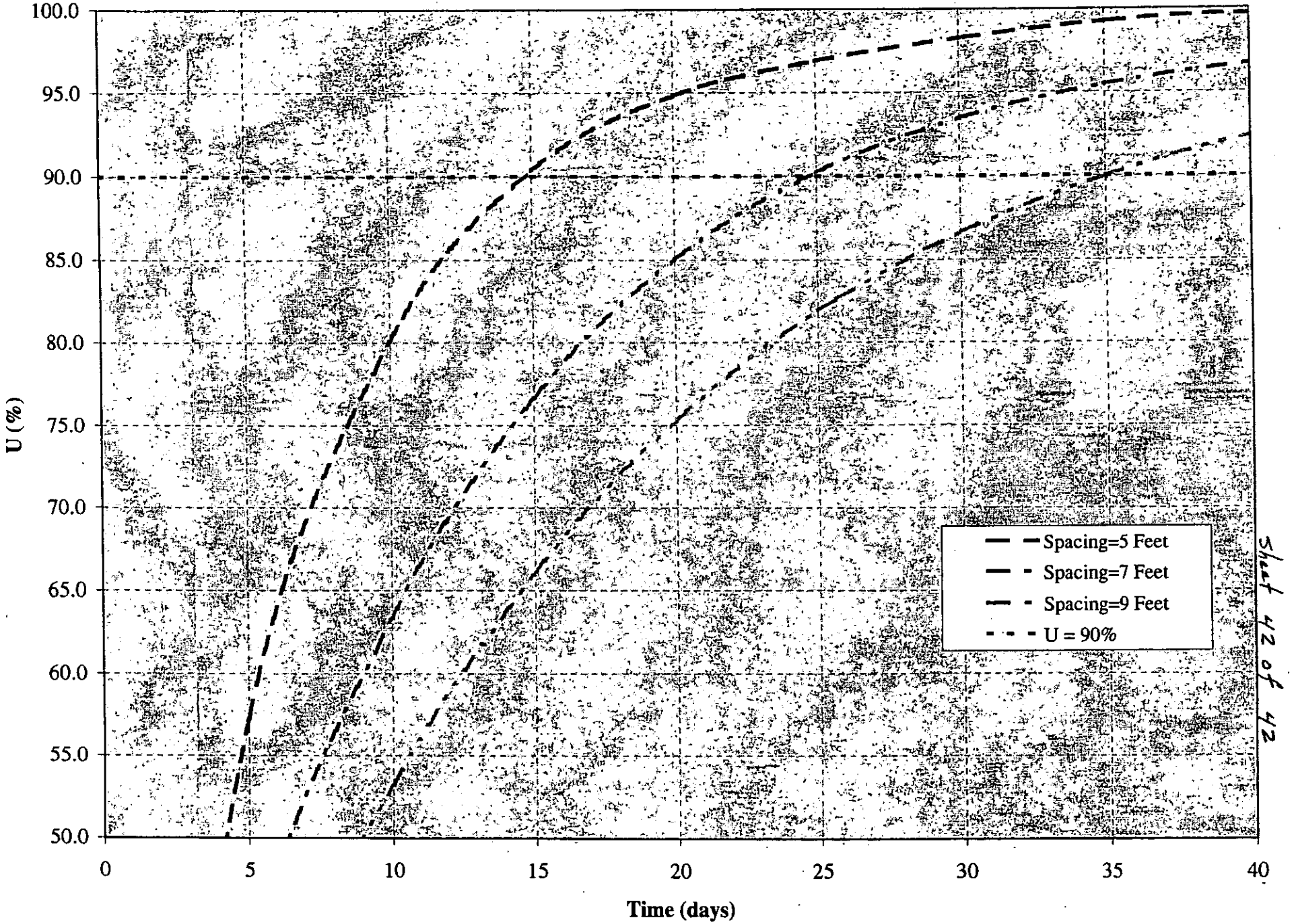
Percent Consolidation vs Time Using Prefabricated Vertical "Wick" Drains
US-23 Interchange, Ramp B. Roadway Embankment-Sta. 2609+07

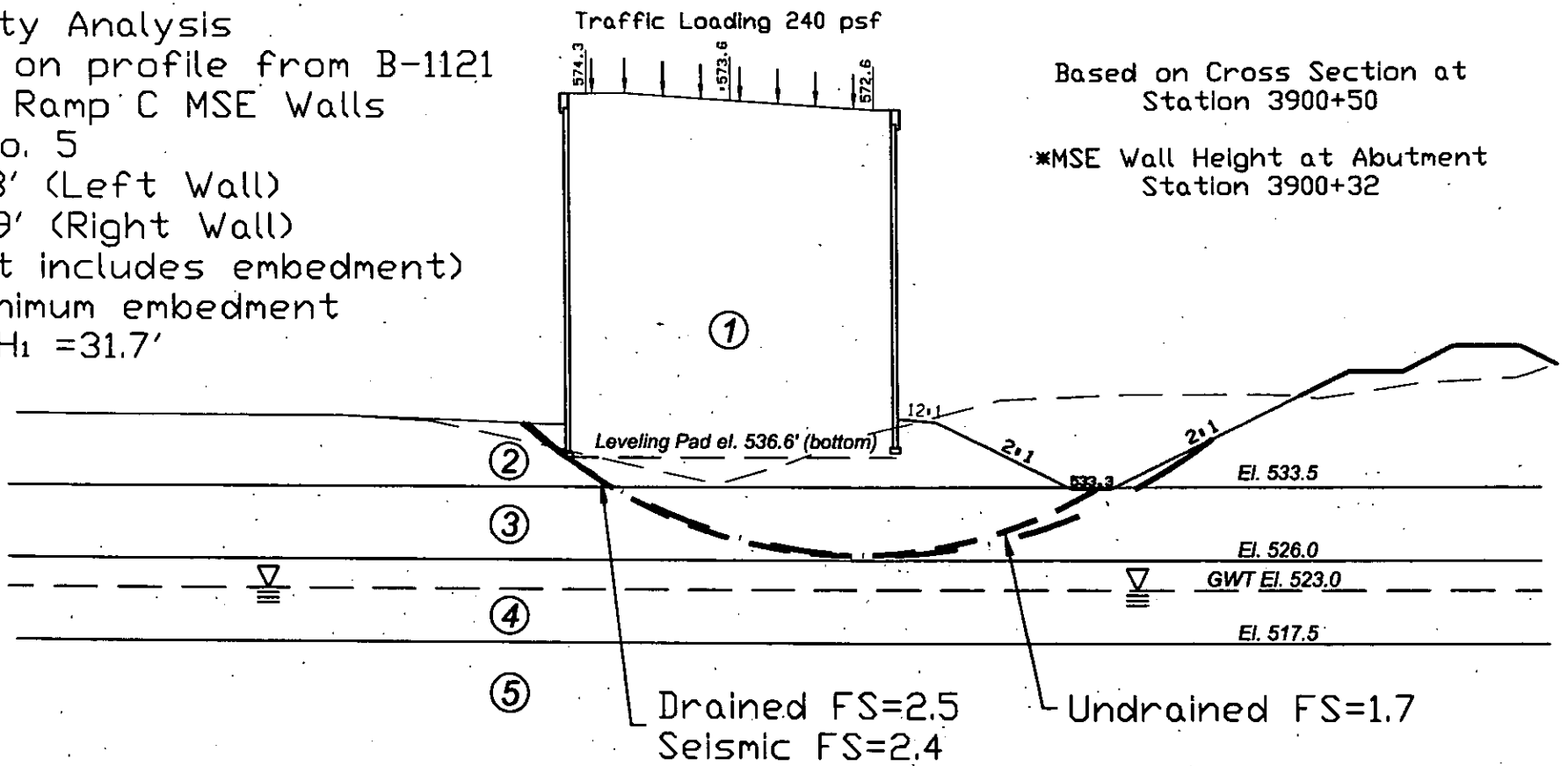


Sheet 42 of 42

US 23 Ramp C
MSE Wall (Wall No. 5) and Embankment Evaluations

			Undrained		Drained		
Material	Consistency	Soil Type	c (psf)	ϕ (deg)	c' (psf)	ϕ' (deg)	γ (pcf)
Material 1	Compacted	MSE Fill	0	34	0	34	120
Material 2	Poss Fill	A-4a/A-6a	2000	0	0	29	120
Material 3	Stiff	A-6a/A-6b	900	0	0	28	120
Material 4	Loose	Gravel/Sand	0	32	0	32	120
Material 5		Bedrock	10000	45	10000	45	145

Stability Analysis
Based on profile from B-1121
US 23 Ramp C MSE Walls
Wall No. 5
H_1=37.3' (Left Wall)
H_2=34.9' (Right Wall)
(Height includes embedment)
3.0' minimum embedment
L=0.85H_1 =31.7'



Stability Analyses performed using UTEXAS3 Version 1.201

EWT 10-19-07
SJK 10-10-07

Sheet 1 of 36

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US-23 Interchange
Ramp C Wall No. 5, Station 3900+32
Based on Boring B-1121

MSE GLOBAL STABILITY ANALYSIS

SCI-823-0.00

PROJECT NO. 0121-3070.03	CALC SJR	DATE 10/2/07

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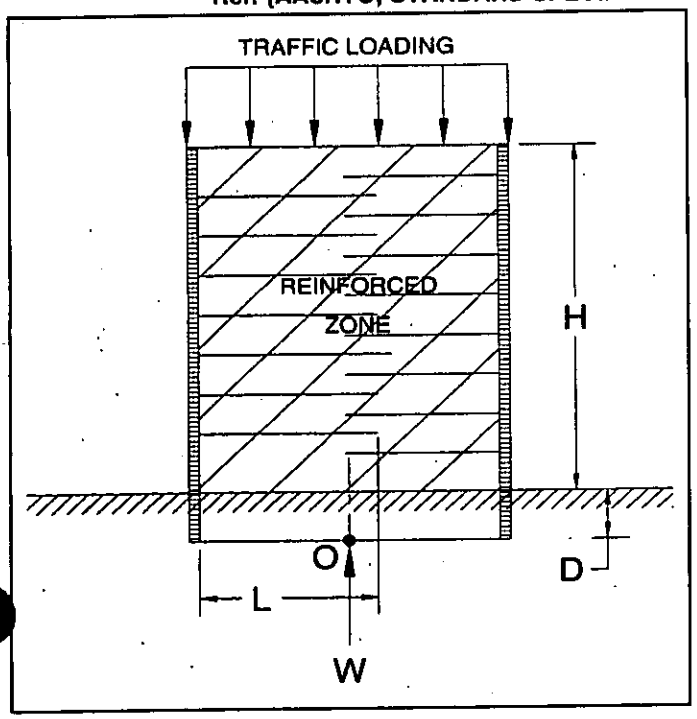
SUBJECT

Client	CH2M Hill
Project	SCI-823 Portsmouth Bypass
Item	MSE Wall Bearing Capacity
	Ramp C Wall No 5, Station 3900+32, Back-to-back walls
	Ka=0.0, for soil reinforcement overlap greater than 0.3*H

JOB NUMBER 0121-3070.03
SHEET NO. 2 OF 36
COMP. BY SJH DATE 10-10-07
CHECKED BY SWT DATE 10-9-07
Using Initial Undrained Strengths

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

Full height using initial UD Strengths.

γ_{RFC}	=	120	pcf	Unit weight Reinforced fill
ϕ'_{RFC}	=	34	deg.	Friction ang. Reinforced fill
γ_{FDN}	=	120	pcf	Unit weight Foundation soil
c	=	900	psf	Cohesion Foundation soil
ϕ	=	0	deg.	Friction ang. Foundation soil
c'	=	0	psf	Cohesion Foundation soil
ϕ'	=	28	deg.	Friction ang. Foundation soil

Loads and Parameters

ω_t	=	240	psf	Traffic loading
L=B	=	31.705	ft	Length of MSE reinforcement
L factor	=	0.85		Length factor-range (0.7 - 1.0)
D	=	3	ft	Embedment depth
Dw	=	0	ft	Groundwater depth
H+D	=	37.3	ft	
H	=	34.3	ft	Height of wall
Ka	=	**0.00**		
⌜ Pa	=	12.433	ft	Moment arm
⌜ Wt	=	18.65	ft	Moment arm
B'	=	31.71	ft	
γ'	=	57.6	pcf	
W_t		7,609	lb/ft of wall	Weight from traffic
W_{mse}	=	141,912	lb/ft of wall	Weight from MSE wall

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 4,716 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma B N_\gamma$$

q_{ULT} = 4,799 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 1,920 psf

Factor of Safety = 1.02 * **No Good**

*See Staged Construction Analysis, pg. 3

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma B N_\gamma$$

q_{ULT} = 17,813 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 7,125 psf

Factor of Safety = 3.78 **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	25.80
N_q	1.00	N_q	14.72
N_γ	0.00	N_γ	16.72

Eccentricity of Resultant Force

e = 0.00 ft

Kern

e < L/6 = 5.28 ft

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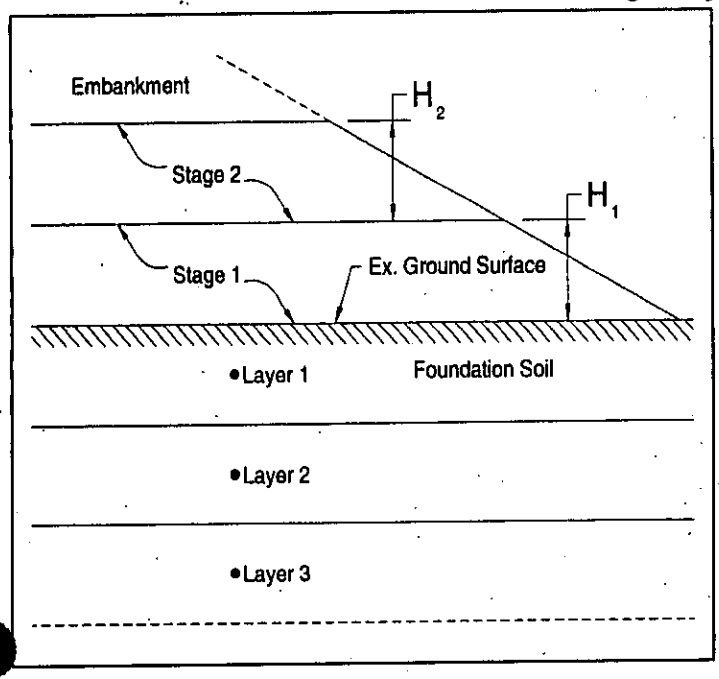
SUBJECT

Client	CH2M Hill	JOB NUMBER	0121-3070.03
Project	SCI-823 Portsmouth Bypass	SHEET NO.	3 OF 36
Item	Undrained Strength Analysis - Staged Const.	COMP. BY	SJK DATE 10-10-07
MSE wall No. 5, US 23 Ramp C, Sta 3900+50 Sta 3900+32		CHECKED BY	GWT DATE 10-19-07

Determine Increase in Undrained Shear Strength Due to Consolidation

Undrained Strength Analysis - Staged Construction

Ref: Ladd, Charles C. (1991). "Stability Evaluation During Staged Construction." *The Twenty-Second Karl Terzaghi Lecture.*, Journal of Geotechnical Engineering, ASCE, 117(4), 540-615



Increase in Undrained Shear Strength from consolidation

$$c_u = c_{ui} + \Delta\sigma' \cdot \tan(\phi_{cu})$$

Where: c_{ui} Initial undrained shear strength, UU or q_u testing

Φ_{cu} Determined from CIU testing

$\Delta\sigma'$ Effective stress increase due to embankment loading

$$\Delta\sigma' = (H_n \cdot \gamma_{emb}) \cdot U$$

Where: U Average degree of consolidation (%)

H_n Height of Embankment, Stage n (ft)

Embankment Fill

γ_{fill} **120** pcf

Depths measured from bottom of leveling pad excavation, below MSE retaining wall

Stage 1 Embankment First Stage Embankment Height H_1= **13.0** Average Percent Consolidation U= **90%**

Depth	Soil Type	Initial Undrained Shear Strength, c_{ui} (psf)	$\Delta\sigma'$ (psf)	Φ_{cu} (deg)	Δc_u (psf)	c_u (psf), *After Consolidation*	Percent Increase
0-3.1	A-4a/A-6a	2000	1404	20.0	511	2511	26%
3.1-11.1	A-6a/A-6b	900	1404	21.3	547	1447	61%

Stage 2 Embankment Second Stage Embankment Height H_2= **10.0** Average Percent Consolidation U= **90%**

0-3.1	A-4a/A-6a	2511	1080	20.0	393	2904	16%
3.1-11.1	A-6a/A-6b	1447	1080	21.3	421	1868	29%

Stage 3 Embankment Third Stage Embankment Height H_3= **8.0** Average Percent Consolidation U= **50%**

0-3.1	A-4a/A-6a	2904	480	20.0	175	3079	6%
3.1-11.1	A-6a/A-6b	1868	480	21.3	187	2055	10%

H_4= 3.3

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CLIENT CH2M Hill
PROJECT SCI-B23 Portsmouth Bypass
SUBJECT US23 Ramp C, MSE Wall No.5
Staged Construction Details

PROJECT NO. 0121-3070.03
SHEET NO. 4 OF 36
COMP. BY SAK DATE 10-10-07
CHECKED BY GWT DATE 10-19-07

* Based on bearing capacity calculations, staged construction is required for Wall No. 5, Ramp C.

- Height of 1st Stage; H_1 = 13.0' (plus 3' embedment)
  Max. excess pore pressures; u_e = 13.0 (120 pcf) = 1560 psf = 10.8 psi
  Prior to placing 2nd stage, u_e should dissipate to U = 90%.
  $u_{e_{90}}$ = (1-0.90)(10.8 psi) = 1.08 psi

- Height of 2nd Stage; H_2 = 10.0'
  Max excess pore pressures; u_e = 10.0' (120 pcf) = 1200 psf = 8.3 psi
  Prior to placing 3rd stage, u_e should dissipate to U = 90%.
  $u_{e_{90}}$ = (1-.90)(8.3) = 0.83 psi

- Height of 3rd Stage; H_3 = 8.0'
  Max excess pore pressures; u_e = 8.0 (120 pcf) = 960 psf = 6.7 psi
  Prior to placing remaining fill, u_e should dissipate to U = 50%.
  $u_{e_{50}}$ = (1-.50)(6.7 psi) = 3.4 psi

Place remaining fill, H_4 = 3.3'

$H_{\text{full height}}$ = 37.3' at abutment location

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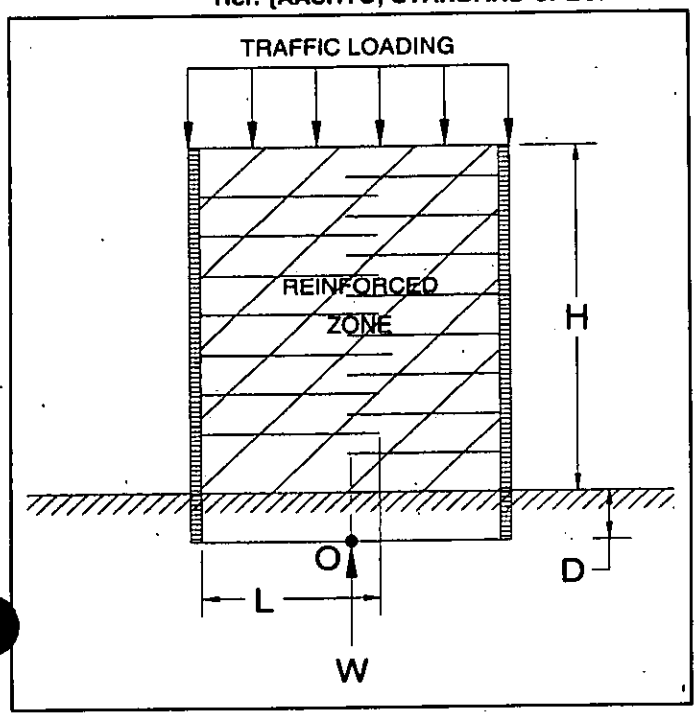
SUBJECT

Client	CH2M Hill
Project	SCI-823 Portsmouth Bypass
Item	MSE Wall Bearing Capacity
	Ramp C Wall No 5, Station 3900+32, Back-to-back walls
	Ka=0.0, for soil reinforcement overlap greater than 0.3*H

JOB NUMBER 0121-3070.03
SHEET NO. 15 OF 36
COMP. BY SJK DATE 10-10-07
CHECKED BY GWJ DATE 10-15-07
FIRST STAGE

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

γ_{RFC}	= 120	pcf	Unit weight	Reinforced fill
ϕ'_{RFC}	= 34	deg.	Friction ang.	Reinforced fill
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 900	psf	Cohesion	Foundation soil
ϕ	= 0	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= 28	deg.	Friction ang.	Foundation soil

Loads and Parameters

ω_t	= 240	psf	Traffic loading	
L=B	= 31.7	ft	Length of MSE reinforcement	
L factor	= 0.85		Length factor-range (0.7 - 1.0)	
D	= 3	ft	Embedment depth	
Dw	= 0	ft	Groundwater depth	
H+D	= 16	ft		
H	= 13	ft	Height of wall	
Ka	= **0.00**			
Γ Pa	= 5.3333	ft	Moment arm	
Γ Wt	= 8	ft	Moment arm	
B'	= 31.70	ft		
γ'	= 57.6	pcf		
W_t	7,608	lb/ft of wall	Weight from traffic	
W_{mse}	= 60,864	lb/ft of wall	Weight from MSE wall	

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 2,160 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma B N_\gamma$$

q_{ULT} = 4,799 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 1,920 psf

Factor of Safety = 2.22* **No Good**

*See multi-layered bearing capacity, Pg. 10

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma B N_\gamma$$

q_{ULT} = 17,808 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 7,123 psf

Factor of Safety = **8.24** **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	25.80
N_q	1.00	N_q	14.72
N_γ	0.00	N_γ	16.72

Eccentricity of Resultant Force

e = 0.00 ft

Kern

e < L/6 = 5.28 ft

DLZ

CLIENT	CH2M Hill	JOB NUMBER	0121-3070.03
PROJECT	SCI-823 Portsmouth Bypass	SHEET NO.	6 of 36
SUBJECT	Multi-Layered Bearing Capacity	COMP. BY	SJK Date 10-10-07
MSE wall No. 5, US 23 Ramp C, Sta 3900+50		CHECKED BY	GW Date 10-19-07

Bearing Capacity
Stiff Over Soft Clay

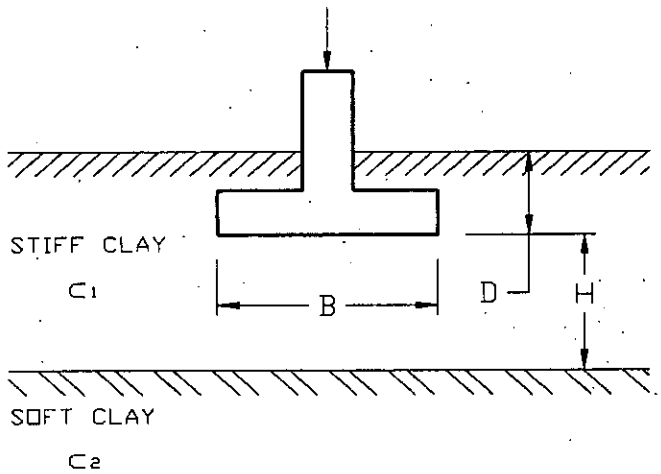
Stage 1 Based on Section at Station 3900+32

AASHTO, Standard Specifications for Highway Bridges, 17th Ed - 2002

Note:
Used for analysis of Ramp C MSE retaining walls.
Using initial undrained strengths

Input

Footing Width (ft)	B	34
Length of Footing (ft)	L	200
Depth below footing to Soil Layer 2	H	31
Cohesion of upper soil layer 1	c_1	2000
Cohesion of lower soil layer 2	c_2	900
Bearing Capacity Factors (φ=0)	N_c	5.14
Bearing Capacity Factors (φ=0)	N_q	1.00
Effective overburnden pressure, D*γ	q	360
Factor of Safety	FS	2.5



Shape Factor	s_c	1.03	$s_c = 1 + \left(B/L\right)\left(N_q/N_c\right)$	Eq: 4.4.7.1.1.2-1
Ratio of Cohesion Values	κ	0.45	$\kappa = c_2/c_1$	
Punching Index	β_m	4.69	$\beta_m = BL/[2(B+L)H]$	
Modified Bearing Capacity Factor	N_m	2.60	$N_m = (1/\beta_m + \kappa s_c N_c) \le s_c N_c$	Eq: 4.4.7.1.1.7-2
Ultimate Undrained Bearing Capacity (psf)	q_{ULT}	5,566	$q_{ULT} = c_1 N_m + q$	Eq: 4.4.7.1.1.7-1
Allowable Undrained Bearing Capacity (psf)	q_{ALL}	**2,226**	$q_{ALL} = q_{ULT}/FS$	

q_{all} = 2,226 psf > $\sigma_{v\,stg1}$ = 2,160 psf

OK Stage 1 UD bearing Capacity

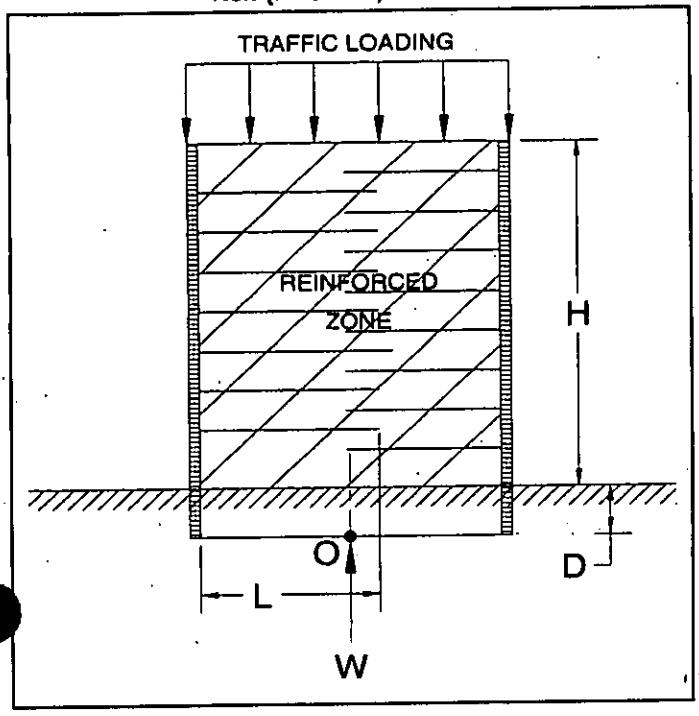
DLZ

SUBJECT

Client	CH2M Hill	JOB NUMBER	0121-3070.03
Project	SCI-823 Portsmouth Bypass	SHEET NO.	17 OF 36
Item	MSE Wall Bearing Capacity	COMP. BY	SJK DATE 10-10-07
	Ramp C Wall No 5, Station 3900+32, Back-to-back walls	CHECKED BY	DATE 10-19-07
	Ka=0.0, for soil reinforcement overlap greater than 0.3*H	SECOND STAGE	

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

γ_{RFC}	= 120	pcf	Unit weight	Reinforced fill
ϕ'_{RFC}	= 34	deg.	Friction ang.	Reinforced fill
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 1447	psf	Cohesion	Foundation soil
ϕ	= 0	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= 28	deg.	Friction ang.	Foundation soil

Loads and Parameters

ω_t	= 240 psf	Traffic loading	
L=B	= 31.7 ft	Length of MSE reinforcement	
L factor	= 0.85	Length factor-range (0.7 - 1.0)	
D	= 3 ft	Embedment depth	
Dw	= 0 ft	Groundwater depth	
H+D	= 26 ft		
H	= 23 ft	Height of wall	
Ka	= 0.00		
Γ Pa	= 8.6667 ft	Moment arm	
Γ Wt	= 13 ft	Moment arm	
B'	= 31.70 ft		
γ'	= 57.6 pcf		
W_t	7,608 lb/ft of wall	Weight from traffic	
W_{mse}	= 98,904 lb/ft of wall	Weight from MSE wall	

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 3,360 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 7,610 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 3,044 psf

Factor of Safety = 2.26 * **No Good**

* See multi-layered bearing capacity, pg. 18

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 17,808 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 7,123 psf

Factor of Safety = 5.30 **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	25.80
N_q	1.00	N_q	14.72
N_γ	0.00	N_γ	16.72

Eccentricity of Resultant Force

e = 0.00 ft

Kern

e < L/6 = 5.28 ft

DLZ

CLIENT	CH2M Hill	JOB NUMBER	0121-3070.03
PROJECT	SCI-823 Portsmouth Bypass	SHEET NO.	8 of 36
SUBJECT	Multi-Layered Bearing Capacity	COMP. BY	SJK Date 10-10-07
MSE wall No. 5, US 23 Ramp C, Sta 3900+50		CHECKED BY	EWT Date 10-19-07

Bearing Capacity
Stiff Over Soft Clay

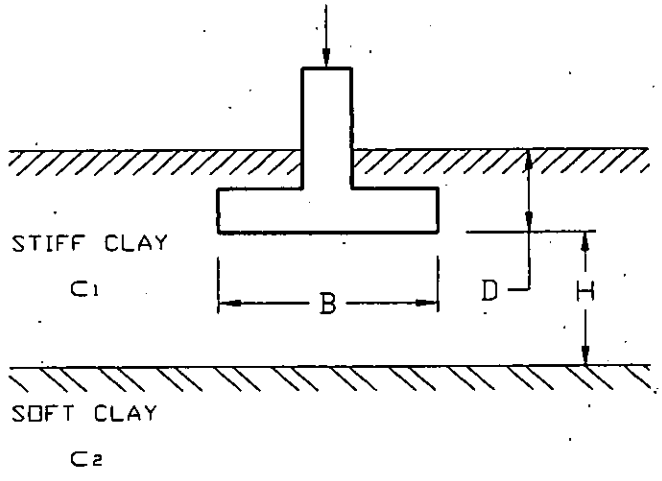
Stage 2 Based on Section at Station 3900+32

AASHTO, Standard Specifications for Highway Bridges, 17th Ed - 2002

Note:
Used for analysis of Ramp C MSE retaining walls.
After consolidating under stage 1 loading

Input

Footing Width (ft)	B	34
Length of Footing (ft)	L	200
Depth below footing to Soil Layer 2	H	31
Cohesion of upper soil layer 1	c_1	2511
Cohesion of lower soil layer 2	c_2	1447
Bearing Capacity Factors (φ=0)	N_c	5.14
Bearing Capacity Factors (φ=0)	N_q	1.00
Effective overburnden pressure, D*γ	q	360
Factor of Safety	FS	2.5



Shape Factor	s_c	1.03	$s_c = 1 + \left(B/L\right)\left(N_q/N_c\right)$	Eq: 4.4.7.1.1.2-1
Ratio of Cohesion Values	κ	0.57626	$\kappa = c_2/c_1$	
Punching Index	β_m	4.69	$\beta_m = BL/[2(B+L)H]$	
Modified Bearing Capacity Factor	N_m	3.27	$N_m = (1/\beta_m + \kappa s_c N_c) \le s_c N_c$	Eq: 4.4.7.1.1.7-2
Ultimate Undrained Bearing Capacity (psf)	q_{ULT}	8,579	$q_{ULT} = c_1 N_m + q$	Eq: 4.4.7.1.1.7-1
Allowable Undrained Bearing Capacity (psf)	q_{ALL}	**3,432**	$q_{ALL} = q_{ULT}/FS$	

$q_{all} = 3,432$ psf $> \sigma_{r_{stg2}} = 3,360$ psf

OK Stage 2 UD bearing Capacity

DLZ

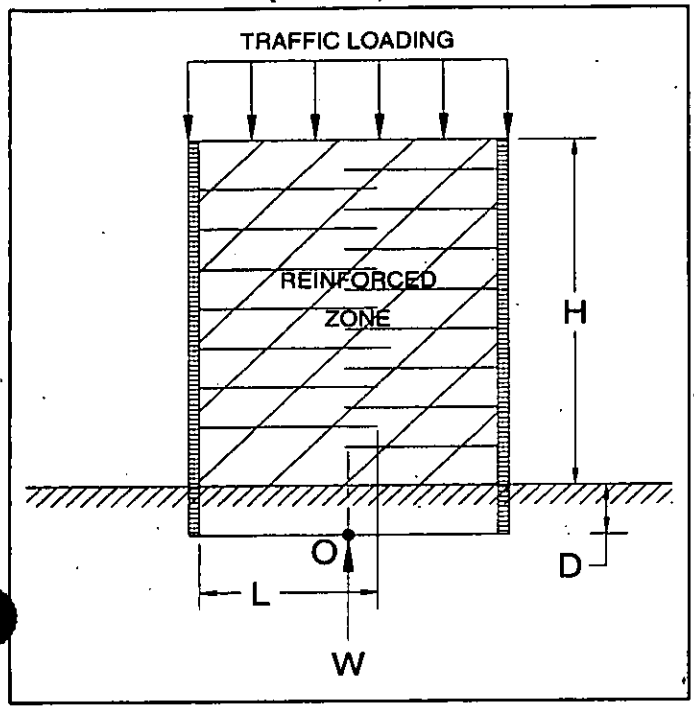
SUBJECT

Client	CH2M Hill	JOB NUMBER	0121-3070.03		
Project	SCI-823 Portsmouth Bypass	SHEET NO.	9	OF	36
Item	MSE Wall Bearing Capacity	COMP. BY	SAK	DATE	10-10-07
Ramp C Wall No 5, Station 3900+32, Back-to-back walls		CHECKED BY	GWT	DATE	10-19-07

Ka=0.0, for soil reinforcement overlap greater than 0.3*H **THIRD STAGE**

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

γ_{RFC}	= 120	pcf	Unit weight	Reinforced fill
ϕ'_{RFC}	= 34	deg.	Friction ang.	Reinforced fill
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 1868	psf	Cohesion	Foundation soil
ϕ	= 0	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= 28	deg.	Friction ang.	Foundation soil

Loads and Parameters

ω_t	= 240	psf	Traffic loading	
L=B	= 31.7	ft	Length of MSE reinforcement	
L factor	= 0.85		Length factor-range (0.7 - 1.0)	
D	= 3	ft	Embedment depth	
Dw	= 0	ft	Groundwater depth	
H+D	= 34	ft		
H	= 31	ft	Height of wall	
Ka	= 0.00			
⌜ Pa	= 11.333	ft	Moment arm	
⌜ Wt	= 17	ft	Moment arm	
B'	= 31.70	ft		
γ'	= 57.6	pcf		
W_t	7,608	lb/ft of wall	Weight from traffic	
W_{mse}	= 129,336	lb/ft of wall	Weight from MSE wall	

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 4,320 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 9,774 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 3,910 psf

Factor of Safety = 2.26* **No Good**

*See multi-layered bearing capacity, pg 10

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 17,808 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 7,123 psf

Factor of Safety = 4.12 **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	25.80
N_q	1.00	N_q	14.72
N_γ	0.00	N_γ	16.72

Eccentricity of Resultant Force

e = 0.00 ft

Kern

e < L/6 = 5.28 ft

DLZ

CLIENT	CH2M Hill	JOB NUMBER	0121-3070.03
PROJECT	SCI-823 Portsmouth Bypass	SHEET NO.	10 of 36
SUBJECT	Multi-Layered Bearing Capacity	COMP. BY	SMR Date 10-10-07
	MSE wall No. 5, US 23 Ramp C, Sta 3900+50	CHECKED BY	GWT Date 10-19-07

Bearing Capacity
Stiff Over Soft Clay

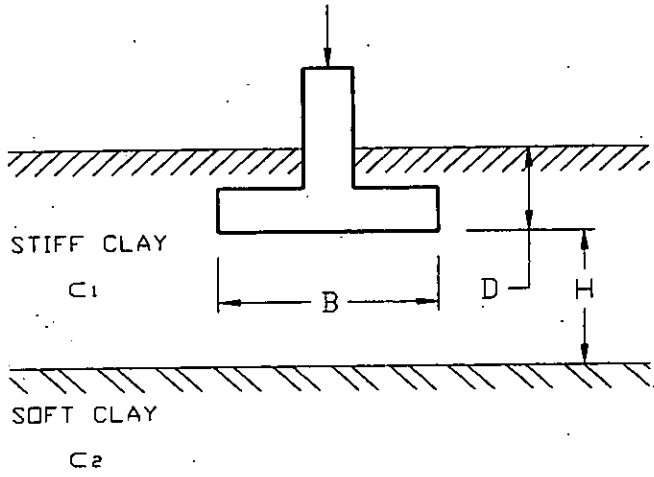
Stage 3 Based on Section at Station 3900+32

AASHTO, Standard Specifications for Highway Bridges, 17th Ed - 2002

Note:
Used for analysis of Ramp C MSE retaining walls.
After consolidating under stage 2 loading

Input

Footing Width (ft)	B	34
Length of Footing (ft)	L	200
Depth below footing to Soil Layer 2	H	3.1
Cohesion of upper soil layer 1	c_1	2904
Cohesion of lower soil layer 2	c_2	1868
Bearing Capacity Factors (φ=0)	N_c	5.14
Bearing Capacity Factors (φ=0)	N_q	1.00
Effective overburnden pressure, D*γ	q	360
Factor of Safety	FS	2.5



Shape Factor	s_c	1.03	$s_c = 1 + \left(B/L\right)\left(N_q/N_c\right)$	Eq: 4.4.7.1.1.2-1
Ratio of Cohesion Values	κ	0.64325	$\kappa = c_2/c_1$	
Punching Index	β_m	4.69	$\beta_m = BL/[2(B+L)H]$	
Modified Bearing Capacity Factor	N_m	3.63	$N_m = (1/\beta_m + \kappa s_c N_c) \le s_c N_c$	Eq: 4.4.7.1.1.7-2
Ultimate Undrained Bearing Capacity (psf)	q_{ULT}	10,899	$q_{ULT} = c_1 N_m + q$	Eq: 4.4.7.1.1.7-1
Allowable Undrained Bearing Capacity (psf)	q_{ALL}	**4,359**	$q_{ALL} = q_{ULT}/FS$	

q_{all} = 4,359 psf > $\sigma_{v\,STG\,3}$ = 4,320 psf

OK UD Bearing Capacity

DLZ

SUBJECT

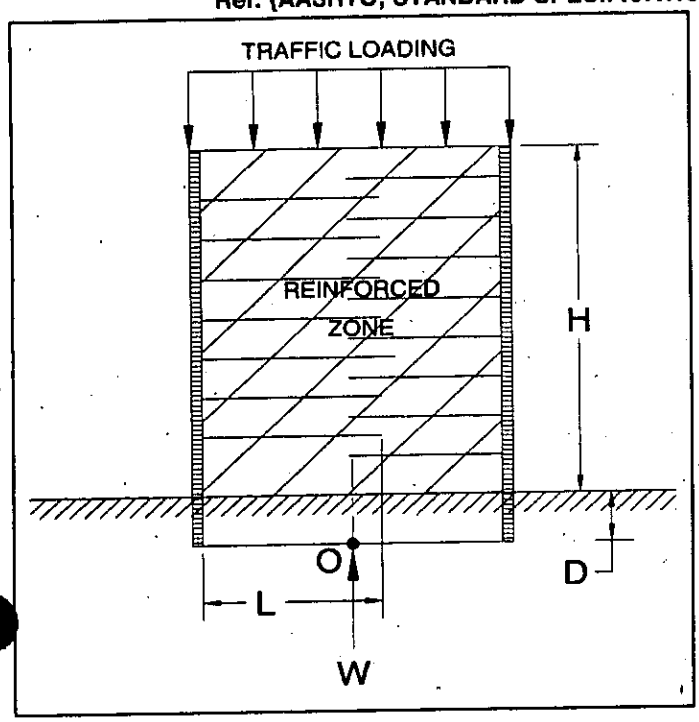
Client CH2M Hill
Project SCI-823 Portsmouth Bypass
Item MSE Wall Bearing Capacity
Ramp C Wall No 5, Station 3900+32, Back-to-back walls
Ka=0.0, for soil reinforcement overlap greater than 0.3*H

JOB NUMBER 0121-3070.03
SHEET NO. 11 OF 36
COMP. BY SAK DATE 10-10-07
CHECKED BY GWT DATE 10-15-07

FOURTH (FINAL) STAGE

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

Full Hieght using modified Strengths

γ_{RFC}	= 120	pcf	Unit weight	Reinforced fill
ϕ'_{RFC}	= 34	deg.	Friction ang.	Reinforced fill
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 2055	psf	Cohesion	Foundation soil
ϕ	= 0	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= 28	deg.	Friction ang.	Foundation soil

Loads and Parameters

ω_t	= 240	psf	Traffic loading	
L=B	= 31.7	ft	Length of MSE reinforcement	
L factor	= 0.85		Length factor-range (0.7 - 1.0)	
D	= 3	ft	Embedment depth	
Dw	= 0	ft	Groundwater depth	
H+D	= 37.3	ft		
H	= 34.3	ft	Height of wall	
Ka	= 0.00			
Γ Pa	= 12.433	ft	Moment arm	
Γ Wt	= 18.65	ft	Moment arm	
B'	= 31.70	ft		
γ'	= 57.6	pcf		
W_t	7,608	lb/ft of wall	Weight from traffic	
W_{mse}	= 141,889	lb/ft of wall	Weight from MSE wall	

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 4,716 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma B N_\gamma$$

q_{ULT} = 10,736 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 4,294 psf

Factor of Safety = 2.28 * **No Good**

*See multi-layered bearing capacity, pg 12

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 17,808 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 7,123 psf

Factor of Safety = 3.78 **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	25.80
N_q	1.00	N_q	14.72
N_γ	0.00	N_γ	16.72

Eccentricity of Resultant Force

e = 0.00 ft

Kern

e < L/6 = 5.28 ft

DLZ

CLIENT	CH2M Hill	JOB NUMBER	0121-3070.03
PROJECT	SCI-823 Portsmouth Bypass	SHEET NO.	12 of 36
SUBJECT	Multi-Layered Bearing Capacity	COMP. BY	SJK Date 10-10-07
	MSE wall No. 5, US 23 Ramp C, Sta 3900+50	CHECKED BY	SWT Date 10-19-07

Bearing Capacity
Stiff Over Soft Clay

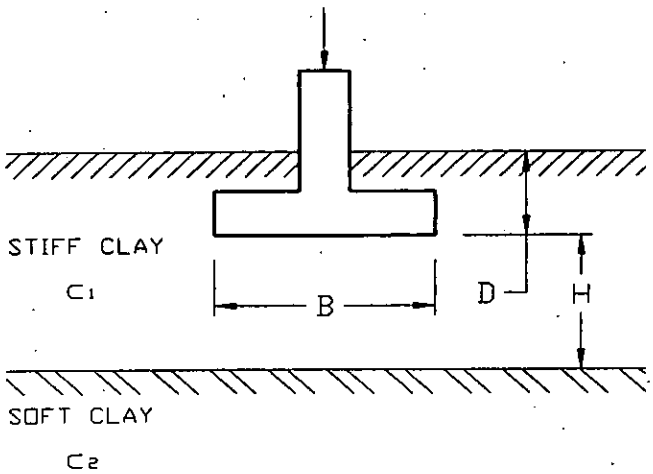
Stage 4 Based on Section at Station 3900+32

AASHTO, Standard Specifications for Highway Bridges, 17th Ed - 2002

Note:
Used for analysis of Ramp C MSE retaining walls.
After consolidating under stage 3 loading

Input

Footing Width (ft)	B	34
Length of Footing (ft)	L	200
Depth below footing to Soil Layer 2	H	31
Cohesion of upper soil layer 1	c_1	3079
Cohesion of lower soil layer 2	c_2	2055
Bearing Capacity Factors (φ=0)	N_c	5.14
Bearing Capacity Factors (φ=0)	N_q	1.00
Effective overburnden pressure, $D^*\gamma$	q	360
Factor of Safety	FS	2.5



Shape Factor	s_c	1.03	$s_c = 1 + \left(B/L\right)\left(N_q/N_c\right)$	Eq: 4.4.7.1.1.2-1
Ratio of Cohesion Values	κ	0.66742	$\kappa = c_2/c_1$	
Punching Index	β_m	4.69	$\beta_m = BL/[2(B+L)H]$	
Modified Bearing Capacity Factor	N_m	3.76	$N_m = (1/\beta_m + \kappa s_c N_c) \le s_c N_c$	Eq: 4.4.7.1.1.7-2
Ultimate Undrained Bearing Capacity (psf)	q_{ULT}	11,929	$q_{ULT} = c_1 N_m + q$	Eq: 4.4.7.1.1.7-1
Allowable Undrained Bearing Capacity (psf)	q_{ALL}	**4,772**	$q_{ALL} = q_{ULT}/FS$	

q_{all} = 4,772 psf > $\sigma_{v\,stg\,4}$ = 4,716 psf

OK UD bearing capacity.

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PLANNERS • SURVEYORS

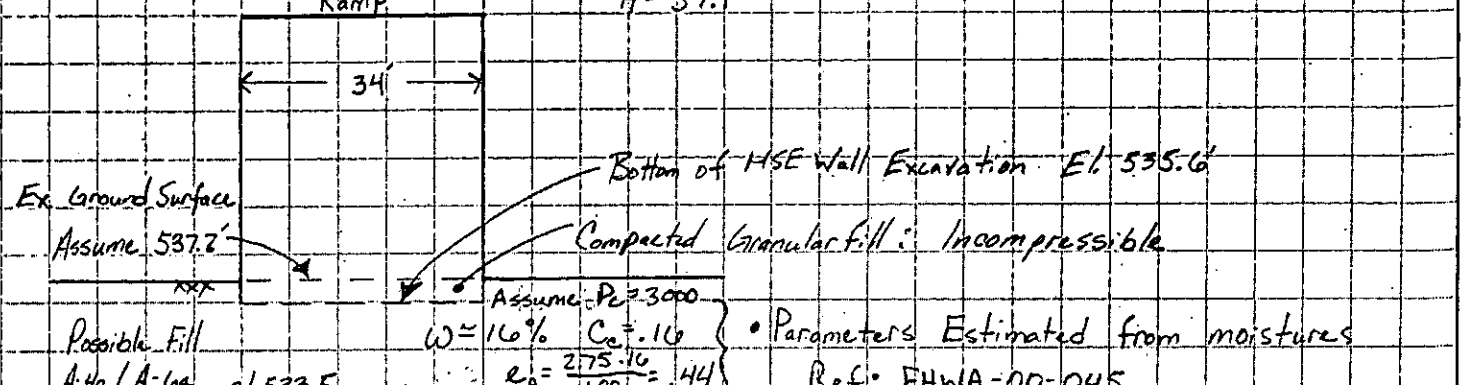
CLIENT CHZM Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Consolidation Parameters
Settlement - Ramp C Station 3900+32

PROJECT NO. 0121-3070.03
SHEET NO. 13 OF 36
COMP. BY SJK DATE 10-10-07
CHECKED BY GNT DATE 10-19-07

Evaluate Settlement at Station 3900+32; Begin Ramp C MSE Wall.
Profile based upon boring B-1121

Cross Section View at Sta. 3900+32 - Abutment location

H = 574.3' - 537.2' = 37.1' (Above ex. ground surface)
H = 37.1'



- Parameters Estimated from moistures
  Ref: FHWA-00-045
  Consolidation Testing from boring B-1122A
  ST-1, A-6a sample.
- c' Estimated from FHWA-00-045 "Soils and Foundations Workshop"

* The computer program EMBANK requires inputs for C_c, C_r and e_o. To evaluate the settlement of granular layers we must calculate equivalent consolidation parameters from c'.

$$\frac{1}{c'} = \frac{C_c}{1+e_o}$$ Say $e_o = 1.0$ in this case

$$\frac{1}{c'} = \frac{C_c}{1+1.0} \longrightarrow \boxed{c' = \frac{2.0}{C_c}} \qquad C_c = \frac{2.0}{c'}$$

When $c' = 60$, $C_c = \frac{2}{60} = 0.03$

* At Station 3900+82

H = 569.2' - 537.2' = 32.0'

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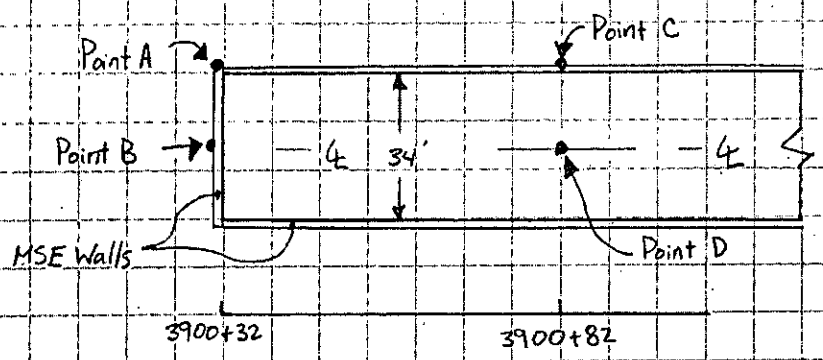
CLIENT CH2M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Consolidation Results
Settlement - Ramp C

PROJECT NO. 0121-3070.03
SHEET NO. 14 OF 36
COMP. BY SJR DATE 10-10-07
CHECKED BY RWT DATE 10-9-07

Plan View - Ramp C



- At abutment location: Sta 3900+32

Point A: δ = 1.6" (at wall face / corner)
Point B: δ = 4.3" (at abutment wall centerline)

- 50' from abutment location: Sta 3900+82

Point C: δ = 3.6" (at wall face)
Point D: δ = 7.9" (at ramp centerline)

Differential Settlement at wall face

Between point A and point C;

$$D_S = \frac{(3.6" - 1.6")(1'/12")}{50'} = 0.003 = 0.3\% < 1.0\% \checkmark \boxed{OK}$$

Ramp C Abutment Wall STA 3900+32 back-to-back MSE SJR 10-10-07 QWT 10-19-07

ÚÄÄÄÄÄ ONE DIMENSIONAL SETTLEMENT ANALYSIS/Federal Highway Administration ÄÄÄÄÄ¿
INCREMENT OF STRESSES BENEATH THE END OF FILL CONDITION

Project Name : SCI-823 Client : CH2M Hill
File Name : RC1 Project Manager : Nix
Date : 10/ 9/10 Computed by : sjr

Settlement for X-Direction

Embank. slope, x direc. = 0.10 (ft) Height of fill H = 37.10 (ft)
y direc. = 0.10 (ft) Unit weight of fill = 120.00 (pcf)
Embankment top width = 34.00 (ft) p load/unit area = 4452.00 (psf)
Embankment bottom width = 34.20 (ft) Foundation Elev. = 537.20 (ft)
Ground Surface Elev. = 537.20 (ft)
Water table Elev. = 523.00 (ft) Unit weight of Wat. = 62.40 (pcf)

N§.	LAYER TYPE	THICK. (ft)	COEFFICIENT COMP.	RECOMP.	SWELL.	UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO
1	INCOMP.	1.6	-----	-----	-----	120.00	----	----
2	COMP.	2.1	0.160	0.020	0.000	120.00	2.65	0.44
3	COMP.	7.5	0.370	0.070	0.000	120.00	2.65	1.10
4	COMP.	8.5	0.030	0.030	0.000	120.00	2.65	1.00

N§.	SUBLAYER THICK. (ft)	ELEV. (ft)	SOIL STRESSES INITIAL (psf)	MAX.PAST PRESS. (psf)
1	INCOMP.			
2	2.10	534.55	318.00	2250.00
3	7.50	529.75	894.00	2250.00
4	8.50	521.75	1776.00	2250.00

Layer	X = Stress (psf)	0.10 Sett. (in.)	X = Stress (psf)	3.50 Sett. (in.)	X = Stress (psf)	6.90 Sett. (in.)	X = Stress (psf)	10.30 Sett. (in.)
1	INCOMP.	INCOMP.	INCOMP.	INCOMP.				
2	1167.23	0.23	2155.74	0.41	2255.72	0.46	2271.22	0.47
3	1127.46	1.06	1699.29	2.18	2001.64	2.94	2123.28	3.22
4	1086.94	0.32	1379.34	0.38	1616.90	0.43	1778.32	0.46
		------		------		------		------
	Pt. A	1.61		2.98		3.83		4.15

Layer	X = Stress (psf)	13.70 Sett. (in.)	X = Stress (psf)	17.10 Sett. (in.)
1	INCOMP.	INCOMP.		
2	2275.12	0.47	2275.99	0.47
3	2169.07	3.33	2180.99	3.35
4	1867.87	0.48	1896.17	0.48
		------		------
		4.27		4.31 Pt. B

Ramp C Abutment Wall STA 3900+82 back-to-back MSE SJK 10-10-07
EWT 10-9-07

ÚÄÄÄÄÄ ONE DIMENSIONAL SETTLEMENT ANALYSIS/Federal Highway Administration ÄÄÄÄÄ¿
INCREMENT OF STRESSES BENEATH THE END OF FILL CONDITION

Project Name : SCI-823 Client : CH2M Hill
File Name : RC1 Project Manager : Nix
Date : 10/ 9/10 Computed by : sjr

Settlement for X-Direction

Embank. slope, x direc. = 0.10 (ft) Height of fill H = 32.00 (ft)
y direc. = 0.10 (ft) Unit weight of fill = 120.00 (pcf)
Embankment top width = 34.00 (ft) p load/unit area = 3840.00 (psf)
Embankment bottom width = 34.20 (ft) Foundation Elev. = 537.20 (ft)
Ground Surface Elev. = 537.20 (ft)
Water table Elev. = 523.00 (ft) Unit weight of Wat. = 62.40 (pcf)

N§.	LAYER TYPE	THICK. (ft)	COEFFICIENT COMP.	RECOMP.	SWELL.	UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO
1	INCOMP.	1.6	-----	-----	-----	120.00	----	----
2	COMP.	2.1	0.160	0.020	0.000	120.00	2.65	0.44
3	COMP.	7.5	0.370	0.070	0.000	120.00	2.65	1.10
4	COMP.	8.5	0.030	0.030	0.000	120.00	2.65	1.00

N§.	SUBLAYER THICK. (ft)	ELEV. (ft)	SOIL STRESSES INITIAL (psf)	MAX.PAST PRESS. (psf)
1	INCOMP.			
2	2.10	534.55	318.00	2250.00
3	7.50	529.75	894.00	2250.00
4	8.50	521.75	1776.00	2250.00

Layer	X = Stress (psf)	0.10 Sett. (in.)	X = Stress (psf)	3.50 Sett. (in.)	X = Stress (psf)	6.90 Sett. (in.)	X = Stress (psf)	10.30 Sett. (in.)
1	INCOMP.	INCOMP.	INCOMP.	INCOMP.				
2	1965.68	0.32	3629.28	0.98	3799.33	1.03	3825.83	1.04
3	1927.52	2.76	2904.38	4.81	3421.58	5.69	3629.96	6.01
4	1860.64	0.48	2362.25	0.56	2769.84	0.62	3046.85	0.66
		------		------		------		------
	Pt. C	3.55		6.35		7.34		7.72

Layer	X = Stress (psf)	13.70 Sett. (in.)	X = Stress (psf)	17.10 Sett. (in.)
1	INCOMP.	INCOMP.		
2	3832.51	1.04	3834.01	1.04
3	3708.49	6.13	3728.93	6.16
4	3200.56	0.68	3249.13	0.69
		------		------
		7.86		7.90 Pt. D

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CLIENT CH2M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Time - rate of consolidation & Downdrag on piles - Ramp C

PROJECT NO. 0121-3070.03
SHEET NO. 17 OF 36
COMP. BY SJK DATE 10-10-07
CHECKED BY GWT DATE 10-15-07

* Station 3900 +32

Profile based upon boring B-1121, Soil properties based upon boring B-1122A

el. 535.6' Bottom of excavation

A-4a/A-6a $\bar{LL} \simeq 36$
el. 533.5' $C_v \simeq 0.35$ ft²/day

A-6a/A-6b $LL \simeq 33$
el. 526.0' $C_v \simeq 0.35$ ft²/day

Assume free draining
el. 517.5' Gravel/Sand

Assume double drainage
$H_v = (535.6 - 526.0)/2 = 4.8$ ft

$$t_{90} = \frac{T_v \cdot H_v^2}{C_v} = \frac{0.848\,(4.8)^2}{0.35\ \text{ft}^2/\text{day}} = 56 \text{ days}$$

C_v estimated based upon LL - Ref: FHWA HI-97-021 Fig 9-5, "Subsurface Investigations"

• Forward Abutment

* To prevent downdrag forces on piles, remaining settlement should be limited to 0.4 inches or less.

Settlement at ℄ of abutment wall, $\delta = 4.3"$
Of the 4.3", 3.8" is consolidation settlement.

$$\left(1 - \frac{0.4}{3.8}\right) = 0.89 \quad \text{OR} \quad U = 89\% \quad \text{Say } 90\%$$

Prior to driving piles, a degree of consolidation of at least $U = 90\%$ should be achieved to prevent downdrag forces from acting on the piles.

Time to $U = 50\%$ Consolidation

$$t_{50} = \frac{T_v \cdot H_v^2}{C_v} \quad \text{when } U = 50\% \rightarrow T_v = 0.20$$

$$t_{50} = \frac{(.20)(4.8')^2}{0.35\ \text{ft}^2/\text{day}} = 13 \text{ days}$$

DLZ

Time Rate of Consolication of Foundation Soils with Wick Drians
US 23 Ramp C Station 3900+32 to 3907+00
Reference: FHWA-RD-86-168

Wick Drain Spacing 5.0 feet Use $\eta = 10$

t (days)	T_R	T_V	U_R	U_V	U_C	δ(inches)	d_e	c_v	H_v	δ_{max}
0	0.0000	0.0000	0.00	0.00	0.0	0.0	5.25	0.35	4.8	7.2
5	0.0635	0.0760	0.29	0.30	50.3	3.6				
10	0.1270	0.1519	0.49	0.46	72.1	5.2				
15	0.1905	0.2279	0.63	0.56	84.0	6.0				
20	0.2540	0.3038	0.74	0.64	90.5	6.5				
25	0.3175	0.3798	0.81	0.69	94.1	6.8				
30	0.3810	0.4557	0.86	0.73	96.2	6.9				
35	0.4444	0.5317	0.89	0.77	97.5	7.0				
40	0.5079	0.6076	0.91	0.80	98.3	7.1				
45	0.5714	0.6836	0.93	0.84	98.9	7.1				

Assumes a Triangular Grid Layout

DLZ

Time Rate of Consolication of Foundation Soils with Wick Drians SJH 10-10-07
US 23 Ramp C **Station 3900+32 to 3907+00** EWT 10-9-07
Reference: FHWA-RD-86-168

Wick Drain Spacing 7.0 feet Use $\eta = 10$

t (days)	T_R	T_V	U_R	U_V	U_C	δ (inches)	d_e	c_v	H_v	δ_{max}
0	0.0000	0.0000	0.00	0.00	0.0	0.0	7.35	0.35	4.8	7.2
5	0.0324	0.0760	0.17	0.30	41.9	3.0				
10	0.0648	0.1519	0.29	0.46	61.6	4.4				
15	0.0972	0.2279	0.40	0.56	73.9	5.3				
20	0.1296	0.3038	0.49	0.64	81.7	5.9				
25	0.1620	0.3798	0.57	0.69	86.8	6.2				
30	0.1944	0.4557	0.64	0.73	90.3	6.5				
35	0.2268	0.5317	0.70	0.77	92.9	6.7				
40	0.2592	0.6076	0.74	0.80	94.9	6.8				
45	0.2915	0.6836	0.78	0.84	96.4	6.9				
50	0.3239	0.7595	0.82	0.87	97.5	7.0				
55	0.3563	0.8355	0.84	0.89	98.3	7.1				
60	0.3887	0.9115	0.86	0.91	98.8	7.1				

Assumes a Triangular Grid Layout

DLZ

Time Rate of Consolication of Foundation Soils with Wick Drians
US 23 Ramp C **Station** **3900+32 to 3907+00**
Reference: FHWA-RD-86-168

GWT 10-19-07
SJG 10-10-07

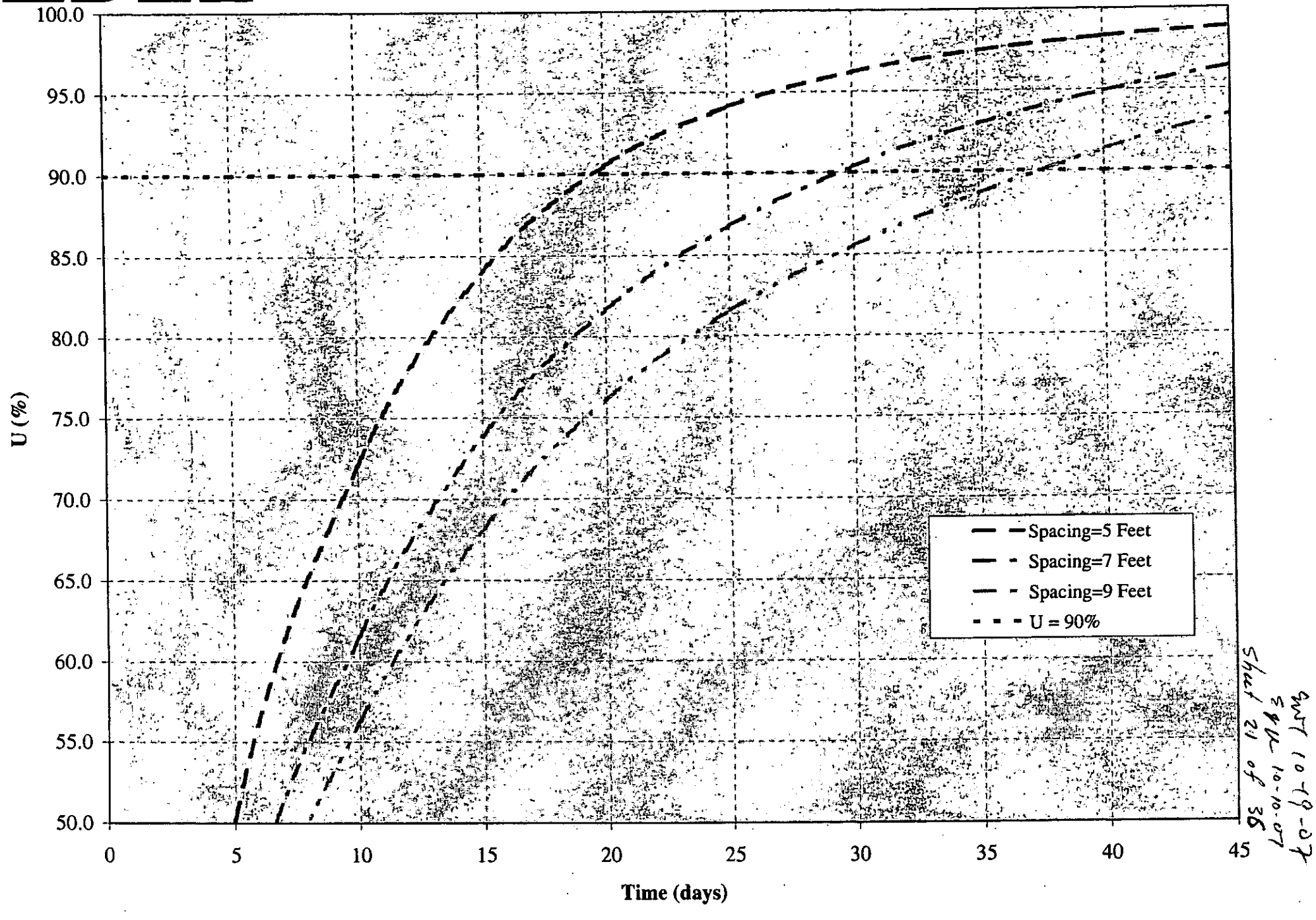
Wick Drain Spacing **9.0** feet Use $\eta = 10$

t (days)	T_R	T_V	U_R	U_V	U_C	δ(inches)	d_e	c_v	H_v	δ_{max}
0	0.0000	0.0000	0.00	0.00	0.0	0.0	9.45	0.35	4.8	7.2
5	0.0196	0.0760	0.11	0.30	38.1	2.7				
10	0.0392	0.1519	0.20	0.46	56.3	4.1				
15	0.0588	0.2279	0.27	0.56	68.2	4.9				
20	0.0784	0.3038	0.34	0.64	76.1	5.5				
25	0.0980	0.3798	0.40	0.69	81.6	5.9				
30	0.1176	0.4557	0.46	0.73	85.5	6.2				
35	0.1372	0.5317	0.51	0.77	88.7	6.4				
40	0.1568	0.6076	0.56	0.80	91.3	6.6				
45	0.1764	0.6836	0.60	0.84	93.5	6.7				
50	0.1960	0.7595	0.64	0.87	95.3	6.9				
55	0.2156	0.8355	0.68	0.89	96.6	7.0				
60	0.2352	0.9115	0.71	0.91	97.4	7.0				
65	0.2548	0.9874	0.74	0.90	97.5	7.0				

Assumes a Triangular Grid Layout

DLZ

Percent Consolidation vs Time Using Prefabricated Vertical "Wick" Drains
US-23 Interchange, Ramp C (Wall No 5)

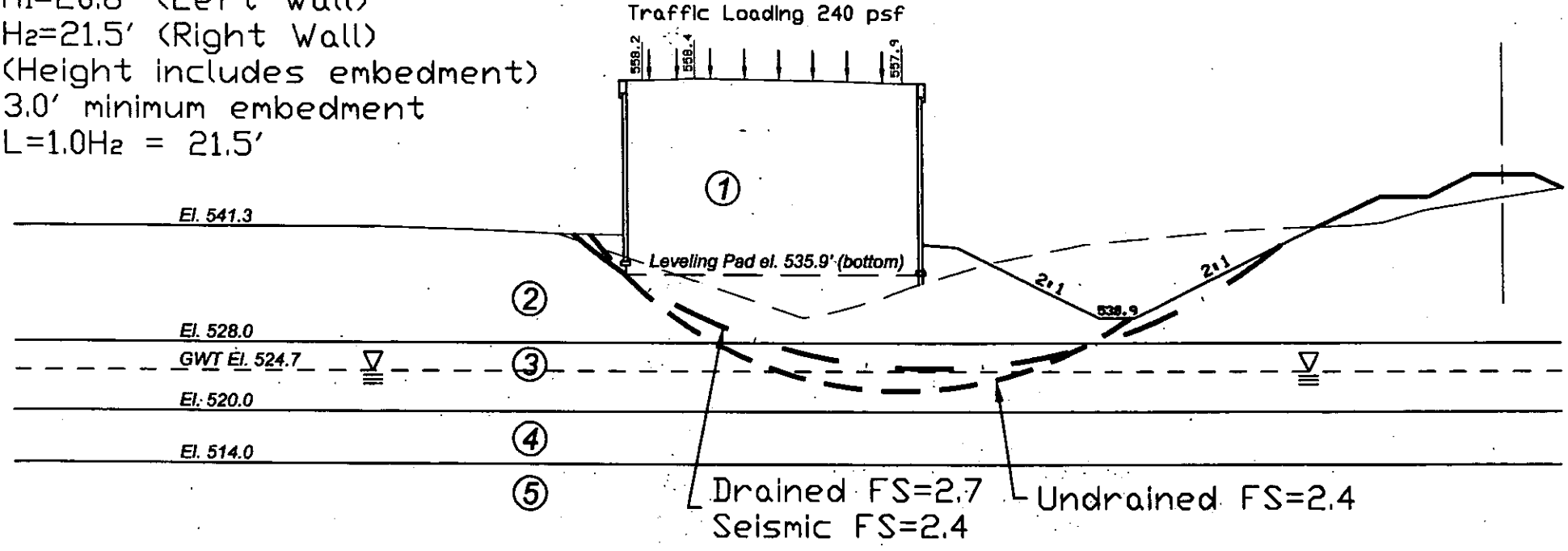


SWT 10-19-07
SQR 10-10-07
Sheet 21 of 36

Material	Consistency	Soil Type	Undrained c (psf)	Undrained ϕ (deg)	Drained c' (psf)	Drained ϕ' (deg)	γ (pcf)
Material 1	Compacted	MSE Fill	0	34	0	34	120
Material 2	Very Stiff	A-4a/A-6a	2000	0	0	29	120
Material 3	Stiff	A-6a/A-6b	900	0	0	28	120
Material 4	Loose	Gravel/Sand	0	32	0	32	120
Material 5		Bedrock	10000	45	10000	45	145

Stability Analysis
Based on profile from B-1122 & B-1121
US 23 Ramp C MSE Walls
Wall No. 5
H_1=20.8' (Left Wall)
H_2=21.5' (Right Wall)
(Height includes embedment)
3.0' minimum embedment
L=1.0H_2 = 21.5'

Based on Cross Section at Station 3902+50



Stability Analyses performed using UTEXAS3 Version 1.201

GWT 10/9-07

M:\proj\0121\3070.03\Interchanges\US 23\embankment stability.dwg, 10/16/2007 4:56:12 PM, Xerox WorkCentre Pro 245 PS

Sheet 22 of 36 SJR 10-10-07

US-23 Interchange
Ramp C Wall No. 5, Station 3902+50
Based on Boring B-1122 & B-1121

MSE GLOBAL STABILITY ANALYSIS

SCI-823-0.00

PROJECT NO. 0121-3070.03	CALC SJR	DATE 10/2/07

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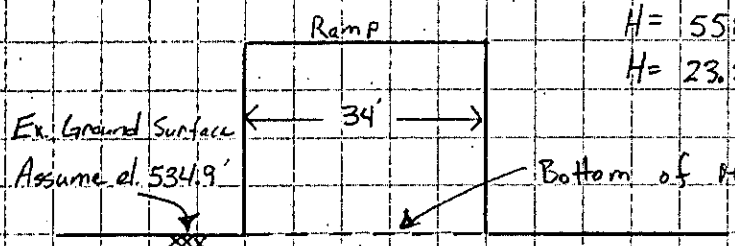
CLIENT CH2M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Consolidation Parameters
Settlement - Ramp C Station 3902+50

PROJECT NO. 0121-3070.03
SHEET NO. 23 OF 36
COMP. BY SJK DATE 10-10-07
CHECKED BY GWT DATE 10-19-07

Evaluate Settlement at Station 3902+50; Ramp C MSE Wall
Profile based upon boring B-1122 and B-1121

Cross Section view at station 3902+50



$H = 558.4' - 534.9' = 23.5'$
$H = 23.5'$

Possible Fill Assume $P_c = 3000$, $\omega = 16\%$, $C_c = .16$
A-4a/A-6a el. 528.0' $e_o = \frac{2.75(16)}{100} = .44$
} Parameters estimated from moistures
Ref: FHWA-00-045

Stiff $C_c = 0.37$ $C_r = 0.07$
A-6a/A-6b el. 520.0' $P_c = 3000$ $e_o = 1.108$
} Consolidation Testing from boring B-1122A
ST-1, A-6a sample

Loose $\gamma = 120$ pcf $\bar{N} = 37$
Gravel and Sand el. 514.0 $\bar{N} = .92(37) = 34$ $\phi' = 115$
TOP OF ROCK
} ϕ' Estimated from FHWA-00-045 "Soils and Foundations Workshop"
* See Sample Calculation pg. 13
* $C_c = C_r = 0.02$

Assume groundwater table at 524.7'

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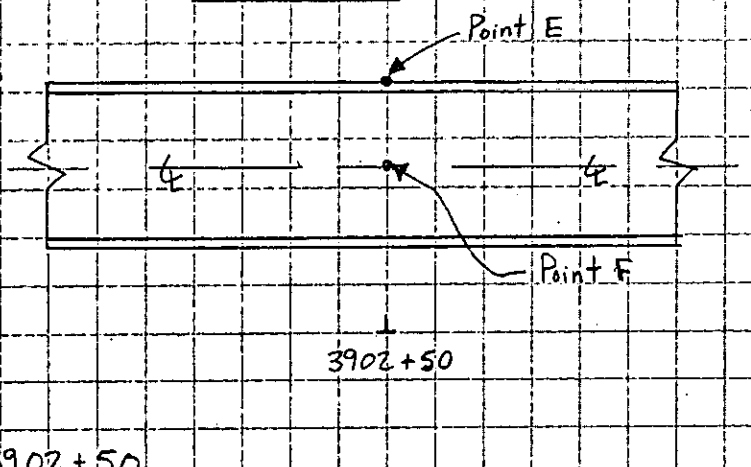
CLIENT CH2M Hill
PROJECT SCI-B23 Portsmouth Bypass
SUBJECT Consolidation Results
Settlement - Ramp C

PROJECT NO. 0121-3070.03
SHEET NO. 24 OF 36
COMP. BY SAK DATE 10-10-07
CHECKED BY GWT DATE 10/9/07

Plan View - Ramp C



- Station 3902+50

Point E: δ = 1.8" (at wall face)

Point F: δ = 4.4" (at ramp centerline)

SJK 10-10-07
SJT 10-19-07

Ramp C Wall STA 3902+50 back-to-back

ÚÄÄÄÄÄ ONE DIMENSIONAL SETTLEMENT ANALYSIS/Federal Highway Administration ÄÄÄÄÄ¿
STRIP SYMMETRICAL VERTICAL EMBANKMENT LOADING

Project Name : SCI-823 Client : CH2M Hill
File Name : RC1 Project Manager : Nix
Date : 10/10/07 Computed by : sjr

Settlement for X-Direction

Embankment slope a = 0.10 (ft) Height of fill H = 23.50 (ft)
Embankment top width = 34.00 (ft) Unit weight of fill = 120.00 (pcf)
Embankment bottom width = 34.20 (ft) p load/unit area = 2820.00 (psf)
Ground Surface Elev. = 534.90 (ft) Foundation Elev. = 534.90 (ft)
Water table Elev. = 524.70 (ft) Unit weight of Wat. = 62.40 (pcf)

N§.	LAYER TYPE	THICK. (ft)	COEFFICIENT COMP.	RECOMP.	SWELL.	UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO
1	COMP.	6.9	0.160	0.016	0.000	120.00	2.65	0.44
2	COMP.	8.0	0.370	0.070	0.000	120.00	2.65	1.10
3	COMP.	6.0	0.020	0.020	0.000	120.00	2.65	1.00

N§.	SUBLAYER THICK. (ft)	ELEV. (ft)	SOIL STRESSES INITIAL (psf)	MAX.PAST PRESS. (psf)
1	6.90	531.45	414.00	3000.00
2	8.00	524.00	1264.32	3000.00
3	6.00	517.00	1667.52	3000.00

Layer	X = 0.10 Stress (psf)	Sett. (in.)	X = 3.50 Stress (psf)	Sett. (in.)	X = 6.90 Stress (psf)	Sett. (in.)	X = 10.30 Stress (psf)	Sett. (in.)
1	1435.40	0.60	2562.95	0.79	2760.62	1.02	2798.18	1.06
2	1400.78	1.04	1920.08	1.64	2286.00	2.44	2489.95	2.85
3	1350.28	0.19	1664.15	0.22	1927.90	0.24	2116.91	0.26
		1.82		2.64		3.70		4.17

Pt. E

Layer	X = 13.70 Stress (psf)	Sett. (in.)	X = 17.10 Stress (psf)	Sett. (in.)
1	2808.25	1.08	2810.55	1.08
2	2585.84	3.03	2613.55	3.09
3	2227.09	0.27	2262.92	0.27
		4.38		4.43

Pt. F

ÀÄÄÄÄÄ Hit arrow keys to display next screen. <F8> Print. <F10> Main Menu ÄÄÄÄÄÙ

DLZ

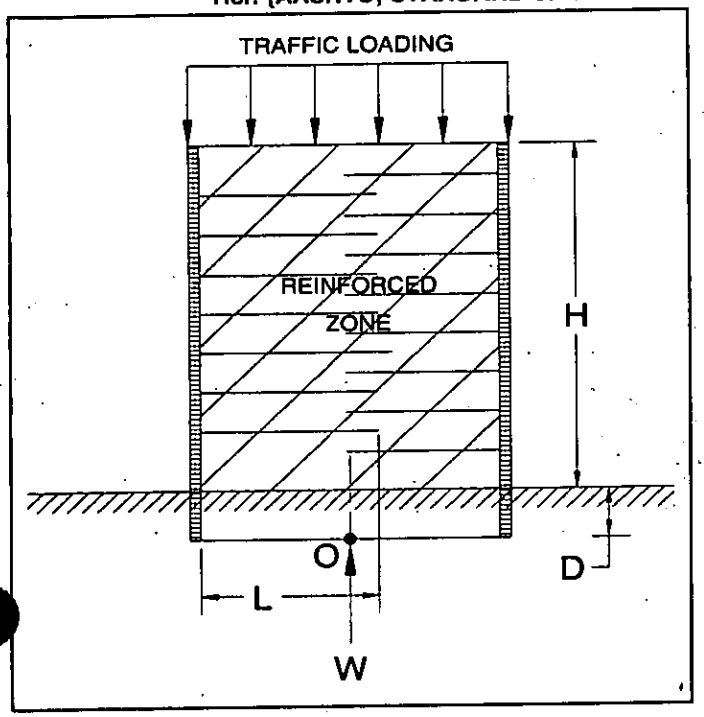
SUBJECT

Client	CH2M Hill
Project	SCI-823 Portsmouth Bypass
Item	MSE Wall Bearing Capacity
	US 23 Ramp C Wall No 5, Station 3902+50, back-to-back walls
	Ka=0.33, for soil reinforcement overlap less than 0.3*H

JOB NUMBER	0121-3070.03
SHEET NO.	26 OF 36
COMP. BY	SJH DATE 10-10-07
CHECKED BY	DWS DATE 10-19-07

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

Using Initial Undrained Strengths

γ_{RFC}	= 120	pcf	Unit weight	Reinforced fill
ϕ'_{RFC}	= 34	deg.	Friction ang.	Reinforced fill
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 900	psf	Cohesion	Foundation soil
ϕ	= 0	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= 28	deg.	Friction ang.	Foundation soil

Loads and Parameters

ω_t	= 240	psf	Traffic loading
L=B	= 21.5	ft	Length of MSE reinforcement
L factor	= 1		Length factor-range (0.7 - 1.0)
D	= 3	ft	Embedment depth
Dw	= 0	ft	Groundwater depth
H+D	= 21.5	ft	
H	= 18.5	ft	Height of wall
Ka	= **0.33**		
Γ Pa	= 7.1667	ft	Moment arm
Γ Wt	= 10.75	ft	Moment arm
B'	= 18.74	ft	
γ'	= 57.6	pcf	
W_t	5,160	lb/ft of wall	Weight from traffic
W_{mse}	= 55,470	lb/ft of wall	Weight from MSE wall

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ'_v = 3,235 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 4,799 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 1,920 psf

Factor of Safety = 1.48 * **No Good**

*See Staged Construction Analyses, pg. 3

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 11,568 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 4,627 psf

Factor of Safety = 3.58 **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	25.80
N_q	1.00	N_q	14.72
N_γ	0.00	N_γ	16.72

Eccentricity of Resultant Force

e = 1.38 ft

Kern

e < L/6 = 3.58 ft

DLZ

SUBJECT

Client	TranSystems Corp	JOB NUMBER	0121-3070.03
Project	SCI-823 Portsmouth Bypass	SHEET NO.	27 OF 36
Item	MSE Wall Stability	COMP. BY	SJH DATE 10-10-07
US 23 Ramp C Wall No 5, Station 3902+50		CHECKED BY	EWT DATE 10-19-07

Based upon boring B-1122 & B-1121

STABILITY OF MSE WALL

Assumptions:

1 Estimated height of embankment; H=18.5'
2 Assumed maximum height with full lateral earth pressure
3 Ground water; Dw=0.0'
4 Traffic loading is neglected in resisting forces
5 Use strengths from shallow softer soil layer

Wall Properties				Foundational Soil Properties			
H+D	=	21.5	feet	c	=	2000	psf Cohesion
γ_{mse}	=	120	pcf	ϕ'	=	29	deg Friction angle
L	=	21.5	feet	ω_T	=	240	psf Traffic loading
L factor	=	1.00		Length factor-range (0.7 - 1.0)			
ϕ	=	30	deg	Friction Angle of Embankment Fill			

RESISTANCE AGAINST SLIDING ALONG BASE

Thrust: $P_a = K_a\left[\frac{1}{2}\gamma H^2 + \omega_T H\right]$

where; $K_a = \tan^2(45 - \frac{\phi}{2})$ K_a = 0.33

P_a = 10,855 lbs per foot of wall

Resistance: $P_r = W(\mu)$ (Drained)

where; $\mu = \left(\frac{2}{3}\right)\tan(\phi)$ μ = 0.37

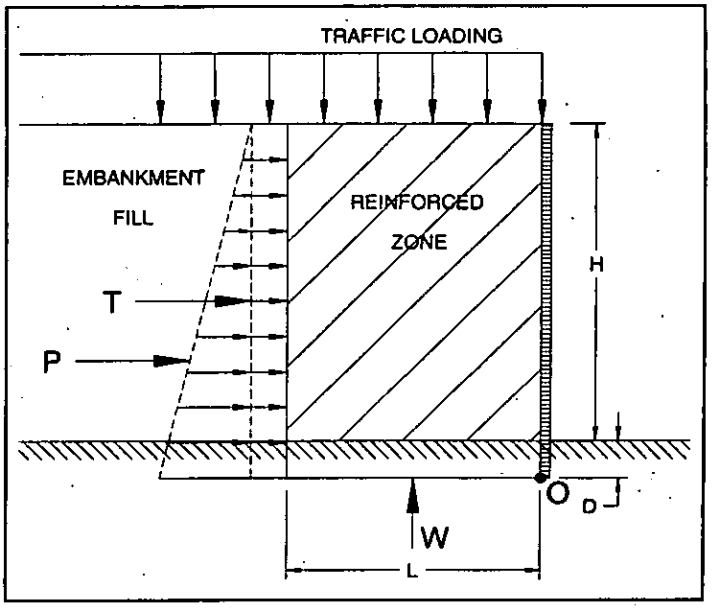
P_r = 20,524 lbs per foot of wall

USE THIS VALUE

$P_r = L(c)$ (Undrained)

P_r = 43,000 lbs per foot of wall

Use Drained Value



	Calculated	Required	
$FS = \frac{P_r}{P_a}$	FS = **1.89**	FS = 1.50	Resistance Against Sliding is **OK**

RESISTANCE AGAINST OVERTURNING

* Summation of Moments about point "O" (base of wall).
* Traffic loading is neglected in resisting forces

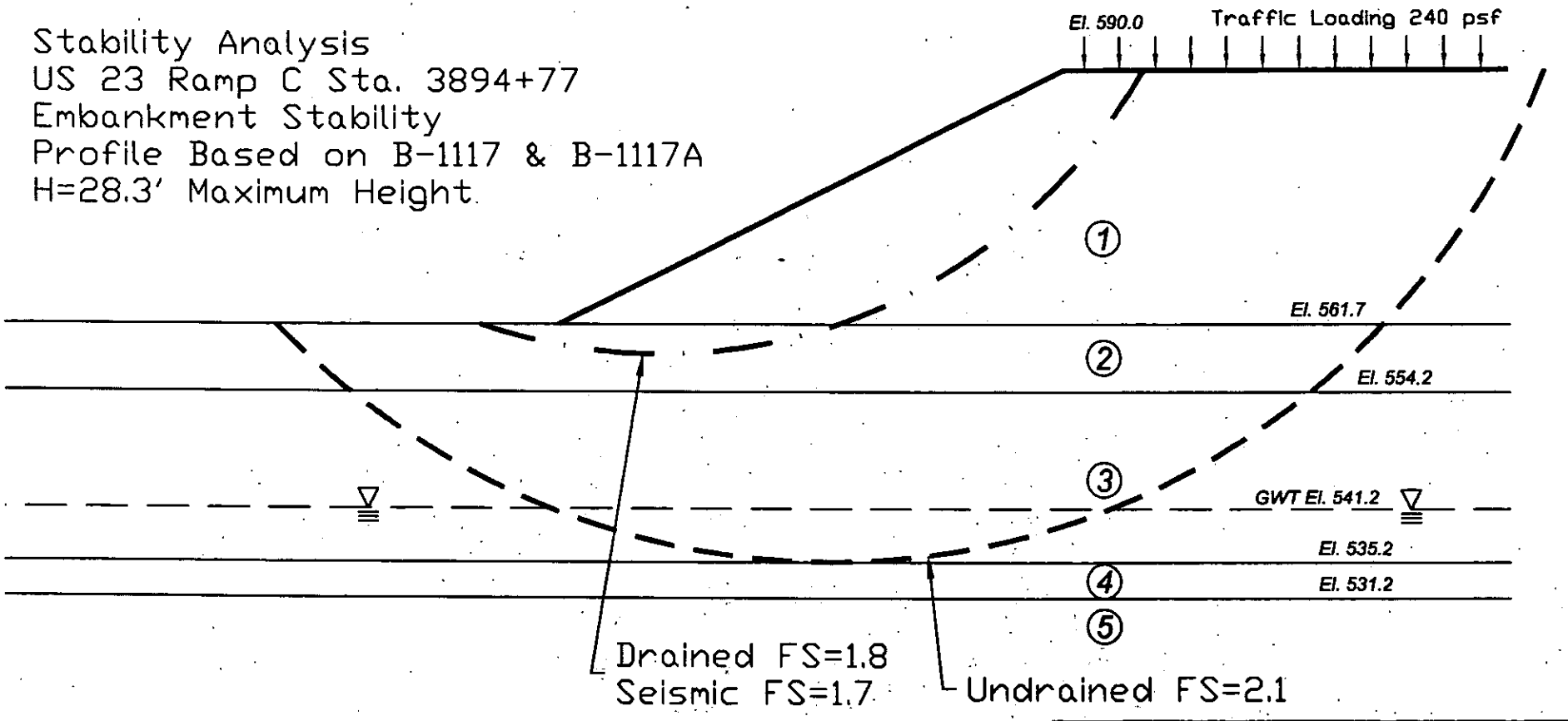
$\Sigma M_{resisting}$ = 596,303 lb-ft $\quad \Sigma M_{resisting} = \gamma H L\left(\frac{L}{2}\right)$

$\Sigma M_{overturning}$ = 83,898 lb-ft $\quad \Sigma M_{overturning} = K_a\left[\frac{1}{2}\gamma H^2\left(\frac{H}{3}\right) + \omega_T H\left(\frac{H}{2}\right)\right]$

	Calculated	Required	
$FS = \frac{\Sigma M_{resisting}}{\Sigma M_{overturning}}$	FS = **7.11**	FS = 2.00	Resistance Against Overturning is **OK**

Material	Consistency	Soil Type	Undrained c (psf)	Undrained φ (deg)	Drained c' (psf)	Drained φ' (deg)	γ (pcf)
Material 1	Compacted	Emb. Fill	2000	0	300	28	120
Material 2	V. Stiff	A-6a	2000	0	0	29	120
Material 3	Loose	A-4b/A-6b	900	0	0	28	120
Material 4		Sand & Grvl	0	32	0	32	120
Material 5		Bedrock	10000	45	10000	45	145

Stability Analysis
US 23 Ramp C Sta. 3894+77
Embankment Stability
Profile Based on B-1117 & B-1117A
H=28.3' Maximum Height



US-23 Interchange
Ramp C Embankment, Using 2H:1V Slopes
Station 3894+77

EMBANKMENT GLOBAL STABILITY ANALYSIS

SCI-823-0.00

PROJECT NO. 0121-3070.03	CALC SJR	DATE 10/2/07

Stability Analyses performed using UTEXAS3 Version 1.201

EOT 10-19-07
Sheet 28 of 36 SJK 10-10-07

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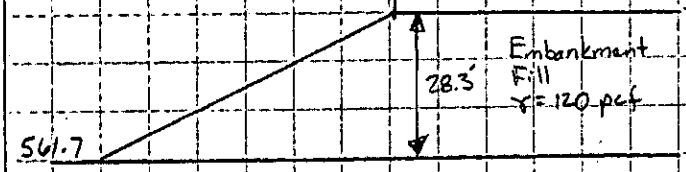
PLANNERS • SURVEYORS

CLIENT CHZM Hill
PROJECT SR1-823 Portsmouth Bypass
SUBJECT Consolidation Parameters
Settlement - Ramp C Station 3894+77

PROJECT NO. 0121-3070.03
SHEET NO. 29 OF 36
COMP. BY SJK DATE 10-10-07
CHECKED BY GWT DATE 10-19-07

Evaluate Settlement at Station 3894+77; Using 2H:1V Slopes
Profile based upon boring B-1117 & B-1117A

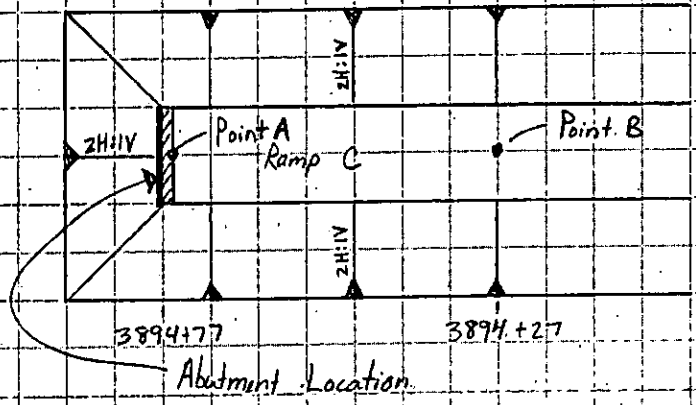


* Assume groundwater table at 541.2'

①	V. Stiff	$\bar{\omega} \pm 15\%$	$C_c = .15$	$C_r = .015$	Estimated from moisture content
554.2	A-6a	$e_o = \frac{2.75(15)}{100} = .413$	Assume $P_c = 2700$		Ref: FHWA-00-045 "Soils and Foundations Workshop"
②	Stiff	$C_c = 0.24$	$C_r = 0.04$	$e_o = .692$	Consolidation Testing from boring B-46
535.2	A-4b/A-6b	$P_c = 2700$ psf			P-1, A-6b sample, 5.0'-7.0'
③	Loose	$\gamma = 120$ pcf	$\bar{N} = 4$		c' estimated from FHWA-00-045
531.2	A-2-6	$\bar{N}' = 4$	$C' = 1.40$		"Soils and Foundations Workshop"

* See Sample Calculation pg. 2
* $C_u = C_r = 0.05$

Plan View - Ramp C



Point A: $\delta = 12.0"$

Point B: $\delta = 12.9"$

Ramp C 3894+77 side slopes

ONE DIMENSIONAL SETTLEMENT ANALYSIS/Federal Highway Administration
INCREMENT OF STRESSES BENEATH THE END OF FILL CONDITION

Project Name : SCI-823
File Name : RC3
Date : 10/10/07
Client : CH2M Hill
Project Manager : Nix
Computed by : sjr

Settlement for X-Direction

Embank. slope, x direc. =	56.60 (ft)	Height of fill H =	28.30 (ft)
y direc. =	56.60 (ft)	Unit weight of fill =	120.00 (pcf)
Embankment top width =	40.00 (ft)	p load/unit area =	3396.00 (psf)
Embankment bottom width =	153.20 (ft)	Foundation Elev. =	561.70 (ft)
Ground Surface Elev. =	561.70 (ft)		
Water table Elev. =	541.20 (ft)	Unit weight of Wat. =	62.40 (pcf)

N§.	LAYER TYPE	THICK. (ft)	COEFFICIENT COMP.	RECOMP.	SWELL.	UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO
1	COMP.	7.5	0.150	0.015	0.000	120.00	2.65	0.41
2	COMP.	19.0	0.240	0.040	0.000	120.00	2.65	0.69
3	COMP.	4.0	0.050	0.050	0.000	120.00	2.65	1.00

N§.	SUBLAYER THICK. (ft)	ELEV. (ft)	SOIL STRESSES INITIAL (psf)	MAX.PAST PRESS. (psf)
1	7.50	557.95	450.00	2700.00
2	19.00	544.70	2040.00	2700.00
3	4.00	533.20	2920.80	2700.00

Layer	X = Stress (psf)	0.00 Sett. (in.)	X = Stress (psf)	15.32 Sett. (in.)	X = Stress (psf)	30.64 Sett. (in.)	X = Stress (psf)	45.96 Sett. (in.)
1	55.02	0.05	928.41	0.47	1832.66	0.68	2743.82	1.44
2	298.58	0.32	954.18	2.11	1770.10	5.50	2512.13	8.00
3	449.85	0.12	986.61	0.19	1646.05	0.27	2231.16	0.34
		0.48		2.77		6.45		9.78

Layer	X = Stress (psf)	61.28 Sett. (in.)	X = Stress (psf)	76.60 Sett. (in.)
1	3333.85	2.15	3339.83	2.15
2	2935.18	9.25	3018.02	9.48
3	2587.79	0.37	2691.50	0.38
		11.77		12.02

P.A.

Hit arrow keys to display next screen. <F8> Print. <F10> Main Menu

Sheet 31 of 35
SJR 10-10-07
SWT 10-9-07

Ramp C 3894+27 side slopes

ÚÄÄÄÄÄ ONE DIMENSIONAL SETTLEMENT ANALYSIS/Federal Highway Administration ÄÄÄÄÄ¿
INCREMENT OF STRESSES BENEATH THE END OF FILL CONDITION

Project Name	: SCI-823	Client	: CH2M Hill
File Name	: RC3	Project Manager	: Nix
Date	: 10/10/07	Computed by	: sjr

Settlement for X-Direction

Embank. slope, x direc.	= 56.60 (ft)	Height of fill H	= 28.30 (ft)
y direc.	= 56.60 (ft)	Unit weight of fill	= 120.00 (pcf)
Embankment top width	= 40.00 (ft)	p load/unit area	= 3396.00 (psf)
Embankment bottom width	= 153.20 (ft)	Foundation Elev.	= 561.70 (ft)
Ground Surface Elev.	= 561.70 (ft)		
Water table Elev.	= 541.20 (ft)	Unit weight of Wat.	= 62.40 (pcf)

N§.	LAYER TYPE	THICK. (ft)	COEFFICIENT COMP.	RECOMP.	SWELL.	UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO
1	COMP.	7.5	0.150	0.015	0.000	120.00	2.65	0.41
2	COMP.	19.0	0.240	0.040	0.000	120.00	2.65	0.69
3	COMP.	4.0	0.050	0.050	0.000	120.00	2.65	1.00

N§.	SUBLAYER THICK. (ft)	ELEV. (ft)	SOIL STRESSES INITIAL (psf)	MAX.PAST PRESS. (psf)
1	7.50	557.95	450.00	2700.00
2	19.00	544.70	2040.00	2700.00
3	4.00	533.20	2920.80	2700.00

Layer	X = Stress (psf)	0.00 Sett. (in.)	X = Stress (psf)	15.32 Sett. (in.)	X = Stress (psf)	30.64 Sett. (in.)	X = Stress (psf)	45.96 Sett. (in.)
1	55.14	0.05	928.71	0.47	1833.57	0.68	2749.17	1.45
2	308.72	0.33	976.08	2.21	1821.67	5.69	2641.17	8.40
3	486.33	0.12	1056.46	0.20	1779.09	0.29	2466.65	0.36
		0.50		2.88		6.65		10.21

Layer	X = Stress (psf)	61.28 Sett. (in.)	X = Stress (psf)	76.60 Sett. (in.)
1	3386.20	2.21	3394.45	2.21
2	3175.54	9.92	3291.61	10.22
3	2926.83	0.40	3069.43	0.42
		12.52		12.85

A.B

ÀÄÄÄÄÄ Hit arrow keys to display next screen. <F8> Print. <F10> Main Menu ÄÄÄÄÄÙ

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CLIENT CH2M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Time-rate of Consolidation & downdrag on piles - Ramp C

PROJECT NO. 0121-3070.03
SHEET NO. 32 OF 36
COMP. BY SJK DATE 10-10-07
CHECKED BY SWT DATE 10-19-07

* Station 3894+77 Profile based upon boring B-1117 & B-1117A

el. 561.7 Bottom of Excavation

A-6a: LL ≈ 34
el. 554.2 $C_v \approx 0.35$ ft²/day

A-4b/A-6b LL ≈ 33
el. 535.2 $C_v \approx 0.35$ ft²/day

A-2-6 Assume Free Draining
el. 531.2

Assume double drainage
$H_v = (561.7 - 535.2)/2 = 13.2'$

$t_{90} = \frac{T_v H_v^2}{C_v} = \frac{0.848 (13.2')^2}{0.35 \text{ ft}^2/\text{day}}$

$t_{90} = 422$ days

* C_v estimates are based upon LL - Ref: FHWA-HI-97-021 Fig 9-5, "Subsurface Investigations"

• Rear Abutment

* To prevent downdrag forces on piles, remaining settlement should be limited to 0.4 inches or less.

Settlement at ℄ of abutment, $\delta = 12.0"$
Of the 12.0", 11.6" is consolidation settlement.

$\left(1 - \frac{0.4}{11.6}\right) = 0.97$ OR $U = 97\%$ Say $U = 95\%$

Prior to driving piles, a degree of consolidation of at least 95% ($U = 95$) should be achieved to prevent downdrag forces from acting on the piles.

DLZ

Time Rate of Consolication of Foundation Soils with Wick Drians

US 23 Ramp C **Station** **3894+77**

Reference: FHWA-RD-86-168

SJK 10-10-07
SWT 10-19-07

Wick Drain Spacing **5.0** feet Use $\eta = 10$

t (days)	T_R	T_V	U_R	U_V	U_C	δ(inches)	d_e	c_v	H_v	δ_{max}
0	0.0000	0.0000	0.00	0.00	0.0	0.0	5.25	0.35	13.2	12
5	0.0635	0.0100	0.29	0.11	36.9	4.4				
10	0.1270	0.0201	0.49	0.15	56.2	6.7				
15	0.1905	0.0301	0.63	0.18	69.7	8.4				
20	0.2540	0.0402	0.74	0.21	79.1	9.5				
25	0.3175	0.0502	0.81	0.24	85.4	10.2				
30	0.3810	0.0603	0.86	0.26	89.5	10.7				
35	0.4444	0.0703	0.89	0.29	92.3	11.1				
40	0.5079	0.0803	0.91	0.31	94.1	11.3				
45	0.5714	0.0904	0.93	0.34	95.4	11.4				
50	0.6349	0.1004	0.94	0.36	96.4	11.6				
55	0.6984	0.1105	0.96	0.38	97.3	11.7				
60	0.7619	0.1205	0.97	0.40	98.2	11.8				
65	0.8254	0.1306	0.98	0.42	98.9	11.9				

Assumes a Triangular Grid Layout

DLZ

Time Rate of Consolication of Foundation Soils with Wick Drians

US 23 Ramp C **Station 3894+77** EWT 10-9-07

Reference: FHWA-RD-86-168

Wick Drain Spacing **7.0** feet Use $\eta = 10$

t (days)	T_R	T_V	U_R	U_V	U_C	δ(inches)	d_e	c_v	H_v	δ_{max}
0	0.0000	0.0000	0.00	0.00	0.0	0.0	7.35	0.35	13.2	12
5	0.0324	0.0100	0.17	0.11	26.3	3.2				
10	0.0648	0.0201	0.29	0.15	39.6	4.8				
15	0.0972	0.0301	0.40	0.18	50.7	6.1				
20	0.1296	0.0402	0.49	0.21	59.8	7.2				
25	0.1620	0.0502	0.57	0.24	67.3	8.1				
30	0.1944	0.0603	0.64	0.26	73.4	8.8				
35	0.2268	0.0703	0.70	0.29	78.4	9.4				
40	0.2592	0.0803	0.74	0.31	82.4	9.9				
45	0.2915	0.0904	0.78	0.34	85.6	10.3				
50	0.3239	0.1004	0.82	0.36	88.1	10.6				
55	0.3563	0.1105	0.84	0.38	90.2	10.8				
60	0.3887	0.1205	0.86	0.40	91.8	11.0				
65	0.4211	0.1306	0.88	0.42	93.1	11.2				
70	0.4535	0.1406	0.89	0.44	94.1	11.3				
75	0.4859	0.1507	0.91	0.45	94.9	11.4				
80	0.5183	0.1607	0.92	0.47	95.6	11.5				
85	0.5507	0.1707	0.93	0.49	96.2	11.5				
90	0.5831	0.1808	0.93	0.50	96.7	11.6				

Assumes a Triangular Grid Layout

SAR 10-10-07

DLZ

Time Rate of Consolication of Foundation Soils with Wick Drians

US 23 Ramp C **Station 3894+77**

Reference: FHWA-RD-86-168

EWT 10-19-07

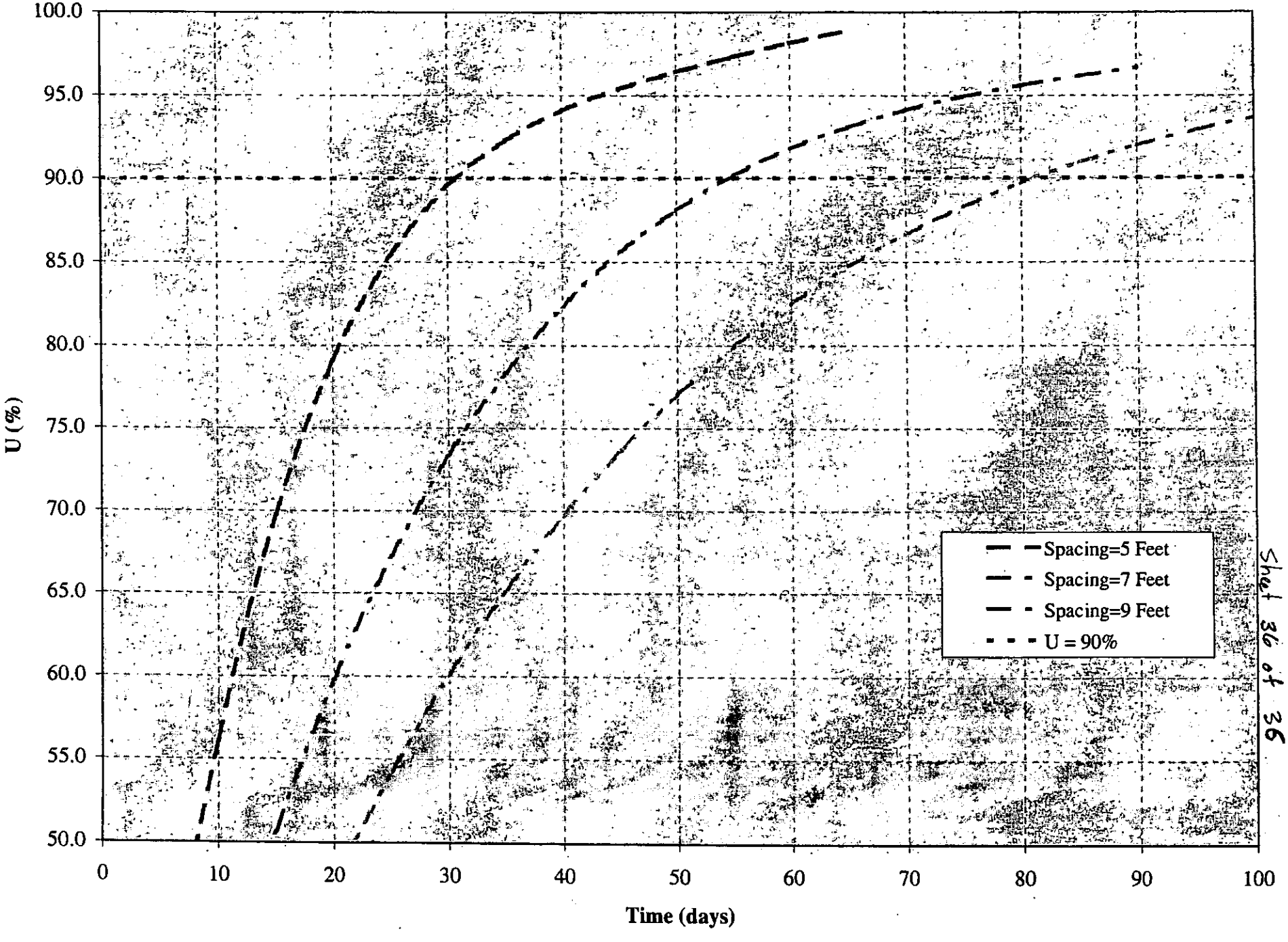
Wick Drain Spacing 9.0 feet Use $\eta = 10$

t (days)	T_R	T_V	U_R	U_V	U_C	δ(inches)	d_e	c_v	H_v	δ_{max}
0	0.0000	0.0000	0.00	0.00	0.0	0.0	9.45	0.35	13.2	12
5	0.0196	0.0100	0.11	0.11	21.5	2.6				
10	0.0392	0.0201	0.20	0.15	31.3	3.8				
15	0.0588	0.0301	0.27	0.18	40.0	4.8				
20	0.0784	0.0402	0.34	0.21	47.6	5.7				
25	0.0980	0.0502	0.40	0.24	54.3	6.5				
30	0.1176	0.0603	0.46	0.26	60.2	7.2				
35	0.1372	0.0703	0.51	0.29	65.3	7.8				
40	0.1568	0.0803	0.56	0.31	69.8	8.4				
45	0.1764	0.0904	0.60	0.34	73.7	8.8				
50	0.1960	0.1004	0.64	0.36	77.1	9.2				
55	0.2156	0.1105	0.68	0.38	80.0	9.6				
60	0.2352	0.1205	0.71	0.40	82.5	9.9				
65	0.2548	0.1306	0.74	0.42	84.7	10.2				
70	0.2743	0.1406	0.76	0.44	86.7	10.4				
75	0.2939	0.1507	0.79	0.45	88.3	10.6				
80	0.3135	0.1607	0.81	0.47	89.7	10.8				
85	0.3331	0.1707	0.82	0.49	90.9	10.9				
90	0.3527	0.1808	0.84	0.50	92.0	11.0				
95	0.3723	0.1908	0.85	0.52	92.9	11.1				
100	0.3919	0.2009	0.86	0.53	93.7	11.2				
105	0.4115	0.2109	0.88	0.54	94.3	11.3				

Assumes a Triangular Grid Layout

DLZ

Percent Consolidation vs Time Using Prefabricated Vertical "Wick" Drains
US-23 Interchange, Ramp C, Sta. 3894+77



Sheet 36 of 36

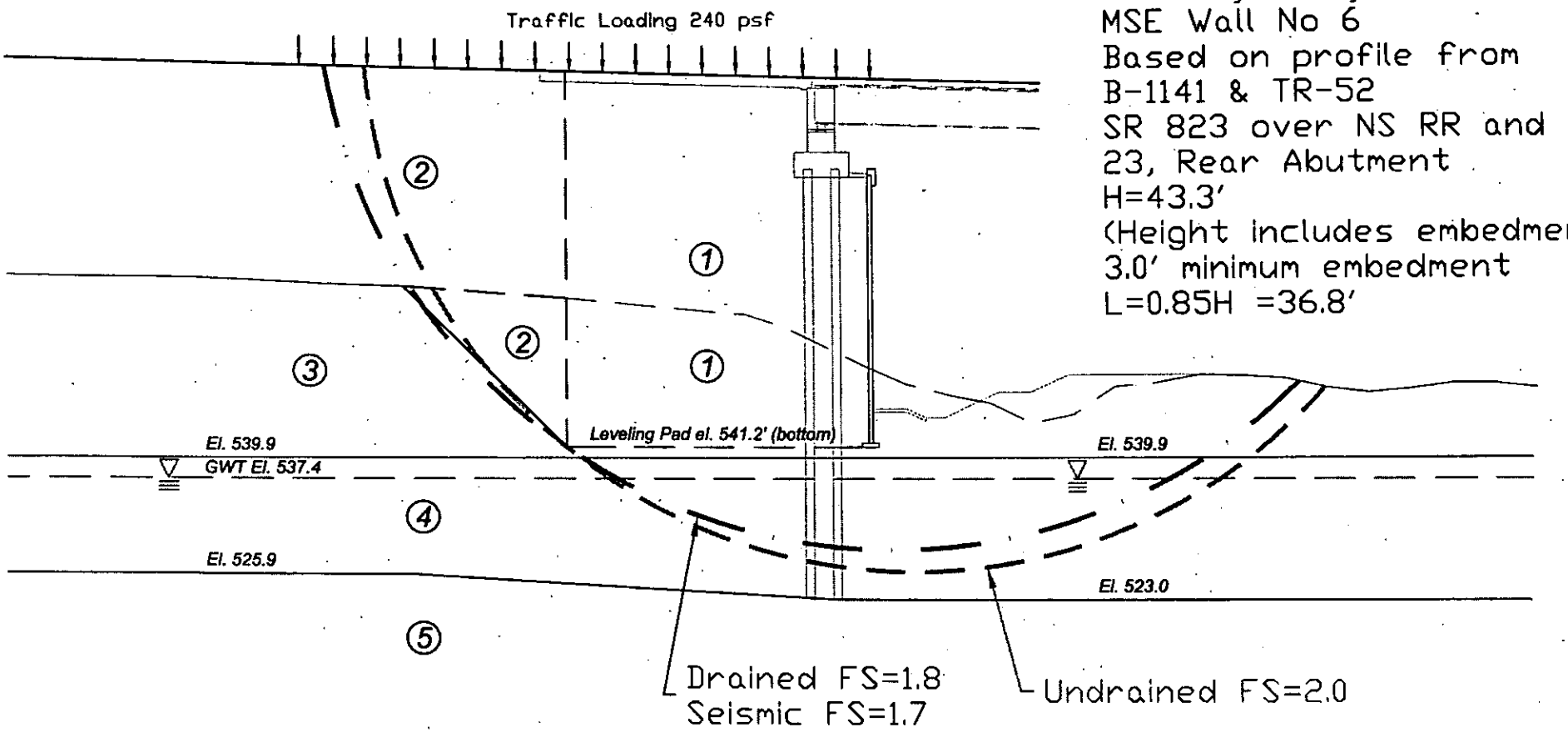
SJR 10-10-07
SWT 10-15-07

SR 823

MSE Retaining Walls (Walls No. 3 & 6) and Embankment Evaluations

Material	Consistency	Soil Type	Undrained c (psf)	Undrained φ (deg)	Drained c' (psf)	Drained φ' (deg)	γ (pcf)
Material 1	Compacted	MSE Fill	0	34	0	34	120
Material 2	Compacted	Emb. Fill	0	30	0	30	120
Material 3	V. Stiff	A-6b/A-4a	2000	0	0	29	120
Material 4	Loose-Med D	A-2-6	0	28	0	28	120
Material 5		Bedrock	3500	42	3500	42	140

Stability Analysis
MSE Wall No 6
Based on profile from
B-1141 & TR-52
SR 823 over NS RR and US
23, Rear Abutment
H=43.3'
(Height includes embedment)
3.0' minimum embedment
L=0.85H =36.8'



Stability Analyses performed using UTEXAS3 Version 1.201

US-23 Interchange
MSE Wall No. 6
Station 895+54

GLOBAL STABILITY ANALYSIS

SCI-823-0.00

PROJECT NO. 0121-3070.03	CALC: SJR	DATE 10/30/07

SWT 11-5-07
pg. 1 of 23 SJK 11-3-07

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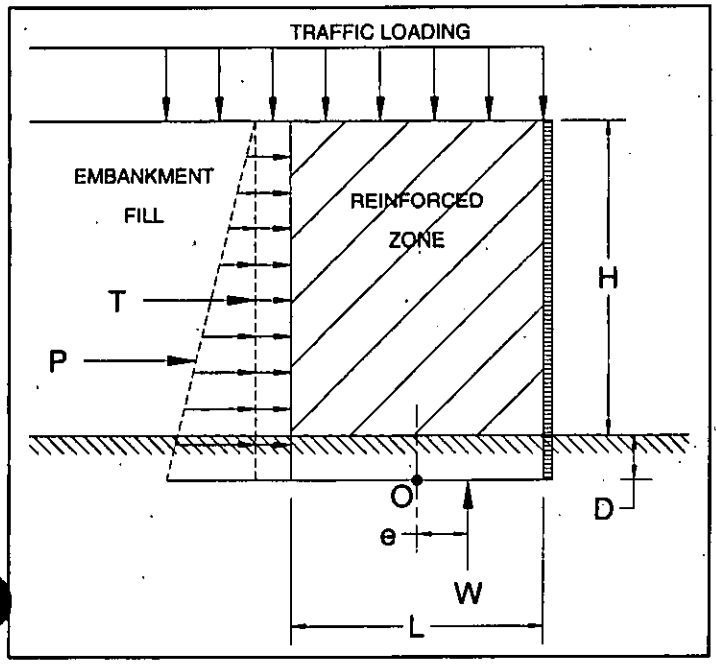
DLZ

SUBJECT

Client	CH2M Hill	JOB NUMBER	0121-3070.03		
Project	SCI-823 Portsmouth Bypass	SHEET NO.	2	OF	23
Item	MSE Wall Bearing Capacity	COMP. BY	SJK	DATE	11-3-07
Rear Abutment, MSE Wall No 6		CHECKED BY	GMT	DATE	11-5-07

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

* Shear strength values from A-2-6 layer at el. 537.4'

γ_{EMB}	= 120	pcf	Unit weight	Embankment fill
ϕ'_{EMB}	= 30	deg.	Friction ang.	Embankment fill
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 0	psf	Cohesion	Foundation soil
ϕ	= * 28	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= * 28	deg.	Friction ang.	Foundation soil

Loads and Parameters

ω_t	= 240	psf	Traffic loading	
L=B	= 36.805	ft	Length of MSE reinforcement	
L factor	= 0.85		Length factor-range (0.7 - 1.0)	
D	= 3	ft	Embedment depth	
Dw	= 0	ft	Groundwater depth	
H+D	= 43.3	ft		
H	= 40.3	ft	Height of wall	
Ka	= 0.33			
⌜ Pa	= 14.433	ft	Moment arm	
⌜ Wt	= 21.65	ft	Moment arm	
B'	= 30.71	ft		
γ'	= 57.6	pcf		
W_t	8,833	lb/ft of wall	Weight from traffic	
W_{mse}	= 191,239	lb/ft of wall	Weight from MSE wall	

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 6,516 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma B N_\gamma$$

q_{ULT} = 17,332 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 6,933 psf

Factor of Safety = 2.66 **OK**

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma B N_\gamma$$

q_{ULT} = 17,332 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 6,933 psf

Factor of Safety = 2.66 **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	25.80	N_c	25.80
N_q	14.72	N_q	14.72
N_γ	16.72	N_γ	16.72

Eccentricity of Resultant Force

e = 3.05 ft

Kern

e < L/6 = 6.13 ft

DLZ

SUBJECT

Client	CH2M Hill
Project	SCI-823 Portsmouth Bypass
Item	MSE Wall Stability
	Rear Abutment, MSE Wall No 6

JOB NUMBER	0121-3070.03
SHEET NO.	3 OF 23
COMP. BY	SJK DATE 11-3-07
CHECKED BY	GWT DATE 11-5-07

STABILITY OF MSE WALL

A-2-6 layer at el. 537.4

Assumptions:

1 Estimated height of embankment; H=40.3'
2 Sssume bridge is supported on deep foundations
3 Ground water; Dw=0.0'
4 Traffic loading is neglected in resisting forces
5 Use shear strength values of granular layer

Wall Properties

H+D = 43.3 feet
γ_{mse} = 120 pcf
L = 36.805 feet
L factor = 0.85 Length factor-range (0.7 - 1.0)
ϕ = 30.8 deg Friction Angle of Embankment Fill

Foundational Soil Properties

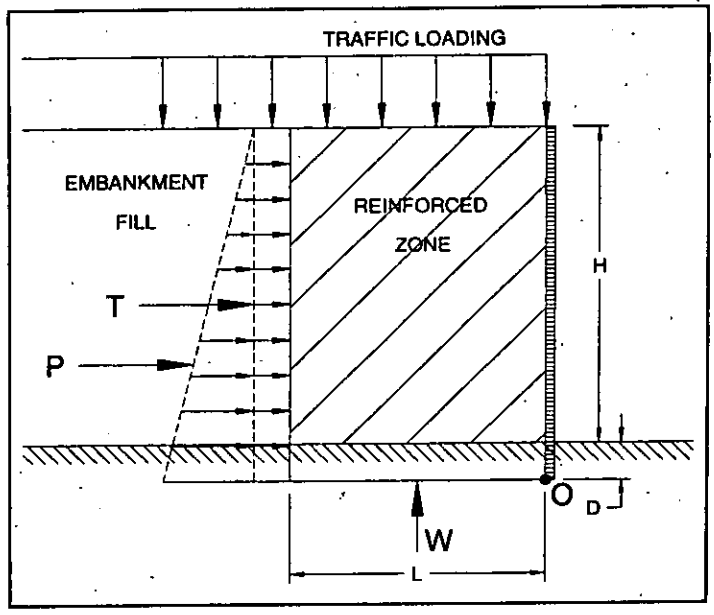
c = 0 psf Cohesion
ϕ' = 28 deg Friction angle
ω_T = 240 psf Traffic loading

RESISTANCE AGAINST SLIDING ALONG BASE

Thrust: $P_a = K_a\left[\frac{1}{2}\gamma H^2 + \omega_T H\right]$

where; $K_a = \tan^2(45 - \frac{\phi}{2})$ K_a = 0.33

P_a = 40,552 lbs per foot of wall



Resistance: $P_r = W(\mu)$ (Drained)

where; $\mu = \left(\frac{2}{3}\right)\tan(\phi)$ μ = 0.36

P_r = 68,846 lbs per foot of wall

USE THIS VALUE

$P_r = L(c)$ (Undrained)

P_r = 0 lbs per foot of wall

Use Drained Value

	Calculated	Required	
$FS = \frac{P_r}{P_a}$	FS = **1.70**	FS = 1.50	Resistance Against Sliding is **OK**

RESISTANCE AGAINST OVERTURNING

* Summation of Moments about point "O" (base of wall).
* Traffic loading is neglected in resisting forces

$\Sigma M_{resisting}$ = 3,519,272 lb-ft $\quad \Sigma M_{resisting} = \gamma H L\left(\frac{L}{2}\right)$

$\Sigma M_{overturning}$ = 610,052 lb-ft $\quad \Sigma M_{overturning} = K_a\left[\frac{1}{2}\gamma H^2\left(\frac{H}{3}\right) + \omega_T H\left(\frac{H}{2}\right)\right]$

	Calculated	Required	
$FS = \frac{\Sigma M_{resisting}}{\Sigma M_{overturning}}$	FS = **5.77**	FS = 2.00	Resistance Against Overturning is **OK**

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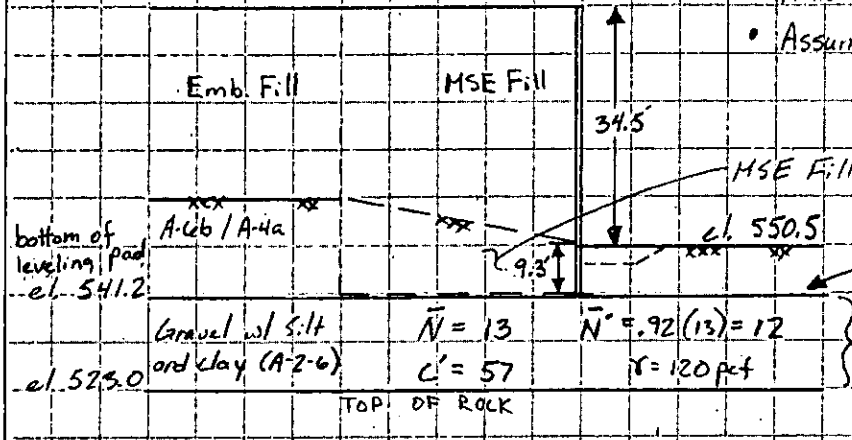
CLIENT CH2M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT MSE Wall No. 6 - Settlement
SR 823 over NSRR and US23 - Rear Abutment

PROJECT NO. 0121-3070.03
SHEET NO. 4 OF 23
COMP. BY SJK DATE 10-30-07
CHECKED BY GWT DATE 11-5-07

Evaluate Settlement at Station 895+48 (Rear Abutment Location)
Profile based upon boring B-1141 and TR-52

Profile at Rear Abutment

- H = 585 - 550.5 = 34.5' (At MSE wall face)
  H is measured above existing ground surface.
- Assume groundwater table = el. 537.4'



} Estimated from FHWA-00-045 "Soils and Foundations Workshop"
*See Sample Calculation below.

Sample Calculation

Calculate equivalent parameters from c' for EMBANK inputs:

$\frac{1}{c'} = \frac{C_c}{1+e_o}$ Say $e_o = 1.0$ in this case

$\frac{1}{c'} = \frac{C_c}{1+1.0} \longrightarrow \boxed{c' = \frac{2.0}{C_c}}$

When $c' = 57 \longrightarrow \frac{2.0}{57} = 0.035$

δ_A = 0.1" @ toe of embankment / wall
δ_B = 1.2" @ ¼ of embankment / wall

- Differential Settlement between pt A and pt B

$DS = \frac{(1.2" - 0.1")\left(\frac{1'}{12"}\right)}{101.5'} = 0.0009$ OR .09% < 1.0%

✓ OK

SR 823 over NS RR and US 23 - Rear Abutment Settlement at MSE Wall Face

ONE DIMENSIONAL SETTLEMENT ANALYSIS/Federal Highway Administration
INCREMENT OF STRESSES BENEATH THE END OF FILL CONDITION

Project Name	: SCI-823	Client	: CH2M Hill
File Name	: 823RA.emb	Project Manager	: Nix
Date	: 10/30/07	Computed by	: sjr

Settlement for X-Direction

Embank. slope, x direc. =	69.00 (ft)	Height of fill H =	34.50 (ft)
y direc. =	69.00 (ft)	Unit weight of fill =	120.00 (pcf)
Embankment top width =	65.00 (ft)	p load/unit area =	4140.00 (psf)
Embankment bottom width =	203.00 (ft)	Foundation Elev. =	550.50 (ft)
Ground Surface Elev. =	550.50 (ft)		
Water table Elev. =	537.40 (ft)	Unit weight of Wat. =	62.40 (pcf)

N§.	LAYER TYPE	THICK. (ft)	COEFFICIENT COMP.	RECOMP.	SWELL.	UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO
1	INCOMP.	9.3	-----	-----	-----	120.00	----	----
2	COMP.	18.2	0.035	0.035	0.000	120.00	2.65	1.00

N§.	SUBLAYER THICK. (ft)	ELEV. (ft)	SOIL STRESSES INITIAL (psf)	MAX.PAST PRESS. (psf)
1	INCOMP.			
2	9.10	536.65	1615.20	1615.20
3	9.10	527.55	2139.36	2139.36

Layer	X = 0.00 Stress (psf)	Sett. (in.)	X = 20.30 Stress (psf)	Sett. (in.)	X = 40.60 Stress (psf)	Sett. (in.)	X = 60.90 Stress (psf)	Sett. (in.)
1	INCOMP.	INCOMP.	INCOMP.	INCOMP.				
2	128.26	0.06	625.78	0.27	1220.75	0.47	1787.10	0.62
3	209.53	0.08	650.21	0.22	1204.71	0.37	1714.48	0.49
		0.14		0.49		0.84		1.11

Pt. A @ toe

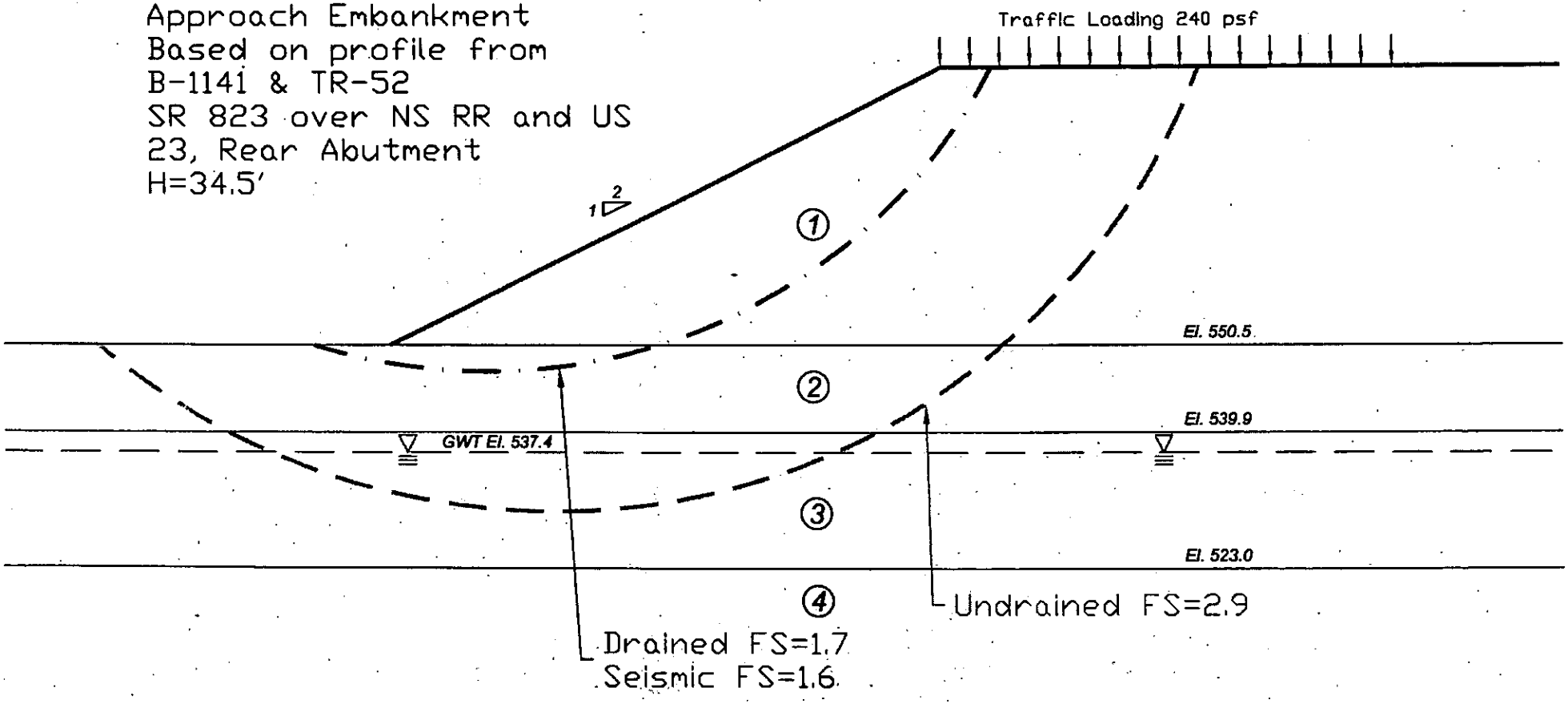
Layer	X = 81.20 Stress (psf)	Sett. (in.)	X = 101.50 Stress (psf)	Sett. (in.)
1	INCOMP.	INCOMP.		
2	2045.87	0.68	2066.79	0.68
3	1979.33	0.54	2026.65	0.55
		1.22		1.24

Pt. B @ ¼ of embankment

Hit arrow keys to display next screen. <F8> Print. <F10> Main Menu

Material	Consistency	Soil Type	Undrained c (psf)	Undrained φ (deg)	Drained c' (psf)	Drained φ' (deg)	γ (pcf)
Material 1	Compacted	Emb. Fill	2000	0	300	28	120
Material 2	V. Stiff	A-6b/A-4a	2000	0	0	29	120
Material 3	Loose-Med D	A-2-6	0	28	0	28	120
Material 4		Bedrock	3500	42	3500	42	140

Stability Analysis
Approach Embankment
Based on profile from
B-1141 & TR-52
SR 823 over NS RR and US
23, Rear Abutment
H=34.5'



Stability Analyses performed using UTEXAS3 Version 1.201

US-23 Interchange
Approach Embankment
Station 895+17 to 895+54

GLOBAL STABILITY ANALYSIS

SCI-823-0.00

PROJECT NO. 0121-3070.03	CALC. SJR	DATE 10/30/07

EWT 11-5-07
SJR 11-3-07

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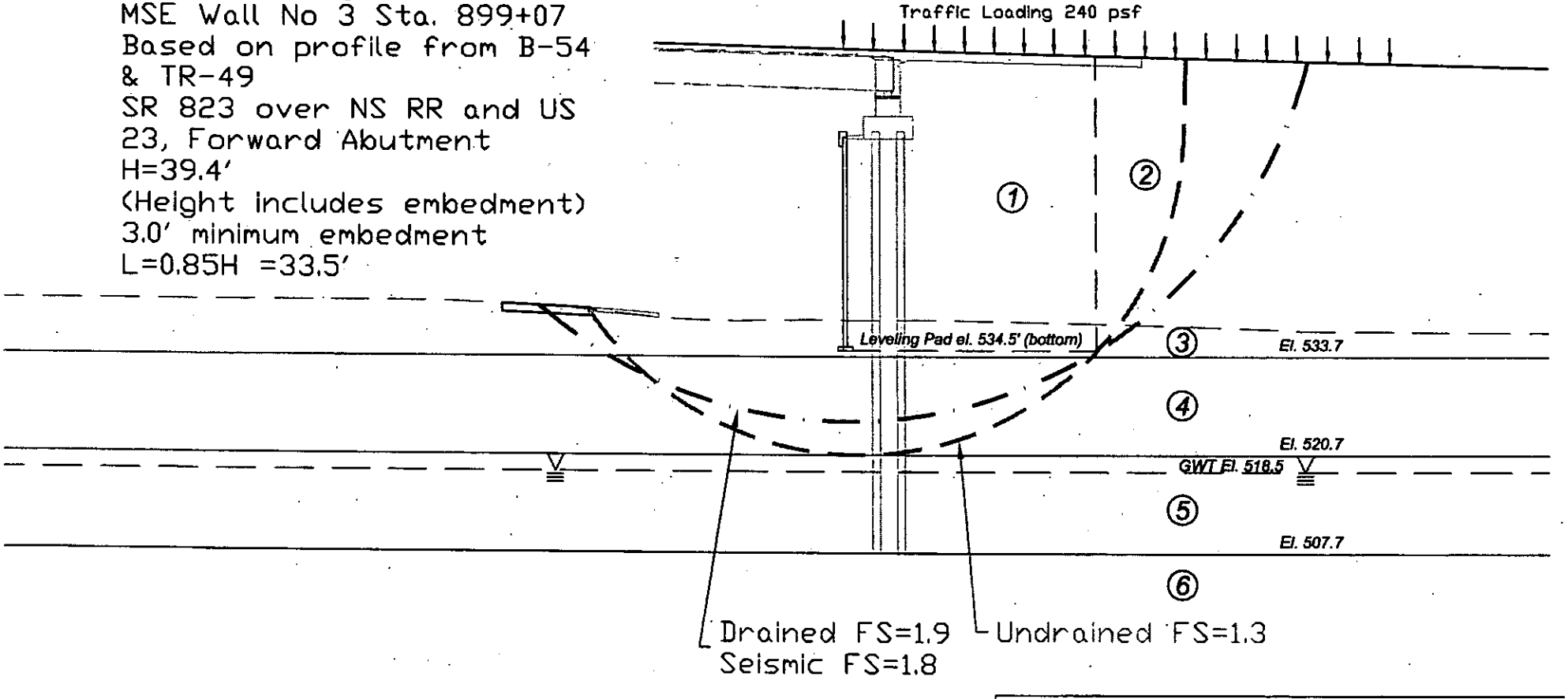
Material	Consistency	Soil Type	Undrained c (psf)	Undrained φ (deg)	Drained c' (psf)	Drained φ' (deg)	γ (pcf)
Material 1	Compacted	MSE Fill	0	34	0	34	120
Material 2	Compacted	Emb. Fill	0	30	0	30	120
Material 3	V. Stiff	A-6a/A-4a	2000	0	0	29	120
Material 4	Med. Stiff	A-6a/A-4a	900	0	0	28	120
Material 5	Med. Dense	Gravel	0	32	0	32	120
Material 6		Bedrock	3500	42	3500	42	140

Stability Analysis
MSE Wall No 3 Sta. 899+07
Based on profile from B-54
& TR-49
SR 823 over NS RR and US
23, Forward Abutment
H=39.4'
(Height includes embedment)
3.0' minimum embedment
L=0.85H =33.5'



Stability Analyses performed using UTEXAS3 Version 1.201

US-23 Interchange
MSE Wall No. 3
Station 899+07

GLOBAL STABILITY ANALYSIS

SCI-823-0.00

PROJECT NO. 0121-3070.03	CALC: SJR	DATE: 10/30/07

EWT 11-3-07
SJR 11-3-07

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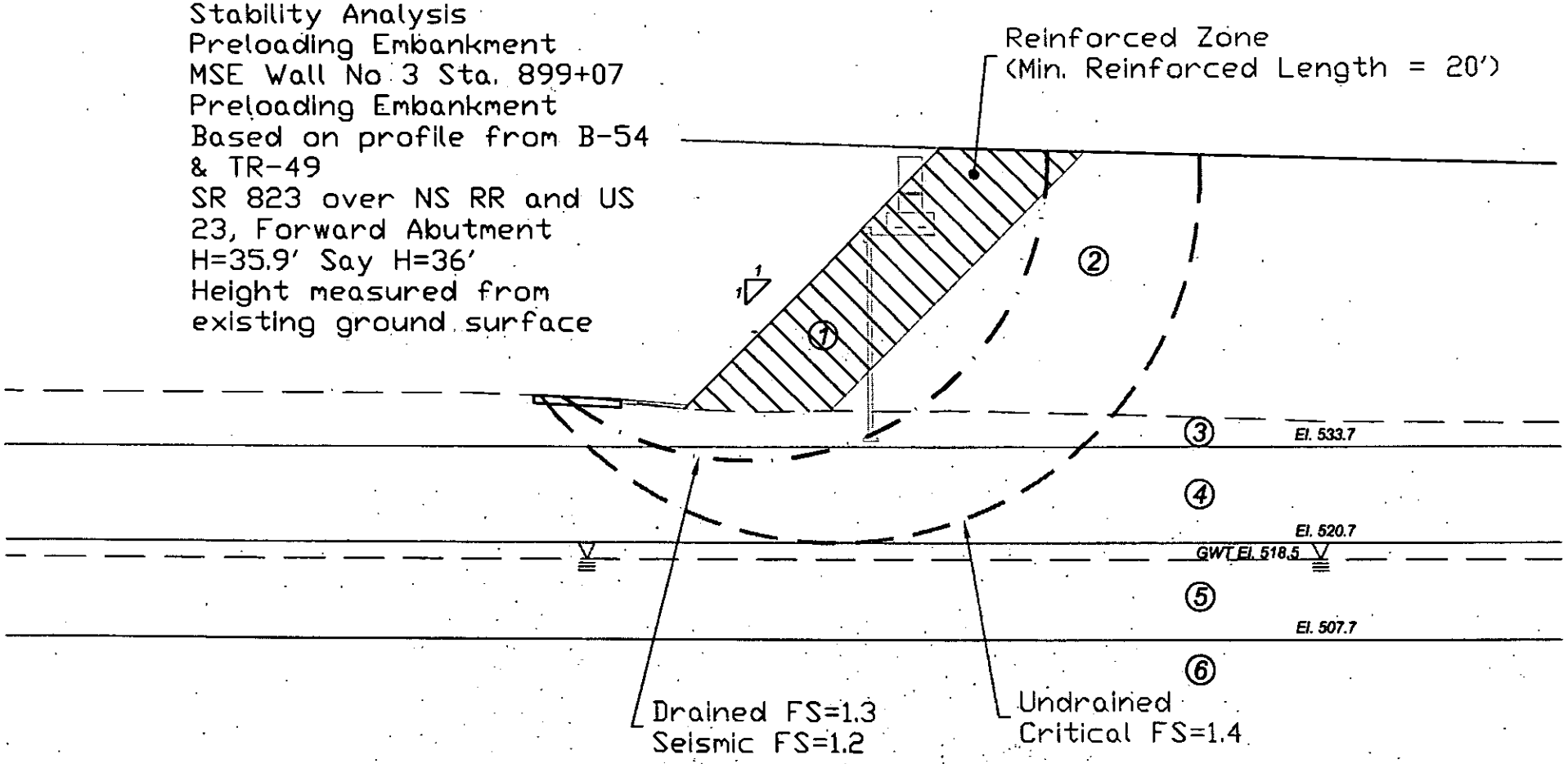
Material	Consistency	Soil Type	Undrained c (psf)	Undrained φ (deg)	Drained c' (psf)	Drained φ' (deg)	γ (pcf)
Material 1	Compacted	Reinforced Fill	2000*	34	2000*	34	120
Material 2	Compacted	Emb. Fill	0	30	0	30	120
Material 3	V. Stiff	A-6a/A-4a	2000	0	0	29	120
Material 4	Med. Stiff	A-6a/A-4a	900	0	0	28	120
Material 5	Med. Dense	Gravel	0	32	0	32	120
Material 6		Bedrock	3500	42	3500	42	140

Stability Analysis
Preloading Embankment
MSE Wall No 3 Sta. 899+07
Preloading Embankment
Based on profile from B-54
& TR-49
SR 823 over NS RR and US
23, Forward Abutment
H=35.9' Say H=36'
Height measured from
existing ground surface



US-23 Interchange
MSE Wall No. 3 (Preloading Embankment)
Station 899+07

GLOBAL STABILITY ANALYSIS

SCI-823-0.00

PROJECT NO. 0121-3070.03	CALC SJR	DATE 10/30/07

Stability Analyses performed using UTEXAS3 Version 1.201

4-5-07
SJR 11-3-07

DLZ

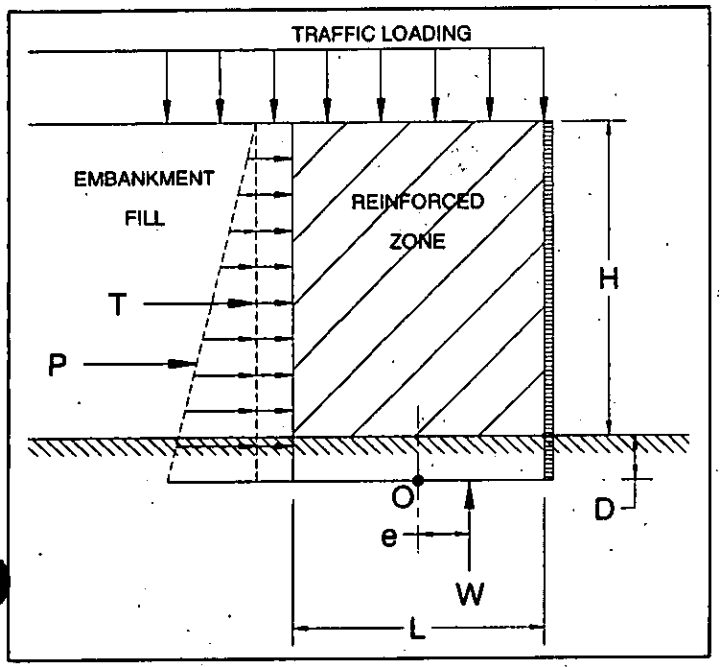
SUBJECT

Client	CH2M Hill
Project	SCI-823 Portsmouth Bypass
Item	MSE Wall Bearing Capacity
	MSE Wall No 3, US 23 Interchange
	SR 823 over NS RR and US 23, Forward Abutment

JOB NUMBER	0121-3070.03		
SHEET NO.	9	OF	23
COMP. BY	SAK	DATE	11-3-07
CHECKED BY	GWT	DATE	11-5-07

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

Using Initial Undrained Shear Strengths

γ_{EMB}	= 120	pcf	Unit weight	Embankment fill
ϕ'_{EMB}	= 30	deg.	Friction ang.	Embankment fill
γ_{FDN}	= 120	pcf	Unit weight	Foundation soil
c	= 900	psf	Cohesion	Foundation soil
ϕ	= 0	deg.	Friction ang.	Foundation soil
c'	= 0	psf	Cohesion	Foundation soil
ϕ'	= 28	deg.	Friction ang.	Foundation soil

Loads and Parameters

ω_t	= 240 psf		Traffic loading
L=B	= 33.49 ft		Length of MSE reinforcement
L factor	= 0.85		Length factor-range (0.7 - 1.0)
D	= 3.5 ft		Embedment depth
Dw	= 0 ft		Groundwater depth
H+D	= 39.4 ft		
H	= 35.9 ft		Height of wall
Ka	= 0.33		
Γ Pa	= 13.133 ft		Moment arm
Γ Wt	= 19.7 ft		Moment arm
B'	= 27.89 ft		
γ'	= 57.6 pcf		
W_t	8,038 lb/ft of wall		Weight from traffic
W_{mse}	= 158,341 lb/ft of wall		Weight from MSE wall

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 5,966 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 4,828 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 1,931 psf

Factor of Safety = 0.81 * **No Good**

See preloading embankment

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 16,398 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 6,559 psf

Factor of Safety = 2.75 **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	25.80
N_q	1.00	N_q	14.72
N_γ	0.00	N_γ	16.72

Eccentricity of Resultant Force

e = 2.80 ft

Kern

e < L/6 = 5.58 ft

DLZ

SUBJECT

Client	CH2M Hill	JOB NUMBER	0121-3070.03
Project	SCI-823 Portsmouth Bypass	SHEET NO.	10 OF 23
Item	MSE Wall Stability	COMP. BY	SAK DATE 11-3-07
MSE Wall No 3, US 23 Interchange		CHECKED BY	SLW DATE 11-5-07
SR 823 over NS RR and US 23, Forward Abutment			

STABILITY OF MSE WALL

Assumptions:

1 Estimated height of embankment; H=36.4' OR 35.9
2 Sssume bridge is supported on deep foundations
3 Ground water; Dw=0.0'
4 Traffic loading is neglected in resisting forces
5 **Using Initial Undrained Shear Strengths**

Wall Properties				Foundational Soil Properties			
H+D	=	39.4	feet	c	=	900	psf Cohesion
γ_{mse}	=	120	pcf	ϕ'	=	28	deg Friction angle
L	=	33.49	feet	ω_T	=	240	psf Traffic loading
L factor	=	0.85		Length factor-range (0.7 - 1.0)			
ϕ	=	30	deg	Friction Angle of Embankment Fill			

RESISTANCE AGAINST SLIDING ALONG BASE

Thrust: $P_a = K_a\left[\frac{1}{2}\gamma H^2 + \omega_T H\right]$

where; $K_a = \tan^2(45 - \frac{\phi}{2})$ K_a = 0.33

P_a = 33,857 lbs per foot of wall

Resistance: $P_r = W(\mu)$ (Drained)

where; $\mu = \left(\frac{2}{3}\right)\tan(\phi)$ μ = 0.36

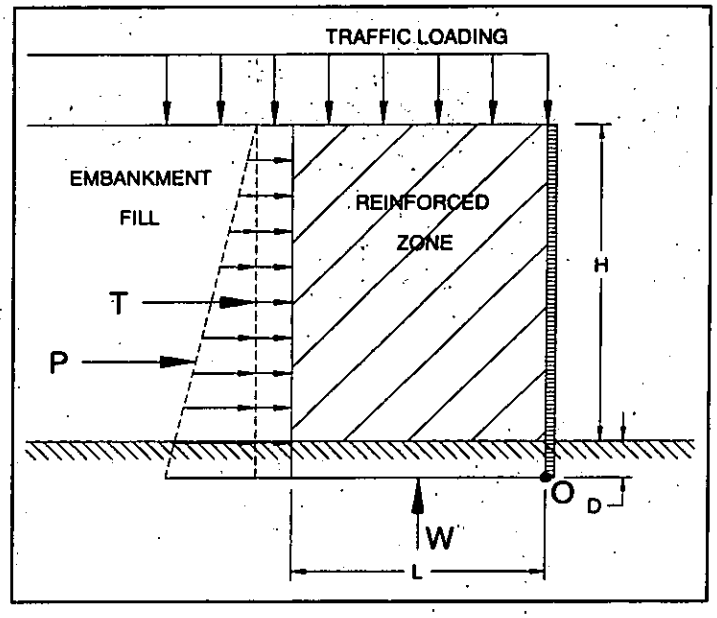
P_r = 57,003 lbs per foot of wall

Use Undrained Value

$P_r = L(c)$ (Undrained)

P_r = 30,141 lbs per foot of wall

USE THIS VALUE



$FS = \frac{P_r}{P_a}$

	Calculated		Required	
FS	= 0.89 *	FS	= 1.50	Resistance Against Sliding is **No Good**

* See Preloading Embankment

Drained Sliding:
FS = $\frac{57,003}{33,857}$ = 1.68 OK

RESISTANCE AGAINST OVERTURNING

* Summation of Moments about point "O" (base of wall).
* Traffic loading is neglected in resisting forces

$\Sigma M_{resisting}$ = 2,651,415 lb-ft

$\Sigma M_{overturning}$ = 465,149 lb-ft

$\Sigma M_{resisting} = \gamma H L\left(\frac{L}{2}\right)$

$\Sigma M_{overturning} = K_a\left[\frac{1}{2}\gamma H^2\left(\frac{H}{3}\right) + \omega_T H\left(\frac{H}{2}\right)\right]$

$FS = \frac{\Sigma M_{resisting}}{\Sigma M_{overturning}}$

	Calculated		Required	
FS	= 5.70	FS	= 2.00	Resistance Against Overturning is **OK** ✓

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CLIENT CH2M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Special Construction
S.R 823 Sta. 899+07, MSE Wall No 3

PROJECT NO. 0121-3070.03
SHEET NO. 11 OF 23
COMP. BY SJK DATE 10-30-07
CHECKED BY SWT DATE 11-5-07

A

Staged Construction was explored to deal with the low undrained bearing capacity. $q_{all} \simeq 1931$ psf * See page 9 *

Estimate increase in undrained shear strength under consolidating stress of ENTIRE fill height.

$H = 36.4'$, $\gamma = 120$ pcf, $\Phi_{cu} = 17.2°$ (from CIU testing, B-54, ST3)

$\Delta\bar{\sigma}_z = 4368$ psf Assume $U = 100\%$ for checking purposes only

$\Delta\bar{\sigma}_z = (H \cdot \gamma_{emb}) \cdot U$ ↑ This is a maximum theoretical increase

$C_u = C_{u_i} + \Delta\bar{\sigma}' \tan(\Phi_{cu})$

$C_u = 900 + 4368 \cdot \tan(17.2°) = 900 + 1352 = 2252$ psf

Using $C = 2237$ psf → $q_{all} \simeq 4,680$ psf OR $FS = 2.0$
* See page 13 *

∴ An adequate factor of safety against undrained bearing capacity failure cannot be provided by staged construction.

B

1) Construct preloading embankment and allow to consolidate to at least $U = 90\%$.

1) Construct Preloading Embankment Using 1H:1V Slopes.
↳ place toe at station 898+82
↳ H = 36' (above existing ground surface
↳ Time to 90% Consolidation = 81 days
$\bar{\sigma} = 9'$

2) Remove preload after at least $U = 90\%$.

3) Construct MSE retaining wall at forward abutment (Wall No. 3)
↳ Drained Strengths will govern behavior.*
MSE wall meets required minimum factors of safety
↳ Refer to Drained bearing Capacity and Sliding on pg 9 & 10.

DLZ

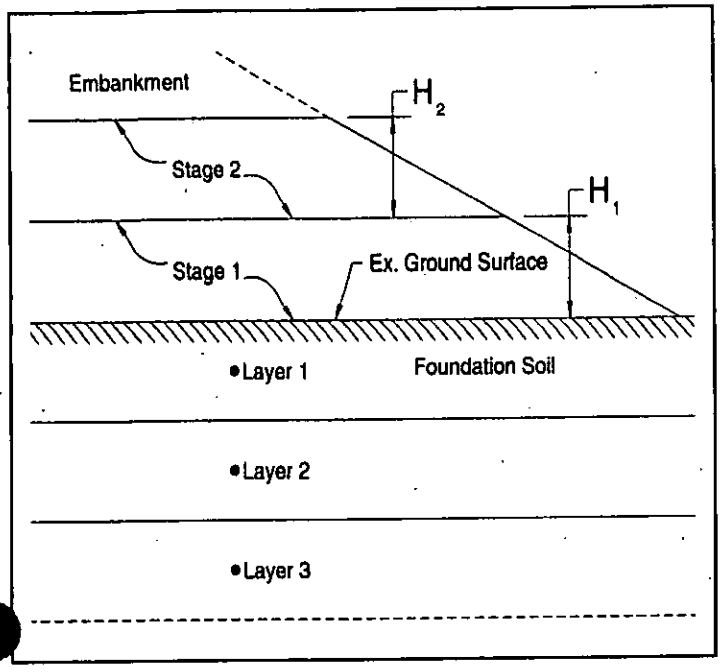
SUBJECT

Client	CH2M Hill	JOB NUMBER	0121-3070.03
Project	SCI-823 Portsmouth Bypass	SHEET NO.	12 OF 23
Item	Undrained Strength Analysis - Staged Const.	COMP. BY	EJH DATE 11-3-07
	SR 823 Sta. 899+07, MSE wall No. 3	CHECKED BY	EWT DATE 11-5-07

Determine Increase in Undrained Shear Strength Due to Consolidation

Undrained Strength Analysis - Staged Construction

Ref: Ladd, Charles C. (1991). "Stability Evaluation During Staged Construction." *The Twenty-Second Karl Terzaghi Lecture.*, Journal of Geotechnical Engineering, ASCE, 117(4), 540-615



Increase in Undrained Shear Strength from consolidation

$$c_u = c_{ui} + \Delta\sigma' \cdot \tan(\phi_{cu})$$

Where: c_{ui} Initial undrained shear strength, UU or q_u testing

ϕ_{cu} Determined from CIU testing

$\Delta\sigma'$ Effective stress increase due to embankment loading

$$\Delta\sigma' = (H_n \cdot \gamma_{emb}) \cdot U$$

Where: U Average degree of consolidation (%)

H_n Height of Embankment, Stage n (ft)

Embankment Fill

γ_{fill} 120 pcf

Test to see if staged construction is possible

Use full height as consolidating pressure and calculate BC.

Depths measured from bottom of leveling pad excavation, below MSE retaining wall

Stage 1 Embankment First Stage Embankment Height H_1= **36.0** Average Percent Consolidation U= **100%**

Depth	Soil Type	Initial Undrained Shear Strength, c_{ui} (psf)	$\Delta\sigma'$ (psf)	ϕ_{cu} (deg)	Δc_u (psf)	c_u (psf), *After Consolidation*	Percent Increase
0.8-13.8	A-6a/A-6b	900	4320	17.2	1337	2237	149%
						Not for use in design.	

Stage 2 Embankment Second Stage Embankment Height H_2= **0.0** Average Percent Consolidation U= **0%**

Stage 3 Embankment Third Stage Embankment Height H_3= **0.0** Average Percent Consolidation U= **0%**

DLZ

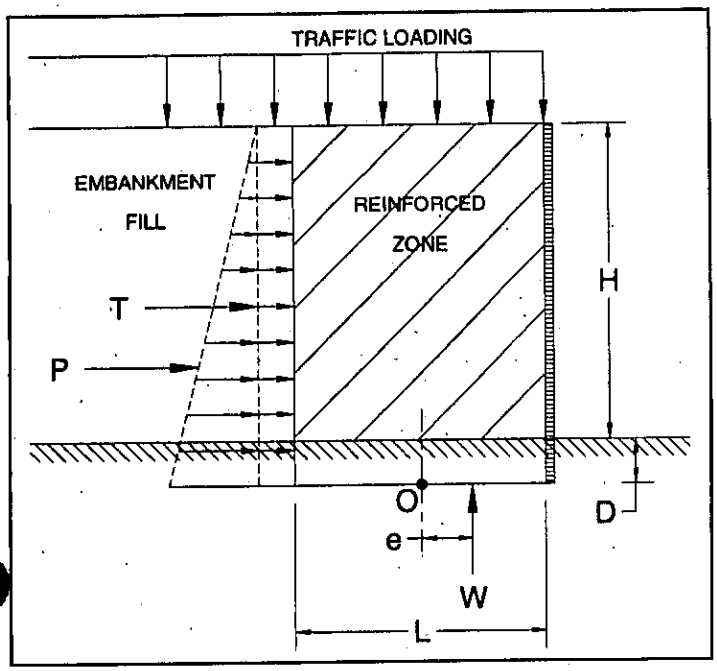
SUBJECT

Client	CH2M Hill
Project	SCI-823 Portsmouth Bypass
Item	MSE Wall Bearing Capacity
	MSE Wall No 3, US 23 Interchange
	SR 823 over NS RR and US 23, Forward Abutment

JOB NUMBER	0121-3070.03		
SHEET NO.	13	OF	23
COMP. BY	SJH	DATE	11-3-07
CHECKED BY	GWT	DATE	11-5-07

BEARING CAPACITY OF A MSE WALL

Ref: {AASHTO; STANDARD SPECIFICATIONS FOR HIGHWAY BRIDGES, 17th Edition, 2002}



Soil Properties

Test to show staged construction will not work (U=100%)

γ_{EMB}	=	120 pcf	Unit weight	Embankment fill
ϕ'_{EMB}	=	30 deg.	Friction ang.	Embankment fill
γ_{FDN}	=	120 pcf	Unit weight	Foundation soil
c	=	2237 psf	Cohesion	Foundation soil
ϕ	=	0 deg.	Friction ang.	Foundation soil
c'	=	0 psf	Cohesion	Foundation soil
ϕ'	=	28 deg.	Friction ang.	Foundation soil

Loads and Parameters

ω_t	=	240 psf	Traffic loading	
L=B	=	33.49 ft	Length of MSE reinforcement	
L factor	=	0.85	Length factor-range (0.7 - 1.0)	
D	=	3.5 ft	Embedment depth	
Dw	=	0 ft	Groundwater depth	
H+D	=	39.4 ft		
H	=	35.9 ft	Height of wall	
Ka	=	0.33		
⌜ Pa	=	13.133 ft	Moment arm	
⌜ Wt	=	19.7 ft	Moment arm	
B'	=	27.89 ft		
γ'	=	57.6 pcf		
W_t		8,038 lb/ft of wall	Weight from traffic	
W_{mse}	=	158,341 lb/ft of wall	Weight from MSE wall	

Effective Bearing Pressure

$$\sigma_v = \frac{W_t + W_{MSE}}{L - 2e}$$

σ_v = 5,966 psf

Ultimate undrained bearing capacity, q_{ult}

$$q_{ULT} = cN_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 11,700 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 4,680* psf

Factor of Safety = 1.96* **No Good**

* Value based on theoretical max strength increase, Not for design.

Ultimate drained bearing capacity, q_{ult}

$$q_{ULT} = c'N_c + \sigma'_D N_q + \frac{1}{2}\gamma' B N_\gamma$$

q_{ULT} = 16,398 psf

$$q_{ALL} = \frac{q_{ULT}}{FS}$$

q_{ALL} = 6,559 psf

Factor of Safety = 2.75 **OK**

Bearing Capacity Factors for Equations (AASHTO)

Undrained		Drained	
N_c	5.14	N_c	25.80
N_q	1.00	N_q	14.72
N_γ	0.00	N_γ	16.72

Eccentricity of Resultant Force

e = 2.80 ft

Kern

e < L/6 = 5.58 ft

SR 823 over NS RR and US 23 - Forward Abutment Settlement Preloading Embankment

ÚÄÄÄÄÄ ONE DIMENSIONAL SETTLEMENT ANALYSIS/Federal Highway Administration ÄÄÄÄÄ¿
INCREMENT OF STRESSES BENEATH THE END OF FILL CONDITION

Project Name	: SCI-823	Client	: CH2M Hill
File Name	: 823FA1.emb	Project Manager	: Nix
Date	: 10/30/07	Computed by	: SJR

Settlement for X-Direction

Embank. slope, x direc. =	72.00 (ft)	Height of fill H =	36.00 (ft)
y direc. =	72.00 (ft)	Unit weight of fill =	120.00 (pcf)
Embankment top width =	65.00 (ft)	p load/unit area =	4320.00 (psf)
Embankment bottom width =	209.00 (ft)	Foundation Elev. =	538.50 (ft)
Ground Surface Elev. =	538.50 (ft)		
Water table Elev. =	518.50 (ft)	Unit weight of Wat. =	62.40 (pcf)

N§.	LAYER TYPE	THICK. (ft)	COEFFICIENT COMP.	RECOMP.	SWELL.	UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO
1	COMP.	4.8	0.170	0.030	0.000	120.00	2.65	0.62
2	COMP.	13.0	0.170	0.030	0.000	120.00	2.65	0.62
3	COMP.	13.0	0.031	0.031	0.000	120.00	2.65	1.00

N§.	SUBLAYER THICK. (ft)	ELEV. (ft)	SOIL STRESSES INITIAL (psf)	MAX. PAST PRESS. (psf)
1	4.80	536.10	288.00	2100.00
2	13.00	527.20	1356.00	2100.00
3	13.00	514.20	2647.68	2100.00

Y= 25.0' @ Proposed MSE Wall location

Layer	X = Stress (psf)	0.00 Sett. (in.)	X = Stress (psf)	20.90 Sett. (in.)	X = Stress (psf)	41.80 Sett. (in.)	X = Stress (psf)	62.70 Sett. (in.)
1	18.55	0.03	1278.82	0.78	2542.56	1.70	2998.20	2.10
2	191.61	0.17	1208.77	1.97	2249.34	4.39	2802.53	5.41
3	353.29	0.37	1093.69	0.61	1891.69	0.81	2428.95	0.93
		0.57		3.36		6.90		8.43

Pt. A

@ toe of wall location

Layer	X = Stress (psf)	83.60 Sett. (in.)	X = Stress (psf)	104.50 Sett. (in.)
1	3002.32	2.10	3002.44	2.10
2	2915.23	5.60	2924.58	5.61
3	2649.87	0.97	2692.34	0.98
		8.67		8.69

Pt. B

@ ℄ of wall location

ÀÄÄÄÄÄ Hit arrow keys to display next screen. <F8> Print. <F10> Main Menu ÄÄÄÄÄÙ

GWT 11-5-07
SJR 11-3-07

SR 823 over NS RR and US 23 - Forward Abutment Settlement MSE Wall After Preloading

ÚÄÄÄÄÄ ONE DIMENSIONAL SETTLEMENT ANALYSIS/Federal Highway Administration ÄÄÄÄÄ¿
INCREMENT OF STRESSES BENEATH THE END OF FILL CONDITION

Project Name	: SCI-823	Client	: CH2M Hill
File Name	: 823FA1.emb	Project Manager	: Nix
Date	: 10/30/07	Computed by	: SJR

Settlement for X-Direction

Embank. slope, x direc. =	72.80 (ft)	Height of fill H =	36.00 (ft)
y direc. =	72.80 (ft)	Unit weight of fill =	120.00 (pcf)
Embankment top width =	65.00 (ft)	p load/unit area =	4368.00 (psf)
Embankment bottom width =	210.60 (ft)	Foundation Elev. =	538.50 (ft)
Ground Surface Elev. =	538.50 (ft)		
Water table Elev. =	518.50 (ft)	Unit weight of Wat. =	62.40 (pcf)

N§.	LAYER TYPE	THICK. (ft)	COEFFICIENT COMP.	RECOMP.	SWELL.	UNIT WEIGHT (pcf)	SPECIFIC GRAVITY	VOID RATIO
1	INCOMP.	4.0	-----	-----	-----	120.00	----	----
2	COMP.	13.8	0.170	0.030	0.000	120.00	2.65	0.62
3	COMP.	13.0	0.031	0.031	0.000	120.00	2.65	1.00

N§.	SUBLAYER THICK. (ft)	ELEV. (ft)	SOIL STRESSES INITIAL (psf)	MAX.PAST PRESS. (psf)
1	INCOMP.			
2	13.80	527.60	1308.00	3888.00
3	13.00	514.20	2647.68	3888.00

Layer	X = 0.00 Stress (psf)	Sett. (in.)	X = 21.00 Stress (psf)	Sett. (in.)	X = 42.00 Stress (psf)	Sett. (in.)	X = 63.00 Stress (psf)	Sett. (in.)
1	INCOMP.	INCOMP.	INCOMP.	INCOMP.				
2	99.88	0.10	642.45	0.53	1268.32	0.90	1878.42	1.19
3	221.67	0.08	675.07	0.24	1247.48	0.41	1780.69	0.54
		------		------		------		------
		0.18		0.77		1.31		1.73

Pt. C
@ toe

Layer	X = 84.00 Stress (psf)	Sett. (in.)	X = 105.00 Stress (psf)	Sett. (in.)
1	INCOMP.	INCOMP.		
2	2175.52	1.30	2190.25	1.31
3	2075.50	0.61	2132.52	0.62
		------		------
		1.91		1.93

Pt. D
@ ℄

ÀÄÄÄÄÄ Hit arrow keys to display next screen. <F8> Print. <F10> Main Menu ÄÄÄÄÄÙ

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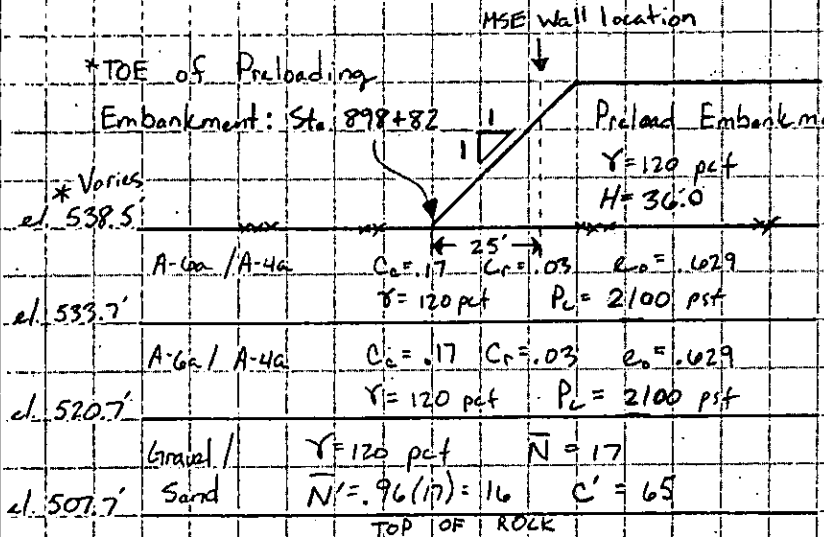
PLANNERS • SURVEYORS

CLIENT CH2 M Hill — PROJECT NO. 0121-3070.03
PROJECT SCI-823 Portsmouth Bypass — SHEET NO. 16 OF 23
SUBJECT MSE Wall No. 3 - Settlement — COMP. BY SAK DATE 10-30-07
SR 823 over NSRR and US 23 - Forward Abutment — CHECKED BY GWT DATE 11-5-07

Evaluate Settlement at Station 899+13 (Forward Abutment Location)
Profile based upon borings B-54 and TR-49

* Settlement Under Preloading Embankment



* Assume Groundwater Table at el. 518.5'

Assume Parameters of underlying layer A-6a

Parameters taken from Consolidation Testing B-54, Sample ST1, A-6a Sample

* Use $C_c = C_r = .031$ and $e_0 = 1.0$ (EMBANK)

* See Sample Calculations, pg 4

* Along Proposed Wall No. 3 Location: Preloading Embankment
1) At toe of embankment/wall, $\delta_A = 0.6"$
2) At ℄ of embankment/wall, $\delta_B = 8.7"$

* Settlement Under MSE wall (After Preloading) Wall No. 3

MSE; H = 36.0'
Bottom of MSE wall leveling pad, el. 534.5'
* Use Profile shown above.

* Along Proposed Wall No. 3 Location: MSE wall after preloading
1) At toe of embankment/wall, $\delta_C = 0.2"$
2) At ℄ of embankment/wall, $\delta_D = 1.9"$

* Differential Settlement, between pt C and pt D.

$$\Delta S = \frac{(1.9" - 0.2")(1'/12")}{105'} = 0.0013 = 0.1\% < 10\%$$

✓ OK

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CLIENT CH2M Hill PROJECT NO. 0121-3070.03
PROJECT SCI-823 Portsmouth Bypass SHEET NO. 17 OF 23
SUBJECT MSE Wall No. 3 - Time-Rate of Settlement COMP. BY SJK DATE 10-31-07
SR 823 over NS RR and US 23 - Forward Abutment CHECKED BY SWT DATE 11-5-07

Assume bottom of MSE Wall Leveling Pad el. 534.5

534.5'				
533.7'	A-6a / A-4a	$\overline{LL} \simeq$ 29%	$C_v \simeq 0.5$ ft²/day	C_v estimated from FHWA HI-97-021 "Subsurface Investigations", Fig 9-5 Taken from NAVFAC, DM-7.1, 1982
520.7'	A-6a / A-4a	$\overline{LL} \simeq$ 29%	$C_v \simeq 0.5$ ft²/day	
		Assume Free Draining		
507.7'	Gravel / Sand			

$H_v = (534.5' - 520.7')/2 = 6.9'$ (Assume Double Drainage)

Time to 90% Consolidation

$$t_{90} = \frac{T_v \cdot H_v^2}{C_v} = \frac{(0.848)(6.9')^2}{.50\ ft^2/day} = 81 \text{ days}$$

* To prevent downdrag on the piles, pile should not be driven until 0.4" or less of the consolidation settlement remains.

Total settlement of MSE wall after preloading, $\delta = 1.8"$
Of the 1.8", 1.2" is consolidation settlement.

$\frac{0.4}{1.2} = 0.33$ $\quad U = 1 - 0.33 = .67$ OR 67%

Say $U = 70\%$ prior to driving piles.

$$t_{70} = \frac{(.403)(6.9)^2}{0.5\ ft^2/day} = 38$$

Waiting period prior to driving piles

SMT 10-5-07
SJK 11-3-07

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Time Rate of Consolication of Foundation Soils with Wick Drians
SR 823, Wall No. 3 Station 899+07
Reference: FHWA-RD-86-168

Wick Drain Spacing **5.0** feet Use $\eta = 10$

t (days)	T_R	T_V	U_R	U_V	U_C	δ(inches)	d_e	c_v	H_v	δ_{max}
0	0.0000	0.0000	0.00	0.00	0.0	0.0	5.25	0.50	6.9	1.2
5	0.0907	0.0525	0.38	0.24	53.0	0.6				
10	0.1814	0.1050	0.61	0.37	75.6	0.9				
15	0.2721	0.1575	0.76	0.47	87.2	1.0				
20	0.3628	0.2100	0.85	0.54	93.0	1.1				
25	0.4535	0.2625	0.89	0.60	95.8	1.1				
30	0.5442	0.3151	0.92	0.65	97.3	1.2				
35	0.6349	0.3676	0.94	0.68	98.2	1.2				
40	0.7256	0.4201	0.96	0.71	98.9	1.2				
45	0.8163	0.4726	0.98	0.74	99.5	1.2				

Assumes a Triangular Grid Layout

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Time Rate of Consolication of Foundation Soils with Wick Drians
SR 823, Wall No. 3 Station 899+07
Reference: FHWA-RD-86-168

Wick Drain Spacing 7.0 feet Use $\eta = 10$

t (days)	T_R	T_V	U_R	U_V	U_C	δ(inches)	d_e	c_v	H_v	δ_{max}
0	0.0000	0.0000	0.00	0.00	0.0	0.0	7.35	0.50	6.9	1.2
5	0.0463	0.0525	0.22	0.24	41.1	0.5				
10	0.0926	0.1050	0.39	0.37	61.2	0.7				
15	0.1388	0.1575	0.52	0.47	74.2	0.9				
20	0.1851	0.2100	0.62	0.54	82.7	1.0				
25	0.2314	0.2625	0.70	0.60	88.2	1.1				
30	0.2777	0.3151	0.77	0.65	91.8	1.1				
35	0.3239	0.3676	0.82	0.68	94.2	1.1				
40	0.3702	0.4201	0.85	0.71	95.7	1.1				
45	0.4165	0.4726	0.88	0.74	96.8	1.2				
50	0.4628	0.5251	0.90	0.76	97.6	1.2				
55	0.5090	0.5776	0.91	0.79	98.2	1.2				
60	0.5553	0.6301	0.93	0.81	98.6	1.2				

Assumes a Triangular Grid Layout

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Time Rate of Consolication of Foundation Soils with Wick Drians
SR 823, Wall No. 3 Station 899+07
Reference: FHWA-RD-86-168

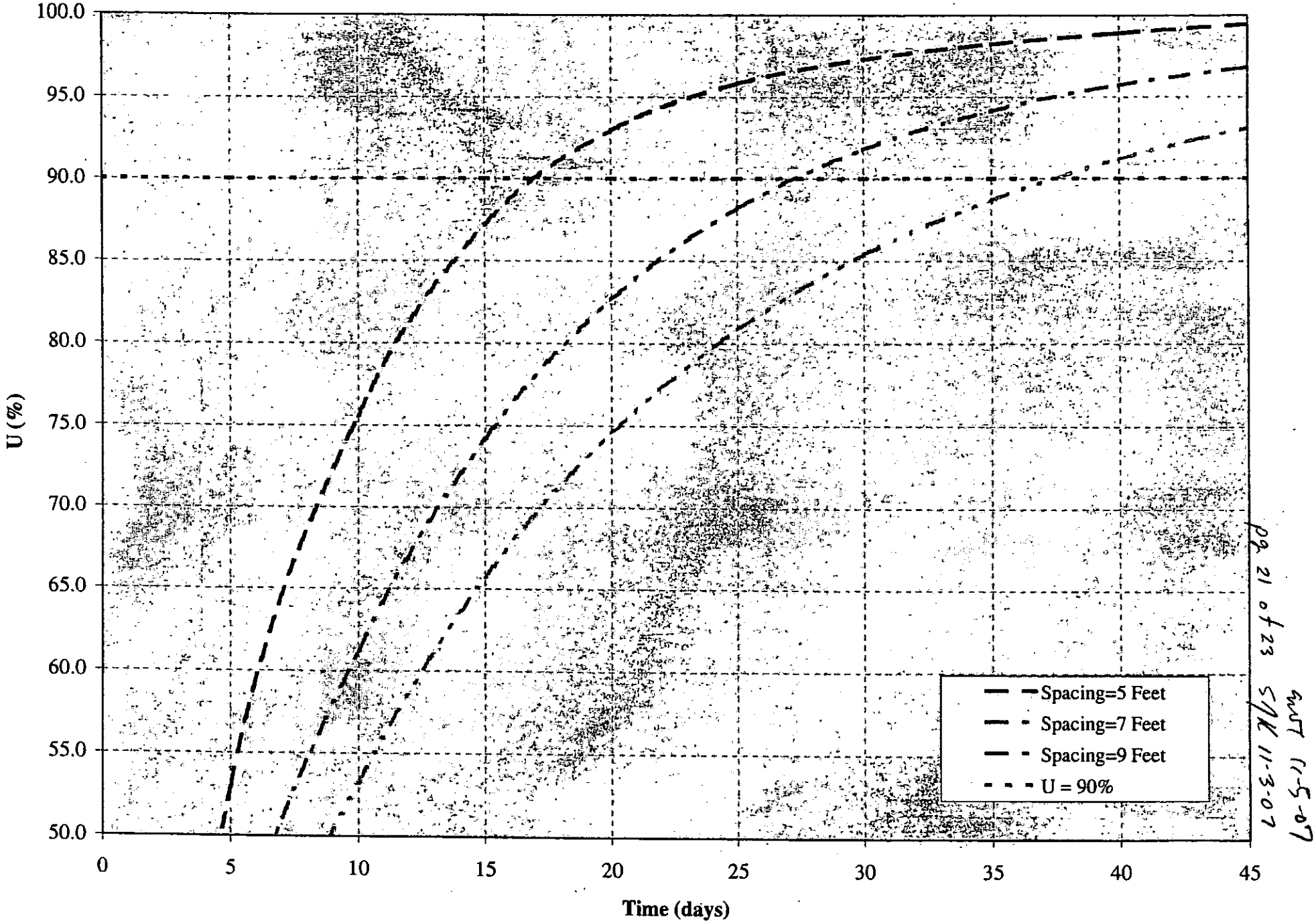
Wick Drain Spacing **9.0** feet Use $\eta = 10$

t (days)	T_R	T_V	U_R	U_V	U_C	δ(inches)	d_e	c_v	H_v	δ_{max}
0	0.0000	0.0000	0.00	0.00	0.0	0.0	9.45	0.50	6.9	1.2
5	0.0280	0.0525	0.15	0.24	35.5	0.4				
10	0.0560	0.1050	0.26	0.37	53.2	0.6				
15	0.0840	0.1575	0.36	0.47	65.7	0.8				
20	0.1120	0.2100	0.44	0.54	74.6	0.9				
25	0.1400	0.2625	0.52	0.60	80.9	1.0				
30	0.1680	0.3151	0.59	0.65	85.4	1.0				
35	0.1960	0.3676	0.64	0.68	88.7	1.1				
40	0.2240	0.4201	0.69	0.71	91.2	1.1				
45	0.2520	0.4726	0.73	0.74	93.1	1.1				
50	0.2799	0.5251	0.77	0.76	94.6	1.1				
55	0.3079	0.5776	0.80	0.79	95.8	1.1				
60	0.3359	0.6301	0.83	0.81	96.7	1.2				
65	0.3639	0.6826	0.85	0.83	97.5	1.2				

Assumes a Triangular Grid Layout

DLZ

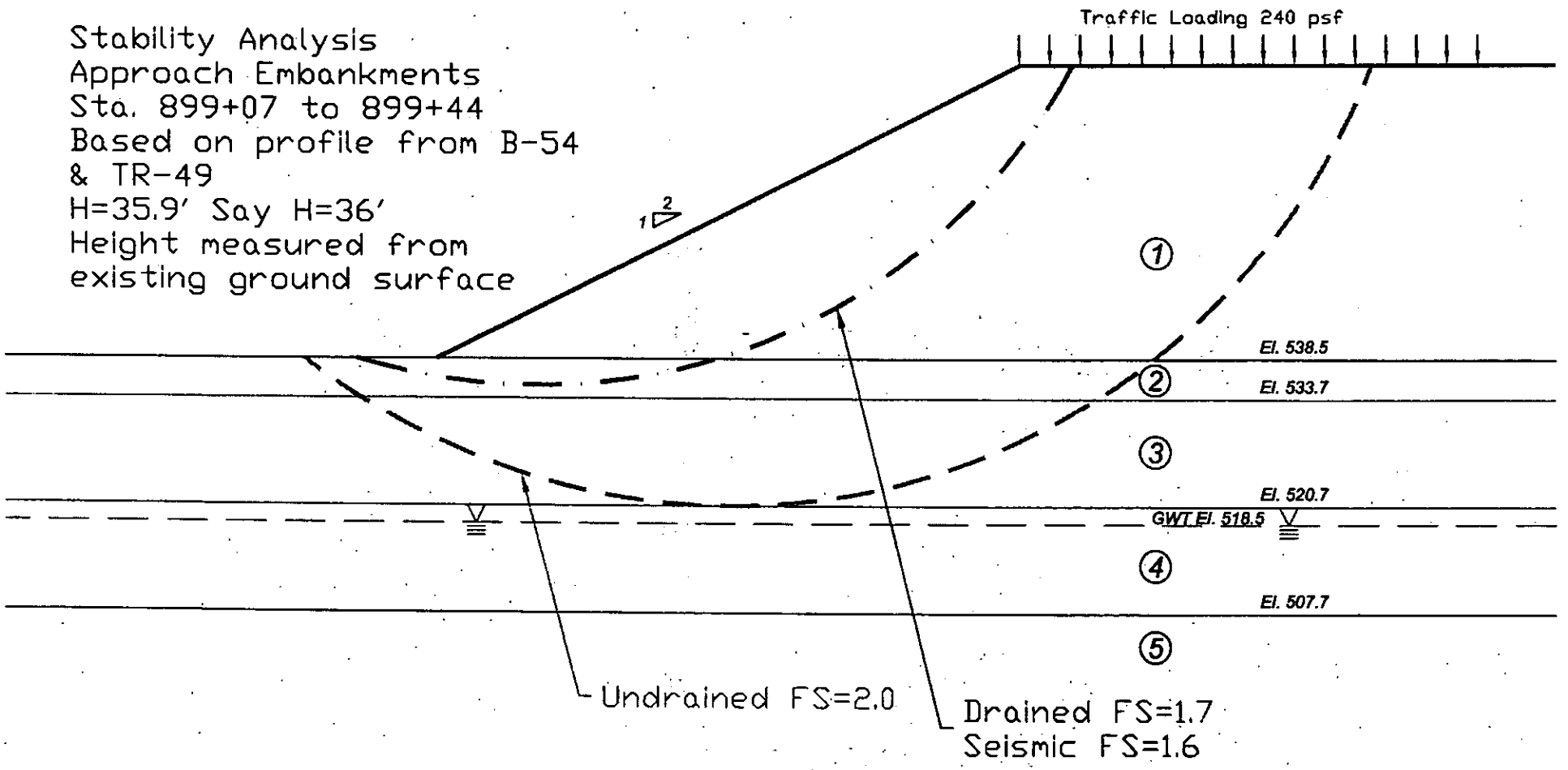
Percent Consolidation vs Time Using Prefabricated Vertical "Wick" Drains
US-23 Interchange, SR 823 over NS RR andUS 23, (Wall No 3)



pg 21 of 23 SJK 11-3-07 GWT 11-5-07

			Undrained		Drained		
Material	Consistency	Soil Type	c (psf)	ϕ (deg)	c' (psf)	ϕ' (deg)	γ (pcf)
Material 1	Compacted	Emb Fill	2000	0	300	28	120
Material 2	V. Stiff	A-6a/A-4a	2000	0	0	29	120
Material 3	Med. Stiff	A-6a/A-4a	900	0	0	28	120
Material 4	Med. Dense	Gravel	0	32	0	32	120
Material 5		Bedrock	3500	42	3500	42	140

Stability Analysis
Approach Embankments
Sta. 899+07 to 899+44
Based on profile from B-54
& TR-49
H=35.9' Say H=36'
Height measured from
existing ground surface



Stability Analyses performed using UTEXAS3 Version 1.201

US-23 Interchange
Approach Embankment
Station 899+07 to 899+44

GLOBAL STABILITY ANALYSIS

SCI-823-0.00

PROJECT NO. 0121-3070.03	CALC. SJR	DATE 10/30/07

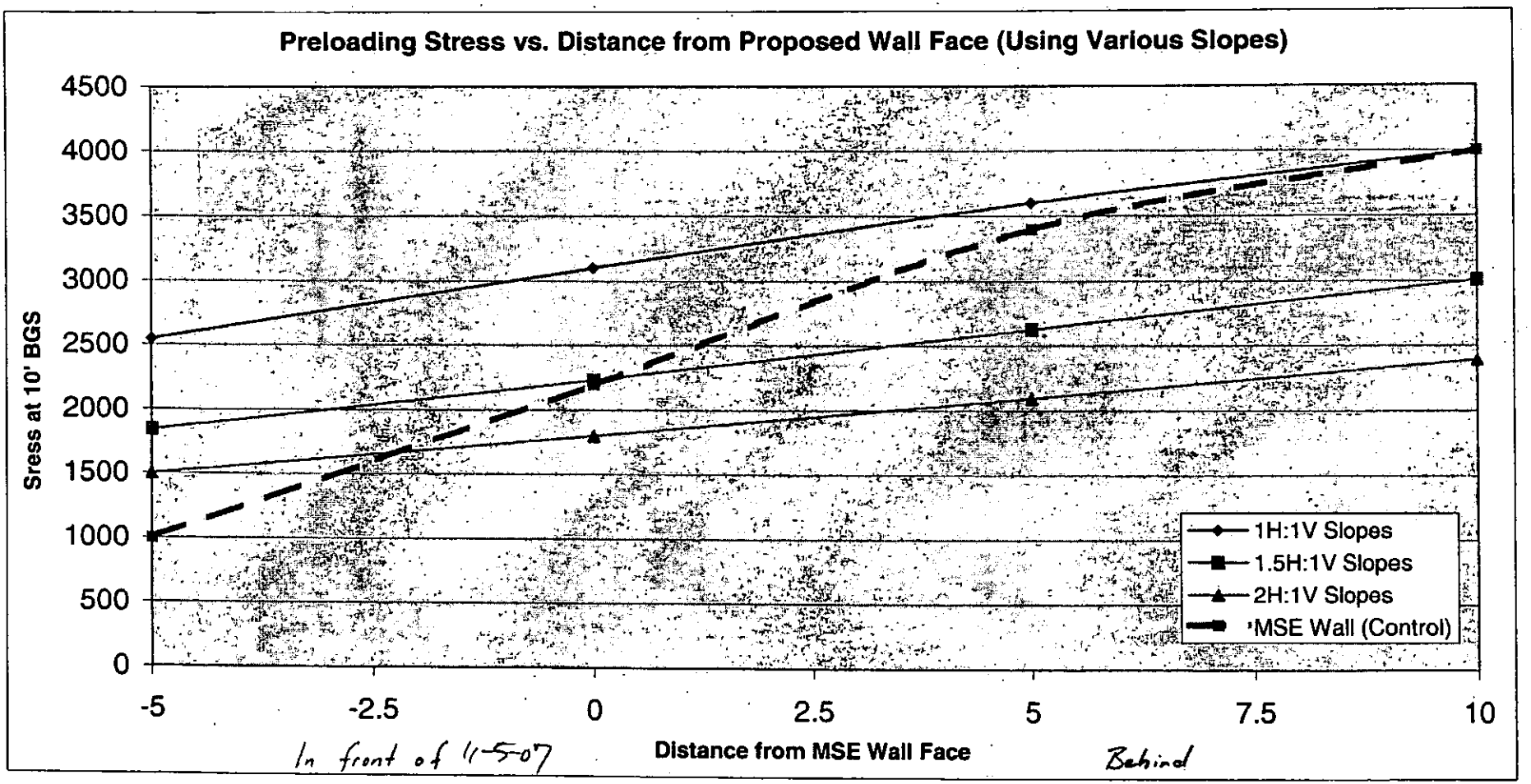
ELW 11-5-07
SJR 11-3-07

M:\proj\0121\3070.03\Interchanges\US 23\embankment stability 11-1-07.dwg, 11/3/2007 8:28:10 AM, Xerox WorkCentre Pro 245 PS

Preloading Embankments **MSE Wall No 3**

Stress Measured at Specified Locations at a Depth of 10' Below the Ground Surface

	Locations Relative to MSE Wall Location			
Slopes	**5' Front**	**Wall Face**	**5' Behind**	**10' Behind**
1H:1V slopes	2545	3100	3600	4000
1.5H:1V slopes	1840	2231	2625	3010
2H:1V slopes	1500	1800	2095	2395
MSE Wall (control)	1000	2200	3400	4000
	-5	0	5	10

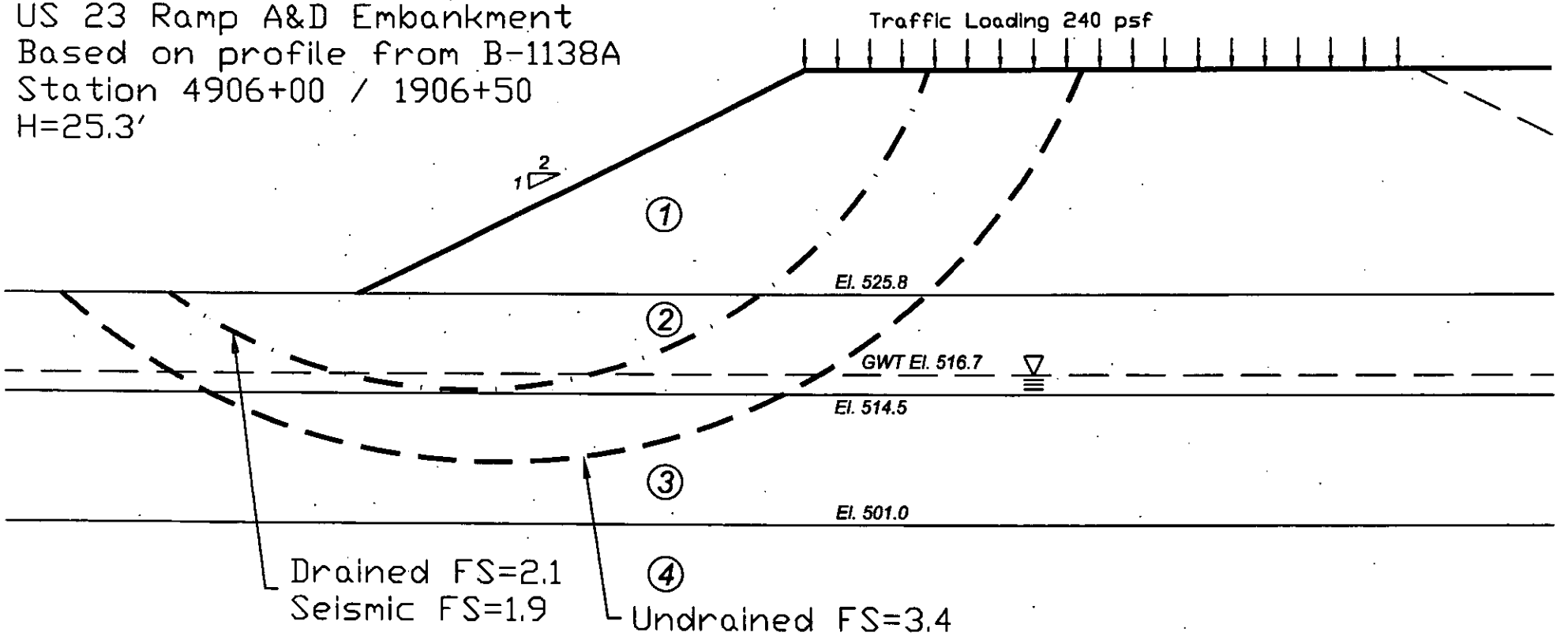


 SJA 11-3-07

US 23 Ramps A & D
Embankment Evaluations

Material	Consistency	Soil Type	Undrained c (psf)	Undrained ϕ (deg)	Drained c' (psf)	Drained ϕ' (deg)	γ (pcf)
Material 1	Compacted	Emb. Fill	2000	0	300	28	120
Material 2	Stiff	A-6b/A-6a	1750	0	0	29	120
Material 3	Loose-Med D	Sand & Grvl	0	32	0	32	120
Material 4		Bedrock	5000	45	5000	45	145

Stability Analysis
US 23 Ramp A&D Embankment
Based on profile from B-1138A
Station 4906+00 / 1906+50
H=25.3'



Stability Analyses performed using UTEXAS3 Version 1.201

GWT #6-07
SJR 11-1-07

US-23 Interchange
Ramps A & D
Station 4906+00 / 1906+50

GLOBAL STABILITY ANALYSIS

SCI-823-0.00

PROJECT NO. 0121-3070.03	CALC SJR	DATE 11/1/07

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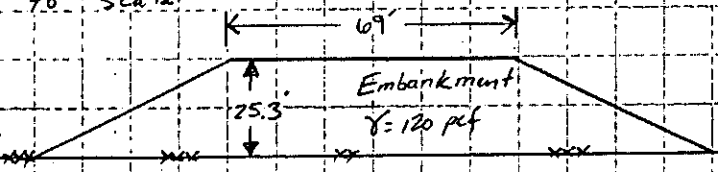
CLIENT CH2M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Embankment Settlement
US23 Ramps A&D Embankment, Sta. 4906+00

PROJECT NO. 0121-3070.03
SHEET NO. 2 OF 16
COMP. BY SJK DATE 11-1-07
CHECKED BY SWT DATE 11-6-07

Sta. 4906+00 / 1906+50 Ramps A & D

Not to scale



* Based on boring B-1138A
* Assume groundwater table at el. 516.7

A-6a / A-6b: $e_o = .721$, $C_c = .25$, $C_r = .05$, $P_c = 2600$, * $C_v = .35$ ft²/day
Parameters taken from test on B-1138A Sample ST2, 8.0'

Sand and Gravel: $\bar{N} \approx 10.4$, $N'/N = .96$, $N' = 10$, $C' = 47$, Assume free draining
Estimated from FHWA NHI-00-045 "Soils and foundation workshop" Figure 6-6

* C_v value estimated from correlations with LL. Ref FHWA HI-97-021 "Subsurface Investigations", taken from NAVFAC, DM-7.1, 1982.

Time-Rate of Consolidation

$H_v = (525.8 - 514.5)/2 = 5.7'$ (Assume double drainage)

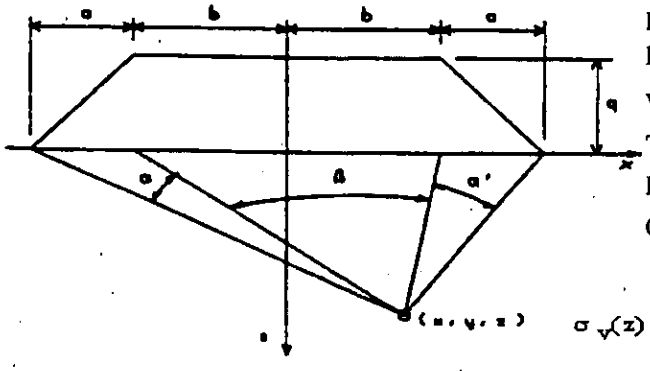
90% Consolidation $t_{90} = \dfrac{(.848)(5.7')^2}{.35\ ft^2/day} = 79$ days

DLZ SUBJECT

Client	CH2M Hill	JOB NUMBER	0121-3070.03
Project	SCI-823 Portsmouth Bypass	SHEET NO.	3 OF 16
Item	Embankment Settlement	COMP. BY	SJR DATE 11-1-07
	US 23 Ramp A&D, Station 4906+00/1906+50	CHECKED BY	GWT DATE 11-6-07

SETTLEMENT ANALYSIS - EMBANKMENT

Embankment Informaiton:



Groundwater Table:	D=	9.1	ft		
Embankment Height:	H =	25.3	ft		
Fill Unit Weight:	γ_{emb} =	120	pcf	q =	3,036 psf
Width of Slope:	a =	50.6			
Top half-width of Emb:	b =	34.5			
Distance from CL:	x =	0			
Output Range:	z =	0	to	28	ft

**See Data output Attached*

$$\sigma_v(z) := \left(\frac{q}{\pi}\right)\left(a\cdot(\alpha(z)+\beta(z)+\alpha'(z)) + b\cdot(\alpha(z)+\alpha'(z)) + x\cdot(\alpha(z)-\alpha'(z))\right)$$

$$\beta(z) := \operatorname{atan}\left[\frac{(b-x)}{z}\right] + \operatorname{atan}\left[\frac{(b+x)}{z}\right] \qquad \alpha'(z) := \operatorname{atan}\left[\frac{(a+b-x)}{z}\right] - \operatorname{atan}\left[\frac{(b-x)}{z}\right] \qquad \alpha(z) := \operatorname{atan}\left[\frac{(a+b+x)}{z}\right] - \operatorname{atan}\left[\frac{(b+x)}{z}\right]$$

Reference: US Army Corps of Engineers EM 1110-1-1904 "Settlement Analysis", Table C-1

Soil Properites: *Settlement is calculated at mid-point of layer*

No.	Bot. of Laye		Soil Type	γ_{soil} (pcf)	σ'_c (psf)	σ'_o (psf)	$\Delta\sigma z$ (psf)	σ'_f (psf)	Cohesionless Soils C'	Cohesive Soils C_r	C_c	e_o
1	11.3	ft	Silt and Clay	120	2,600	678	3,034	3,712	0.0	0.05	0.25	0.721
2	27.6	ft	Grvl & Sand	120	0	1,688	2,983	4,671	47.0			
3	0.0			0	0							
4	0.0			0	0							
5	0.0			0	0							
6	0.0			0	0							
7	0.0			0	0							
8	0.0			0	0							
9	0.0			0	0							
10	0.0			0	0							

No.	Settlement:		Total Settlement
1	0.446	ft	
2	0.153	ft	0.599 ft
3			
4			
5			7.2 in
6			
7			
8			
9			
10			

Reference: Geotechnical Engineering Principles and Practices; Coduto, 1999

Overconsolidated Soils - Case I ($\sigma'_0<\sigma'_c$) Eqn:11.24

$$(\delta_c)_{ult} = \sum \frac{C_r}{1+e_0} H \log\left(\frac{\sigma'_f}{\sigma'_0}\right)$$

Overconsolidated Soils - Case II ($\sigma'_0<\sigma'_c<\sigma_f$) Eqn:11.25

$$(\delta_c)_{ult} = \sum\left[\frac{C_r}{1+e_0} H \log\left(\frac{\sigma'_c}{\sigma'_0}\right) + \frac{C_c}{1+e_0} H \log\left(\frac{\sigma'_f}{\sigma'_c}\right)\right]$$

Normally Consolidated Soils ($\sigma'_0=\sigma'_c$) Eqn: 11.23

$$(\delta_c)_{ult} = \sum \frac{C_c}{1+e_0} H \log\left(\frac{\sigma'_f}{\sigma'_0}\right)$$

Reference: FHWA NHI-00-045

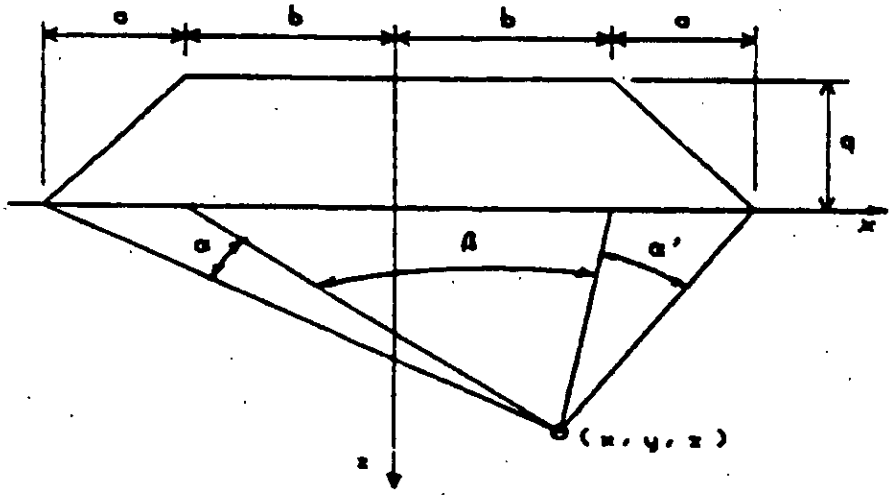
Cohesionless Soils ($\sigma'_0=\sigma'_c$)

$$(\delta_c)_{ult} = \sum \frac{1}{C'} H \log\left(\frac{\sigma'_f}{\sigma'_0}\right)$$

DLZ SUBJECT

Client	CH2M Hill	JOB NUMBER	0121-3070.03
Project	SCI-823 Portsmouth Bypass	SHEET NO.	4 OF 16
Item	Embankment Settlement	COMP. BY	SJA DATE 11-1-07
US 23 Ramp A&D, Station 4906+00/1906+50		CHECKED BY	DATE 11-8-07

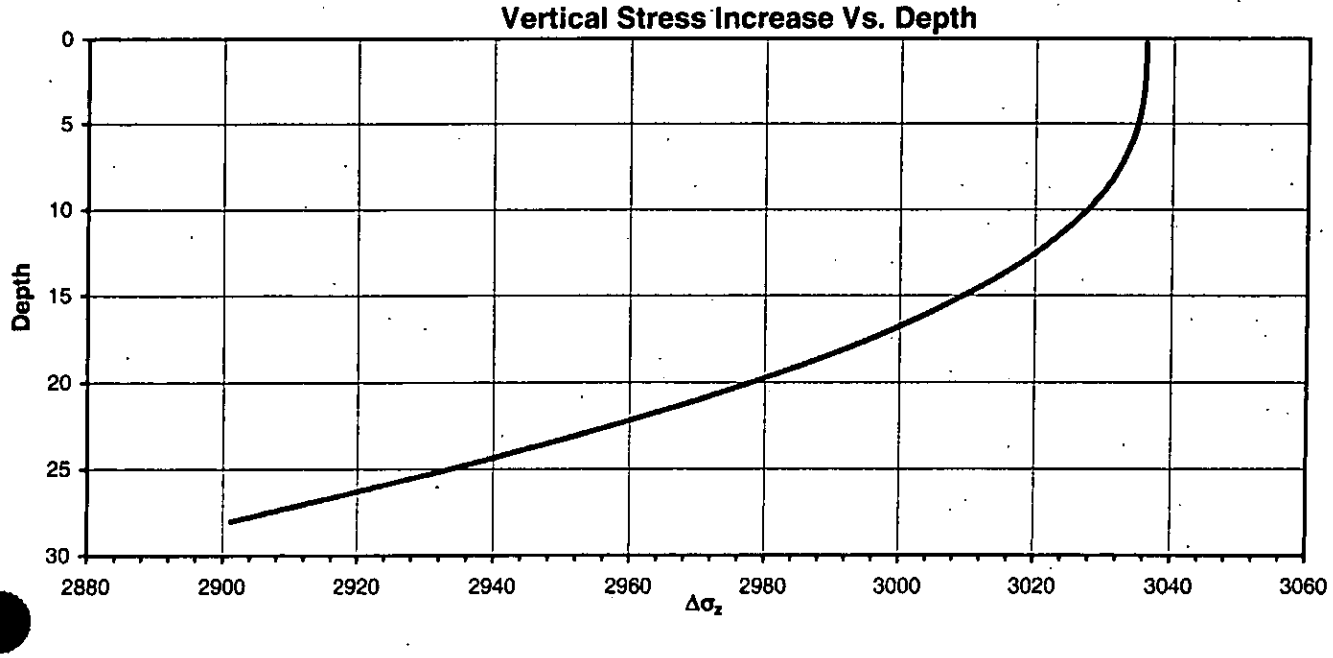
INCREASE IN VERTICAL STRESS DUE TO EMBANKMENT LOADING



q =	3036		load
a =	50.6		width of slope
b =	34.5		top half-width of embankment
x =	0		distance from CL
z =	0	to 28	depth range

$$\sigma_v(z) := \left(\frac{q}{\pi\, a}\right)\left(a\cdot(\alpha(z)+\beta(z)+\alpha'(z)) + b\cdot(\alpha(z)+\alpha'(z)) + x\cdot(\alpha(z)-\alpha'(z))\right)$$

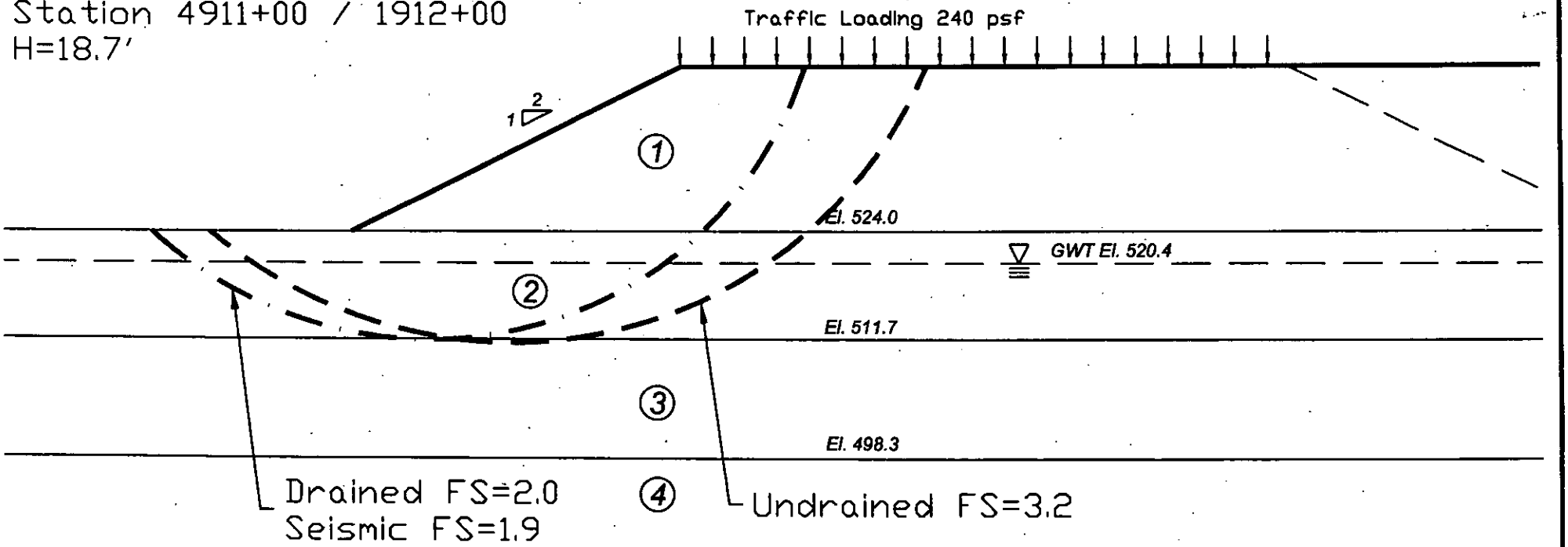
$$\beta(z) := \operatorname{atan}\left[\frac{(b-x)}{z}\right] + \operatorname{atan}\left[\frac{(b+x)}{z}\right] \quad ; \quad \alpha'(z) := \operatorname{atan}\left[\frac{(a+b-x)}{z}\right] - \operatorname{atan}\left[\frac{(b-x)}{z}\right] \quad \alpha(z) := \operatorname{atan}\left[\frac{(a+b+x)}{z}\right] - \operatorname{atan}\left[\frac{(b+x)}{z}\right]$$



Reference: US Army Corps of Engineers EM 1110-1-1904 "Settlement Analysis", Table C-1

Material	Consistency	Soil Type	Undrained c (psf)	Undrained ϕ (deg)	Drained c' (psf)	Drained ϕ' (deg)	γ (pcf)
Material 1	Compacted	Emb. Fill	2000	0	300	28	120
Material 2	Med. Stiff	A-4b/A-6a	1000	0	0	28	120
Material 3	Loose-Med D	Sand & Silt	0	28	0	28	120
Material 4		Bedrock	5000	45	5000	45	145

Stability Analysis
US 23 Ramp A&D Embankment
Based on profile from B-1136A
Station 4911+00 / 1912+00
H=18.7'



Stability Analyses performed using UTEXAS3 Version 1.201

GWT 11-6-07
SJK 11-1-07

US-23 Interchange
Ramps A & D
Station 4911+00 / 1912+00

GLOBAL STABILITY ANALYSIS

SCI-823-0.00

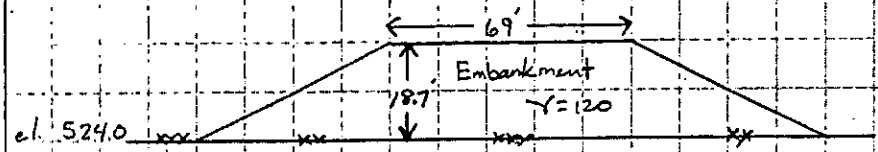
PROJECT NO. 0121-3070.03	CALC: SJR	DATE 11/1/07

DLZ
ENGINEERS · ARCHITECTS · SCIENTISTS
PLANNERS · SURVEYORS

CLIENT CH2M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Embankment Settlement
US23 Ramps A & D Embankment, Sta 4911+00

PROJECT NO. 0121-3070.03
SHEET NO. 6 OF 16
COMP. BY SJK DATE 11-1-07
CHECKED BY CWT DATE 11-5-07

Sta 4911+00 / 1912+00 Ramps A & D



* Profile based on B-1136A
* Assume groundwater table, el 520.4'

el. 511.7 — A-6a / A-4b — e_o = .752 C_c = .23 C_r = .05 P_c = 2300 psf — Parameters taken from test on B-1136A, ST1, 6.0'

C_v ≈ 0.50 ft²/day *

$\bar{N}$ ≈ 9.4 Use N'/N = 1 N' = 9 — Estimated from FHWA NHI-00-045 "Soils and Foundations Workshop" Figure 6-6

el. 498.3 — C' = 40 Assume free draining

TOP OF ROCK

* C_v value estimated from correlations with LL. Ref: FHWA HI-97-021, "Subsurface Investigations", taken from NAVFAC, DM-7.1, 1982.

Time - Rate of Consolidation

H_{dr} = (524.0 - 511.7)/2 = 6.2' (Assumes double drainage)

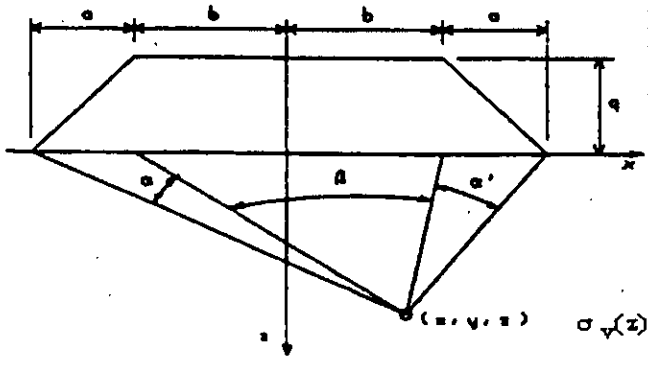
90% Consolidation $t_{90} = \frac{(.848)(6.2')^2}{.50\ ft^2/day} = 65$ days

DLZ SUBJECT

Client	CH2M Hill	JOB NUMBER	0121-3070.03
Project	SCI-823 Portsmouth Bypass	SHEET NO.	7 OF 16
Item	Embankment Settlement	COMP. BY	SJK DATE 11-1-07
	US 23 Ramp A&D, Station 4911+00/1912+00	CHECKED BY	SMT DATE 11-6-07

SETTLEMENT ANALYSIS - EMBANKMENT

Embankment Informaiton:



Groundwater Table:	D=	3.6	ft		
Embankment Height:	H =	18.7	ft		
Fill Unit Weight:	γ_{emb} =	120	pcf	q =	2,244 psf
Width of Slope:	a =	37.4			
Top half-width of Emb:	b =	34.5			
Distance from CL:	x =	0			
Output Range:	z =	0	to	26	ft

**See Data output Attached*

$$\sigma_v(z) := \left(\frac{q}{\pi}\right)\left(a\cdot(\alpha(z)+\beta(z)+\alpha'(z)) + b\cdot(\alpha(z)+\alpha'(z)) + x\cdot(\alpha(z)-\alpha'(z))\right)$$

$$\beta(z) := \operatorname{atan}\left[\frac{(b-x)}{z}\right] + \operatorname{atan}\left[\frac{(b+x)}{z}\right] \qquad \alpha'(z) := \operatorname{atan}\left[\frac{(a+b-x)}{z}\right] - \operatorname{atan}\left[\frac{(b-x)}{z}\right] \qquad \alpha(z) := \operatorname{atan}\left[\frac{(a+b+x)}{z}\right] - \operatorname{atan}\left[\frac{(b+x)}{z}\right]$$

Reference: US Army Corps of Engineers EM 1110-1-1904 "Settlement Analysis", Table C-1

Soil Properites: *Settlement is calculated at mid-point of layer*

No.	Bot. of Laye		Soil Type	γ_{soil} (pcf)	σ'_c (psf)	σ'_o (psf)	$\Delta\sigma z$ (psf)	σ'_f (psf)	Cohesionless Soils C'	Cohesive Soils C_r	Cohesive Soils C_c	Cohesive Soils e_o
1	12.3	ft	Silt and Clay	120	2,300	579	2,242	2,821	0.0	0.05	0.23	0.752
2	25.7	ft	Grvl & Sand	120	0	1,319	2,198	3,517	40.0			
3	0.0			0	0							
4	0.0			0	0							
5	0.0			0	0							
6	0.0			0	0							
7	0.0			0	0							
8	0.0			0	0							
9	0.0			0	0							
10	0.0			0	0							

No.	Settlement:		Total Settlement
1	0.354	ft	
2	0.143	ft	**0.496 ft**
3			
4			
5			**6.0 in**
6			
7			
8			
9			
10			

Reference: Geotechnical Engineering Principles and Practices; Coduto, 1999

Overconsolidated Soils - Case I ($\sigma'_0<\sigma'_c$) Eqn:11.24

$$(\delta_c)_{ult} = \sum \frac{C_r}{1+e_0} H \log\left(\frac{\sigma'_f}{\sigma'_0}\right)$$

Overconsolidated Soils - Case II ($\sigma'_0<\sigma'_c<\sigma_f$) Eqn:11.25

$$(\delta_c)_{ult} = \sum\left[\frac{C_r}{1+e_0} H \log\left(\frac{\sigma'_c}{\sigma'_0}\right) + \frac{C_c}{1+e_0} H \log\left(\frac{\sigma'_f}{\sigma'_c}\right)\right]$$

Normally Consolidated Soils ($\sigma'_0=\sigma'_c$) Eqn: 11.23

$$(\delta_c)_{ult} = \sum \frac{C_c}{1+e_0} H \log\left(\frac{\sigma'_f}{\sigma'_0}\right)$$

Reference: FHWA NHI-00-045

Cohesionless Soils ($\sigma'_0=\sigma'_c$)

$$(\delta_c)_{ult} = \sum \frac{1}{C'} H \log\left(\frac{\sigma'_f}{\sigma'_0}\right)$$

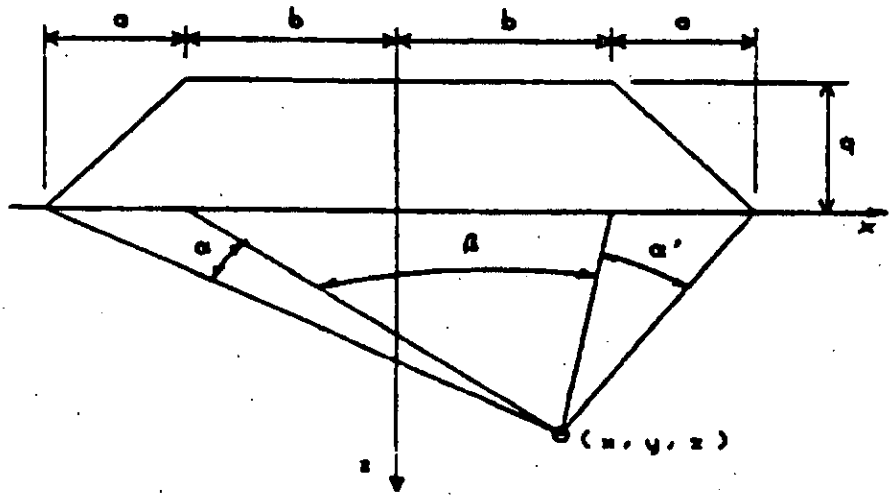
DLZ

SUBJECT

Client	CH2M Hill
Project	SCI-823 Portsmouth Bypass
Item	Embankment Settlement
US 23 Ramp A&D, Station 4911+00/1912+00	

JOB NUMBER 0121-3070.03
SHEET NO. 8 OF 16
COMP. BY SJH DATE 11-1-07
CHECKED BY GWT DATE 11-6-07

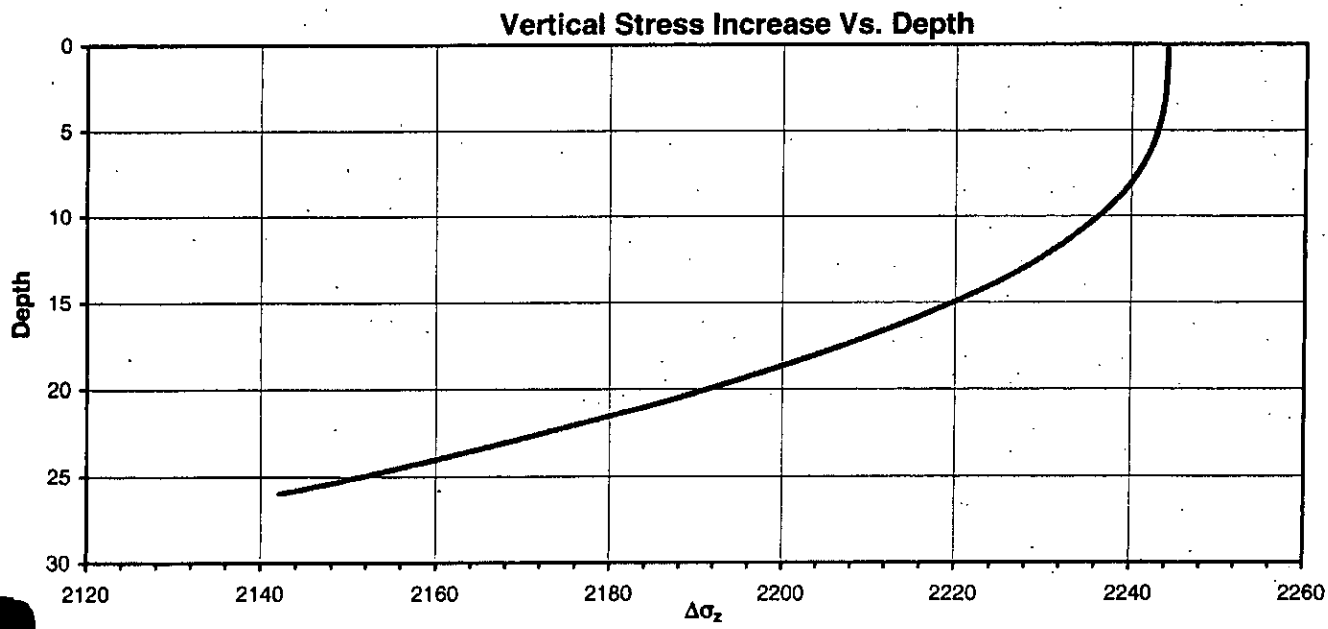
INCREASE IN VERTICAL STRESS DUE TO EMBANKMENT LOADING



q =	2244		load
a =	37.4		width of slope
b =	34.5		top half-width of embankment
x =	0		distance from CL
z =	0	to 26	depth range

$$\sigma_v(z) := \left(\frac{q}{\pi}\right)\left(a\cdot(\alpha(z)+\beta(z)+\alpha'(z)) + b\cdot(\alpha(z)+\alpha'(z)) + x\cdot(\alpha(z)-\alpha'(z))\right)$$

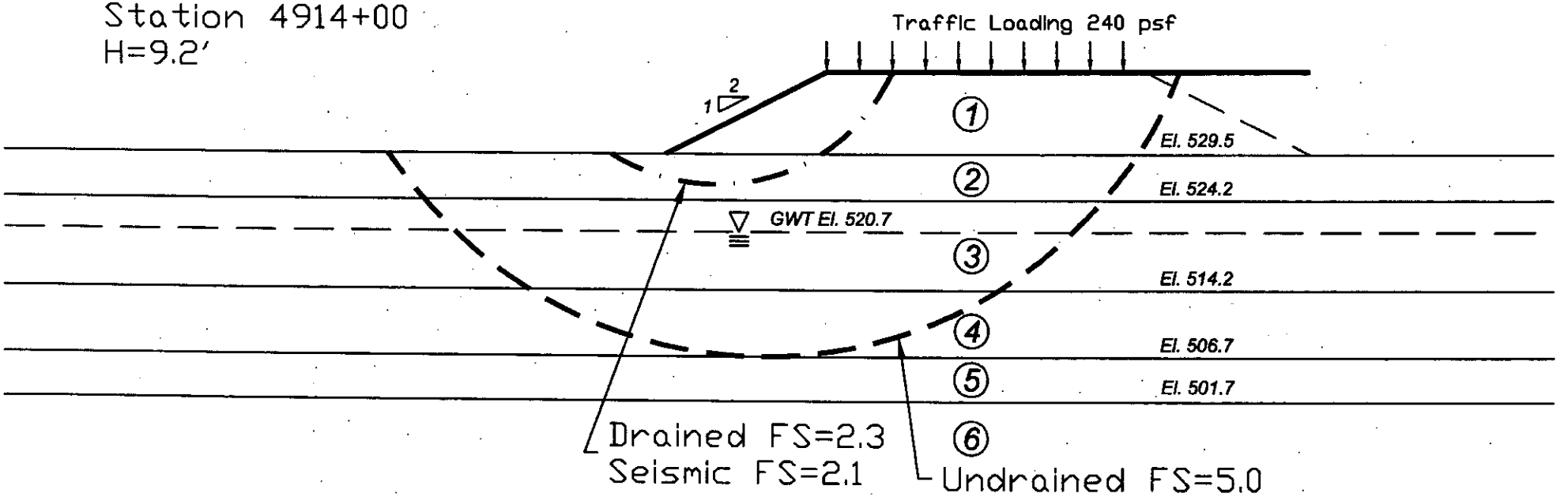
$$\beta(z) := \operatorname{atan}\left[\frac{(b-x)}{z}\right] + \operatorname{atan}\left[\frac{(b+x)}{z}\right] \quad ; \quad \alpha'(z) := \operatorname{atan}\left[\frac{(a+b-x)}{z}\right] - \operatorname{atan}\left[\frac{(b-x)}{z}\right] \quad \alpha(z) := \operatorname{atan}\left[\frac{(a+b+x)}{z}\right] - \operatorname{atan}\left[\frac{(b+x)}{z}\right]$$



Reference: US Army Corps of Engineers EM 1110-1-1904 "Settlement Analysis", Table C-1

Material	Consistency	Soil Type	Undrained c (psf)	Undrained Φ (deg)	Drained c' (psf)	Drained Φ' (deg)	γ (pcf)
Material 1	Compacted	Emb. Fill	2000	0	300	28	120
Material 2	Med. Stiff	A-4a	2000	0	0	29	120
Material 3	Loose-Med D	Grvl & Sand	0	30	0	30	120
Material 4	Stiff	A-6b	900	0	0	28	120
Material 5	Loose-Med D	Grvl & Sand	0	32	0	32	120
Material 6		Bedrock	5000	45	5000	45	145

Stability Analysis
US 23 Ramp D Embankment
Based on profile from B-1147
Station 4914+00
H=9.2'



Stability Analyses performed using UTEXAS3 Version 1.201

GWT 11-6-07
SJK 11-1-07

US-23 Interchange
Ramp D
Station 4914+00

GLOBAL STABILITY ANALYSIS

SCI-823-0.00

PROJECT NO. 0121-3070.03 | CALC: SJR | DATE: 11/1/07

M:\proj\0121\3070.03\Interchanges\US 23\embankment stability 11-1-07.dwg, 11/6/2007 10:56:20 AM, Xerox WorkCentre Pro 245 PS

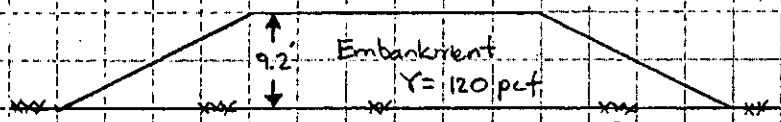
DLZ
ENGINEERS · ARCHITECTS · SCIENTISTS
PLANNERS · SURVEYORS

CLIENT CH2M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Embankment Settlement
US 23 Ramp D, Sta. 4914+00

PROJECT NO. 0121-3070.03
SHEET NO. 10 OF 16
COMP. BY SJL DATE 11-1-07
CHECKED BY GWT DATE 11-6-07

Station 4914+00 Ramp D

* Profile based on 8-1147
* Assume groundwater table, el. 520.7



el. 529.5'

	A-4a ①	e_o = .752	C_c = .23	C_r = .05	P_c = 2300 psf	Parameters taken from test on B-1136A, ST1., 6.0'
el. 524.2'	Assume LL = 30 *	C_v = .50 ft²/day				
	Sand and Gravel ②	$\bar{N}$ = 8	Use N'/N = 1.0			Estimated from FHWA NHI-00-045 "Soils and Foundations Workshop", Fig. 6-6
el. 514.2'		C' = 47	Assume free-draining			
	A-6b ③	e_o = .752	C_c = .23	C_r = .05	P_c = 2300 psf	Parameters taken from test on B-1136A, ST1, 6.0'.
el. 506.7'	Assume LL = 35 *	C_v = .35 ft²/day				
	Sand and Gravel ④	$\bar{N}$ = 28	$\bar{N}' \simeq$ 27			Ref. FHWA NHI-00-045
el. 498.3'		C' = 87	Assume free-draining			

TOP OF ROCK

* C_v value estimated from correlations with LL. Ref: FHWA HI-97-021, "Subsurface Investigations", taken from NAVFAC, DM-7.1, 1982.

Time-Rate of Consolidation

Layer ① $H_v = (529.5 - 524.2)/2 = 2.7'$

Layer ③ $H_v = (514.2 - 506.7)/2 = 3.8'$ * Use Layer 3

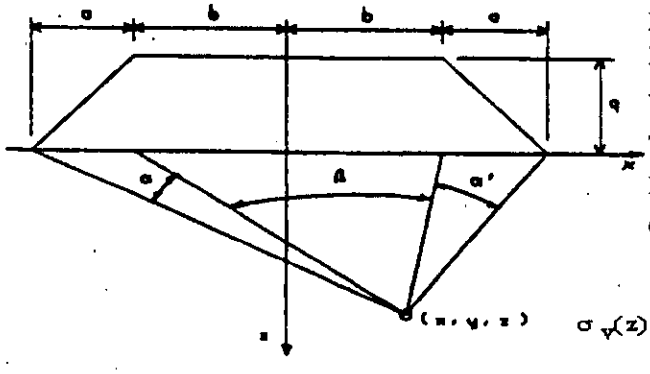
$$t_{90} = \frac{(.848)(3.8')^2}{.35\ ft^2/day} = 35\ days$$

DLZ

SUBJECT	Client CH2M Hill	JOB NUMBER	0121-3070.03
	Project SCI-823 Portsmouth Bypass	SHEET NO.	11 OF 16
	Item Embankment Settlement	COMP. BY	SJR DATE 11-1-07
	US 23 Ramp D, Station 4914+00	CHECKED BY	GWT DATE 11-6-07

SETTLEMENT ANALYSIS - EMBANKMENT

Embankment Informaiton:



Groundwater Table:	D=	8.8	ft		
Embankment Height:	H =	9.2	ft		
Fill Unit Weight:	γ_{emb} =	120	pcf	q =	1,104 psf
Width of Slope:	a =	17.6			
Top half-width of Emb:	b =	18			
Distance from CL:	x =	0			
Output Range:	z =	0	to	32	ft

**See Data output Attached*

$$\sigma_v(z) := \left(\frac{q}{\pi}\right)\left(a\cdot(\alpha(z)+\beta(z)+\alpha'(z)) + b\cdot(\alpha(z)+\alpha'(z)) + x\cdot(\alpha(z)-\alpha'(z))\right)$$

$$\beta(z) := \operatorname{atan}\left[\frac{(b-x)}{z}\right] + \operatorname{atan}\left[\frac{(b+x)}{z}\right] \qquad \alpha'(z) := \operatorname{atan}\left[\frac{(a+b-x)}{z}\right] - \operatorname{atan}\left[\frac{(b-x)}{z}\right] \qquad \alpha(z) := \operatorname{atan}\left[\frac{(a+b+x)}{z}\right] - \operatorname{atan}\left[\frac{(b+x)}{z}\right]$$

Reference: US Army Corps of Engineers EM 1110-1-1904 "Settlement Analysis", Table C-1

Soil Properites: *Settlement is calculated at mid-point of layer*

No.	Bot. of Laye		Soil Type	γ_{soil} (pcf)	σ'_c (psf)	σ'_o (psf)	$\Delta\sigma z$ (psf)	σ'_f (psf)	Cohesionless Soils C'	Cohesive Soils C_r	C_c	e_o
1	5.3	ft	Sandy Silt	120	2,300	318	1,103	1,421	0.0	0.05	0.23	0.752
2	15.3	ft	Grvl & Sand	120	0	1,142	1,078	2,220	47.0			
3	22.8	ft	Silty Clay	120	2,300	1,646	992	2,639	0.0	0.05	0.23	0.752
4	31.2	ft	Grvl & Sand	120	0	2,104	890	2,994	87.0			
5	0.0			0	0							
6	0.0			0	0							
7	0.0			0	0							
8	0.0			0	0							
9	0.0			0	0							
10	0.0			0	0							

No.	Settlement:		Total Settlement
1	0.098	ft	
2	0.061	ft	0.264 ft
3	0.090	ft	
4	0.015	ft	
5			3.2 in
6			
7			
8			
9			
10			

Reference: Geotechnical Engineering Principles and Practices; Coduto, 1999

Overconsolidated Soils - Case I ($\sigma'_o<\sigma'_c$) Eqn:11.24

$$(\delta_c)_{ult} = \sum \frac{C_r}{1+e_0} H \log\left(\frac{\sigma'_f}{\sigma'_o}\right)$$

Overconsolidated Soils - Case II ($\sigma'_o<\sigma'_c<\sigma_f$) Eqn:11.25

$$(\delta_c)_{ult} = \sum\left[\frac{C_r}{1+e_0} H \log\left(\frac{\sigma'_c}{\sigma'_o}\right) + \frac{C_c}{1+e_0} H \log\left(\frac{\sigma'_f}{\sigma'_c}\right)\right]$$

Normally Consolidated Soils ($\sigma'_o=\sigma'_c$) Eqn: 11.23

$$(\delta_c)_{ult} = \sum \frac{C_c}{1+e_0} H \log\left(\frac{\sigma'_f}{\sigma'_o}\right)$$

Reference: FHWA NHI-00-045

Cohesionless Soils ($\sigma'_o=\sigma'_c$)

$$(\delta_c)_{ult} = \sum \frac{1}{C'} H \log\left(\frac{\sigma'_f}{\sigma'_o}\right)$$

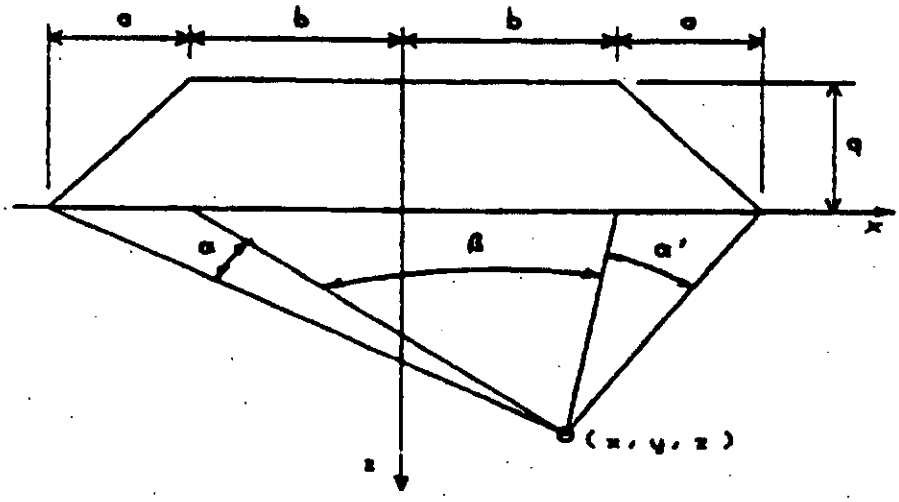
DLZ

SUBJECT

Client	CH2M Hill
Project	SCI-823 Portsmouth Bypass
Item	Embankment Settlement
	US 23 Ramp D, Station 4914+00

JOB NUMBER 0121-3070.03
SHEET NO. 12 OF 100
COMP. BY SJR DATE 11-1-07
CHECKED BY GWT DATE 11-6-07

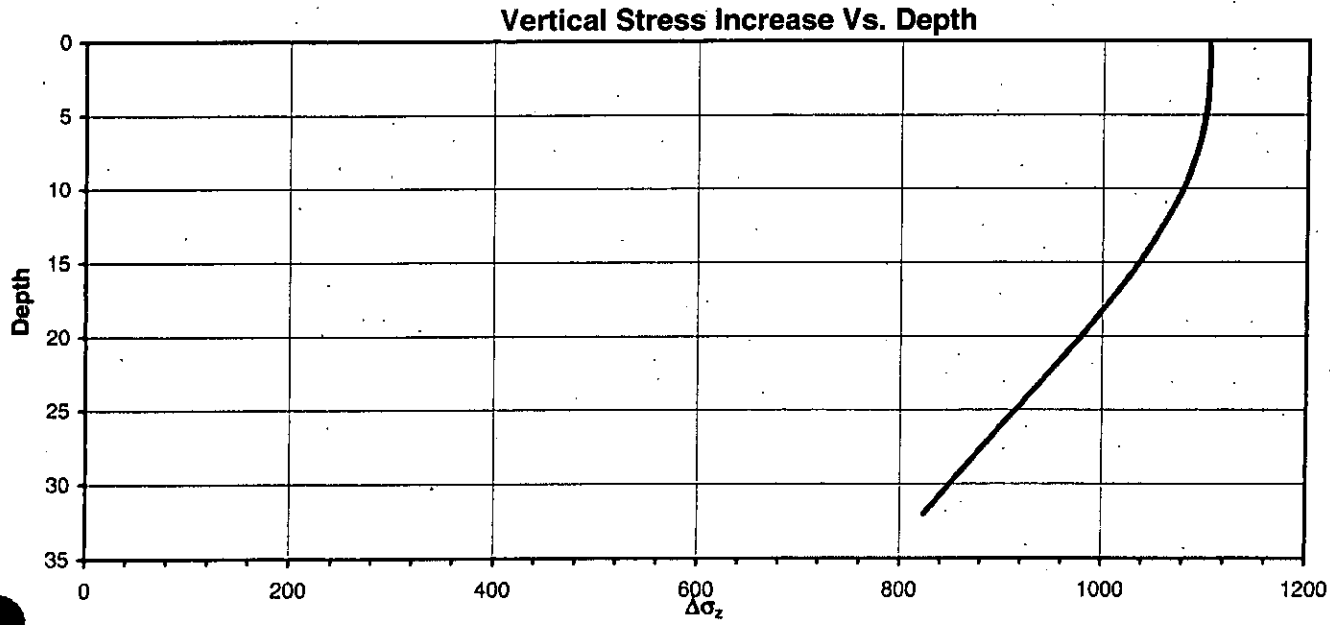
INCREASE IN VERTICAL STRESS DUE TO EMBANKMENT LOADING



q =	1104	load
a =	17.6	width of slope
b =	18	top half-width of embankment
x =	0	distance from CL
z =	0 to 32	depth range

$$\sigma_v(z) := \left[\frac{q}{\pi\, a}\right]\left(a\cdot(\alpha(z)+\beta(z)+\alpha'(z)) + b\cdot(\alpha(z)+\alpha'(z)) + x\cdot(\alpha(z)-\alpha'(z))\right)$$

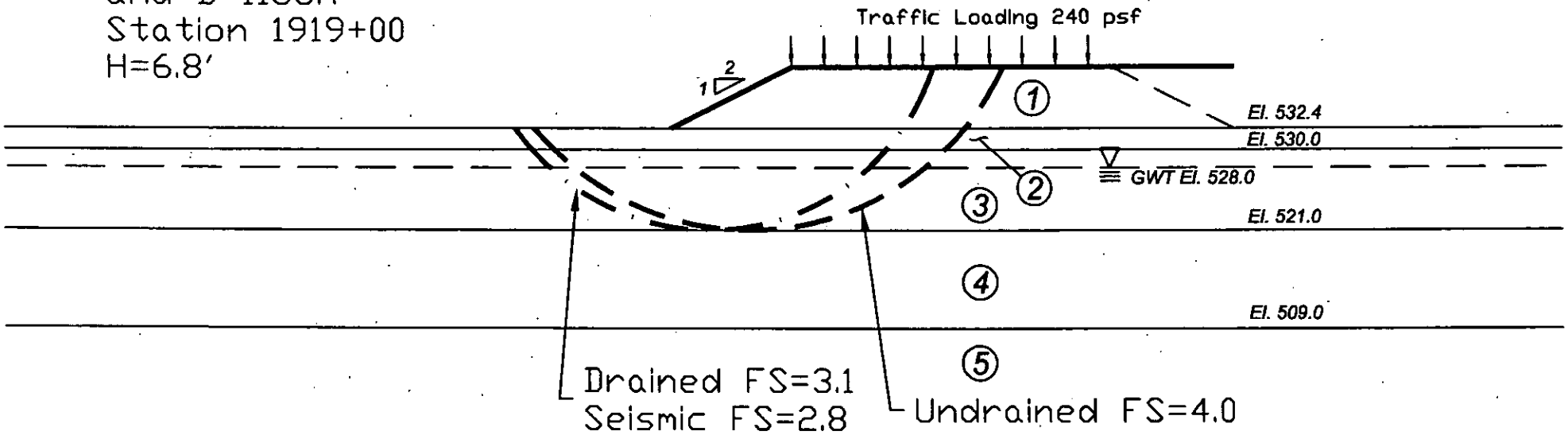
$$\beta(z) := \operatorname{atan}\left[\frac{(b-x)}{z}\right] + \operatorname{atan}\left[\frac{(b+x)}{z}\right] \quad ; \quad \alpha'(z) := \operatorname{atan}\left[\frac{(a+b-x)}{z}\right] - \operatorname{atan}\left[\frac{(b-x)}{z}\right] \quad \alpha(z) := \operatorname{atan}\left[\frac{(a+b+x)}{z}\right] - \operatorname{atan}\left[\frac{(b+x)}{z}\right]$$



Reference: US Army Corps of Engineers EM 1110-1-1904 "Settlement Analysis", Table C-1

Material	Consistency	Soil Type	Undrained c (psf)	Undrained ϕ (deg)	Drained c' (psf)	Drained ϕ' (deg)	γ (pcf)
Material 1	Compacted	Emb. Fill	2000	0	300	28	120
Material 2	Stiff	Silty Clay	2000	0	0	29	120
Material 3	Soft-Med. St	Sandy Silt	300	0	0	28	120
Material 4	Loose	C & F Sand	0	32	0	32	120
Material 5		Bedrock	5000	45	5000	45	145

Stability Analysis
US 23 Ramp A Embankment
Based on profile from B-1134
and B-1133A
Station 1919+00
H=6.8'



Stability Analyses performed using UTEXAS3 Version 1.201

GWT 11-6-07
SJR 11-1-07

US-23 Interchange Ramp A Station 1919+00			
GLOBAL STABILITY ANALYSIS SCI-823-0.00			
PROJECT NO. 0121-3070.03	CALC SJR	DATE 11/1/07	

M:\proj\0121\3070.03\Interchanges\US 23\embankment stability 11-1-07.dwg, 11/6/2007 10:58:25 AM, Xerox WorkCentre Pro 245 PS

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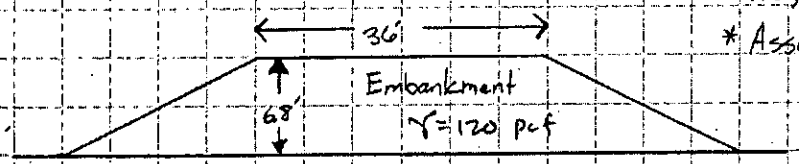
PLANNERS • SURVEYORS

CLIENT CH2M Hill
PROJECT SCI-823 Portsmouth Bypass
SUBJECT Embankment Settlement
US 23 Ramp A, Sta. 1919+00

PROJECT NO. 0121-3070.03
SHEET NO. 14 OF 16
COMP. BY SAK DATE 11-1-07
CHECKED BY GWT DATE 11-6-07

Station 1919+00 Ramp A

* Profile based upon B-1134 & B-1133A
* Assume groundwater table, el. 528.0



el. 532.4'

el. 530.0'	A-4b/A-6b $w\% = 20\%$ $C_c = .20$ $C_r = .02$ $e_o = .53$ Assume $P_c = 3500$ psf Assume LL% = 36% * $C_v = .35$ ft²/day	Estimated from correlations with moisture content. + See below.
el. 521.0'	A-4a/A-6a $e_o = 1.108$ $C_c = .43$ $C_r = .08$ $P_c = 3500$ psf Assume LL% ≈ 25 * $C_v = .65$ ft²/day	Parameters taken from test on B-1133A, ST2, 20.3'
el. 509.0'	Sand and Gravel $\bar{N} = 20$ Use $N'/N = 1.0$ $N' = 20$ $c' = 72$ Assume Free Draining TOP OF ROCK	Estimated from FHWA NHI-00-045 "Soils and Foundations Workshop", Fig. 6-1e

+ Estimate Consolidation Parameters ; Ref FHWA NHI-00-045

$w = 20\%$

$$e_o = \frac{w \cdot G_s}{100} = \frac{20\,(2.65)}{100} = 0.53$$

$$C_c = \frac{w}{100} = \frac{20}{100} = 0.20$$

$$C_r = \frac{w}{1000} = \frac{20}{1000} = 0.02$$

Time-Rate of Consolidation

Use "weighted" C_v value :

$$C_v = \frac{(0.35\ ft^2/day)(2.4') + (.65\ ft^2/day)(9')}{2.4' + 9.0'}$$

$$C_v = 0.59\ ft^2/day$$

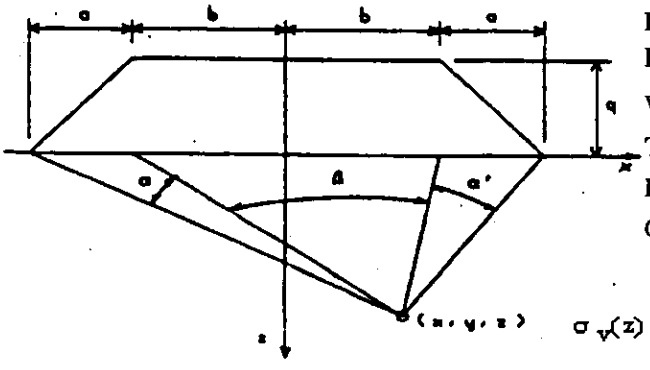
$U = 90\%$ $\quad t_{90} = \dfrac{(.848)(11.4')^2}{.59\ ft^2/day} = 187$ days

DLZ SUBJECT

Client CH2M Hill	JOB NUMBER	0121-3070.03	
Project SCI-823 Portsmouth Bypass	SHEET NO.	15	OF 160
Item Embankment Settlement	COMP. BY	SJH	DATE 11-1-07
US 23 Ramp A, Station 1919+00	CHECKED BY	GWT	DATE 12-6-07

SETTLEMENT ANALYSIS - EMBANKMENT

Embankment Informaiton:



Groundwater Table:	D=	4.4	ft			
Embankment Height:	H =	6.8	ft			
Fill Unit Weight:	γ_{emb} =	120	pcf	q =	816	psf
Width of Slope:	a =	13.6				
Top half-width of Emb:	b =	18				
Distance from CL:	x =	0				
Output Range:	z =	0	to	24	ft	

**See Data output Attached*

$$\sigma_v(z) := \left(\frac{q}{\pi}\right)\left(a\cdot(\alpha(z)+\beta(z)+\alpha'(z)) + b\cdot(\alpha(z)+\alpha'(z)) + x\cdot(\alpha(z)-\alpha'(z))\right)$$

$$\beta(z) := \operatorname{atan}\left[\frac{(b-x)}{z}\right] + \operatorname{atan}\left[\frac{(b+x)}{z}\right] \qquad \alpha'(z) := \operatorname{atan}\left[\frac{(a+b-x)}{z}\right] - \operatorname{atan}\left[\frac{(b-x)}{z}\right] \qquad \alpha(z) := \operatorname{atan}\left[\frac{(a+b+x)}{z}\right] - \operatorname{atan}\left[\frac{(b+x)}{z}\right]$$

Reference: US Army Corps of Engineers EM 1110-1-1904 "Settlement Analysis", Table C-1

Soil Properites: *Settlement is calculated at mid-point of layer*

No.	Bot. of Laye		Soil Type	γ_{soil} (pcf)	σ'_c (psf)	σ'_o (psf)	$\Delta\sigma z$ (psf)	σ'_f (psf)	Cohesionless Soils C'	Cohesive Soils C_r	C_c	e_o
1	2.4	ft	Silty Clay	120	3,500	144	816	960	0.0	0.02	0.20	0.530
2	11.4	ft	Sandy Silt	120	3,500	672	809	1,481	0.0	0.08	0.43	1.108
3	23.4	ft	C&F Sand	120	0	1,277	738	2,015	72.0	0.00	0.00	0.000
4	0.0			0	0							
5	0.0			0	0							
6	0.0			0	0							
7	0.0			0	0							
8	0.0			0	0							
9	0.0			0	0							
10	0.0			0	0							

No.	Settlement:		Total Settlement
1	0.026	ft	
2	0.117	ft	0.176 ft
3	0.033	ft	
4			
5			2.1 in
6			
7			
8			
9			
10			

Reference: Geotechnical Engineering Principles and Practices; Coduto, 1999

Overconsolidated Soils - Case I ($\sigma'_o<\sigma'_c$) Eqn:11.24

$$(\delta_c)_{ult} = \sum \frac{C_r}{1+e_0} H \log\left(\frac{\sigma'_f}{\sigma'_o}\right)$$

Overconsolidated Soils - Case II ($\sigma'_o<\sigma'_c<\sigma_f$) Eqn:11.25

$$(\delta_c)_{ult} = \sum\left[\frac{C_r}{1+e_0} H \log\left(\frac{\sigma'_c}{\sigma'_o}\right) + \frac{C_c}{1+e_0} H \log\left(\frac{\sigma'_f}{\sigma'_c}\right)\right]$$

Normally Consolidated Soils ($\sigma'_o=\sigma'_c$) Eqn: 11.23

$$(\delta_c)_{ult} = \sum \frac{C_c}{1+e_0} H \log\left(\frac{\sigma'_f}{\sigma'_o}\right)$$

Reference: FHWA NHI-00-045

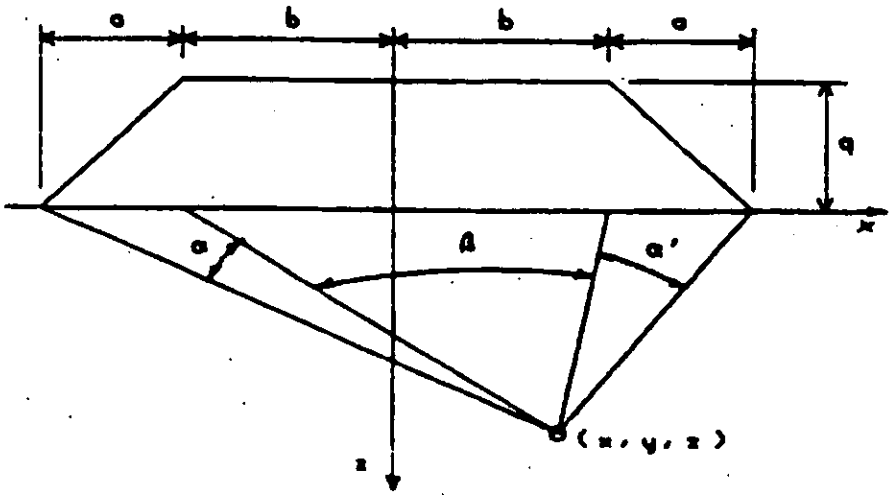
Cohesionless Soils ($\sigma'_o=\sigma'_c$)

$$(\delta_c)_{ult} = \sum \frac{1}{C'} H \log\left(\frac{\sigma'_f}{\sigma'_o}\right)$$

DLZ

SUBJECT	Client	CH2M Hill	JOB NUMBER 0121-3070.03
	Project	SCI-823 Portsmouth Bypass	SHEET NO. 16 OF 16
	Item	Embankment Settlement	COMP. BY SAR DATE 11-1-07
		US 23 Ramp A, Station 1919+00	CHECKED BY GWT DATE 11-6-07

INCREASE IN VERTICAL STRESS DUE TO EMBANKMENT LOADING

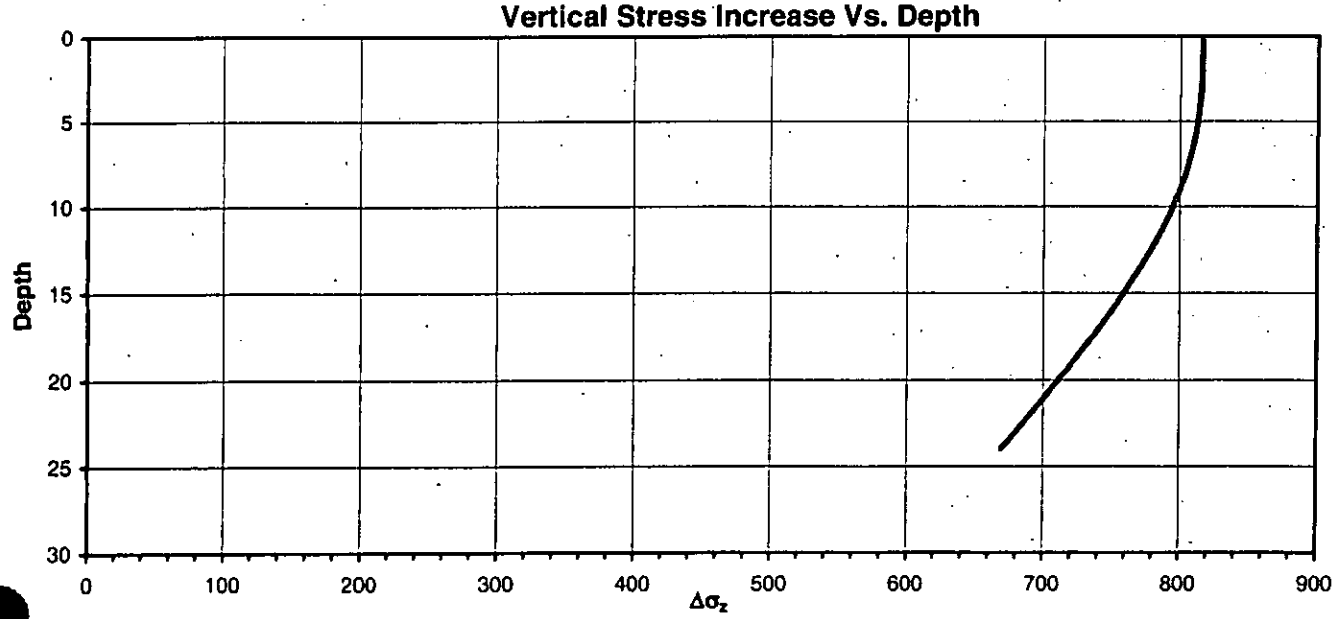


q =	816		load
a =	13.6		width of slope
b =	18		top half-width of embankment
x =	0		distance from CL
z =	0	to 24	depth range

$$\sigma_v(z) := \left(\frac{q}{\pi a}\right)\left(a\cdot(\alpha(z)+\beta(z)+\alpha'(z)) + b\cdot(\alpha(z)+\alpha'(z)) + x\cdot(\alpha(z)-\alpha'(z))\right)$$

$$\beta(z) := \operatorname{atan}\left[\frac{(b-x)}{z}\right] + \operatorname{atan}\left[\frac{(b+x)}{z}\right] \quad ; \quad \alpha'(z) := \operatorname{atan}\left[\frac{(a+b-x)}{z}\right] - \operatorname{atan}\left[\frac{(b-x)}{z}\right] \quad \alpha(z) := \operatorname{atan}\left[\frac{(a+b+x)}{z}\right] - \operatorname{atan}\left[\frac{(b+x)}{z}\right]$$

Vertical Stress Increase Vs. Depth



Reference: US Army Corps of Engineers EM 1110-1-1904 "Settlement Analysis", Table C-1

Geotechnical Engineering Checklist

III.B. Embankments Checklist

C-R-S: SCI-823-10.13 US 23/SR 823 Interchange	PID: 79977	Reviewer: SJR	Date: 11-15-07

Settlement

(Y)	N	X	1	If soil conditions and project requirements warrant, have settlement issues been addressed? If not applicable (X), go to Question **14**	
(Y)	N	X	2	Have consolidation properties of the foundation soils been determined? Check methods used: **X** laboratory consolidation tests **X** empirical correlations with moisture content and Atterberg values other	
(Y)	N	X	3	Have calculations been performed to estimate the total expected embankment settlement and the time of consolidation? Check method used: **X** EMBANK or equivalent software **X** hand calculations	
(Y)	N	X	4	If differing foundation soil and/or loading conditions occur throughout the embankment area, have sufficient analyses been completed to evaluate consolidation at locations representative of the most critical conditions?	
Y	(N)	X	5	Have the total settlement and the time of consolidation analyses indicated acceptable values at all locations for the scope of the embankment work?	
(Y)	N	X	6	If total settlement or time of consolidation is unacceptable, have the stations and lateral extent of the problem areas been defined?	
(Y)	N	X	7	Has a method been chosen as a solution to the settlement issues? Check methods used: **X** waiting periods with monitoring drainage blanket and wick drains **X** surcharge (preloading) removal and replacement of weak soil lowering proposed grade / change alignment lightweight fill	

III.B. Embankments Checklist

	9 other	List Other items:	
(Y) N X	8	Based on accepted design practices, and where applicable, adhering to published guidelines and design recommendations from FHWA, have calculations been performed to evaluate the effectiveness of the chosen solution(s)?	
Y N (X)	9	Has an economic analysis been performed to evaluate the cost benefits of the recommended solution compared to others?	
(Y) N X	10	Have all necessary notes, specifications, and details for the chosen solution been determined?	
(Y) N X	11	Have the need, locations, type, plan notes, and reading schedule for settlement platforms been determined?	
Y N (X)	12	Have the effects of the predicted settlement and the chosen solution been determined and accounted for on the construction schedule?	
(Y) N X	13	Has the effect of any foundation soil consolidation (including differential settlement) been evaluated with regard to adjacent structures (e.g., bridges, buildings, culverts, utilities) which will also undergo settlement and be subject to stresses induced by the consolidation of the surrounding soil?	

Notes :

Stage 1:

III.B. Embankments Checklist

Stability					
(Y) N X	14	If soil conditions and project requirements warrant, have stability issues been addressed?			
		If not applicable (X), go to Question **27**			
(Y) N X	15	Has the total (short term) and effective (long term) shear strength of the foundation soils been determined?			
		Check method used:			
		X laboratory shear tests			
		X estimation from SPT or field tests			
(Y) N X	16	Have the OGE's recommended values of shear strength for proposed embankment fill material (total: c = 2000 psf, phi = 0; effective: c = 300 psf, phi = 28) been used in the stability analyses?			
(Y) N X	17	Have calculations been performed to determine the F.S. for stability?			
		Check method used:			
		X STABL, XSTABL, or equivalent software			
		hand calculations			
	18	Have the following F.S. been met or exceeded, as determined by the calculations, for the given stability conditions:			
Y (N) X		a 1.30 for short term condition		MSE Walls Only	
(Y) N X		b 1.30 for long term condition			
(Y) N X		c 1.10 for rapid drawdown, flood condition		For Seismic Condition	
Y N X		d 1.50 for embankment supporting bridge abutments (not on deep foundations)			
(Y) N X	19	When differing soil or loading conditions occur throughout the embankment area, have sufficient analyses been completed to evaluate the stability at locations representative of the most critical conditions?			
(Y) N X	20	If the F.S. was not met or exceeded, have the stations and lateral extent of the problem areas been defined?			
(Y) N X	21	Has a method been chosen as a solution to the stability issues?			
		Check the method(s) used:			
		flattening slopes			
		counterberm			
		lightweight embankment			

III.B. Embankments Checklist

		reinforced soil slope	
		soil nailing	
		drainage blanket and wick drains	
		removal of soft soil, adding shear key	
		reduced grade / change alignment	
		X stage construction	
		controlled rate of fill placement	
		drilled shaft slope stabilization	
		X other List Other items:	Use Preloading embankment to surcharge foundation soils.
(Y)	N X 22	Based on accepted design practices, and where applicable, adhering to published guidelines and design recommendations from FHWA, have calculations been performed to evaluate the effectiveness of the chosen solution(s)?	
Y	N (X) 23	Has an economic analysis been performed to evaluate the cost benefits of the recommended solution compared to others?	
(Y)	N X 24	Have all necessary notes, specifications, and details for the chosen solution been determined?	
(Y)	N X 25	Have the need, location, type, plan notes, and reading schedule for piezometers and inclinometers been determined?	
(Y)	N X 26	If piezometers will be used, has the critical pressure value been determined and the appropriate information included in the plans?	
Y	N (X) 27	Have the effects of the stability solution been determined and accounted for on the construction schedule?	
(Y)	N X 28	Has the effect of the stability solution been evaluated with regard to structures (e.g., bridges, buildings, culverts, utilities) which may be subject to unusual stresses or require special construction considerations?	

Notes:

Stage 1:

III.B. Embankments Checklist

Sidehill Fills			
Y N (X)	29	If soil conditions and project requirements warrant, have sidehill fill issues been addressed?	Special Benching has been provided where necessary.
		If not applicable (X), go to Question **34**	
Y N X	30	In accordance with Geotechnical Bulletin 2: Special Benching and Sidehill Embankment Fills (GB 2), have sidehill fills been evaluated to determine if special benching or shear keys are needed?	
	31	In accordance with GB 2, if special benching or shear keys are required, has	
Y N X		a Plan Note G110 from L&D3 been included in the General Notes?	It was recommended that this note be included in the plans.
Y N X		b quantities for both excavation and embankment been calculated for the benched areas and added to the plan General Quantities?	
Y N X		c the special benching or shear keys been indicated on the appropriate cross sections?	Information was provided to Client.
Y N X	32	Have water bearing zones been identified and their impact addressed?	
Y N X	33	Have subsurface drainage controls been adequately addressed?	

Notes:

Stage 1:

III.B. Embankments Checklist

Special			
Y N(X)	34	Have all of the environmental factors, including wetlands, stream mitigation, and landfills, been considered and incorporated prior to design and analysis of embankment settlement and stability, including EPA or other government agencies' involvement, mitigation, or special design or construction considerations?	
	35	If an embankment is to be placed through standing water or over weak, wet soils (with or without a fabric separator), the fill should be placed by the method of end dumping to a given height above the standing water or until compaction is achievable over the soft soil. If end dumping is to be specified,	
Y N(X)		a has the material type for the fill to be end dumped been specified?	
Y N(X)		b has the need for a fabric separator or filter layer been determined?	
Y N(X)		c has the height of fill to be end dumped been determined?	
Y N(X)		d have all notes and specifications for end dumping been developed?	

Notes:

Stage 1: