GEOTECHNICAL EXPLORATION
Proposed Development Area
East of Evans Road, between 31st St. and Pine
Tulsa, Oklahoma
STEC Project No. 2130-2575

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January 14, 2002

The Robson Companies, Inc.
901 North Forest Ridge Blvd.
Broken Arrow, Oklahoma 74014

Attention: Mr. Douglas Shrout

SUBJECT: PRELIMINARY GEOTECHNICAL EXP LORATION
Proposed Development Area
East of Evans Road, between 31st St. and Pine
Tulsa, Oklahoma
Project No. 2130-2575

Dear Mr. Shrout:

This is a report of a preliminary geotechnical exploration performed for the proposed development area which is located on the east side of Evans Road between 31st Street and Pine in Tulsa, Oklahoma. This exploration was authorized with a signed Agreement for Services, dated November 20, 2001.

PROJECT INFORMATION

We understand the following about the project:

1. The proposed development will consist of residential and commercial development within an area of reclaimed strip mines;
2. The "older" abandoned strip mines are expected to be approximately 25 feet deep and the "more recent" abandoned strip mines are expected to be approximately 100 feet deep, per Mr. Joe Robson; and
3. The type of proposed structures are unknown at this point in time. The report is to provide recommendations for planning purposes only.

EXPLORATION OBJECTIVES

The primary purposes of this study were to evaluate the soil conditions at the site and develop preliminary geotechnical criteria for planning of project foundations. To accomplish these purposes, a three-phase study was performed composed of:

1. A field exploration consisting of twelve sample borings and site reconnaissance;

2. A laboratory testing program to evaluate the pertinent physical characteristics and engineering properties of the soils; and

3. An analysis of the field and laboratory data to formulate preliminary geotechnical criteria for planning of project foundations and to develop preliminary recommendations for construction of foundations, floor slabs, pavement sections, and earthwork.

It should be noted that it was not a purpose of this geotechnical study to evaluate or address environmental conditions at the site.

The recommendations provided in this report should solely be used for planning purposes and should not be used for design purposes. Once the actual location of the proposed structures are determined, additional borings are recommended within the actual footprint area of the proposed structures to establish actual geotechnical design criteria.

FIELD EXPLORATION AND LABORATORY TESTING

Subsurface soil conditions at the site were explored by drilling twelve sample borings at the approximate locations directed by Mr. Joe Robson. The approximate locations of the borings are shown on the attached Plan of Borings. The approximate latitude and longitude of the boring locations were determined with a Global Positioning System and are noted on the boring logs. The borings were of 6.5 inch nominal diameter and were drilled to depths of approximately 18.5 to 21.5 feet where auger refusal was encountered in borings B-1 and B-11. Logs of the borings, giving descriptions of the various soils encountered and results of field tests, are attached.

Disturbed samples of the soils were obtained by driving a 2 inch O.D. split spoon sampler into the soil using blows of a 140 pound automatic hammer dropped 30 inches. The number of blows required to advance the split spoon the final 12 inches of an 18 inch total drive is defined as the standard penetration number, N-value, and is shown in the Blows Per Foot column on the boring logs. The N-value can be correlated generally to some significant physical properties of the soils.

Limited laboratory testing was performed because of the preliminary nature of this exploration. Atterberg limits tests were performed on selected soil samples to verify field classification. Natural moisture content determinations were performed to establish a soil moisture profile for the borings. The results of the laboratory tests are shown on the attached Summary of Laboratory Test Data sheet. The laboratory results are also indicated symbolically on the boring logs.

GENERAL SOIL CONDITIONS

The materials comprising the subsurface soils across the site, as determined by the soil exploration, are shown on the boring logs. Review of the logs indicates the stratigraphy can be characterized generally as described in the following paragraph.

The soils encountered in the borings consisted of fill material to the boring termination depths of 18.5 to 21.5 feet. Auger refusal was encountered in borings B-1 and B-11 at depths of 18.5 feet and 19 feet, respectively, where very hard native limestone was encountered . The fill material was primarily composed of lean clays, some silty sand (boring B-3 only), clayey shale and shale with various amounts of coal, limestone, sandstone and siltstone fragments ranging in size from gravel to boulders. The lean clays exhibited low to fairly high plasticity characteristics and were stiff to very stiff. The silty sand exhibited trace plasticity characteristics and was very dense. The clayey shale exhibited fairly low to fairly high plasticity characteristics and was firm to very stiff. The shale exhibited fairly low to medium plasticity characteristics and was soft to very stiff.

Groundwater was encountered in boring B-1 at a depth of 12.5 during drilling and at a depth of 11.8 feet at the completion of drilling. The other borings were dry during drilling and at the completion of drilling.

The properties of the soils considered pertinent to this project are: (a) the presence of fill material to the termination depths of the borings; (b) the low to fairly high shrink-swell potential of the fill material; (c) the low to high shear strength of the fill material; (d) the presence of gravel, cobbles and boulders in the fill material; (e) the presence of groundwater in boring B-1 at the time of the field study; (f) soft zones were encountered in boring B-1; and (g) the presence of native limestone in borings B-1 and B-11 within the zone of exploration. The relationship of these factors to design and construction is considered in the following recommendations.

ANALYSIS AND PRELIMINARY RECOMMENDATIONS

The primary considerations in the design of a safe and economical foundation system for structures are the shear strength, settlement characteristics and volumetric stability of the soils within the zone of interaction of the structures. These factors were considered in the development of the preliminary recommendations presented in subsequent paragraphs.

A. **Earthwork.** Prior to construction, the site should be stripped of vegetation, topsoil and any other deleterious materials. Where trees are removed the larger portions of the root system should be removed and the stump holes properly filled.

Prior to placing fill, the exposed subgrade should be prepared as follows:

1. The exposed subgrade should be scarified to a depth of at least 8 inches and proof-rolled with a fully loaded tandem axle dump truck;

2. If there is no sign of pumping, the moisture content of the scarified soil should be adjusted to within a range of +/-2 percentage points of the optimum moisture content and compacted to at least 95 percent of the maximum dry density determined by the standard Proctor Moisture-Density Relation test (ASTM D698); and

3. Soils which are observed to rut or pump excessively during proof-rolling should be undercut, moisture conditioned and re-compacted in-place or replaced with properly compacted fill. The moisture content should be adjusted to within a range of +/-2 percentage points of the optimum moisture content and compaction should be at least 95 percent of the maximum dry

density determined by the standard Proctor Moisture-Density Relation test (ASTM D698). These soils can also be stabilized with lime, cement kiln dust or Class "C" fly ash to help facilitate compaction.

Fill material should be select material composed of a nonplastic to fairly low plasticity sandy clay, clayey sand, or silty sand meeting the following requirements:

• Amount finer than 2-inch sieve	=	100%
• Amount finer than No. 200 sieve	=	12% minimum and, if PI ≤ 7, 60% maximum
• Liquid Limit (LL)	=	40 maximum
• Plasticity Index (PI)	=	17 maximum

Fill material should be placed in continuous, horizontal lifts having a maximum precompacted thickness of 8 inches. Each lift should be compacted to at least 95 percent of standard Proctor maximum dry density within -2 to +2 percentage points of the optimum moisture content.

Constructed fill slopes should be no steeper than 3H:1V for purpose of long term stability. Building pads should be of sufficient size to provide a minimum of 4 feet of horizontal distance between the crest of the fill slope and any portion of the foundation system. Since it is difficult to compact soils at the edges of slopes, it is recommended that the slopes be overbuilt 2 feet and cut back to the design contours to allow proper compaction of the structural fill. The structural fill material to be used for the building pad is moderately to highly erodible. Consequently, appropriate slope protection should be provided as soon as practicable to minimize slope deterioration.

B. Foundation Systems. It should be emphasized that the following foundations are suggested foundation systems. Actual foundation system recommendations can only be provided once the type of structure, actual design loads and subsurface conditions, including depth to native rock, within the footprint area of the proposed structure have been determined.

B.1 Residential Structures. Some of the existing fill material is moderately to highly active and will shrink and swell with soil moisture variations. Calculations based on empirical relationships between the plasticity indices and potential vertical rise of the soil

indicate slabs placed on the in situ soils have a potential for vertical movement on the order of 1.5 inches.

Also, to the existing fill material encountered across the site, it is expected that shallow footing foundations and conventional slabs-on-grade supported on this fill may experience excessive differential settlements. To reduce the amount of differential settlement to tolerable and predictable levels, it would be necessary to remove the fill in it's entirety and replace it with controlled fill. However, project budgetary concerns must be considered and therefore, the following alternate foundation systems are recommended:

Support residential structures on ribbed mat foundations on the existing fill material. The purpose of using a ribbed mat is to allow the structures to move in a uniform manner, rather than differentially. Because of the nature of the fill material, it is not possible to accurately determine the expected differential settlements. Therefore, it is the responsibility of the owner to determine the amount of acceptable settlement risks. It should be noted that utility connections should be designed to allow for differential movements.

A ribbed mat, either reinforced or post-tensioned, may be used to support the structures by founding the exterior stiffening beams at a depth of 2 feet below the finish exterior grade and utilizing the stiffening beams as continuous, shallow footings designed for a maximum allowable net bearing pressure of 2,000 psf. The stiffening beams should have a minimum width of 16 inches. Such a foundation may be designed using the procedure detailed in "Design of Slabs on Grade," American Concrete Institute publication 360R-92, Section 8.6 (also published as the Post Tensioning Institute, "Design and Construction of Post-Tensioned Slabs-On-Ground"). The following design parameters should be used for the existing fill material:

- Soil Modulus of Elasticity, E_s ..... 1,100 psi
- Slab Subgrade Friction Coefficient, μ 1.0
- Modulus of Subgrade Reaction ..... 75 pci
- Center Lift Moisture Variation Distance, e_m ..... 4.25 feet
- Edge Lift Moisture Variation Distance, e_m ..... 5.00 feet
- Center Lift Differential Soil Movement, Y_m (assumed) ..... 1.0 inch
- Edge Lift Differential Soil Movement, Y_m (assumed) ..... 1.0 inch

B.2 Commercial Structures. Commercial structures may be supported by ribbed mat foundation systems, either reinforced or post-tensioned, if the risk of differential settlements in excess of 1 inch is considered acceptable.

If differential settlement criteria are critical and strict, a shallow foundation system founded in the existing fill material will likely not be practical. Alternative foundation systems which avoid the risk of differential settlements of the existing fill material will have to be considered. Such foundation systems may include, but are not limited to:

Drilled piers along with grade beams and elevated structural floor slabs in areas where the depth to native rock material is considered reasonable. However, according to Mr. Joe Robson, areas with reclaimed strip mines to depths of 100 feet are present within the development area. For these particular areas, driven steel H-piles may be a practical alternative foundation system.

C. Floor Slabs. A 4 inch layer of clean, crushed stone having a gradation corresponding to ASTM C33 size 6, 7, or 67 should be placed beneath the floor slab. This material should be rolled in place. A water reducing admixture should be used in the slab concrete to reduce concrete permeability or a polyethylene film placed beneath the slab to inhibit moisture migration through the slab.

D. Roadway Pavements.

D.1 Subgrade. The near-surface existing fill material consists of soils with a plasticity indices ranging from 12 to 26 percent. STEC recommends that the pavement subgrade be stabilized with lime, cement kiln dust (CKD) or Class "C" fly ash to a minimum depth of 8 inches and be prepared as follows:

The on-site soils can be chemically stabilized by using lime. We recommend that the site clays be mixed with the percentage of lime corresponding to the optimum lime addition, as determined by the "pH method" (ASTM C977 Appendix X) plus 1 percent, based on the compacted dry weight of soil. We estimate the amount of lime required to be approximately 5 percent, which should be verified in the laboratory. The methods of preparing the subgrade, scarifying the soil, applying the lime, mixing, curing, re-mixing, and compaction of the lime-soil mixture should be in accordance with Oklahoma Department of

Transportation (ODOT) "Standard Specifications for Highway Construction", Section 307. The lime-soil mixture should be placed in continuous lifts not exceeding 8 inches precompacted thickness. Each lift should be compacted to at least 95 percent of the maximum dry density determined by the standard Proctor Moisture-Density Relation Test (ASTM D698) within -2 to +2 percentage points of the optimum moisture content.

The on-site soils may also be improved by stabilization with CKD. We recommend that the site soils be admixed with not less than 10 percent CKD based on compacted dry weight of the soil, which should be verified in the laboratory. The procedures used to stabilize the soils with the CKD should conform reasonably to ODOT "Standard Specifications for Highway Construction" Section 317. The success of the stabilization of the soils depends on reasonable conformance to the execution procedures stated in the specifications. The CKD-soil mixture should be placed in continuous lifts not exceeding 8 inches precompacted thickness. Each lift should be compacted to at least 95 percent of the maximum dry density determined by the standard Proctor Moisture-Density Relation Test (ASTM D698) within -2 to +2 percentage points of the optimum moisture content.

The on-site soils can also be improved by stabilization with Class "C" fly ash. We recommend that the site soils be admixed with not less than 15 percent Class "C" fly ash based on compacted dry weight of the soil, which should be verified in the laboratory. Additions of fly ash, mixing, compacting, and curing should be performed in strict conformance with the Oklahoma Department of Transportation (ODOT) "Standard Specifications for Highway Construction" Section 317. **It should be noted that time limitations in mixing and compacting the soil are critical.** The fly ash-soil mixture should be placed in continuous lifts not exceeding 8 inches precompacted thickness. Each lift should be compacted to at least 95 percent of the maximum dry density determined by the standard Proctor Moisture-Density Relation Test (ASTM D698) within -2 to +2 percentage points of the optimum moisture content.

D.2 <u>Pavements.</u> Based on the assumption of a properly stabilized subgrade, minimum subgrade moduli, and our estimate of the traffic conditions, the following pavement sections are recommended for this project:

Pavement Type	Material	Minor and High Density Minor in Residential Areas	Residential Collector	Commercial and Industrial Collector
		Thickness (inches)		
Flexible	HMAC Surface Course, Type "B" or "C"	2.0	2.5	3.0
	HMAC Base Course, Type "A"	4.0	4.0	4.0
	Stabilized Subgrade	8.0	8.0	8.0
Rigid	Portland Cement Concrete	6.0	7.0	7.5
	Stabilized Subgrade	8.0	8.0	8.0

HMAC - Hot Mixed Asphaltic Concrete

Once actual anticipated traffic data is provided, the recommended pavement thicknesses can be re-evaluated.

If rigid pavement is used for this project, the Portland cement concrete should have a minimum 28-day compressive strength of 4,000 psi and should be air-entrained with 4 to 6 percent total air. Adequate numbers of properly constructed control joints should also be incorporated in the pavement. Control joint spacing, both ways, should not exceed 12 feet for 5-inches-thick pavement or 15 feet for pavements 6 inches or more in thickness. Control joints should be saw cut at least 0.125 inch wide and one-quarter of the pavement thickness deep approximately six (6) to nine (9) hours after placing concrete. The joints should be cleaned by a high pressure air jet and sealed with a high quality joint sealer to prevent surface water infiltration through the joints.

The edges of the pavement must be protected by use of curbs and gutters or thickened edge pavement sections. Handling, placing, and curing of pavement materials should be performed in accordance with procedures specified by the ODOT "Standard Specifications for Highway Construction."

E. Drainage. As with all projects, adequate site drainage should be established prior to and continued during and following construction operations to prevent ponding of water on or adjacent to the construction areas. Maintaining proper drainage through all phases of the project will expedite construction and improve the performance of the proposed structures and the pavements. Pavements should be designed to facilitate drainage, with a minimum slope of one (1) percent.

F. **Future Studies.** The preliminary recommendations provided in this report are based on information derived from twelve widely spaced test borings. These preliminary recommendations should only be used in cost feasibility studies and not for design. As planning matures, a comprehensive geotechnical study should be performed to establish actual geotechnical design criteria and soil-structure interaction analysis.

We will be pleased to discuss our preliminary recommendations with you and would welcome the opportunity to provide the additional geotechnical study and construction testing services necessary to complete this project. We look forward to serving as your geotechnical engineer and construction materials testing laboratory on the remainder of this project and on future projects.

Respectfully submitted,
STANDARD TESTING AND ENGINEERING COMPANY

Endeson Juanda, E.I.
Project Manager

Marco V. Vicente Silvestre, E.I.
Geotechnical Engineering Manager

R. Steve Crain, P.E.
Manager - Tulsa Operations

REGISTERED PROFESSIONAL ENGINEER
ROBERT STEVEN CRAIN II
19312
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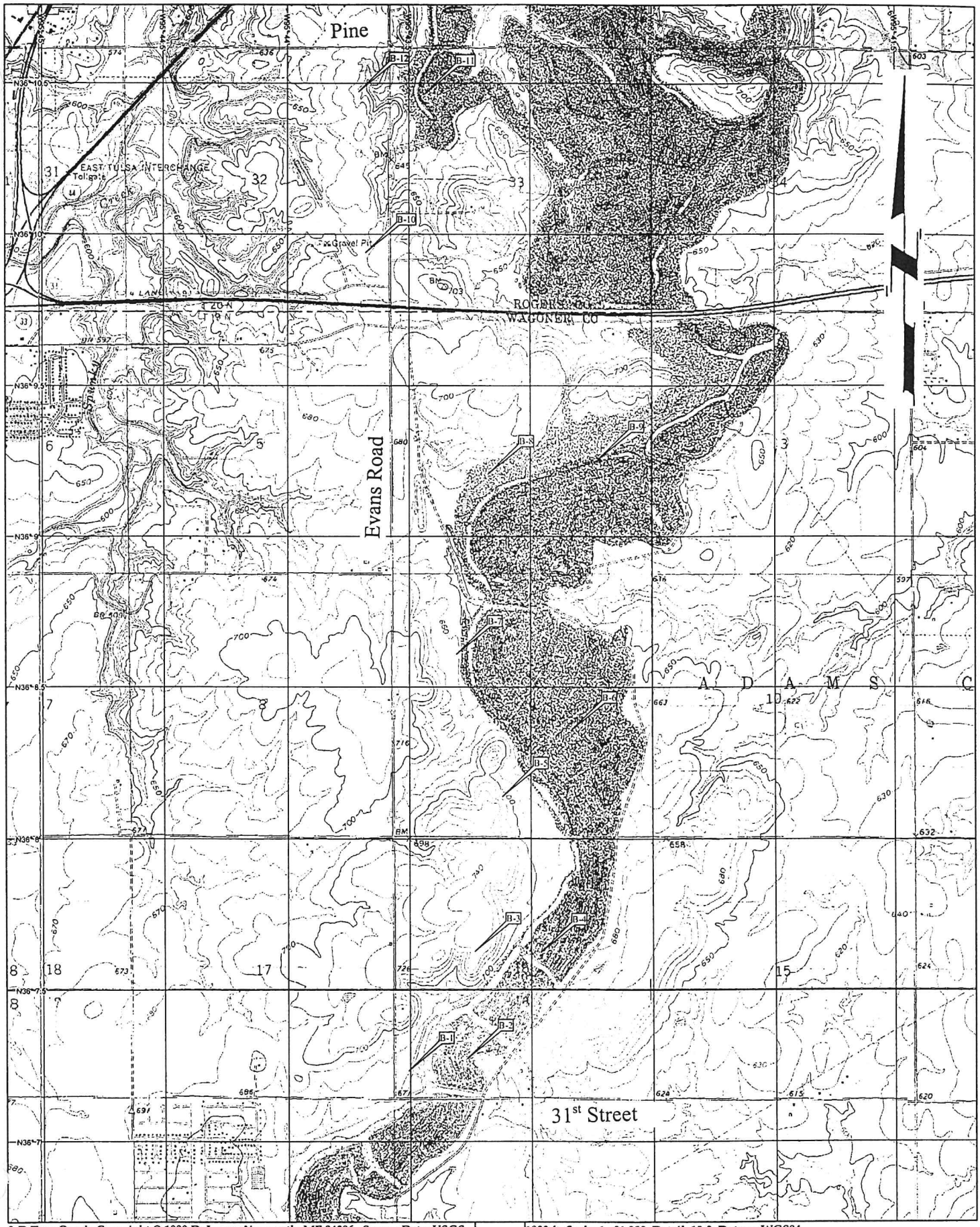
OKLAHOMA

attachments (18 pages)

CA #77
Expires 6-30-03

PROPOSED DEVELOPMENT AREA; 2130-2575



3-D TopoQuads Copyright © 1999 DeLorme Yarmouth, ME 04096 Source Data: USGS 1000 ft Scale: 1 : 31,250 Detail: 13-0 Datum: WGS84

TESTING AND ENGINEERING COMPANY

KEY TO SOIL AND ROCK CLASSIFICATION

COHESIVE SOILS

Consistency		
Description Term	*Unconfined Compressive Strength (tsf)*	*Cohesion Symbols*
Very soft	≤ 0.25	○ = Cohesive Shear Strength ▲ = Triaxial Shear Strength
Soft	0.25 - 0.50	
Firm	0.50 - 1.00	
Stiff	1.00 - 2.00	
Very Stiff	2.00 - 4.00	
Hard	≥ 4.00	

COHESIVE SOILS

Plasticity		
Description Term	*Plasticity Index (%)*	*Plasticity Symbols*
Trace	≤ 4	LL=Liquid Limit PL=Plastic Limit PI=Plasticity Index
Low	5 - 11	
Fairly Low	12 - 16	
Medium	17 - 23	
Fairly High	24 - 28	
High	≥ 29	

COHESIONLESS SOILS

Relative Density	
Description Term	*Standard Penetration Resistance Blows / Foot*
Very Loose	≤ 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	≥ 51

INTACT ROCK

Hardness	
Description Term	*Approximate Range of Uniaxial Compression Strength (tsf)*
Very Soft	10 - 250
Soft	250 - 500
Hard	500 - 1000
Very Hard	1000 - 2000
Extremely Hard	≥ 2000

TEST DATA AND SAMPLER SYMBOLS

% fines = Percent finer than #200 sieve
Phi = Angle of Internal Friction (degrees)
qu = Uniaxial Compressive Strength (psi)
Recovery = Percent Recovery per core run
RQD = Rock Quality Designation per core run

▽ = Water level 24 hrs after completion
▼ = Water level at completion

Split Spoon (ASTM D1586)

Shelby Tube (ASTM D1587)

Rock Core (ASTM D2113)

N R No Recovery

Cuttings Sample (ASTM D1452)

THD Cone

Dynamic Cone Penetrometer

TEST BORING LOG

Boring No

B-1

Project: Proposed Development Area	**Project No:** 2130-2575
Project Location: Tulsa, Oklahoma	**Boring Location:** See Plan of Borings
Date Drilled: December 5, 2001	**Drill Method:** 3.25" HSA, B-56
Project Engineer: Endeson Juanda, E.I.	**Driller:** T. Fife
Water Depth 11.8 feet at Completion	**Elevation**

Remarks: Wet at 12.5 feet during drilling; Lat/Long: 36° 7.233'/95° 43.508'

Elevation/ Depth, feet	Symbol	Samples	Blows per Foot	Water	SOIL DESCRIPTION	DD pcf
0			21		Topsoil with grass and roots	
					LL=36, PI=18	
			41		FILL - Gray, brown and amber, lean clay, slightly moist, medium plasticity, very stiff	
5			51		FILL - Gray and amber, shale with sandstone fragments, slightly moist, fairly low plasticity, very stiff	
					LL=33, PI=13	
			6		FILL - Gray and amber, shale with sandstone fragments, slightly moist, fairly low plasticity, firm to very stiff	
10			19		(with coal fragments)	
				▼	(Wet at 12.5 feet during drilling)	
15			4		FILL - Gray and brown, shale with coal fragments, very moist, fairly low plasticity, soft	
			50/0.0"		(ROCK) Limestone, slightly moist, very hard	
20					(Auger refusal at 18.5 feet)	
25						
30						

Cohesion, Ton/Sq. Ft.

0.2 0.4 0.6 0.8 1 1.2 1.4

Plastic Limit — Water Content — Liquid Limit

10 20 30 40 50 60 70

STANDARD TESTING AND ENGINEERING CO.

TEST BORING LOG

Boring No

B-2

Project: Proposed Development Area	Project No: 2130-2575
Project Location: Tulsa, Oklahoma	Boring Location: See Plan of Borings
Date Drilled: December 5, 2001	Drill Method: 3.25" HSA, B-56
Project Engineer: Endeson Juanda, E.I.	Driller: T. Fife
Water Depth Dry at Completion	Elevation
Remarks: Lat/Long: 36° 7.275'/95° 43.264'	

Elevation/ Depth, feet	Symbol	Samples	Blows per Foot	Water	SOIL DESCRIPTION	DD pcf
0			37		Topsoil with grass and roots	
					LL=40, PI=24 FILL - Brown, lean clay, moist, fairly high plasticity, very stiff	
			25		FILL - Tannish, orange pale and brown, shale, slightly moist, fairly low plasticity, very stiff	
5			33		FILL - Mottled grayish brown, gray and amber, clayey shale with ferrous nodules, sandstone fragments and coal fragments, moist to slightly moist, fairly low plasticity, very stiff	
			43		LL=34, PI=12 FILL - Tannish brown and grayish brown, shale, slightly moist, fairly low plasticity, very stiff	
10			26		FILL - Grayish brown, brown and gray, shale with coal fragments, slightly moist, fairly low plasticity, very stiff	
15			17		FILL - Brown, gray and amber, shale, slightly moist, fairly low plasticity, very stiff to stiff	
20			10		(with coal fragments)	
25						
30						

Cohesion, Ton/Sq. Ft.

0.2 0.4 0.6 0.8 1 1.2 1.4

Plastic Limit — Water Content — Liquid Limit

10 20 30 40 50 60 70

STANDARD TESTING AND ENGINEERING CO.

TEST BORING LOG

Boring No

B-3

Project: Proposed Development Area	Project No: 2130-2575
Project Location: Tulsa, Oklahoma	Boring Location: See Plan of Borings
Date Drilled: December 5, 2001	Drill Method: 3.25" HSA, B-56
Project Engineer: Endeson Juanda, E.I.	Driller: T. Fife
Water Depth Dry at Completion	Elevation
Remarks: Lat/Long: 36° 7.627'/95° 43.232'	

Elevation/ Depth, feet	Symbol	Samples	Blows per Foot	Water	SOIL DESCRIPTION	DD pcf
0			17		Topsoil with grass and roots	
					FILL - Brown to gray, shale with sandstone fragments, slightly moist, fairly low plasticity, very stiff	
			8/6.0" 50/4.0"		LL=28, PI=9	
5			12		FILL - Grayish brown, sandy lean clay with sandstone gravel, cobbles and boulders, and shale fragments, slightly moist, low plasticity, stiff to very stiff	
			20			
10			87		LL=19, PI=3	
					FILL - Brown, silty sand with sandstone fragments, moist, trace plasticity, very dense	
15			17		FILL - Gray, shale, slightly moist, fairly low plasticity, very stiff	
20			30			
25						
30						

Cohesion, Ton/Sq. Ft.

0.2 0.4 0.6 0.8 1 1.2 1.4

Plastic Limit — Water Content — Liquid Limit

10 20 30 40 50 60 70

STANDARD TESTING AND ENGINEERING CO.

TEST BORING LOG

Boring No

B-4

Project: Proposed Development Area	**Project No:** 2130-2575
Project Location: Tulsa, Oklahoma	**Boring Location:** See Plan of Borings
Date Drilled: December 11, 2001	**Drill Method:** 3.25" HSA, B-56
Project Engineer: Endeson Juanda, E.I.	**Driller:** T. Fife
Water Depth Dry at Completion	**Elevation**
Remarks: Lat/Long: 36° 7.625'/95° 42.961'	

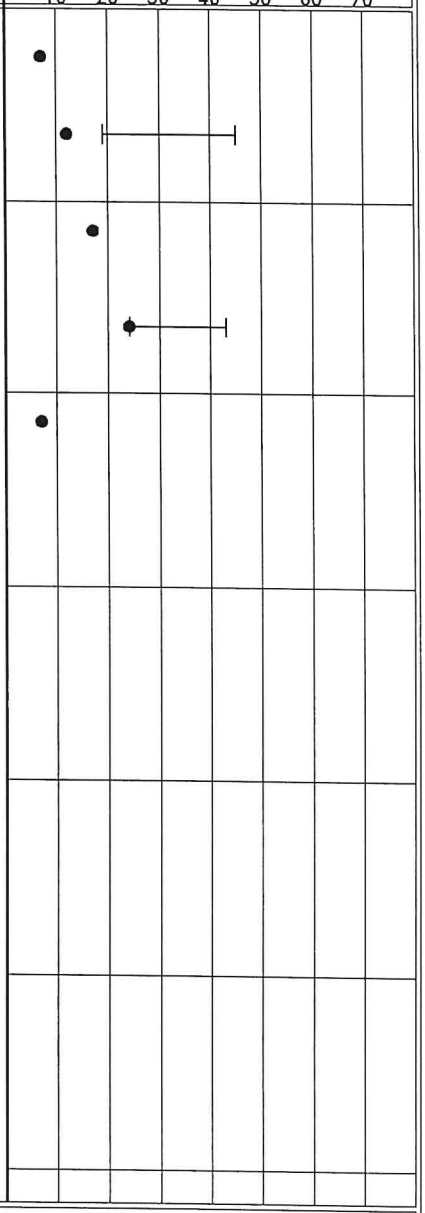
Elevation/ Depth, feet	Symbol	Samples	Blows per Foot	Water	SOIL DESCRIPTION	DD pcf
0			15		Topsoil with grass and roots	
			32		FILL - Grayish brown, gray and amber, lean clay with shale fragments, slightly moist, fairly high plasticity, stiff to very stiff LL=45, PI=26	
5			36		(with coal fragments)	
			30		LL=43, PI=19 FILL - Grayish brown, gray and amber, lean clay with shale fragments, moist, medium plasticity, very stiff	
10			68		FILL - Gray and amber, shale, slightly moist, fairly low plasticity, very stiff to stiff	
15			50/2.5"		(with sandstone boulders)	
20			15		(with coal fragments)	
25						
30						

Cohesion, Ton/Sq. Ft.

0.2 0.4 0.6 0.8 1 1.2 1.4

Plastic Limit — Water Content — Liquid Limit

10 20 30 40 50 60 70



STANDARD TESTING AND ENGINEERING CO.

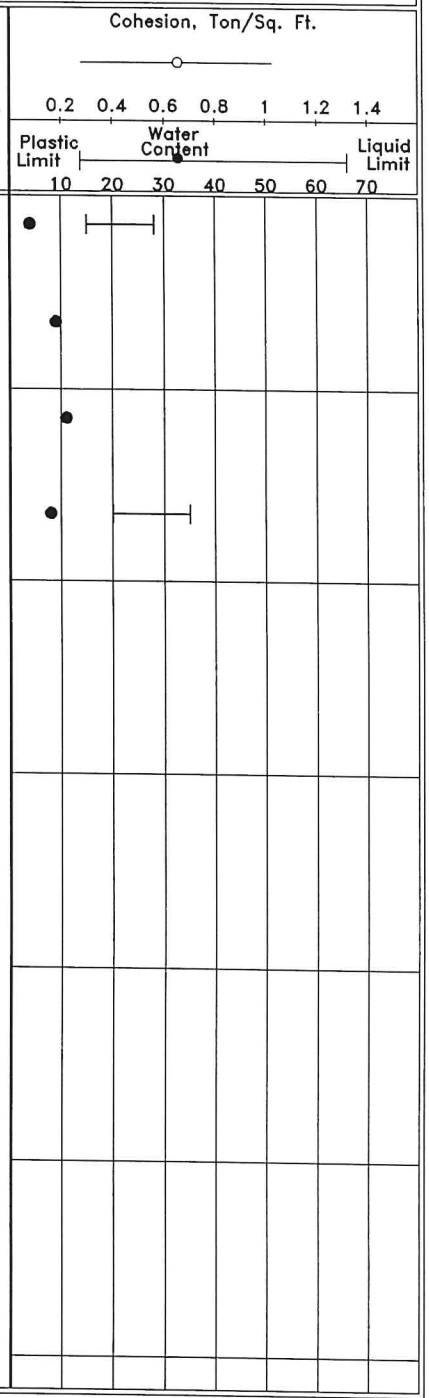
TEST BORING LOG

Boring No

B-5

Project: Proposed Development Area	Project No: 2130-2575
Project Location: Tulsa, Oklahoma	Boring Location: See Plan of Borings
Date Drilled: December 5, 2001	Drill Method: 3.25" HSA, B-56
Project Engineer: Endeson Juanda, E.I.	Driller: T. Fife
Water Depth Dry at Completion	Elevation
Remarks: Lat/Long: 36° 8.140'/95° 43.117'	

Elevation/ Depth, feet	Symbol	Samples	Blows per Foot	Water	SOIL DESCRIPTION	DD pcf
0			50/5.5"		Topsoil with grass and roots	
					LL=28, PI=13	
			56		FILL - Brown to gray, lean clay with limestone cobbles and boulders, slightly moist, fairly low plasticity, very stiff	
5			53		FILL - Gray, lean clay with shale and limestone fragments, slightly moist, fairly low plasticity, very stiff	
			34		FILL - Gray and brown, shale with sandstone fragments, slightly moist, fairly low plasticity, very stiff (without sandstone fragments) LL=35, PI=15	
10			40		FILL - Gray, shale, slightly moist, fairly low plasticity, very stiff	
15			27			
20			31			
25						
30						



STANDARD TESTING AND ENGINEERING CO.

TEST BORING LOG

Boring No

B-6

Project: Proposed Development Area	Project No: 2130-2575
Project Location: Tulsa, Oklahoma	Boring Location: See Plan of Borings
Date Drilled: December 11, 2001	Drill Method: 3.25" HSA, B-56
Project Engineer: Endeson Juanda, E.I.	Driller: T. Fife
Water Depth Dry at Completion	Elevation
Remarks: Lat/Long: 36° 8.356'/95° 42.834'	

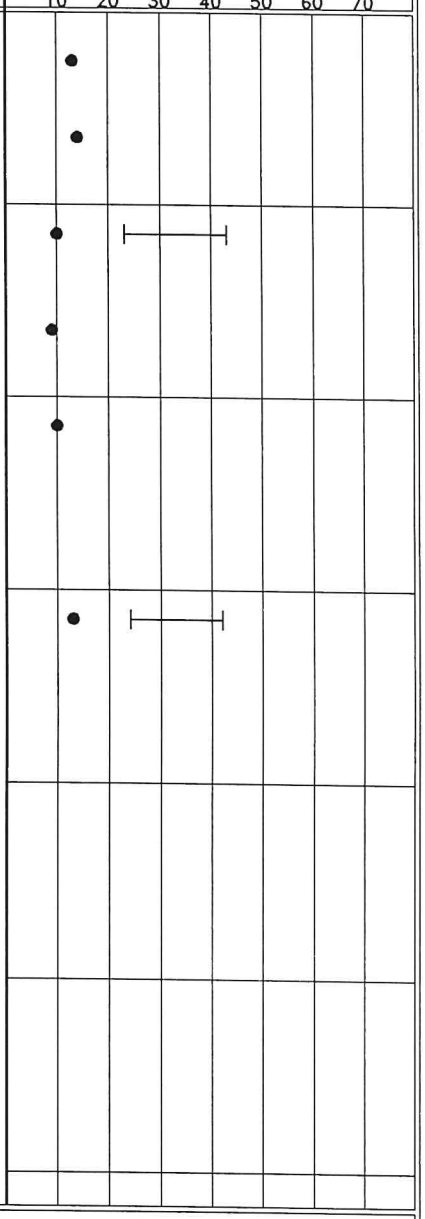
Elevation/ Depth, feet	Symbol	Samples	Blows per Foot	Water	SOIL DESCRIPTION	DD pcf
0			12		Topsoil with grass and roots	
			9		FILL - Brown and amber, clayey shale with coal and shale fragments, slightly moist, medium plasticity, stiff	
5			77		LL=43, PI=20	
			20		FILL - Gray and amber, shale wtih siltstone gravel, slightly moist, medium plasticity, very stiff to stiff	
10			20		(with coal fragments)	
15			12		LL=42, PI=18	
20			6/6.0" 50/4.0"		(with sandstone boulders)	
25						
30						

Cohesion, Ton/Sq. Ft.

0.2 0.4 0.6 0.8 1 1.2 1.4

Plastic Limit — Water Content — Liquid Limit

10 20 30 40 50 60 70



STANDARD TESTING AND ENGINEERING CO.

TEST BORING LOG

Boring No

B-7

Project: Proposed Development Area	Project No: 2130-2575
Project Location: Tulsa, Oklahoma	Boring Location: See Plan of Borings
Date Drilled: December 5, 2001	Drill Method: 3.25" HSA, B-56
Project Engineer: Endeson Juanda, E.I.	Driller: T. Fife
Water Depth Dry at Completion	Elevation
Remarks: Lat/Long: 36° 8.608'/95° 43.305'	

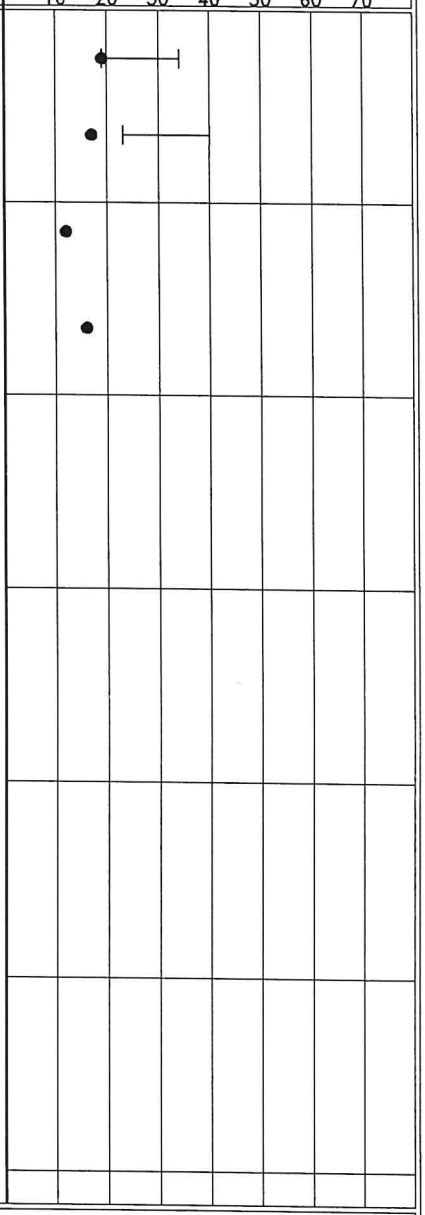
Elevation/ Depth, feet	Symbol	Samples	Blows per Foot	Water	SOIL DESCRIPTION	DD pcf
0			8		Topsoil with grass and roots	
			20		LL=34, PI=15 FILL - Grayish brown, clayey shale with red sandstone fragments, moist to slightly moist, fairly low to medium plasticity, firm to very stiff LL=40, PI=17	
5			11		FILL - Gray and tannish brown, shale, slightly moist, fairly low plasticity, stiff	
			9		(with red sandstone fragments)	
10			55		FILL - Gray, shale with siltstone gravel, slightly moist, fairly low plasticity, very stiff	
15			38			
20			40			
25						
30						

Cohesion, Ton/Sq. Ft.

0.2 0.4 0.6 0.8 1 1.2 1.4

Plastic Limit — Water Content — Liquid Limit

10 20 30 40 50 60 70



STANDARD TESTING AND ENGINEERING CO.

TEST BORING LOG

Boring No

B-8

Project: Proposed Development Area	Project No: 2130-2575
Project Location: Tulsa, Oklahoma	Boring Location: See Plan of Borings
Date Drilled: December 11, 2001	Drill Method: 3.25" HSA, B-56
Project Engineer: Endeson Juanda, E.I.	Driller: T. Fife
Water Depth Dry at Completion	Elevation
Remarks: Lat/Long: 36° 9.206'/95° 43.175'	

Elevation/ Depth, feet	Symbol	Samples	Blows per Foot	Water	SOIL DESCRIPTION	DD pcf
0			13		Topsoil with grass and roots	
					LL=41, PI=25	
			26		FILL - Grayish brown, amber and gray, clayey shale, moist, fairly high plasticity, stiff	
					FILL - Tannish brown, clayey shale with shale fragments, slightly moist, fairly low plasticity, very stiff	
5			18		LL=36, PI=15	
					FILL - Grayish brown, clayey shale with shale fragments, slightly moist, fairly low plasticity, very stiff	
			12		FILL - Mottled grayish brown, amber and gray, lean clay with ferrous nodules, moist, fairly high plasticity, stiff	
10			30		FILL - Grayish brown and amber, shale, slightly moist, fairly low plasticity, very stiff to stiff	
					LL=35, PI=14	
15			25			
20			15			
25						
30						

Cohesion, Ton/Sq. Ft.

0.2 0.4 0.6 0.8 1 1.2 1.4

Plastic Limit — Water Content — Liquid Limit

10 20 30 40 50 60 70

STANDARD TESTING AND ENGINEERING CO.

TEST BORING LOG

Boring No

B-9

Project: Proposed Development Area	Project No: 2130-2575
Project Location: Tulsa, Oklahoma	Boring Location: See Plan of Borings
Date Drilled: December 11/12, 2001	Drill Method: 3.25" HSA, B-56
Project Engineer: Endeson Juanda, E.I.	Driller: T. Fife
Water Depth Dry at Completion	Elevation
Remarks: Lat/Long: 36° 9.255'/95° 42.722'	

Elevation/ Depth, feet	Symbol	Samples	Blows per Foot	Water	SOIL DESCRIPTION	DD pcf
0			12		Topsoil with grass and roots	
					FILL - Grayish brown and amber, lean clay, moist, medium plasticity, stiff	
			28		FILL - Brown and gray, lean clay, moist, medium plasticity, very stiff	
5			27		LL=45, PI=22 FILL - Brown and gray, clayey shale with shale fragments, slightly moist, medium plasticity, very stiff	
			23		FILL - Yellowish brown and gray, lean clay with ferrous nodules, moist, fairly high plasticity, very stiff	
10			61		LL=39, PI=18 FILL - Gray, shale with limestone fragments, slightly moist, medium plasticity, very stiff	
15			19		(without limestone)	
20			23		FILL - Gray and amber, shale, slightly moist, fairly low plasticity, very stiff	
25						
30						

Cohesion, Ton/Sq. Ft.

0.2 0.4 0.6 0.8 1 1.2 1.4

Plastic Limit — Water Content — Liquid Limit

10 20 30 40 50 60 70

STANDARD TESTING AND ENGINEERING CO.

TEST BORING LOG

Boring No

B-10

Project: Proposed Development Area	Project No: 2130-2575
Project Location: Tulsa, Oklahoma	Boring Location: See Plan of Borings
Date Drilled: December 13, 2001	Drill Method: 3.25" HSA, B-56
Project Engineer: Endeson Juanda, E.I.	Driller: T. Fife
Water Depth Dry at Completion	Elevation
Remarks: Lat/Long: 36° 9.940'/95° 43.679'	

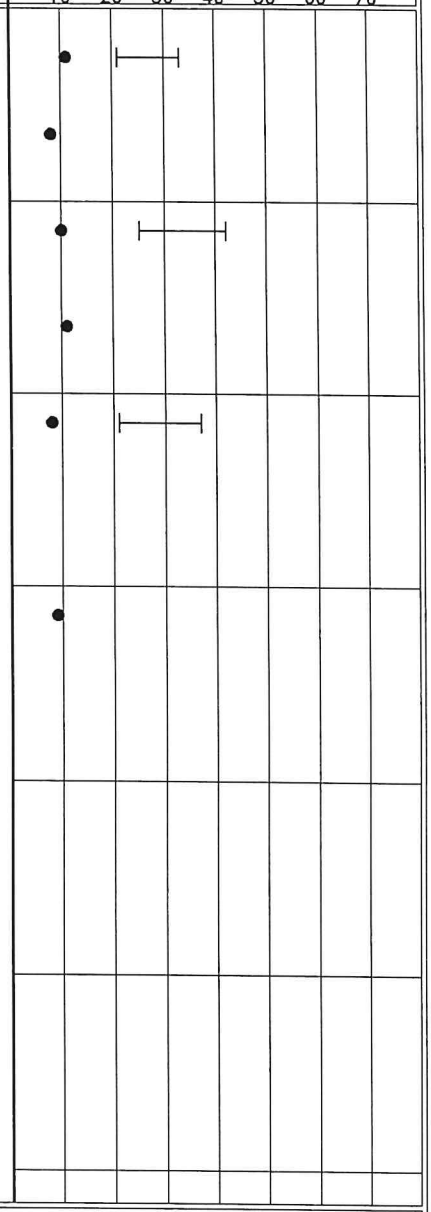
Elevation/ Depth, feet	Symbol	Samples	Blows per Foot	Water	SOIL DESCRIPTION	DD pcf
0			25		Topsoil with grass and roots	
					LL=33, PI=12	
			37		FILL - Dark brown, lean clay, slightly moist, fairly low plasticity, stiff	
5			31		FILL - Gray, dark gray and brown, shale with sandstone fragments, slightly moist, medium to fairly low plasticity, very stiff to firm	
					LL=42, PI=17	
			11			
10			8		LL=37, PI=16	
15			32			
20			9			
25						
30						

Cohesion, Ton/Sq. Ft.

0.2 0.4 0.6 0.8 1 1.2 1.4

Plastic Limit — Water Content — Liquid Limit

10 20 30 40 50 60 70



STANDARD TESTING AND ENGINEERING CO.

TEST BORING LOG

Boring No

B-11

Project: Proposed Development Area	Project No: 2130-2575
Project Location: Tulsa, Oklahoma	Boring Location: See Plan of Borings
Date Drilled: December 13, 2001	Drill Method: 3.25" HSA, B-56
Project Engineer: Endeson Juanda, E.I.	Driller: T. Fife
Water Depth Dry at Completion	Elevation
Remarks: Lat/Long: 36° 10.465'/95° 43.433'	

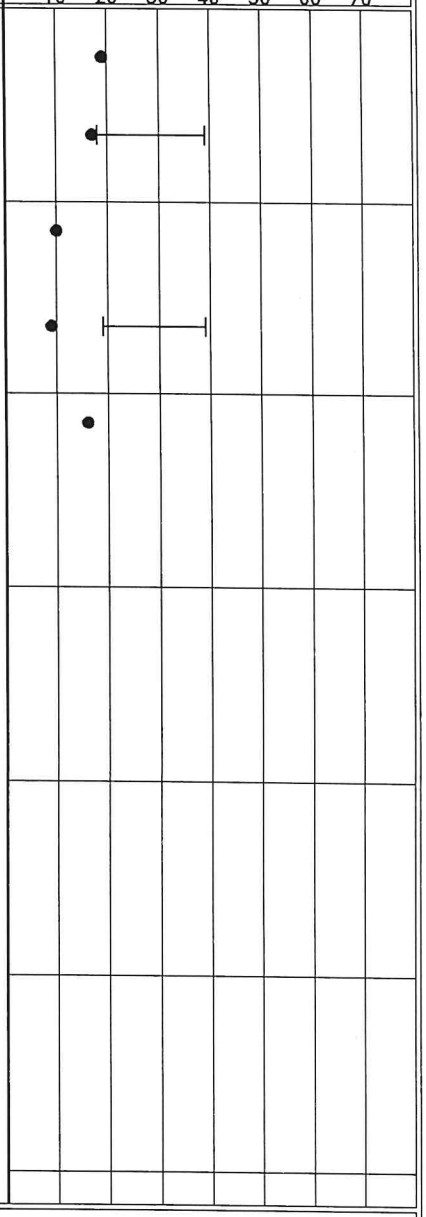
Elevation/ Depth, feet	Symbol	Samples	Blows per Foot	Water	SOIL DESCRIPTION	DD pcf
0			18		Topsoil with grass and roots	
			23		FILL - Dark brown and amber, lean clay, moist, medium plasticity, very stiff LL=39, PI=21	
5			25		FILL - Gray and dark gray, shale, slightly moist, fairly low plasticity, very stiff	
			34		FILL - Gray and brown, shale with limestone and coal fragments, slightly moist, medium plasticity, very stiff LL=39, PI=20	
10			27			
15			20			
			50/0.25"		(ROCK) Limestone, slightly moist, very hard	
20					(Auger refusal at 19 feet)	
25						
30						

Cohesion, Ton/Sq. Ft.

0.2 0.4 0.6 0.8 1 1.2 1.4

Plastic Limit — Water Content — Liquid Limit

10 20 30 40 50 60 70



STANDARD TESTING AND ENGINEERING CO.

TEST BORING LOG

Boring No

B-12

Project: Proposed Development Area	Project No: 2130-2575
Project Location: Tulsa, Oklahoma	Boring Location: See Plan of Borings
Date Drilled: December 13, 2001	Drill Method: 3.25" HSA, B-56
Project Engineer: Endeson Juanda, E.I.	Driller: T. Fife
Water Depth Dry at Completion	Elevation
Remarks: Lat/Long: 36° 10.473'/95° 43.707'	

Elevation/ Depth, feet	Symbol	Samples	Blows per Foot	Water	SOIL DESCRIPTION	DD pcf
0			15		Topsoil with grass and roots	
					LL=37, PI=15	
			44		FILL - Dark brown, lean clay, slightly moist, fairly low plasticity, stiff	
					FILL- Gray, dark gray and brown, shale, slightly moist, fairly low plasticity, stiff to very stiff	
5			12			
			10		LL=30, PI=12	
10			10			
15			11			
20			46		LL=30, PI=12	
25						
30						

Cohesion, Ton/Sq. Ft.

0.2 0.4 0.6 0.8 1 1.2 1.4

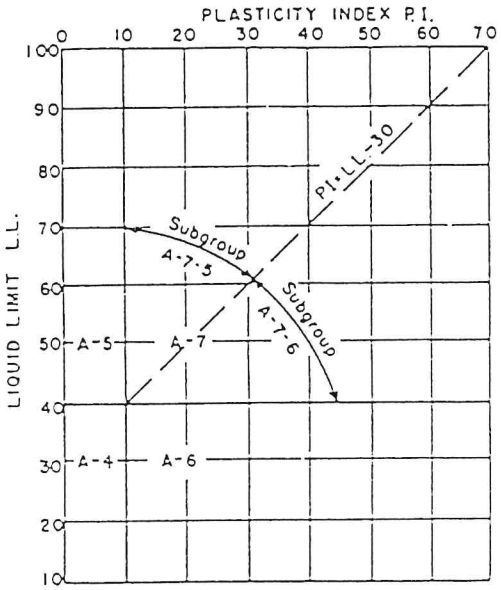
Plastic Limit | Water Content | Liquid Limit

10 20 30 40 50 60 70

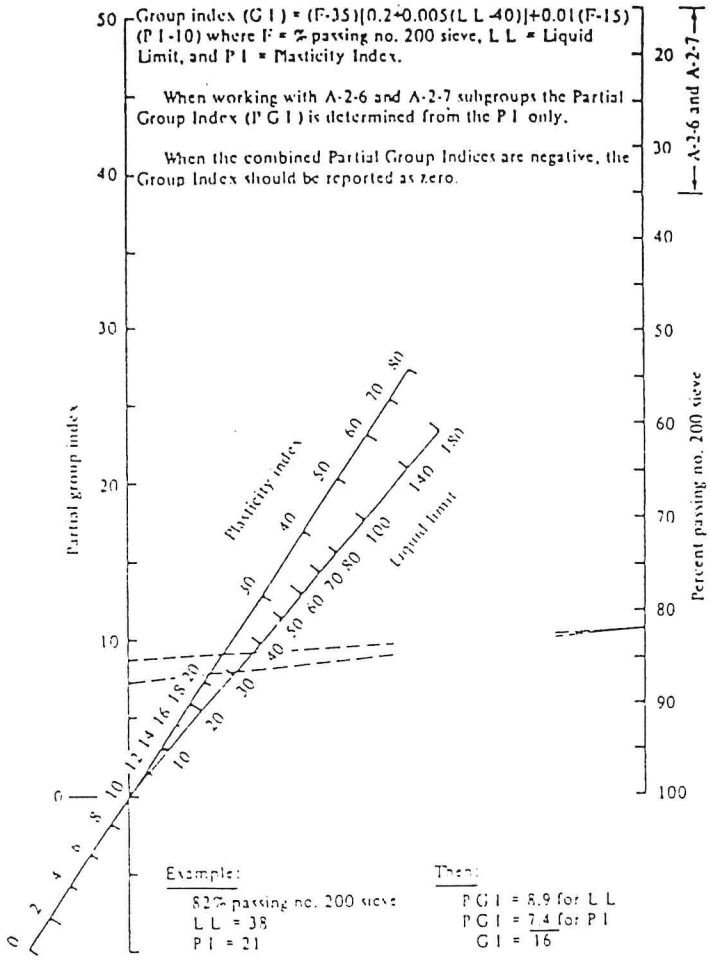
STANDARD TESTING AND ENGINEERING CO.

Soil Classification System — American Association of State Highway and Transportation Officials

The tables and charts given below are from AASHTO Designation: M 145-83, The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes. More detailed information as to the background and application of the system may be obtained from the report.



Liquid-limit and plasticity-index ranges for the A-4, A-5, A-6 and A-7 subgrade groups.



Group index chart

Classification of Soils and Soil-Aggregate Mixtures (with Suggested Subgroups)

General classification	Granular materials (35 per cent or less passing No. 200)							Silt-clay materials (More than 35 per cent passing No. 200)			
Group classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5; A-7-6
Sieve analysis: Per cent passing:											
No. 10	50 max.	—	—	—	—	—	—	—	—	—	—
No. 40	30 max.	50 max.	51 min.	—	—	—	—	—	—	—	—
No. 200	15 max.	25 max.	10 max.	35 max.	35 max.	35 max.	35 max.	36 min.	36 min.	36 min.	36 min.
Characteristics of fraction passing No. 40:											
Liquid limit	—		—	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.	40 max.	41 min.
Plasticity index	6 max.		NP	10 max.	10 max.	11 min.	11 min.	10 max.	10 max.	11 min.	11 min.*
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General rating as subgrade	Excellent to good							Fair to poor			

*P.I. of A-7-5 subgroup is equal to or less than LL minus 30. P.I. of A-7-6 subgroup is greater than LL minus 30

SUMMARY OF LABORATORY TEST DATA

Client: The Robson Companies

Project: Proposed Development Area

Date: December 6, 2001

Project No.: 2130-2575

Boring Number	Depth (inches)	Dry Density (pcf)	Moisture Content (%)	Atterberg Limits (% Moisture)			Unconfined Compression (tsf)	Strain (%)	Sieve Gradation % Passing								USCS	AASHTO
				LL	PL	PI			3/4"	1/2"	3/8"	#4	#10	#40	#100	#200		
B-1	0.5-2.0		11	36	18	18												
	2.5-4.0		9															
	5.0-6.5		7	33	20	13												
	7.5-9.0		7															
	10.0-11.5		11															
B-2	0.5-2.0		16	40	16	24												
	2.5-4.0		12															
	5.0-6.5		19															
	7.5-9.0		10	34	22	12												
	10.0-11.5		12															
B-3	0.5-2.0		9															
	2.5-4.0		7	28	19	9												
	5.0-6.5		8															
	7.5-9.0		7															
	10.0-11.5		7	19	16	3												
B-4	0.5-2.0		7															
	2.5-4.0		12	45	19	26												
	5.0-6.5		17															
	7.5-9.0		24	43	24	19												
	10.0-11.5		7															
B-5	0.5-2.0		4	28	15	13												
	2.5-4.0		9															
	5.0-6.5		11															
	7.5-9.0		8	35	20	15												
B-6	0.5-2.0		13															
	2.5-4.0		14															
	5.0-6.5		10	43	23	20												
	7.5-9.0		9															
	10.0-11.5		10															
	15.0-16.5		13	42	24	18												
B-7	0.5-2.0		19	34	19	15												
	2.5-4.0		17	40	23	17												
	5.0-6.5		12															
	7.5-9.0		16															
B-8	0.5-2.0		16	41	16	25												
	2.5-4.0		9															
	5.0-6.5		11	36	21	15												
	7.5-9.0		22															
	15.0-16.5		11	35	21	14												
	20.0-21.5		14															

SUMMARY OF LABORATORY TEST DATA

Client: The Robson Companies

Project: Proposed Development Area

Date: December 6, 2001

Project No.: 2130-2575

Boring Number	Depth (inches)	Dry Density (pcf)	Moisture Content (%)	Atterberg Limits (% Moisture)			Unconfined Compression (tsf)	Strain (%)	Sieve Gradation % Passing								USCS	AASHTO
				LL	PL	PI			3/4"	1/2"	3/8"	#4	#10	#40	#100	#200		
B-9	0.5-2.0		19															
	2.5-4.0		14															
	5.0-6.5		15	45	23	22												
	7.5-9.0		18															
	10.0-11.5		10	39	21	18												
B-10	0.5-2.0		11	33	21	12												
	2.5-4.0		8															
	5.0-6.5		10	42	25	17												
	7.5-9.0		11															
	10.0-11.5		8	37	21	16												
	15.0-16.5		9															
B-11	0.5-2.0		19															
	2.5-4.0		17	39	18	21												
	5.0-6.5		10															
	7.5-9.0		9	39	19	20												
	10.0-11.5		16															
B-12	0.5-2.0		10	37	22	15												
	2.5-4.0		9															
	5.0-6.5		7															
	7.5-9.0		10	30	18	12												
	10.0-11.5		13															
	15.0-16.5		9															
	20.0-21.5		8	30	18	12												