### Exploratory Soil Borings At Two Locations For The U.S. Department of Transportation

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**Sponsoring Agency Name and Address:**
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Federal Railroad Administration
Washington, D.C. 20591

**Abstract**

Exploratory borings and soil classification studies are reported on for two locations; southeast Kansas and northeast New Mexico.

The objective of the work was the revelation of sufficient sub-soil information to enable a decision on the part of the sponsoring agency as to where to most appropriately install a railroad test track.

Duplication of physical conditions most representative of present railroad track support conditions and economics of construction were important considerations.

**Key Words**
- Geological evaluations
- Soil classifications
- Engineering analysis
- Laboratory soil tests
- Core descriptions

**Distribution Statement**
Availability is unlimited. Copies may be purchased from the National Technical Information Service, Springfield, Va. 22151, for $3.00 a copy.
I - Introduction

A. Purpose of Survey

The purpose of the survey was to examine the proposed U. S. Department of Transportation test track site in Kansas from a geological and laboratory testing investigation through the use of samples obtained from prescribed test borings taken along its center-line.

B. Location of Site

The test track site is located 30 feet west of the center-line of the existing Santa Fe track between mile posts 161 and 163, approximately 11.3 miles northeast of El Dorado, Kansas on Highway 177, or 7.2 miles southwest of the small community of Cassoday, Kansas. The terrain of the site area is rolling with two hill areas necessitating excavation.

C. Test Borings

The following 16 test borings were augered, drilled and cored on April 16, 17, 23, 24, 1969 by means of a 750 Failing truck mounted core drill:

<table>
<thead>
<tr>
<th>Boring Number</th>
<th>Station Number</th>
<th>Description</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>8513+00</td>
<td>Embankment</td>
<td>6.0'</td>
</tr>
<tr>
<td>#2</td>
<td>8514+62</td>
<td>Embankment</td>
<td>6.0'</td>
</tr>
<tr>
<td>#3</td>
<td>8517+00</td>
<td>Embankment</td>
<td>6.0'</td>
</tr>
<tr>
<td>#4</td>
<td>8523+00</td>
<td>Excavation</td>
<td>16.2'</td>
</tr>
<tr>
<td>#5</td>
<td>8535+22</td>
<td>Excavation</td>
<td>13.0'</td>
</tr>
<tr>
<td>#6</td>
<td>8542+00</td>
<td>Embankment</td>
<td>6.0'</td>
</tr>
<tr>
<td>#7</td>
<td>8549+39</td>
<td>Embankment</td>
<td>6.0'</td>
</tr>
</tbody>
</table>
III - Geological Survey

A. Type Soils

Three representative soils were found to be present in the overburden section above the bed rock between Santa Fe mile posts 161 and 163, Kansas.

The uppermost of these three soils is best described as a clay, silty, black, moist and plastic varying in thickness from total absence in borings Nos. 8 and 16 to a maximum thickness of 3.8 feet in boring No. 11. Average thickness of this upper soil where present is 1.3 feet.

The next lower soil type beneath that of above when present is a clay, slightly silty, reddish brown, moist and plastic. It varies in thickness from total absence in boring Nos. 1, 2, 7, 8, 9, 11, 15 to a maximum of 5.3 feet in boring No. 12. The average thickness where present is 1.0 foot. In boring No. 11, 3 feet of this particular clay was used as a fill and noted immediately at the surface.

The third and lowest soil type where present is described as a gradational clay, mottled gray, yellow, tan, moist to wet (due to rainfall drainage at this time of year from ditching adjacent
to present track), plastic, grading into this same colored clay-shale which is refusal to the penetrometer. This type was found to be absent in boring Nos. 1, 7, and 8 and reached a maximum thickness of 4.0 feet in boring No. 5. Average thickness of the unit where present was found to be 0.8 foot, wherein approximately half of this total thickness can be considered clay and the bottom half clay-shale or refusal.

B. Bed Rock

Bed rock as herein described will denote the top of the Fort Riley limestone of Permian Geologic Age. However, in most of the borings actual refusal occurs a few inches above the top of the limestone in a weathered form of shale that appears to be more of a clay-shale as mentioned above. The weathered and soft condition of the shale was evident from the poor core recovery in this thin interval immediately on top of the limestone.

The Fort Riley limestone in the borings was characterized by being mostly dense, buff to gray and of medium hardness in its pure state while in a number of instances it appeared shaley, interbedded with thin clay-shale to shale layers, and in some instances only minute shale laminae. Vugular openings due to solution in this near surface carbonate section occurred in borings Nos. 3, 7, 12 and 16. Less common than the vugs were vertical fractures found in boring Nos. 2, 13, and 14. According to the Kansas State Geological Survey, fractures or jointing occur quite common in the Fort Riley limestone.

Due to the effects of erosion on top the surface of the Fort Riley limestone and its interbedded shale layers, it would appear that its grade approximates 0.5 foot per 100 feet or expressed as 28 feet per mile or 0.3 degree of dip in a southwest direction. Less than one degree dip to the southwest is likewise accepted by the State Geological Survey.

C. Surface Ground Water

Although several drainage patterns cross through the two-mile area of the present and test track area, the general pattern of drainage for the area is to the southwest or parallel to the direction of the track.
Only drainage water was encountered in several of the borings, this being due to their nearness to present ditching carrying or holding water after heavy rainfall this time of year. The water table for the area is reported at approximately 180 feet by a water well drilling firm active in the area.

### III - Engineering Analysis

Conditions existing at proposed site location in Kansas offers a much more variable soil profile than those existing in New Mexico. There exist three basic types of soil at this location which may be used as fill or embankment material. Because of topography there may exist fills of approximately 6 feet. The silty clay uppermost soil has a remolded modified Proctor compacted dry unit weight of 105.7 pounds per cubic foot with an optimum moisture content of 17%. Undisturbed samples obtained for this material indicate an average unconfined compressive strength of 2.0 ksf. Upon remolding the unconfined compressive strength was found to be an average of 6.0 ksf. The large increase in strength in the remolded state, compacted to 95% modified Proctor density, results from the relatively large increase in dry unit weight of the material.

The next underlying material is a CH material with an undisturbed compressive strength averaging about 2.5 ksf. Remolded strength of this material compacted to 95% modified Proctor density averaged about 6.0 ksf which was the same as overlying soil. The strength gain here again is contributed to the increased unit dry weight of the remolded compacted soil. Remolded unit dry weight of modified Proctor for this material was 106 pounds per cubic foot with an optimum moisture content of 19%.

Soil lying just above the limestone and shale was a silty clay of good remolded unconfined compressive strength (averaging about 6 ksf). The modified Proctor unit dry weight of this material was found to be 109 pounds per cubic foot with an optimum moisture content of 16.6%. This material might be classified as a CL material.

Since segregation of this material will be almost impossible during excavation, the resulting borrow will be a mixture of all three types of soil. No foreseen difficulties should arise from mixing these soils. Before placing and compacting these soils they should be thoroughly mixed if they are to be used together.
Lime stabilization of this material would not be recommendable except for possibly the top six inches of the road bed to provide a tight durable surface on which to construct tracks. The lime content used in this layer should be sufficient to obtain a strength gain and not a percentage that would reduce plasticity only. In this case as well as with the cement content additional tests would be necessary to recommend a percentage. This information could be made available upon request.

A detailed slope stability study of this material was not attempted since testing was conducted in accordance with specifications issued for bidding, and we do not feel that we have sufficient information from the investigation to make a detailed study.

The problem present at the Kansas site location which should arouse some discussion is the possibility of differential movement between sections of track that will be located on bed rock and those sections which will be placed on embankments. To prevent this occurrence it would be advisable to undercut bed rock at transition sections to allow at least 4.0 feet of fill to be placed. This would allow for a more uniform depth of fill; thus, more uniform compacted soil behavior.

HEMPHILL CORPORATION

John T. Hold, Geologist

B. D. Marks, III, B.S.C.E., M.S.C.E.
Soils Consultant

Jack P. Stewart, Engineer

"hemphill the name you can trust"
UNCONFINED COMPRESSION TEST

DATE: April 22, 1969
CLIENT: The Atchinson, Topeka and Santa Fe Railway System
PROJECT: U. S. Department of Transportation for Kansas Area, Test Track

TEST RESULTS

HOLE NO. 1 SAMPLE NO. _______________ FROM 1.0 TO 2.0

MATERIAL DESCRIPTION: Black Silty Clay - Moist, Plastic

UNCONFINED
COMPRESSIVE
STRENGTH LBS
PER SQ. FT. 1,516.32

PERCENT STRAIN 5.93

PERCENT MOISTURE 35.9

DRY DENSITY LBS
PER CU. FT. 83.4

LIQUID LIMIT

PLASTIC LIMIT

PLASTICITY INDEX

SHRINKAGE LIMIT

SHRINKAGE RATIO

CLASSIFICATION CL

FAILURE CONDITIONS

HEMPHILL CORPORATION
4834 S. 83RD E. AVE. TULSA, OKLAHOMA
UNCONFINED COMPRESSION TEST

DATE: April 22, 1969

CLIENT: The Atchinson, Topeka and Santa Fe Railway System

PROJECT: U. S. Department of Transportation for Kansas Area, Test Track

TEST RESULTS

HOLE NO. 2 SAMPLE NO. ______________ FROM 0.5 TO 1.5

MATERIAL DESCRIPTION: Black Silty Clay - Moist, Plastic

<table>
<thead>
<tr>
<th>PHYSICAL PROPERTIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNCONFINED COMPRESSIVE STRENGTH LBS PER SQ. FT.</td>
</tr>
<tr>
<td>PERCENT STRAIN</td>
</tr>
<tr>
<td>PERCENT MOISTURE</td>
</tr>
<tr>
<td>DRY DENSITY LBS PER CU. FT.</td>
</tr>
<tr>
<td>LIQUID LIMIT</td>
</tr>
<tr>
<td>PLASTIC LIMIT</td>
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<tr>
<td>PLASTICITY INDEX</td>
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<tr>
<td>SHRINKAGE LIMIT</td>
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<tr>
<td>SHRINKAGE RATIO</td>
</tr>
<tr>
<td>CLASSIFICATION</td>
</tr>
</tbody>
</table>

FAILURE CONDITIONS

HEMPHILL CORPORATION

4834 S. 83RD E. AVE. TULSA, OKLAHOMA
UNCONFINED COMPRESSION TEST

DATE: April 22, 1969

CLIENT: The Atchinson, Topeka and Santa Fe Railway System

PROJECT: U. S. Department of Transportation for Kansas Area, Test Track

TEST RESULTS

HOLE NO. 3 SAMPLE NO. FROM 1.5 TO 2.5

MATERIAL DESCRIPTION: Reddish Brown Clay, Slightly Silty - Moist, Plastic

PHYSICAL PROPERTIES

UNCONFINED COMRESSIVE STRENGTH LBS PER SQ. FT. 1,352.16
PERCENT STRAIN 3.84
PERCENT MOISTURE 28.5
DRY DENSITY LBS PER CU. FT. 88.8
LIQUID LIMIT
PLASTIC LIMIT
PLASTICITY INDEX
SHRINKAGE LIMIT
SHRINKAGE RATIO
CLASSIFICATION CI

FAILURE CONDITIONS

UNIT STRAIN - PERCENT

HEMPHILL CORPORATION

4834 S. 83RD E. AVE. TULSA, OKLAHOMA
UNCONFINED COMPRESSION TEST

DATE: April 22, 1969

CLIENT: The Atchinson, Topeka and Santa Fe Railway System

PROJECT: U.S. Department of Transportation for Kansas Area, Test Track

TEST RESULTS

HOLE NO. 4 SAMPLE NO. ________ FROM 0.0 TO 1.0

MATERIAL DESCRIPTION: Black Silty Clay, Moist, Plastic

<table>
<thead>
<tr>
<th>PHYSICAL PROPERTIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNCONFINED COMPRESSIVE STRENGTH LBS PER SQ. FT.</td>
</tr>
<tr>
<td>PERCENT STRAIN</td>
</tr>
<tr>
<td>PERCENT MOISTURE</td>
</tr>
<tr>
<td>DRY DENSITY LBS PER CU. FT.</td>
</tr>
<tr>
<td>LIQUID LIMIT</td>
</tr>
<tr>
<td>PLASTIC LIMIT</td>
</tr>
<tr>
<td>PLASTICITY INDEX</td>
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<tr>
<td>SHRINKAGE LIMIT</td>
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<tr>
<td>SHRINKAGE RATIO</td>
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<tr>
<td>CLASSIFICATION</td>
</tr>
</tbody>
</table>

FAILURE CONDITIONS

HEMPHILL CORPORATION

4634 S. 83RD E. AVE. TULSA, OKLAHOMA
UNCONFINED COMPRESSION TEST

DATE: April 22, 1969
CLIENT: The Atchinson, Topeka and Santa Fe Railway System
PROJECT: U.S. Department of Transportation for Kansas Area, Test Track

TEST RESULTS

HOLE NO. 6  SAMPLE NO. ___________ FROM 2.0 TO 3.0
MATERIAL DESCRIPTION: Reddish Brown Clay - Moist, Plastic

PHYSICAL PROPERTIES

UNCONFINED COMPRESSIVE STRENGTH LBS PER SQ. FT. 3,587.04
PERCENT STRAIN 7.68
PERCENT MOISTURE 25.5
DRY DENSITY LBS PER CU. FT. 94.1
LIQUID LIMIT 39.8
PLASTIC LIMIT 25.8
PLASTICITY INDEX 14.0
SHRINKAGE LIMIT 17.41
SHRINKAGE RATIO 1.787
CLASSIFICATION CH

#200 Sieve 58.8%

FAILURE CONDITIONS

UNIT STRAIN - PERCENT

HEMPHILL CORPORATION
4834 S. 83RD E. AVE. TULSA, OKLAHOMA
UNCONFINED COMPRESSION TEST

DATE: April 22, 1969
CLIENT: The Atchinson, Topeka and Santa Fe Railway System
PROJECT: U. S. Department of Transportation for Kansas Area, Test Track

TEST RESULTS

HOLE NO. 9       SAMPLE NO.       FROM 0.0 TO 1.0

MATERIAL DESCRIPTION: Black Silty Clay - Moist, Plastic

PHYSICAL PROPERTIES

<table>
<thead>
<tr>
<th>PROPERTY</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNCONFINED COMRESSIVE STRENGTH</td>
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<tr>
<td>PERCENT STRAIN</td>
<td>6.98</td>
</tr>
<tr>
<td>PERCENT MOISTURE</td>
<td>34.8</td>
</tr>
<tr>
<td>DRY DENSITY LBS PER CU. FT.</td>
<td>82.0</td>
</tr>
<tr>
<td>LIQUID LIMIT</td>
<td></td>
</tr>
<tr>
<td>PLASTIC LIMIT</td>
<td></td>
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<tr>
<td>PLASTICITY INDEX</td>
<td></td>
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<tr>
<td>SHRINKAGE LIMIT</td>
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<td>SHRINKAGE RATIO</td>
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<tr>
<td>CLASSIFICATION</td>
<td>CI</td>
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</tbody>
</table>

FAILURE CONDITIONS

HEMPHILL CORPORATION
4634 S. 83RD E. AVE. TULSA, OKLAHOMA
UNCONFINED COMPRESSION TEST

DATE: April 22, 1969

CLIENT: The Atchinson, Topeka and Santa Fe Railway System

PROJECT: U. S. Department of Transportation for Kansas Area, Test Track

TEST RESULTS

HOLE NO. 10 SAMPLE NO. ___________ FROM 0.0 TO 1.0

MATERIAL DESCRIPTION: Black Silty Clay - Moist, Plastic

PHYSICAL PROPERTIES

- UNCONFINED COMPRESSIVE STRENGTH LBS PER SQ. FT. 2,748.96
- PERCENT STRAIN 6.98
- PERCENT MOISTURE 25.4
- DRY DENSITY LBS PER CU. FT. 94.4
- LIQUID LIMIT
- PLASTIC LIMIT
- PLASTICITY INDEX
- SHRINKAGE LIMIT
- SHRINKAGE RATIO
- CLASSIFICATION CL

FAILURE CONDITIONS

HEMPHILL CORPORATION

4834 S. 83RD E. AVE. TULSA, OKLAHOMA
UNCONFINED COMPRESSION TEST

DATE: April 22, 1969
CLIENT: The Atchinson, Topeka and Santa Fe Railway System
PROJECT: U.S. Department of Transportation for Kansas Area, Test Track

TEST RESULTS

HOLE NO. 15  SAMPLE NO. ___________ FROM 0.5 TO 1.5

MATERIAL DESCRIPTION: Black to Brown Silty Clay - Moist, Plastic

![Graph showing physical properties]

UNCONFINED
COMPRESSIVE
STRENGTH LBS
PER SQ. FT. 2,113.92
PERCENT STRAIN 4.36
PERCENT MOISTURE 29.3
DRY DENSITY LBS
PER CU. FT. 88.0
LIQUID LIMIT ___________
PLASTIC LIMIT ___________
PLASTICITY INDEX ___________
SHRINKAGE LIMIT ___________
SHRINKAGE RATIO ___________
CLASSIFICATION CL

FAILURE CONDITIONS

HEMPHILL CORPORATION
4634 S. 83RD E. AVE. TULSA, OKLAHOMA
DATE: April 29, 1969

CLIENT: The Atchinson, Topeka and Santa Fe Railway System

PROJECT: U. S. Department of Transportation for Kansas Area, Test Track

MATERIAL: Black Silty Clay Topsoil

MATERIAL SOURCE: Approximate depth 0.0' - 1.3'

METHOD OF TEST: A.S.T.M. D 1557, Method A

TEST RESULTS

MAXIMUM DRY DENSITY = 105.7 LBS PER CU. FT.

OPTIMUM MOISTURE CONTENT = 17.0 %

PHYSICAL PROPERTIES

LIQUID LIMIT = __ %

PLASTIC LIMIT = __ %

PLASTICITY INDEX = __ %

SHRINKAGE LIMIT = __ %
**UNCONFINED COMPRESSION TEST**

**DATE:** April 29, 1969  
**CLIENT:** The Atchinson, Topeka and Santa Fe Railway System  
**PROJECT:** U. S. Department of Transportation for Kansas Area, Test Track

### TEST RESULTS

**HOLE NO.** Remolded  
**SAMPLE NO.** one (1)  
**FROM** 0.0  
**TO** 1.3

**MATERIAL DESCRIPTION:** Black Silty Clay Topsoil

| UNCONFINED COMPRESSION STRENGTH LBS PER SQ. FT. | 7,454.88 |
| PERCENT STRAIN | 3.90 |
| PERCENT MOISTURE | 16.8 |
| DRY DENSITY LBS PER CU. FT. | 95% Max. |
| LIQUID LIMIT |  |  |
| PLASTIC LIMIT |  |  |
| PLASTICITY INDEX |  |  |
| SHRINKAGE LIMIT |  |  |
| SHRINKAGE RATIO |  |  |
| CLASSIFICATION | CL |  |

**FAILURE CONDITIONS**

**UNIT STRAIN - PERCENT**

HEMPHILL CORPORATION  
4834 S. 83RD E. AVE.  
TULSA, OKLAHOMA
UNCONFINED COMPRESSION TEST

DATE: April 29, 1969

CLIENT: The Atchinson, Topeka and Santa Fe Railway System

PROJECT: U. S. Department of Transportation for Kansas Area, Test Track

TEST RESULTS

HOLE NO. Remolded SAMPLE NO. Two (2) FROM 0.0 TO 1.3

MATERIAL DESCRIPTION: Black Silty Clay Topsoil

PHYSICAL PROPERTIES

UNCONFINED COMPRSSIVE STRENGTH LBS PER SQ. FT. 7,737.12

PERCENT STRAIN 3.78

PERCENT MOISTURE 18.9

DRY DENSITY LBS PER CU. FT. 6,000

LIQUID LIMIT

PLASTIC LIMIT

PLASTICITY INDEX

SHRINKAGE LIMIT

SHRINKAGE RATIO

CLASSIFICATION CL

FAILURE CONDITIONS

HEMPHILL CORPORATION

4834 S. 63RD E. AVE. TULSA, OKLAHOMA
MOISTURE - DENSITY CURVE

DATE: April 29, 1969

CLIENT: The Atchinson, Topeka and Santa Fe Railway System

PROJECT: U. S. Department of Transportation for Kansas Area, Test Track

MATERIAL: Reddish Brown Clay, slightly silty

MATERIAL SOURCE: Approximate depth 1.5' - 3.0'

METHOD OF TEST: A.S.T.M. D 1557, Method A

TEST RESULTS

MAXIMUM DRY DENSITY = 106.4 LBS PER CU. FT.

OPTIMUM MOISTURE CONTENT = 19.1 %

PHYSICAL PROPERTIES

LIQUID LIMIT = 47.3 %

PLASTIC LIMIT = 18.7 %

PLASTICITY INDEX = 28.6 %

SHRINKAGE LIMIT = ___ %
UNCONFINED COMPRESSION TEST

DATE: April 29, 1969
CLIENT: The Atchinson, Topeka and Santa Fe Railway System
PROJECT: U. S. Department of Transportation for Kansas Area Test Track

TEST RESULTS

HOLE NO. Remolded SAMPLE NO. one (1) FROM 1.5' TO 3.0'

MATERIAL DESCRIPTION: Reddish Brown Clay, slightly silty

PHYSICAL PROPERTIES

UNCONFINED COMPRESSIVE STRENGTH LBS PER SQ. FT. 9,672.48
PERCENT STRAIN 4.63
PERCENT MOISTURE 20.1
DRY DENSITY LBS PER CU. FT. 95% Max.
LIQUID LIMIT 47.3
PLASTIC LIMIT 18.7
PLASTICITY INDEX 28.6
SHRINKAGE LIMIT
SHRINKAGE RATIO
CLASSIFICATION CL

FAILURE CONDITIONS

HEMPHILL CORPORATION
4834 S. 83RD E. AVE. TULSA, OKLAHOMA
UNCONFINED COMPRESSION TEST

DATE: April 29, 1969

CLIENT: The Atchinson, Topeka and Santa Fe Railway System

PROJECT: U.S. Department of Transportation for Kansas Area Test Track

TEST RESULTS

HOLE NO. Remolded SAMPLE NO. two (2) FROM 1.5' TO 3.0'

MATERIAL DESCRIPTION: Reddish Brown Clay, slightly silty

PHYSICAL PROPERTIES

UNCONFINED COMPRESSION STRENGTH LBS PER SQ. FT. 8,271.36
PERCENT STRAIN 4.20
PERCENT MOISTURE 20.8
DRY DENSITY LBS PER CU. FT. 95.7 Max.
LIQUID LIMIT 47.3
PLASTIC LIMIT 18.7
PLASTICITY INDEX 28.6
SHRINKAGE LIMIT
SHRINKAGE RATIO
CLASSIFICATION CL

FAILURE CONDITIONS

HEMPHILL CORPORATION
4834 S. 83RD E. AVE. TULSA, OKLAHOMA
DATE: April 29, 1969

CLIENT: The Atchinson, Topeka and Santa Fe Railway System

PROJECT: U.S. Department of Transportation for Kansas Area, Test Track

MATERIAL: Mottled gray, yellow, tan clay with shale particles

MATERIAL SOURCE: Approximate depth 3.0' - 3.7'

METHOD OF TEST: A.S.T.M. D 1557, Method A

TEST RESULTS

MAXIMUM DRY DENSITY = 109.0 LBS PER CU. FT.

OPTIMUM MOISTURE CONTENT = 16.6 %

PHYSICAL PROPERTIES

LIQUID LIMIT = 31.5 %

PLASTIC LIMIT = 20.5 %

PLASTICITY INDEX = 11.0 %

SHRINKAGE LIMIT = %
UNCONFINED COMPRESSION TEST

DATE: April 29, 1969

CLIENT: The Atchinson, Topeka and Santa Fe Railway System

PROJECT: U. S. Department of Transportation for Kansas Area
Test Track

TEST RESULTS

HOLE NO. Remolded SAMPLE NO. One (1) FROM 3.0 TO 3.7

MATERIAL DESCRIPTION: Mottled gray, yellow, tan clay with shale particles

<table>
<thead>
<tr>
<th>Physical Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>UNCONFINED COMPRESSION STRENGTH LBS PER SQ. FT.</td>
</tr>
<tr>
<td>PERCENT STRAIN</td>
</tr>
<tr>
<td>PERCENT MOISTURE</td>
</tr>
<tr>
<td>DRY DENSITY LBS PER CU. FT.</td>
</tr>
<tr>
<td>LIQUID LIMIT</td>
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<tr>
<td>PLASTIC LIMIT</td>
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<tr>
<td>PLASTICITY INDEX</td>
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<tr>
<td>SHRINKAGE LIMIT</td>
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<tr>
<td>SHRINKAGE RATIO</td>
</tr>
<tr>
<td>CLASSIFICATION</td>
</tr>
</tbody>
</table>

FAILURE CONDITIONS

H EMPHILL CORPORATION

4834 S. 83RD E. AVE. TULSA, OKLAHOMA
UNCONFINED COMPRESSION TEST

DATE: April 29, 1969

CLIENT: The Atchinson, Topeka and Santa Fe Railway System

PROJECT: U. S. Department of Transportation for Kansas Area, Test Track

TEST RESULTS

HOLE NO. Remolded SAMPLE NO. Two (2) FROM 3.0 TO 3.7

MATERIAL DESCRIPTION: Mottled gray, yellow, tan clay with shale particles

<table>
<thead>
<tr>
<th>PHYSICAL PROPERTIES</th>
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</thead>
<tbody>
<tr>
<td>UNCONFINED COMRESSIVE STRENGTH LBS PER SQ. FT.</td>
</tr>
<tr>
<td>PERCENT STRAIN</td>
</tr>
<tr>
<td>PERCENT MOISTURE</td>
</tr>
<tr>
<td>DRY DENSITY LBS PER CU. FT.</td>
</tr>
<tr>
<td>LIQUID LIMIT</td>
</tr>
<tr>
<td>PLASTIC LIMIT</td>
</tr>
<tr>
<td>PLASTICITY INDEX</td>
</tr>
<tr>
<td>SHRINKAGE LIMIT</td>
</tr>
<tr>
<td>SHRINKAGE RATIO</td>
</tr>
<tr>
<td>CLASSIFICATION</td>
</tr>
</tbody>
</table>

FAILURE CONDITIONS

HEMPHILL CORPORATION

4834 S. 83RD E. AVE. TULSA, OKLAHOMA
<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH AND SCALE</th>
<th>LEGEND</th>
<th>NO. OF BLOWS PER FOOT</th>
<th>DESCRIPTION OF MATERIALS</th>
<th>CORE RECOVERY</th>
<th>SAMPLE</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1417.2</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td>14/21</td>
<td>Clay, Silty, Black, Plastic, Moist</td>
<td>Air Drilling</td>
</tr>
<tr>
<td>1415.2</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td>4 2/4</td>
<td>Limestone, Tan to Gray, Dense, Medium Hard w/Very Thin Interbedded Tan Shale Layers, Refusal: Permian Age - Ft. Riley member</td>
<td>Coring</td>
</tr>
<tr>
<td>1413.2</td>
<td>6.0</td>
<td></td>
<td></td>
<td></td>
<td>38%</td>
<td>Bottom of Hole</td>
<td></td>
</tr>
</tbody>
</table>

HOLE NO. 1

HOLE LOCATION Station 8513+00 See Boring Location Plan
GROUND ELEV. 1417.2' G.W. ELEV.
BORED BY Risenhoover
LOGGED BY John Eildt

SAMPLER DATA 2" Split Spoon
WT. OF HAMMER 140# FALL OF HAMMER 30"

PENETROMETER DATA
WT. OF HAMMER
FALL OF HAMMER

AUGER DATA

HOLE NO. 1

MEMPHILL & SHELBY DRILLING COMPANY
TULSA, OKLAHOMA
# Boring Log

**Project:** U. S. Department of Transportation - Test Track - Kansas  
**Hole No.:** 2  
**Sheet No.:** 1 of 1  
**Hole Location:** Station 8514+62  
**Date:** 4-16-69  
**Sample Data:** 2" Split Spoon  
**Sampler Data:** 2" Split Spoon  
**WT. of Hammer:** 140#  
**Fall of Hammer:** 30"  
**Remarks:** (Drilling Characteristics, Drilling Fluid Loss, Casing Data, Etc.)

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH AND SCALE</th>
<th>NO. OF BLOWs PER FOOT</th>
<th>DESCRIPTION OF MATERIALS (Type, Color, Texture, Consistency)</th>
<th>% CORE RECOVERY</th>
<th>CORE SAMPLE</th>
<th>REASONS</th>
</tr>
</thead>
</table>
| 1416.7| 7.0             |                       | Clay, Silty, Black  
Gradation into Reddish  
Brown, Plastic, Moist | Air Drilling 0.5 |             |         |
| 1413.8| 2.0             |                       | Gradational Clay, Silty,  
to Clay-Shale, Bottled  
Yellow, Tan, Brown,  
Slightly Moist.  
Refusal Permian Age -  
Ft. Rilev member | Shelby Tube 1.5 |             |         |
| 1412.9| 3.0             | 3/5                   | Limestone, Gray, Dense,  
Medium Hard w/Thin Layers  
of Interbedded Tan Shale  
Note: Natural Vertical  
Fractures from 4.5 = 5.3 | Coring 4.0 |             |         |
| 1410.7| 6.0             |                       | Bottom of Hole |             |             |         |

**Remarks:** Natural Vertical Fractures from 4.5 = 5.3

**Note:** No Natural Horizontal Fractures

---

**HOLE NO.** 2

**Hole No.:** 2  
**ELEV.:** 1416.7  
**DEP. & SCALE:** 7.0  
**NO. OF BLOWs PER FOOT:** 3/5  
**DESCRIPTION OF MATERIALS:** Clay, Silty, Black  
Gradation into Reddish  
Brown, Plastic, Moist  
Gradational Clay, Silty,  
to Clay-Shale, Bottled  
Yellow, Tan, Brown,  
Slightly Moist.  
Refusal Permian Age -  
Ft. Rilev member  
Limestone, Gray, Dense,  
Medium Hard w/Thin Layers  
of Interbedded Tan Shale  
Note: Natural Vertical  
Fractures from 4.5 = 5.3

**Bottom of Hole**
**BORING LOG**

**PROJECT:** U.S. Department of Transportation - Test Track - Kansas  
**HOLE LOCATION:** Station 8517+00  
**SAMPLE DATA:** 2" Split Spoon  
**MOISTURE:** 140#/FALL OF HAMMER  
**DATE:** 4-17-69  
**BORED BY:** Risephoover  
**LOGGED BY:** John Eidt  
**SHEET NO. 1 OF 1**

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH AND SCALE</th>
<th>NO. OF BLOWS PER FOOT</th>
<th>DESCRIPTION OF MATERIALS (Type, Color, Texture, Consistency)</th>
<th>% CORE RECOVERY</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1417.5</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1416.5</td>
<td>1.0</td>
<td></td>
<td>Clay, Silty, Black, Moist, Plastic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1415.0</td>
<td>2.5</td>
<td></td>
<td>Clay, Slightly Silty, Reddish Brown, Moist, Plastic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1414.5</td>
<td>3.0</td>
<td></td>
<td>Clay, to Clay-Shale, Yellow, Refusal: Permian Age -</td>
<td>100%</td>
<td>Coring</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Ft. Riley member</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1411.5</td>
<td>6.0</td>
<td></td>
<td>Limestones, Buff, Shaley, Dense, Medium Soft, Vugular from 4.1 to 4.6 Note: Drainage or seepage water at 3.2'</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Bottom of Hole**

**MEMPHILL & SHELBY DRILLING COMPANY**  
TULSA, OKLAHOMA
### Boring Log

**Project:** U.S. Department of Transportation - Test Track - Kansas  
**Sheet No.:** 1 of 1  
**Hole Location:** Station 8524+00  
**Date:** 4-24-69  
**E.S.D. & G.W. Elev.:** 1422.4 & 1422.4'  
**Logger:** Risenhoover  
**Hammer Data:** 2" Split Spoon  
**Test Track: Kansas**  
**Sheet 100: 1 of 1**

**Location Station:** 8500  
**Date:** 4-24-69  
**E.S.D.:** DEOL  
**G.W.:** DEOL

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH AND SCALE (ft)</th>
<th>LEGEND</th>
<th>NO. OF BLOWS PER FOOT</th>
<th>DESCRIPTION OF MATERIALS (Type, Color, Texture, Consistency)</th>
<th>CORE BARREL &amp; BIT DATA</th>
<th>REMARKS</th>
<th>DRILLING CHARACTERISTICS, DRILLING FIELD LAY, CASING DATA, ETC.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1422.4</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Air Drilling</td>
</tr>
<tr>
<td>1421.3</td>
<td>1.1</td>
<td></td>
<td></td>
<td>Clay, Silty, Black, Moist, Plastic</td>
<td></td>
<td></td>
<td>Shelby Tube 1.0</td>
</tr>
<tr>
<td></td>
<td>1.5</td>
<td></td>
<td></td>
<td>Clay, Slightly Silty,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2.5</td>
<td></td>
<td></td>
<td>Reddish Brown</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1418.4</td>
<td>4.0</td>
<td></td>
<td></td>
<td>Gradation Clay - Clay-Shale</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gray Tan, Slightly Moist and Slightly Plastic in</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Upper Part Only</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Refusal Permian Age -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ft. Filey member</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1417.1</td>
<td>5.3</td>
<td></td>
<td></td>
<td>Limestone, Buff to Gray,</td>
<td></td>
<td></td>
<td>Coring 6.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dense, Medium Hard</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>w/Interbedded Thin Tan,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Medium Soft Shale Laminae and Becoming Shaley</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Limestone From 14.7 - 16.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Bottom of Hole:** 16.2

**Remarks:**  
- Air Drilling  
- Shelby Tube 1.0  
- Coring 6.0  
- 100%  
- Bottom of Hole

**Core Barrel & Bit Data:** NX Heavy Duty

---

**Hemphill & Shelby Drilling Company**  
**Tulsa, Oklahoma**  
**Hole No.: 4**
BORING LOG

PROJECT U.S. Department of Transportation - Test Track - Kansas

HOLE LOCATION Station 8635+22

HOLE ELEV. 1416.1' G.W. ELEV.

BORED BY Risenhoover

SAMPLE DATA 2" Split Spoon

MT. OF HAMMER 140# FALL OF HAMMER 30"

SAMPLER DATA

MT. OF NAILER FALL OF NAILER

CHENOMETER DATA

14/23

AUGER DATA

97%

DEPTH

DESCRIPION OF MATERIALS

FALL OF NAILER

(LEGEND)

1416.1 0.0

Clay, Silty, Black, Slightly
Moist w/Chunks of Free
Limestone on Surface

1415.7 0.5

Clay, Slightly Silty,
Reddish Brown, Moist,
Plastic

1414.9 2.2

Gradational Clay - Clay
Shale, Gray Tan, Slightly
Moist and Plastic From
2.2 - 3.0

1414.1 4.0

Refusal: Pennian Age -
Pt. Riley member

1409.9 6.2

Limestone, Buff to Gray,
Shaley From 6.2 to 11.5
(Rather than interbedded)
Medium Soft Where Shaley
and Then Grading into Dense
Medium Hard Limestone

1403.1 13.0

Bottom of Hole

REMARDS

(Drilling Characteristics, Drilling
Fluid Loss, Casing Data, Etc.)

Air Drilling

Coring 7.5

87%

HOLE NO. 5

HOLE NO. 5

HOLPILL & SHELBY DRILLING COMPANY

TULSA, OKLAHOMA
<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH AND SCALE</th>
<th>NO. OF BLOWS PER FOOT</th>
<th>DESCRIPTION OF MATERIALS</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1410.4</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1409.5</td>
<td>1.2</td>
<td></td>
<td>Clay, Silty, Black, Plastic, Moist</td>
<td>Air Drilling</td>
</tr>
<tr>
<td>1407.6</td>
<td>2.3</td>
<td></td>
<td>Clay, Reddish Brown, Plastic, Moist</td>
<td>Shelby Tube</td>
</tr>
<tr>
<td>1407.3</td>
<td>3.3</td>
<td></td>
<td>Clay, Grading into a Clay-Shale, Mottled Gray, Yellow Tan, With a Few Fine Gravels, Slightly Moist Refusal: Permian Age - 25' Riley member</td>
<td>Coring</td>
</tr>
<tr>
<td>1404.4</td>
<td>6.0</td>
<td></td>
<td>Limestone, Buff to Gray, Dense, Medium Hard w/Interbedded Thin Layers of Tan to Yellow Shale</td>
<td>Bottom of Hole</td>
</tr>
</tbody>
</table>

**Core Barrel & Bit Data**: NX Heavy Duty

**Remarks**: Drilling Characteristics, Drilling Fluid Loss, Casing Data, Etc.
<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH AND SCALE</th>
<th>NO. OF BLOWS PER FOOT</th>
<th>DESCRIPTION OF MATERIALS (Type, Color, Texture, Consistency)</th>
<th>% CORE RECOVERY</th>
<th>TO</th>
<th>REMARKS (Drilling Characteristics, Drilling Fluid Loss, Casing Data, Etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1398.3</td>
<td>1.7</td>
<td></td>
<td>Clay, Silty, Black, Plastic, Moist</td>
<td>Air Drilling</td>
<td></td>
<td>(Attempted Penetration @ 1.5')</td>
</tr>
<tr>
<td>1397.5</td>
<td>2.5</td>
<td></td>
<td>Limestone, Gray to Tan, Medium Soft, Shaley</td>
<td>Coring</td>
<td>4.2</td>
<td></td>
</tr>
<tr>
<td>1396.2</td>
<td>3.3</td>
<td></td>
<td>Clay-Shale, Yellow, Moist (Saved Jar Sample) Refusals; Permian Age - 4.5 Ft. Riley member</td>
<td>100%</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>1395.7</td>
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<td></td>
<td>Limestone, Buff-Gray, Dense, Medium Hard w/ Vugs From 4.4 - 4.5</td>
<td>Bottom of Hole</td>
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</tbody>
</table>

**HOLE NO. 7**

HEMPHILL & SHELBY DRILLING COMPANY
TULSA, OKLAHOMA
<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH AND SCALE</th>
<th>LEGEND</th>
<th>NO. OF BLOWS PER FOOT</th>
<th>DESCRIPTION OF MATERIALS (Type, Color, Texture, Consistency)</th>
<th>CORE BARREL &amp; BIT DATA</th>
<th>HEAVY DUTY NX</th>
<th>REMARKS (Drilling Characteristics, Drilling Fluid Loss, Casing Date, Etc.)</th>
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<tbody>
<tr>
<td>1308.3</td>
<td>0.0</td>
<td></td>
<td></td>
<td>Mixture of Limestone, Boulders, Clay and Clay-</td>
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<td>Air Drilling</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Shale at Surface</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Refusal: Permian Age -</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Ft. Pilow member</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1307.8</td>
<td>0.5</td>
<td></td>
<td></td>
<td>Limestone, Buff to Gray, Dense, Medium Hard to</td>
<td></td>
<td></td>
<td>Coring 2.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hard w/Limey Shale in Core</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>From 2.0 - 2.2' and Several</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Very Thin Slightly</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Weathered Shale Layers Below</td>
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</tr>
<tr>
<td>1302.3</td>
<td>6.0</td>
<td></td>
<td></td>
<td>Bottom of Hole</td>
<td></td>
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</tr>
</tbody>
</table>

**HOLE NO. 8**

**HEMPHILL & SHELBY DRILLING COMPANY**

**TULSA, OKLAHOMA**
### BORING LOG

**HOLE NO. 9**

**PROJECT** U.S. Department of Transportation - Test Track - Kansas

**HOLE LOCATION** Sta. 8563+06 See Boring Location Plan

**ELEV.** 1394.0

**G.W. ELEV.**

**EDGED BY** Riserhoover

**DUG BY** John Eidt

**DATE** 4-17-69

**SAMPLER DATA** 2" Split Spoon

**WT. OF HAMMER** 1400

**FALL OF HAMMER** 20"

**PESESTROMETER DATA**

**WT. OF HAMMER**

**FALL OF HAMMER**

**AUGER DATA**

**CORE BARREL & BIT DATA** Heavy Duty NX

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DESCRIPTION OF MATERIALS (Type, Color, Texture, Consistency)</th>
<th>REMARKS (Drilling Characteristics, Drilling Field Log, Cutting Data, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1394.0</td>
<td>Clay, Silty, Black, Plastic Moist</td>
<td>Shelby Tube 1.0</td>
</tr>
<tr>
<td>1392.8</td>
<td>Clay-Shale, Mottled Yellow Tan, Brown, Slightly Moist Refusal: Fernian Age - Ft. Riley member</td>
<td>Coring 2.0</td>
</tr>
<tr>
<td>1392.6</td>
<td>Limestone, Buff to Gray, Dense, Medium Soft to Medium Hard w/Interbedded Tan, Medium Soft Shale Layers</td>
<td>Air Drilling 100%</td>
</tr>
<tr>
<td>1390.6</td>
<td>Clay-Shale, Mottled Yellow Tan, Medium Soft, Slightly Moist</td>
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</tr>
<tr>
<td>1390.4</td>
<td>Limestone, Gray, Dense, Medium Hard w/Interbedded Thin Laminae of Tan, Medium Soft Shale</td>
<td></td>
</tr>
<tr>
<td>1388.0</td>
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</tr>
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</table>

**Hemmeill & Shelby Drilling Company**

**Tulsa, Oklahoma**
<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH AND SCALE</th>
<th>NO. OF BLOWS PER FOOT</th>
<th>DESCRIPTION OF MATERIALS (Type, Color, Texture, Consistency)</th>
<th>REMARKS</th>
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</thead>
<tbody>
<tr>
<td>393.9</td>
<td>1.1</td>
<td></td>
<td>Clay, Silty, Black, Moist Plastic</td>
<td>Shelby Tube 1.0</td>
</tr>
<tr>
<td>392.8</td>
<td>1.3</td>
<td></td>
<td>Clay, Reddish Brown, Slightly Silty, Moist Plastic</td>
<td>Coring 1.7</td>
</tr>
<tr>
<td>391.4</td>
<td>2.6</td>
<td></td>
<td>Gradational From Clay-Shale, Yellow Tan, Medium Hard to Shale, Tan, Limey, Medium Hard w/Interbedded Dense, Medium Hard, Limestone Refusal: Permian Age - 100% Ft. Riley member</td>
<td></td>
</tr>
<tr>
<td>390.9</td>
<td>5.0</td>
<td></td>
<td>Limestone, Dense, Buff to Gray, Medium Hard w/Very Thin Layers of Tan, Medium Soft Shale</td>
<td>6.0</td>
</tr>
</tbody>
</table>

Bottom of Hole
**BORING LOG**

**HOLE NO. 11**

**PROJECT** U.S. Department of Transportation - Test Track - Kansas  
**SITE LOCATION** Station 8575+42 - See Boring Location Plan  
**DATE** 4-24-69

**ELEV.** 1397.8'  
**G.W. ELEV.**  
**LOGGED BY** Risenhoover  
**LOADED BY** John Eidt

**DATA** 2" Split Spoon  
**WT. OF HAMMER** 140#  
**FALL OF HAMMER** 30"

**AUGER DATA**

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>NO. OF BLOWS</th>
<th>DESCRIPTION OF MATERIALS</th>
<th>WT. OF HAMMER</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1397.6</td>
<td></td>
<td>Clay, Slightly Silty, Reddish Brown, Moist, Plastic (All Fill)</td>
<td>140#</td>
<td>Air Drilling</td>
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<tr>
<td>1384.8</td>
<td>3.0</td>
<td>Clay, Silty, Black, Wet from Adjacent Ditch Drainage, Plastic</td>
<td>140#</td>
<td>(Attempted Penetration from 6.5-6.8 total 5 blows)</td>
</tr>
<tr>
<td>3.6</td>
<td></td>
<td>Clay, Yellow Gray Grading into Clay-Shale @ 6.8' Refusal: Permian Age - Ft. Riley member</td>
<td>140#</td>
<td>7.8</td>
</tr>
</tbody>
</table>

**HOLE NO. 11**

**HEMPHILL & SHILDY DRILLING COMPANY**  
**TULSA, OKLAHOMA**
<table>
<thead>
<tr>
<th>DEPTH</th>
<th>NO. OF BLOWS PER FOOT</th>
<th>DESCRIPTION OF MATERIALS</th>
<th>REMARKS</th>
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<tbody>
<tr>
<td>1284.2</td>
<td>13.6</td>
<td>Bottom of Hole</td>
<td></td>
</tr>
</tbody>
</table>
**BORING LOG**

**PROJECT** U.S. Department of Transportation - Test Track - Kansas

**HOLE LOCATION** Station 5387+00  See Boring Location Plan

**ELEV. REV.** 1396.7'  G.W. ELEV.

**BORED BY** Risenhoover

**LOGGED BY** John Eidt

**SAMPLER DATA**

**W.T. OF HAMMER**

**FALL OF HAMMER**

**PENETROMETER DATA**

**W.T. OF HAMMER**

**FALL OF HAMMER**

**ASSET DATA**

**CORE BARREL & BIT DATA** Heavy Duty NX

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>NO. OF BLOWS PER FOOT</th>
<th>DESCRIPTION OF MATERIALS (Type, Color, Texture, Consistency)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1396.7</td>
<td>0.0</td>
<td>Clay, Silty, Black, Moist, Plastic</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Clay, Slightly Silty, Reddish-Brown, Moist, Plastic</td>
</tr>
<tr>
<td>1393.2</td>
<td>3.5</td>
<td>Clay, Tan Gray, More Moist Than Above Clay, Plastic w/Trace of Gravel Grading into a Clay-Shale from 4.3 to 4.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Refusal: Permian Age - Ft, Riley member</td>
</tr>
<tr>
<td>1322.2</td>
<td>4.5</td>
<td>Limestone, Buff to Gray, Dense, Medium Soft to Medium Hard w/Vertical Fracture from 4.5 to 5.5; Shale, Tan, Limey, Medium Soft from 5.7 to 6.1, from 7.5 to 7.9, from 11.4 to 11.6, and 13.4 to 13.6 and 15.4; Open Vertical Fracturing from 15.4 to 16.4; Also Closed Cross-Vertical Fractures Noted from 8.0 to 9.0'</td>
</tr>
</tbody>
</table>

**REMARKS**

Air Drilling

Coring 4.5

Bottom of Hole 18.0
### Boring Log

**Project:** U. S. Department of Transportation - Test Track - Kansas

**Hole No.:** 14

**Sheet No.:** 1 of 1

**Location:** Station 8590+00 Sea Boring Location Plan

**Date:** 4-23-69

**Hammer Data:** 2" Split Spoon

**Coring Data:**
- **Wt. of Hammer:** 140 lbs
- **Fall of Hammer:** 30"

**Auger Data:**
- **Wt. of Hammer:**
- **Fall of Hammer:**

**Core Barrel & Bit Data:** Heavy Duty NX

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH AND SCALE</th>
<th>NO. BLOWS PER FOOT</th>
<th>DESCRIPTION OF MATERIALS (Type, Color, Texture, Consistency)</th>
<th>% BOREHOLE</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1392.0</td>
<td>0.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1391.0</td>
<td>1.0</td>
<td></td>
<td>Clay, Silty, Black, Moist, Plastic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1391.0</td>
<td>1.0</td>
<td></td>
<td>Clay, Slightly Silty, Red, Moist, Plastic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1391.0</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1390.2</td>
<td>2.0</td>
<td></td>
<td>Clay, Yellowish-Gray, Slightly Moist, Grading into Clay-Shale</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1388.7</td>
<td>3.3</td>
<td></td>
<td>Refusal: Permian Age - Ft, Riley member</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>1385.7</td>
<td>3.3</td>
<td></td>
<td>Limestone, Buff to Gray, Dense, Shale from 3.3 to 3.7 and Containing a Vertical Fracture from 3.3 to 4.5</td>
<td>92%</td>
<td></td>
</tr>
<tr>
<td>1366.6</td>
<td>6.0</td>
<td></td>
<td>Bottom of Hole</td>
<td>6.0</td>
<td></td>
</tr>
</tbody>
</table>

**Remarks:**
- Air Drilling
- Shelby Tube
- Coring

**Drilling Characteristics, Fluid Loss, Casing Data, Etc.:**
**BORING LOG**

**PROJECT** U. S. Department of Transportation - Test Track - Kansas

**HOLE NO.** 15

**DATE** 4-23-69

**LOCATED STATION** 852400

**SHEET NO.** 1

**ELEV.** 1386.0' G.W. ELEV. BORED BY Risenhoover

**WT. OF HAMMER** 140# FALL OF HAMMER

**WT. OF HAMMER** 140# FALL OF HAMMER

**SUMMARY DATA** 2” Split Spoon

**LOGGED** By John Eild

**SENSORIMETER DATA**

**HOLE NO.** 15

**TULSA, OKLAHOMA**

---

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH AND SCALE</th>
<th>NO. OF BLOWS PER FOOT</th>
<th>DESCRIPTION OF MATERIALS (Type, Color, Texture, Consistency)</th>
<th>% CORE RECOVERY</th>
<th>REMARKS (Drilling Characteristics, Drilling Fluid Loss, Casing Data, Etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1386.0</td>
<td>1383.5</td>
<td>2.5</td>
<td>Air Drilling 0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1383.5</td>
<td>1382.8</td>
<td>3.2</td>
<td>Shelby Tube 1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1382.8</td>
<td>1380.0</td>
<td>6.0</td>
<td>(Attempted Shelby Tube @ 2.5 but obtained jar sample only) 3.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1380.0</td>
<td>Bottom of Hole</td>
<td></td>
<td>Coring</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Clay, Silty, Black to Brown Moist, Plastic
- Clay-Shale, Mottled Yellow Brown Gray, Medium Hard (Note: Too Hard to Push and too Soft to Recover Core)
- Refusal: Permian Age - Ft. Riley member
- Limestone, Buff to Gray, Dense, Medium Hard w/ a Few Very Thin Laminae of Shale, Tan, Medium Hard
- Bottom of Hole

**HEMPHILL & SHELBY DRILLING COMPANY**

**TULSA, OKLAHOMA**
<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH AND SCALE</th>
<th>NO. OF BLOWS PER FOOT</th>
<th>DESCRIPTION OF MATERIALS (Type, Color, Texture, Consistency)</th>
<th>CORE BARREL &amp; BIT DATA</th>
<th>REMARKS (Drilling Characteristics, Drilling Fluid Loss, Casing Data, Etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>132.8</td>
<td>52</td>
<td>0.9</td>
<td>---</td>
<td></td>
<td></td>
</tr>
<tr>
<td>162.6</td>
<td>1.2</td>
<td></td>
<td>Clay, Slightly Silty, Reddish Brown, Moist, Plastic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>180.7</td>
<td>2.1</td>
<td></td>
<td>Gradational Clay-Shale, Medium Soft, Tan to Tan Shale w/Interbedded Dense Limestone Refusal: Permian Age - Ft. Riley member</td>
<td></td>
<td></td>
</tr>
<tr>
<td>276.8</td>
<td>6.0</td>
<td></td>
<td>Limestone, Buff to Gray, Dense, Medium Hard w/ an Occasional Thin Laminae of Tan, Medium Soft Shale also a Vug Noted at 5.3 and Shale, Tan, Medium Soft from 5.5 to 5.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>376.8</td>
<td>6.0</td>
<td></td>
<td>Bottom of Hole</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
REPORT FOR
U. S. DEPARTMENT OF TRANSPORTATION
TEST TRACK
NEW MEXICO

I - Introduction

A. Purpose of Survey

The purpose of the survey was to examine the proposed U. S. Department of Transportation test track site in New Mexico from a geological and laboratory testing investigation through the use of samples obtained from prescribed test borings taken along its center-line and potential borrow areas.

B. Location of Site

The test track site is located 30 feet south of the center-line of the existing Santa Fe track between mile posts 684 and 686, between Melrose and Cantara, New Mexico, while the borrow borings were taken 60 feet south of the existing track. The natural terrain of the site is relatively flat.

C. Test Borings

The following 17 test borings were augered and drilled on April 23, 24, 1969 by means of a 1500 Failing truck mounted core drill:

<table>
<thead>
<tr>
<th>Boring Number</th>
<th>Station Number</th>
<th>Description</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1</td>
<td>1950+00</td>
<td>Embankment</td>
<td>6.0'</td>
</tr>
<tr>
<td>#2</td>
<td>1958+00</td>
<td>Embankment</td>
<td>6.0'</td>
</tr>
<tr>
<td>#3</td>
<td>1966+00</td>
<td>Embankment</td>
<td>6.0'</td>
</tr>
<tr>
<td>#4</td>
<td>1974+00</td>
<td>Embankment</td>
<td>6.0'</td>
</tr>
<tr>
<td>#5</td>
<td>1982+00</td>
<td>Embankment</td>
<td>6.0'</td>
</tr>
<tr>
<td>#6</td>
<td>1990+00</td>
<td>Embankment</td>
<td>6.0'</td>
</tr>
</tbody>
</table>
**II - Geological Survey**

**A. Type Soils**

Only two representative soils were found to be present in the 6 feet of subsurface investigation throughout the two mile test track site between Santa Fe mile posts 684 and 686, New Mexico.

The upper soil consisted of brown silt, very little if any moisture, having a very slight amount of clay. The thickness in the eleven center line borings ranged from as little as 0.5 foot to a maximum of 2.0 feet. The average thickness was 1.2 feet. That in the six borrow borings ranged from 1.8 to 2.5 feet, with an average of 2.2 feet.

The lower soil consisted of sand, very silty and very fine grained, multicolored white-reddish white to tan, very limey with a trace of clay and varying amounts of caliche particles. Larger

<table>
<thead>
<tr>
<th>Boring Number</th>
<th>Station Number</th>
<th>Description</th>
<th>Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>#7</td>
<td>1998+00</td>
<td>Embankment</td>
<td>6.0'</td>
</tr>
<tr>
<td>#8</td>
<td>2006+00</td>
<td>Embankment</td>
<td>6.0'</td>
</tr>
<tr>
<td>#9</td>
<td>2014+00</td>
<td>Embankment</td>
<td>6.0'</td>
</tr>
<tr>
<td>#10</td>
<td>2022+00</td>
<td>Embankment</td>
<td>6.0'</td>
</tr>
<tr>
<td>#11</td>
<td>2030+00</td>
<td>Embankment</td>
<td>6.0'</td>
</tr>
<tr>
<td>#8-12 (60' south of center line of existing track)</td>
<td>1950+00</td>
<td>Borrow</td>
<td>6.0'</td>
</tr>
<tr>
<td>#8-13</td>
<td>1965+00</td>
<td>Borrow</td>
<td>6.0'</td>
</tr>
<tr>
<td>#8-14</td>
<td>1980+00</td>
<td>Borrow</td>
<td>6.0'</td>
</tr>
<tr>
<td>#8-15</td>
<td>1995+00</td>
<td>Borrow</td>
<td>6.0'</td>
</tr>
<tr>
<td>#8-16</td>
<td>2010+00</td>
<td>Borrow</td>
<td>6.0'</td>
</tr>
<tr>
<td>#8-17</td>
<td>2025+00</td>
<td>Borrow</td>
<td>6.0'</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>102.0'</strong></td>
</tr>
</tbody>
</table>
sizes of caliche were noted in the western half of the test track site commencing with boring No. 7 thru 11. The sand is of Tertiary Geologic Age and is referred to as the Ogallala Formation, with the caliche characterizing the nearby terrace deposits of Recent Geologic Age.

B. Bed Rock

6.0' feet being the maximum depth of investigation, bed rock was not encountered anywhere in the test track site.

C. Surface Ground Water

No moisture or drainage water was encountered in any of the borings and it is reported the static water level is at a considerable depth in the area.

III - Engineering Analysis

The uppermost soil existing at the New Mexico site could be classified as a CL material with a compacted modified proctor of 118 pounds per cubic foot at an optimum moisture content of 11.4%. Unconfined compressive strength of a remolded sample compacted to 95 per cent modified proctor was 3.0 ksf. The low unconfined compressive strength in this case results from lack of clay sufficient to contribute cohesive strength.

The underlying soil, a very fine grained sand of medium density, was completely lacking in plasticity and may be classified as a SF material. This material yielded a modified proctor compacted unit weight of 118 pounds per cubic foot at an optimum moisture content of 11%. Thus, the compaction properties of the two existing natural soils is very similar.

The New Mexico site offers ideal conditions for construction of a uniformly conditioned test site. Since soil conditions are uniform throughout the section and very little excavation or embankment would be necessary; differential settlements of the track bed might be expected to be negligible. Environmental conditions existing at this site would also be a most ideal situation for controlled research.

Based on topography at the site and existing soils, the following may be considered an adequate subgrade design. Excavation to an elevation of 3998 feet would expose the sandy, non-plastic
material throughout the test section. A one to two foot base for track foundation could be constructed above this material by using silty clay material (excavated) stabilized with Portland cement. The one to two foot of soil-cement base would offer an ideal track bed foundation. The existing material promises to respond to cement stabilization very favorably since it is a very friable low plasticity material. After treatment it would be unexpected to find unconfined compressive strengths greatly in excess of those obtained on raw soil. Additional tests would be required to find optimum cement content required for this particular material. If such information is required in the future planning and design of the test section, it could be made available on request.

HEMPHILL CORPORATION

John T. Euts, Geologist

B. D. Marks, III, B.S.C.E., M.S.C.E.
Soils Consultant

Jack F. Stewart, Engineer
MOISTURE - DENSITY CURVE

DATE: April 29, 1969
CLIENT: The Atchison, Topeka and Santa Fe Railway System
PROJECT: U. S. Department of Transportation for New Mexico Area, Test Track

MATERIAL: Brown Silt Topsoil
MATERIAL SOURCE:
METHOD OF TEST: ASTM D 1557, Method A

TEST RESULTS

MAXIMUM DRY DENSITY = 118.4 LBS PER CU. FT.
OPTIMUM MOISTURE CONTENT = 11.4 %

PHYSICAL PROPERTIES

LIQUID LIMIT = ___ %
PLASTIC LIMIT = ___ %
PLASTICITY INDEX = NP ___ %
SHRINKAGE LIMIT = ___ %
UNCONFINED COMPRESSION TEST

DATE: May 5, 1969

CLIENT: The Atchinson, Topeka and Santa Fe Railway System

PROJECT: U.S. Department of Transportation for New Mexico Area, Test Track

TEST RESULTS

HOLE NO. Remolded SAMPLE NO. One (1) FROM TO

MATERIAL DESCRIPTION: Brown Silt Topsoil

PHYSICAL PROPERTIES

UNCONFINED COMPRESSIVE STRENGTH LBS PER SQ. FT. 2,966.40
PERCENT STRAIN 3.33
PERCENT MOISTURE 12.0
DENS PER CU. FT. 95% Max.
LIQUID LIMIT
PLASTIC LIMIT
PLASTICITY INDEX N.P.
SHRINKAGE LIMIT
SHRINKAGE RATIO
CLASSIFICATION OL

FAILURE CONDITIONS

HEMPhILL CORPORATION

4834 S. 83RD E. AVE. TULSA, OKLAHOMA
MOISTURE - DENSITY CURVE

DATE: April 29, 1969

CLIENT: The Atchinson, Topeka and Santa Fe Railway System

PROJECT: U. S. Department of Transportation for New Mexico Area, Test Track

MATERIAL: Caliche with silt and fine grain sand

MATERIAL SOURCE:

METHOD OF TEST: ASTM D 1557, Method A

TEST RESULTS

MAXIMUM DRY DENSITY = 118.2 LBS PER CU. FT.

OPTIMUM MOISTURE CONTENT = 10.5 %

PHYSICAL PROPERTIES

LIQUID LIMIT = 25.2 %

PLASTIC LIMIT = 15.9 %

PLASTICITY INDEX = 9.3 %

SHRINKAGE LIMIT = ___ %

MOISTURE - PERCENT OF DRY WEIGHT
### Boring Log

**HOLE NO. 1**

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH AND SCALE</th>
<th>SPORD</th>
<th>NO. OF BLOWS PER FOOT</th>
<th>DESCRIPTION OF MATERIALS (Type, Color, Texture, Consistency)</th>
<th>% CORE RECOVERY</th>
<th>REMARKS (Drilling Characteristics, Drilling Fluid Loss, Casing Data, Etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4401.5</td>
<td>4401.5</td>
<td></td>
<td></td>
<td>Silt, Very Slight Amount of Clay, Brown</td>
<td></td>
<td>Air Drilling</td>
</tr>
<tr>
<td>4400.9</td>
<td>0.6</td>
<td></td>
<td></td>
<td>Sand, Very Silty, Very Fine Grained, reddish White to Tan, limy, w/Trace of Clay and Variable Amounts of Caliche Particles Tertiary Age - Ogallala Formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4395.5</td>
<td>6.0</td>
<td></td>
<td></td>
<td>Bottom of Hole</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTICE**

--coded by Woodall
-logged by Same.
# Boring Log

**HOLE NO. 2**

**PROJECT** U.S. Department of Transportation - Test Track - New Mexico  
**HOLE LOCATION** Station 1958+00 See Boring Location Plan  
**DATE** 4-24-69

**MATERIAL DATA** 2" Split Spoon  
**METHOD** AIR DRILLING

## Core Barrel & Bit Data

<table>
<thead>
<tr>
<th>ELEV. (ft)</th>
<th>DEPTH AND SCALE</th>
<th>NO. OF BLOWS PER FOOT</th>
<th>DESCRIPTION OF MATERIALS (Type, Color, Texture, Consistency)</th>
<th>% CORE SAMPLE</th>
<th>REMARKS (Drilling Characteristics, Drilling Fluid Loss, Casing Data, Etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4400.0</td>
<td>0.0</td>
<td>0</td>
<td>Silt, Very Slight Amount of Clay, Brown</td>
<td></td>
<td>Air Drilling</td>
</tr>
<tr>
<td>4398.9</td>
<td>1.0</td>
<td>2/3/7</td>
<td>Sand, Very Silty, Very Fine Grained, Reddish White to Tan, Limey, w/ Trace of Clay and Variable Amounts of Caliche Particles Tertiary Age - Ogallala Formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4304.0</td>
<td>6.0</td>
<td>8/9/10</td>
<td>Bottom of Hole</td>
<td>6.0</td>
<td></td>
</tr>
</tbody>
</table>

**CU. ELEV.** 4400.0, G.W. ELEV. **BORED BY** Woodall  
**LOGGED BY** Samm

**PARAMETER DATA** Split Spoon

**WT. OF HAMMER** 140#/**FALL OF HAMMER** 30"

**DATE** 4-24-69

**ELEV.** 4400.0, G.W. ELEV. **BORED BY** Woodall  
**LOGGED BY** Samm

**PARAMETER DATA** Split Spoon

**WT. OF HAMMER** 140#/**FALL OF HAMMER** 30"

**DATE** 4-24-69

**FREE DOOR AND SCALE** 0.0

**DESCRIPTION OF MATERIALS (Type, Color, Texture, Consistency)**

- Silt, Very Slight Amount of Clay, Brown
- Sand, Very Silty, Very Fine Grained, Reddish White to Tan, Limey, w/ Trace of Clay and Variable Amounts of Caliche Particles Tertiary Age - Ogallala Formation
- Bottom of Hole

**HOLE NO.** 2

**HEMPHILL & SHELBY DRILLING COMPANY**  
**TULSA, OKLAHOMA**
<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH AND SCALE</th>
<th>NO. OF BLOWS PER FOOT</th>
<th>DESCRIPTION OF MATERIALS (Type, Color, Texture, Consistency)</th>
<th>% CORE RECOVERY</th>
<th>REMARKS (Drilling Characteristics, Drilling Fluid Loss, Casing Date, Etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4798.0</td>
<td>11/11/11</td>
<td></td>
<td>Sand, Very Silty, Very Fine Grained, Reddish White to Tan, Limey, w/Trace of Clay and Variable Amounts of Caliche Particles Tertiary Age - Ogallala Formation</td>
<td>6.0</td>
<td>Air Drilling</td>
</tr>
<tr>
<td>4792.3</td>
<td>6.0</td>
<td></td>
<td>Bottom of Hole</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MEMPHILL & SHELBY DRILLING COMPANY
TULSA, OKLAHOMA

HOLE NO. 3
# Boring Log

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH AND SCALE</th>
<th>NO. OF BLOWS PER FOOT</th>
<th>DESCRIPTION OF MATERIALS</th>
<th>% CON. RECOVERY</th>
<th>SAMPLE NO.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4,398.3</td>
<td>1.0</td>
<td></td>
<td>Silt, Very Slight Amount of Clay, Brown</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>3/4/1</td>
<td>Sand, Very Silty, Very Fine Grained, Reddish</td>
<td>Air Drilling</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.0</td>
<td>6/6/4</td>
<td>White to Tan, Limey, w/Trace of Clay and Variable Amounts of Caliche Particles Tertiary Age - Ogallala Formation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.9</td>
<td>6/15/18</td>
<td>Bottom of Hole</td>
<td></td>
<td></td>
<td>6.0</td>
</tr>
</tbody>
</table>

**Hole Location:** Station 1974+00  See Boring Location Plan  
**Date:** 4-24-69  
**E.M. Elev.: 4,399.3'  
**Method:** By Woodall  
**Sampler:** 2" Split Spoon  
**Wt. of Hammer:** 140#  
**Fall of Hammer:** 30"  
**Core Barrel & Bit Data:**  

**Remarks:** (Drilling Characteristics, Drilling Fluid Loss, Casing Data, Etc.)

---

**Hemphill & Shelby Drilling Company**  
**Tulsa, Oklahoma**
### BORING LOG

**PROJECT**: U.S. Department of Transportation - Test Track - New Mexico  
**HOLE NO.**: 5  
**DATE**: 4-24-69

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH AND SCALE</th>
<th>NO. OF BLOWS PER FOOT</th>
<th>DESCRIPTION OF MATERIALS</th>
<th>% COMPLETION</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>4398.2</td>
<td>0.5</td>
<td></td>
<td>Silt, Very Slight Amount of Clay, Brown</td>
<td></td>
<td>Air Drilling</td>
</tr>
<tr>
<td>4397.2</td>
<td>1.0</td>
<td></td>
<td>Sand, Very Silty, Very Fine Grained, Reddish White to Tan, Limey, w/Trace of Clay and Variable Amounts of Caliche Particles Tertiary Age - Ogallala Formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4396.5</td>
<td>2.0</td>
<td>3/11/13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4392.2</td>
<td>6.0</td>
<td>9/11/12</td>
<td>Bottom of Hole</td>
<td>6.0</td>
<td></td>
</tr>
</tbody>
</table>

**LOGGED BY**: Woodall  
**LOGGED BY**: Samm  
**SMOOTHER DATA**: 2" Split Spoon  
**WT. OF HAMMER**: 140#  
**FALL OF HAMMER**: 30"

**CODE BARREL & BIT DATA**

**PROJECT**: HEMPHILL & SHELBY DRILLING COMPANY  
**TULSA, OKLAHOMA**

**HOLE NO.** 5
**BORING LOG**

**HOLE NO. 6**

**PROJECT U. S. DEPARTMENT OF TRANSPORTATION - TEST TRACK - NEW MEXICO**  SHEET NO. 1 of 1

**HOLE LOCATION** Station 1990+00  See Boring Location Plan  **DATE** 4-24-69

**T.M. ELEV. 4,988.4**  **S.W. ELEV.**  **BORED BY** Woodall  **LOGGED BY** Same

**SAMPLER DATA** 2" Split Spoon  **WT. OF HAMMER** 140#  **FALL OF HAMMER** 30"

**PREDICTED DATA**

**SAND OF** Tertiary Age  *Ogallala* Formation

**BOTTOM OF HOLE**

---

<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DEPTH &amp; SCALE</th>
<th>NO. OF BLOWS PER FOOT</th>
<th>DESCRIPTION OF MATERIALS (Type, Color, Texture, Consistency)</th>
<th>% CORE RECOVERY</th>
<th>REMARKS (Drilling Characteristics, Drilling Fluid Loss, Casing Data, Etc.)</th>
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**HOLE NO. 6**

**HTEMPHILL & SHELBY DRILLING COMPANY**  **TULSA, OKLAHOMA**
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**CORING LOG**

HOLE NO. 7

HOLE NO. 7
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**PROJECT:** U.S. Department of Transportation - Test Track - New Mexico  
**LOCATION:** Station 2014+00  
**DATE:** 4-23-69  
**BORED BY:** Woodall  
**LOGGED BY:** Samm  
**WT. OF HAMMER:** 140#  
**FALL OF HAMMER:** 30"  
**WT. OF BARREL:** 0  
**FALL OF BARREL:** 0  

**REMARDS:** (Drilling Characteristics, Drilling Fluid Loss, Casing Date, Etc.)
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### Boring Log

**Location:** Station 2030+00  
**Date:** 4-23-69  
**Logged By:** Woodall  
**Hammer:** 2" Split Spoon  
**WT. of Hammer:** 140#  
**FALL of Hammer:** 30"  

<table>
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<th>ELEV.</th>
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<th>NO. OF BLOWS PER FOOT</th>
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<td>Bottom of Hole</td>
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**Remarks:**
- Air Drilling
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<th>ELEV.</th>
<th>DEPTH AND SCALE</th>
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**PROJECT** U.S. Department of Transportation - Test Track - New Mexico

**SITE LOCATION** Station 1950+00 See Boring Location Plan

**HOLE NO.** B-12

**DATE** 4-24-69

**EDITED BY** Woodall

**LOGGED BY** Same

**CODE BUCKET & BIT DATA**

**REMINDERS** (Drilling Characteristics, Drilling Fluid Loss, Casing Data, Etc.)

HEMPHILL & SHELBY DRILLING COMPANY
TULSA, OKLAHOMA
<table>
<thead>
<tr>
<th>ELEV.</th>
<th>DESCRIPTION OF MATERIALS</th>
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<td>Amounts of Caliche Particles Tertiary Age -</td>
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<td>ELEV.</td>
<td>DESCRIPTION OF MATERIALS</td>
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**REMARKS**
Air Drilling
# Boring Log

**Project:** U.S. Department of Transportation - Test Track - New Mexico  
**Site Location:** Station 1995+00  
**Date:** 4-24-69  
**Logged By:** Woodall  
**Boring Location Plan:** See Boring Location Plan  
**WT. OF HAMMER:**  
**FALL OF HAMMER:**

<table>
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<th>ELEV.</th>
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**Remarks:** Air Drilling  
**Hole No.** B-15  
**Hemphill & Shelby Drilling Company**  
**Tulsa, Oklahoma**
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**DESCRIPTION OF MATERIALS**

- **482.0**: Silt, Very Slight Amount of Clay, Brown
- **476.2**: Sand, Very Silty, Very Fine Grained, Reddish White to Tan, Limy, w/Trace of Clay and Varying Amounts of Caliche Particles Tertiary Age - Ogallala Formation
- **478.0**: Bottom of Hole

**REMARKS**

- Air Drilling
<table>
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