January 12, 2023
Kleinfelder Project No.: 20230052.005A

Ms. Cynthia Y. Lynn, PE
Thunderhead Testing, LLC
1540 N. 107th E. Avenue
Tulsa, Oklahoma 74116

Subject: **Geotechnical Engineering Report**
Pavement Improvements
S. Cincinnati Avenue, E. 4th Street, and S. Lansing Avenue
Tulsa, Oklahoma

Dear Ms. Lynn:

Kleinfelder has completed the authorized subsurface exploration and geotechnical engineering evaluation for the above-referenced project. The purpose of the geotechnical study was to explore and evaluate the existing pavement and subsurface conditions for the proposed pavement rehabilitation project along S. Cincinnati Avenue, E. 4th Street, and S. Lansing Avenue in Tulsa, Oklahoma. The attached Kleinfelder report contains a description of the findings of our field exploration and laboratory testing program, our engineering interpretation of the results with respect to the project characteristics, and our geotechnical site development recommendations as well as construction guidelines for the planned project.

Recommendations provided herein are contingent on the provisions outlined in the ADDITIONAL SERVICES and LIMITATIONS sections of this report. The project Owner should become familiar with these provisions in order to assess further involvement by Kleinfelder and other potential impacts to the proposed project.

We appreciate the opportunity to be of service to you on this project and are prepared to provide the recommended additional services. Please call us if you have any questions concerning this report.

Sincerely,
KLEINFELDER, INC.
Certificate of Authorization #7292, Expires 6/30/23

Bobby Goben
Staff Professional

Shiyun (Simon) Wang, PE
Senior Professional

GEOTECHNCIAL ENGINEERING REPORT
PAVEMENT IMPROVEMENTS
S. CINCINNATI AVENUE, E. 4TH STREET, AND S. LANSING AVENUE
TULSA, OKLAHOMA

KLEINFELDER PROJECT NO.: 20230052.005A

JANUARY 12, 2023

A Report Prepared for:

Ms. Cynthia Y. Lynn
Thunderhead Testing, LLC
1540 N. 107th E. Avenue
Tulsa, Oklahoma 74116

GEOTECHNICAL ENGINEERING REPORT
PAVEMENT IMPROVEMENTS
S. CINCINNATI AVENUE, E. 4TH STREET, AND S. LANSING AVENUE
TULSA, OKLAHOMA

Prepared by:

Bobby Goben
Staff Professional

Shiyun (Simon) Wang, PE
Oklahoma: 27716

KLEINFELDER
12727 E. 61st St., Ste A
Tulsa, OK 74146
Phone: 918.627.6161

January 12, 2023
Kleinfelder Project No.: 20230052.005A

TABLE OF CONTENTS

GEOTECHNICAL ENGINEERING REPORT
PAVEMENT IMPROVEMENTS
S. CINCINNATI AVENUE, E. 4TH STREET, AND S. LANSING AVENUE
TULSA, OKLAHOMA

1. INTRODUCTION

1.1 GENERAL

Kleinfelder has completed the authorized subsurface exploration and geotechnical engineering evaluation for the proposed pavement improvements project along S. Cincinnati Avenue, E. 4th Street, and S. Lansing Avenue in Tulsa, Oklahoma. The services provided were in general accordance with our proposal No.: TUL22P144341 dated August 25, 2022, and the contract was executed on November 9, 2022.

This report includes our recommendations related to the geotechnical aspects of the project design and construction. Conclusions and recommendations presented in the report are based on the subsurface information encountered at the locations of our exploration and the provisions and requirements outlined in the ADDITIONAL SERVICES and LIMITATIONS sections of this report. In addition, an article prepared by the Geoprofessional Business Association (GBA), *Important Information About This Geotechnical Engineering Report*, has been included in APPENDIX C. We recommend that all individuals read the report limitations along with the included GBA document.

1.2 PROPOSED CONSTRUCTION AND SCOPE OF WORK

We understand that City of Tulsa is planning to improve the following streets:

- S. Cincinnati Avenue from E. 8th Street to E. 13th Street approximately 2,000 feet long.
- E. 4th Street from S. Detroit Avenue to S. Lansing Avenue approximately 1,900 feet long.
- S. Lansing Avenue from E. 2nd Street to E. 4th Street approximately 700 feet long.

Full depth reconstruction with rigid pavement is proposed as part of the improvements. Traffic counts from INCOG were used for pavement design. Geotechnical investigations were performed to measure the existing pavement thicknesses and evaluate subgrade soil properties and subsurface conditions of the existing pavement at eleven (11) locations.

The scope of the exploration and engineering evaluation for this study, as well as the conclusions and recommendations in this report, were based on our understanding of the project as described above. If pertinent details of the project have changed or otherwise differ from our descriptions, we must be notified and engaged to review the changes and modify our recommendations, if needed.

2. SITE CONDITIONS

2.1 SITE DESCRIPTION

The project site is located in downtown Tulsa, Oklahoma. The general location of the site is shown on the top right corners of the Figures 1 and 2, Exploration Location Plan and Vicinity Map(s). The existing S. Cincinnati Avenue is a four-lane one-way asphaltic concrete (AC) paved roadway with shoulder parking and curb and gutters. The existing E. 4th Street is a three-lane two-direction AC paved roadway with shoulder parking and curb and gutter. The existing S. Lansing Avenue is a two-lane two-direction AC paved roadway with shoulder parking and curb and gutter. The project site is surrounded by commercial businesses. Existing overhead and underground utilities were observed within the current right-of-way during our field explorations.

2.2 SUBSURFACE CONDITIONS

Kleinfelder explored the subsurface conditions along the project alignments by drilling and sampling a total of 11 borings: 5 on S. Cincinnati Avenue (A-1 through A-5), 2 on S. Lansing Avenue (B-1 and B-2), and 4 on E. 4th Street (B-3 through B-6) on November 22 and December 2, 2022. Approximate boring locations are shown in Figures 1 and 2, Exploration Location Plan and Vicinity Map(s). The results of the field exploration and laboratory testing programs are presented in APPENDIX A and APPENDIX B, respectively.

Table 2-1 presents a summary of the existing pavement thicknesses, liquid limits (LL), plastic indices (PI), percent passing No. 200 sieve, and subgrade soil classifications at each pavement boring location. Specific subsurface conditions encountered at the boring locations are presented on the respective coring logs in APPENDIX A. The thicknesses indicated on the logs represent the approximate boundaries between material types; in-situ, the transitions may vary or be gradual.

Table 2-1. Summary of Pavement and Subgrade Conditions									
Boring No.	GPS Location	Pavement and Base Thickness*	Sample No.	SUBGRADE**					
				% Moisture	LL	PL	PI	% Passing No. 200	Subsurface Material
A-1	36.14899 N -95.98592 E	AC 4” PCC 6”	A-1A A-1B	21.7 18.7	- 26	- 20	- 6	- 84	Silty Clay with Sand Silty Clay with Sand (A-4)
A-2	36.14798 N -95.98543 E	AC 4.5” PCC 6”	A-2A A-2B	19.3 18.3	- 26	- 19	- 7	- 82	Silty Clay with Sand Silty Clay with Sand (A-4)
A-3	36.14708 N -95.98487 E	AC 7” PCC 6”	A-3A A-3B	20.4 21.8	- 29	- 19	- 10	- 78	Lean Clay with Sand Lean Clay with Sand (A-4)
A-4	36.14600 N -95.98444 E	AC 6.5” PCC 5.5”	A-4A A-4B	28.3 24.7	- 28	- 18	- 10	- 80	Lean Clay with Sand Lean Clay with Sand (A-4)
A-5	36.14507 N -95.98391 E	AC 7” PCC 6”	A-5A A-5B	23.8 24.7	- 31	- 18	- 13	- 80	Lean Clay with Sand Lean Clay with Sand (A-6)
B-1	36.15722 N -95.98271 E	AC 4.5” PCC 6”	B-1A B-1B	20.4 18.4	- 39	- 17	- 22	- 96	Lean Clay Lean Clay (A-6)
B-2	36.15601 N -95.98096 E	AC 2.5” PCC 6.5”	B-2A B-2B	21.3 15.5	- 33	- 17	- 16	- 79	Lean Clay Lean Clay with Sand (A-6)
B-3	36.15521 N -95.98271 E	AC 7” PCC 6”	B-3A B-3B	20.3 18.4	- 33	- 16	- 17	- 87	Lean Clay Lean Clay (A-6)
B-4	36.15475 N -95.98389 E	AC 3.5” Brick 4” PCC 6.5”	B-4A B-4B B-4C	21.5 24.1 18.2	- - 29	- - 15	- - 14	- - 67	Lean Clay Lean Clay Sandy Lean Clay (A-6)
B-5	36.15436 N -95.98518 E	AC 6” PCC 5”	B-5A B-5B	22.6 16.4	- 40	- 17	- 23	- 86	Lean Clay Lean Clay (A-6)
B-6	36.15388 N -95.98638 E	AC 5.25” Brick 4” PCC 4”	B-6A B-6B	23.1 17.5	- 38	- 18	- 20	- 90	Lean Clay Lean Clay (A-6)
Comp A	A-1 to A-5			-	27	19	8	78	Lean Clay with Sand (A-4)
Comp B	B-1 to B-6			-	33	18	15	81	Lean Clay with Sand (A-6)

*AC = Asphaltic Concrete, AB = Aggregate Base, PCC = Portland Cement Concrete
**LL = Liquid Limit, PI = Plastic Index, NP = Non-Plastic

2.3 LABORATORY TESTING

Atterberg limit tests were performed on the selected samples and on the composite bulk samples in general accordance with AASHTO T-89 and T-90. Sieve analyses were performed on the same samples in general accordance with AASHTO T-88. The soils were classified in general accordance with the American Association of State Highway and Transportation Officials (AASHTO) soil classification system (AASHTO M-145) and are presented on the Laboratory Test Results Summary, included in Appendix B.

Moisture-Density relationship (Standard Proctor) tests were performed in general accordance with AASHTO T-99 on the composite bulk samples. The moisture-density test reports, including the curves, are also included in Appendix B.

Resilient modulus tests were also performed in accordance with AASHTO T-307 on the composite bulk samples as outlined below:

- At approximately 95% of the AASHTO T-99 maximum dry density and the moisture content located on the wet side of the Proctor curve for AASHTO A-6, A-7 and +2% of optimum moisture content for other soils.

According to AASHTO T-307, the composite samples were classified as Type 2 materials and were tested with confining pressures of approximately 6.0, 4.0, and 2.0 psi. The results of the resilient modulus tests are included in APPENDIX B. Table 2-3 summarizes the laboratory testing results for the composite bulk sample collected from the borings.

Table 2-3. Lab Results for Composite Samples

Composite Number	Soil Description (USCS Classification)	AASHTO Classification	Optimum Moisture Content (%)	Maximum Dry Density (pcf)	Resilient Modulus
Comp A	Lean Clay with Sand	A-4(5)	14.1	111.2	4,536
Comp B	Lean Clay with Sand	A-6(1)	18.7	105.7	2,278

2.4 GROUNDWATER OBSERVATIONS

No groundwater seepage was observed during and at completion of drilling operations. The materials encountered in the test borings have a wide range of permeabilities and observations over an extended period of time through use of piezometers or cased borings would be required to better define groundwater conditions. Fluctuations of groundwater levels can occur due to seasonal variations in the amount of rainfall, runoff, and other factors not evident at the time the borings were performed. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

3. CONCLUSIONS AND RECOMMENDATIONS

3.1 GENERAL

The primary geotechnical concerns for this project are the variations in the pavement thicknesses and conditions, and moderate to moderately high plasticity soils encountered along the project alignment. Recommendations addressing these primary geotechnical concerns as well as general recommendations regarding geotechnical aspects of the project design and construction are presented below.

The recommendations submitted herein are based, in part, upon data obtained from our subsurface explorations. The nature and extent of subsurface variations that may exist at the proposed project site will not become evident until construction. If variations appear evident, then the recommendations presented in this report should be re-evaluated. In the event that any changes in the nature, design, or location of the proposed project are planned, the conclusions and recommendations contained in this report will not be considered valid unless the changes are reviewed, and our recommendations modified in writing.

3.2 PRIMARY GEOTECHNICAL CONCERNS

3.2.1 Variable Thicknesses/Conditions of Existing Pavement

The existing composite pavement consisted of asphaltic concrete pavement with thicknesses ranging from 2.5 inches to 7 inches underlain by 4 to 6.5 inches of Portland cement concrete. A 4-inch brick layer was encountered in borings B-4 and B-6 between the asphalt and concrete layer. From the pavement cores, the underlain concrete exhibited various degree of distresses and cracks.

3.2.2 Moderate to Moderately High Plasticity Clay Soils

Clay soils that have a moderate to moderately high shrink-swell potential (PI$\geq$22) was observed in borings B-1 and B-5. Depending upon the design grades, these materials could be exposed at the finished subgrade level. Undercutting or stabilization of these soils should be anticipated.

It is recommended that in areas where the moderate to moderately high plasticity clay soils are exposed at the pavement subgrade level, an 8-inch-thick layer of stabilized subgrade or removal and replacement with a minimum of 6 inches of ODOT Type "A" aggregate base in conjunction with the use of an ODOT Type 2 geogrid could be considered to reduce the impact of the moderate to moderately high plasticity clay soils underneath the pavements.

Typical measures for subgrade stabilization include treating or stabilizing the moderate to moderately high plasticity clay soils with class "C" fly ash, hydrated lime, or Portland cement. A complete soil stabilization mix design is beyond the scope of this project but should be considered during construction in accordance with Oklahoma Department of Transportation (ODOT) "OHD L-50 Soil Stabilization Mix Design Procedure."

3.3 PAVEMENT RECOMMENDATIONS

3.3.1 General

Kleinfelder performed the pavement design in accordance with the AASHTO Guide for Design of Pavement Structures (1993), based on provided information, observations and measurements recorded from our field investigations and laboratory testing results. The recommended pavement thicknesses may vary if conditions encountered during reconstruction differ from the assumptions made in our pavement design.

INCOG Annual Average Daily Traffic (AADT) were used. Truck percentages were estimated by Kleinfelder. If actual traffic volume is greater than that anticipated, a shortened pavement life would be expected. The following traffic information was used in the pavement design:

Average Daily Traffic (Cincinnati)	6,895
Average Daily Traffic (Lansing and E. 4th St)	2,037
Roadway Type	Arterial
Design Life for New Pavement	20 Years

Kleinfelder used the following performance design parameters for the subject project:

Design Lane Distribution (Cincinnati) 65%
Design Lane Distribution (Lansing and E. 4th St.) 100%
Directional Distribution (Cincinnati) 100%
Directional Distribution (Lansing and E. 4th St.) 60%
Growth Rate (assumed)..... .....2%
Percent Trucks 5%
Initial Serviceability..... .....4.2
Terminal Serviceability..... 2.5
Reliability.....90%

The pavement design assumes that at least fair drainage will be provided. As the subgrade consisted of primarily clayey materials, drainage coefficient of 1 was used for the pavement design in this project. Kleinfelder should be contacted if our assumptions are inconsistent with the proposed design requirements.

3.3.2 Rigid Pavement

In addition to the design variables detailed in Sections 3.3.1, the rigid pavement design was based on the following variables:

Resilient Modulus (Cincinnati).....4,536 psi
Resilient Modulus (Lansing and E. 4th St.).....2,278 psi
Standard Deviation 0.35
Aggregate Base Thickness..... 12 inches
Aggregate Base Resilient Modulus .....30,000 psi
Load Transfer Coefficient..... 2.7
Flexural Strength of Concrete .....650 psi
Modulus of Elasticity of Concrete..... .....4,400,000 psi

Based on the provided traffic information and the assumptions/estimations made by Kleinfelder as described, design ESALs as summarized in Table 3-2 were determined. Using these design ESALs and the design variables stated previously, the following pavement sections in Table 3-2 are recommended.

Table 3-2. Rigid Pavement Recommendations		
Street(s)	**Design ESAL**	**Pavement Recommendations**
S. Cincinnati Ave.	6,621,133	8.5-inches Dowel Jointed PC Pavement 12-inches ODOT Type "A" Aggregate Base Separator Fabric 8-inches Recompacted Subgrade
S. Lansing Ave. and E. 4th St.	1,801,513	8.0-inches Dowel Jointed PC Pavement 12-inches ODOT Type "A" Aggregate Base Separator Fabric 8-inches Recompacted Subgrade

3.3.3 Pavement Construction Considerations

Handling and placing of pavement materials should be performed in accordance with the procedures specified by the Oklahoma Department of Transportation (ODOT) "Standard Specifications for Highway Construction" (2019).

Proper drainage below the pavement section helps prevent softening of the subgrade and has a significant impact on pavement performance and pavement life of all pavement types. Therefore, we recommend that a granular blanket drain be constructed at all storm sewer inlets within the pavement areas. The blanket drain should be wrapped with appropriate geotextile materials (Tencate-Mirafi S2000 or equivalent). The blanket drain should consist of clean, crushed stone aggregate extending a minimum of 6 inches below pavement subgrade level. The blanket drains should extend a minimum of 8 feet away from the curb at all storm sewer inlets and should be a minimum of 8 feet wide. The grade within the blanket drain should be sloped toward the storm sewer inlet, and weep holes should be drilled through the inlet to provide drainage of the granular section into the inlet. Placement of geotextile filter fabric across the weep holes should be considered to prevent loss of soil through the weep holes.

Construction traffic on the pavements has not been considered in the design. If construction scheduling dictates the pavements will be subject to traffic by construction equipment/vehicles, the design should be reconsidered to include the effects of the additional traffic loading.

4. EARTHWORK AND SITE DEVELOPMENT

4.1 DEMOLITION

All broken asphaltic concrete, and other debris from demolition should be removed from the project site. Areas disturbed during demolition should be thoroughly evaluated by the geotechnical engineer prior to placement of structural fill. All disturbed soils should be scarified, moisture conditioned and recompacted in accordance with Section 4.3 or undercut to stable materials prior to placement of structural fill.

4.2 EXISTING UTILITY TRENCHES

Any planned relocation or removal of existing utility lines along the proposed alignment should be completed as part of the site preparation. Excavations created by removal of the existing lines should be cut wide enough to allow for use of heavy construction equipment to compact the backfill. As an alternative, excavations can also be backfilled with controlled low strength materials (CLSM). In addition, the base of the excavations should be thoroughly evaluated by a geotechnical engineer or engineering technician prior to placement of backfill. All backfill should be placed in accordance with the recommendations presented in Section 4.7 of this report.

If existing utilities will remain within proposed reconstruction areas, the trench backfill should be thoroughly evaluated particularly if existing pavement distress has occurred over the extents of the trench backfill. The trench backfill should be evaluated by proof-rolling, and any areas which exhibit soft or inconsistent soils should be thoroughly evaluated to determine the composition and consistency of the backfill material. If unsuitable material is encountered, it should be undercut and replaced with structural fill or CLSM.

4.3 SCARIFICATION, MOISTURE CONDITIONING, AND COMPACTION

Prior to placement of structural fill, the moisture content of the exposed subgrade soils should be evaluated. Depending on the in-situ moisture content of the soils exposed, moisture conditioning of the exposed grade may be required prior to proof-rolling and/or fill placement. The moisture content of the exposed subgrade soil in the fill areas should be adjusted to the moisture range recommended in Section 4.8.2 of this report, to allow the exposed material to be compacted to a minimum of 95 percent of the standard Proctor density.

Extremely wet or unstable areas that hamper compaction of the subgrade may require undercutting and replacement with structural fill or other stabilization techniques. If the soils are desiccated and have a high swell potential, additional undercutting may also be required. Suitable structural fill should be placed to the finished subgrade elevation as soon as practical to avoid moisture changes in the underlying soils. If bedrock is encountered at the finished subgrade elevation, no scarification, moisture conditioning, and compaction is required.

4.4 PROOFROLLING

Following moisture conditioning and prior to placement of structural fill (if required), it is recommended that the exposed grade be proof rolled. Proofrolling of the subgrade provides identification soft or disturbed areas. Unsuitable areas identified by the proofrolling operation should be undercut and replaced with structural fill. If large areas of soft or unstable soil conditions extend to depths greater than 18 inches below the finished pavement subgrade elevation, we should be notified to provide additional recommendations concerning appropriate stabilization methods.

Proofrolling should be accomplished with multiple passes of a fully loaded, tandem-axle dump truck or similar equipment providing an equivalent subgrade loading. If any significant event, such as precipitation, occurs after proof rolling, the subgrade should be reviewed by qualified geotechnical engineering personnel immediately prior to placing the pavement. The subgrade should be in its finished form at the time of the final review.

4.5 WEATHER CONDITONS

Weather conditions will influence the required site preparation. Following periods of rainfall, the moisture content of the near-surface soils may be significantly above the optimum moisture content. These conditions could seriously impede grading by causing an unstable subgrade condition. Typical remedial measures include aerating the wet subgrade to dry followed by re-compaction, removal of the wet materials and replacing them with dry materials or treating the wet materials with Portland cement, class ‘C’ fly ash, or hydrated lime.

If site grading commences during summer months, moisture contents may be low and higher plasticity clay soils could have a high swell potential. Typically disking and moisture conditioning of the exposed subgrade materials to the moisture content criteria outlined in Section 4.8 will reduce the swell potential of the dry clay soils. As an alternative, the dry clay soils could be undercut and replaced with structural fill materials.

If construction of the project is to be performed during winter months, appropriate measures should be taken to prevent the soils from freezing. In no case should fill or pavements be placed on or against frozen or partially frozen materials. Frozen materials should be removed and replaced with suitable materials and should not be included in any compacted fills.

4.6 CHEMICAL STABILIZATION/MODIFICATION

If unstable areas are encountered, consideration could be given to stabilizing at least the top 9 inches of the unstable soils with Portland cement, class 'C' fly ash, or hydrated lime. In lieu of chemical stabilization, removal/replacement of the existing subgrade with ODOT Type "A" aggregate base as provided in Table 3-1 could be performed. Table 4-1 summarized a general percentage of the stabilizing agent required to stabilize the onsite soils on a dry unit weight basis.

Table 4-1. Soil Stabilization Table

Stabilizing Agent	Percent on a dry weight basis by experience
Portland Cement	5
Class 'C' Fly Ash	14
Hydrated Lime	4

In addition to reducing the pumping of the soils, stabilization of the subgrade will provide a more stable subgrade, less subject to disturbance during construction. Laboratory tests will be necessary to determine the actual amount required and to determine the moisture content to achieve maximum potential strength. The stabilizing agent should be placed, mixed, and compacted in accordance with ODOT "Standard Specifications for Highway Construction, Section 307" (2019).

The producer of the proposed stabilizing/modifying agent should submit chemical analysis sheets to Kleinfelder for review and approval prior to beginning construction. A complete soil stabilization mix

design is beyond the scope of this project, and it should be performed during construction in accordance with Oklahoma Department of Transportation (ODOT) "OHD L-50 SOIL STABILIZATION MIX DESIGN PROCEDURE".

4.7 STRUCTURAL FILL

4.7.1 Materials

All structural fill required to achieve design grades should consist of approved materials, free of organic matter and debris. All structural fill placed within the project limit should consist of non-plastic to lower plasticity, gravelly sand, clayey sand, lean clay, or sandy lean clay with a Plasticity Index (PI) less than 22, as determined by the Atterberg limits test ASTM D4318, wet preparation procedure.

4.7.2 Compaction Criteria

Fill should be placed in lifts having a maximum loose lift thickness of 9 inches and compacted using the following criteria as shown in Table 4-2. Moisture contents should be maintained within this range until completion of the pavement construction.

Table 4-2. Compaction Criteria

PI	Moisture	Density	ASTM
< 12	-2% to +2% of OMC	95%	D698
> 12	0% to 4% above OMC	95%	D698

*OMC = Optimum Moisture Content derived from ASTM D698

5. ADDITIONAL SERVICES

5.1 PLANS AND SPECIFICATIONS REVIEW

We recommend that Kleinfelder conduct a general review of the final plans and specifications to evaluate that our earthwork recommendations have been properly interpreted and implemented during design. In the event Kleinfelder is not retained to perform this recommended review, we will assume no responsibility for misinterpretation of our recommendations.

5.2 CONSTRUCTION OBSERVATION AND TESTING

We recommend that all earthwork during construction be monitored by a representative from Kleinfelder, or other qualified firm, including site preparation and placement of all engineered fill.

6. LIMITATIONS

This work was performed in a manner consistent with that level of care and skill ordinarily exercised by other members of Kleinfelder's profession practicing in the same locality, under similar conditions and at the date the services are provided. Our conclusions, opinions, and recommendations are based on a limited number of observations and data. It is possible that conditions could vary between or beyond the data evaluated. Kleinfelder makes no other representation, guarantee, or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided. The scope of our services did not include any environmental assessment or exploration for the presence of hazardous or toxic materials in the soil, surface water, groundwater, or air, on, below or around this site.

This report may be used only by the Client and the registered design professional in responsible charge and only for the purposes stated for this specific engagement within a reasonable time from its issuance, but in no event later than two (2) years from the date of the report. Land use, site conditions (both on-site and off-site), regulations, or other factors may change over time, and additional work may be required with the passage of time. Any party other than the client who wishes to use this report shall notify Kleinfelder of such intended use. Based on the intended use of the report, Kleinfelder may require that additional work be performed and that an updated report be issued. Non-compliance with any of these requirements by the client or anyone else will release Kleinfelder from any liability resulting from the use of this report by any unauthorized party and client agrees to defend, indemnify, and hold harmless Kleinfelder from any claim or liability associated with such unauthorized or non-compliance.

The work performed was based on project information provided by Client. If Client does not retain Kleinfelder to review any plans and specifications, including any revisions or modifications to the plans and specifications, Kleinfelder assumes no responsibility for the suitability of our recommendations. In addition, if there are any changes in the field to the plans and specifications, Client must obtain written approval from Kleinfelder's engineer that such changes do not affect our recommendations. Failure to do so will vitiate Kleinfelder's recommendations.

KLEINFELDER
Bright People. Right Solutions.

Figures

VICINITY MAP

NOT TO SCALE

NOTE:
BASE MAPPING AND VICINITY MAP CREATED FROM LAYERS COMPILED BY ESRI PRODUCTS AND 2022 MICROSOFT CORPORATION.
COORDINATE SYSTEM: NAD 1983 2011 STATEPLANE OKLAHOMA NORTH FIPS 3501

LEGEND

◎ PAVEMENT CORING

N

0 200 400

1 " = 200 SCALE IN FEET

KLEINFELDER
Bright People. Right Solutions.

PROJECT NO.	20230052.005A
DRAWN BY:	B. Goben
CHECKED BY:	S. Wang
DATE:	12-06-2022

EXPLORATION LOCATION PLAN AND VICINITY MAP

Thunderhead 4th St, Lansing, and Cincinn
Downtown Tulsa
Tulsa, Oklahoma

FIGURE 1

VICINITY MAP

NOT TO SCALE

NOTE:
BASE MAPPING AND VICINITY MAP CREATED FROM LAYERS COMPILED BY ESRI PRODUCTS AND 2022 MICROSOFT CORPORATION.
COORDINATE SYSTEM: NAD 1983 2011 STATEPLANE OKLAHOMA NORTH FIPS 3501

LEGEND

◎ PAVEMENT CORING

N

0 200 400

1 " = 200 SCALE IN FEET

KLEINFELDER
Bright People. Right Solutions.

PROJECT NO.	20230052.005A
DRAWN BY:	B. Goben
CHECKED BY:	S. Wang
DATE:	12-06-2022

EXPLORATION LOCATION PLAN AND VICINITY MAP

Thunderhead 4th St, Lansing, and Cincinn
Downtown Tulsa
Tulsa, Oklahoma

FIGURE 2

GIS FILE PATH: K:_clients_Automated_Exploration Plans\20230052.005A_Thunderhead4thStLansingandCincinnati_20221206_bgoben\MXD\
GIS FILE NAME: 20230052.005A_ELP_11x17_20221206_2118_bg
PLOTTED: 12/6/2022 9:19:49 PM BY: BGOBEN

KLEINFELDER

Bright People. Right Solutions.

Appendix A

APPENDIX A
FIELD EXPLORATION PROGRAM

Kleinfelder conducted the field work on November 22 and December 2, 2022. The exploration consisted of a total of 11 borings, including 5 pavement cores on Cincinnati Avenue and 6 pavement cores on Lansing Ave and 4th Street, at locations indicated in Figures 1 and 2, Exploration Location Plan and Vicinity Map(s).

Representatives of Kleinfelder established the boring locations in the field by using a handheld Global Positioning System (GPS) with an approximate accuracy of 15 feet. Elevations at the boring locations were not obtained. Locations of the borings should be considered accurate only to the degree implied by the methods used to obtain them.

The existing pavement was cored with a 6-inch diameter core barrel. The borings were advanced with a hand auger to 3 feet below the bottom of the pavement, aggregate base, existing ground surface, or auger refusal, if encountered.

The core logs included in this APPENDIX present such data as soil descriptions, depths, sampling intervals, and observed groundwater conditions. Conditions encountered in each of the borings were monitored and recorded by Kleinfelder's field professional. Field logs included visual classification of the materials encountered during drilling, as well as drilling characteristics. Our final core logs represent the engineer's interpretation of the field logs combined with laboratory observation and testing of the samples. Stratification boundaries indicated on the core logs were based on observations during our field work, an extrapolation of information obtained by examining samples from the borings, and comparisons of soils with similar engineering characteristics. Locations of these boundaries are approximate, and the transitions between material types may be gradual rather than clearly defined.

PROJECT / LOCATION DATA:

CORE DATE November 22, 2022
LOCATION Cincinnati - Southbound
GPS 36.14899° N / -95.98592° E

CORE LAYER DATA:

Surface Material Type:	☒ A.C.	☒ P.C.C.	☐ Continuously Reinforced Concrete
Stripping or Separation in Asphalt:	☒ Stripping	☒ Separation	☐ N/A
Honeycomb or "D" Cracking PCC:	☒ Honeycomb	☒ "D" Cracking	☐ N/A
Stabilized Subgrade Beneath Pavement or Subbase?	☐ Yes	☒ No	☐ Unknown

CORE & BASE LAYER DATA (FROM TOP TO BOTTOM):

Core No.	Layer Type	Layer Characteristics	Layer Thickness (in)
A-1	ASPHALTIC CONCRETE	Separtaion at 4 inches	4
A-1	PORTLAND CEMENT CONCRETE		6
	Total Core Thickness		**10**

SUBGRADE LAYER DATA (FROM BELOW CORES, OR AGGREGATE BASE, IF PRESENT):

Sample No.	Layer Type	Layer Depth (in)
A-1A	Silty CLAY with Sand (CL-ML): brown, moist	0.0 to 6.0
A-1B	Silty CLAY with Sand (CL-ML): brown to reddish brown, moist	6.0 to 36.0

TOP

KLEINFELDER
Bright People. Right Solutions.

PROJECT NO.: 20230052.005A
DRAWN BY: BAG
CHECKED BY: SYW
DATE: 12/13/2022

PAVEMENT CORING LOG A-1

Thunderhead 4th St, Lansing, and Cincinnati
Downtown Tulsa
Tulsa, Oklahoma

CORE
A-1

PROJECT / LOCATION DATA:

CORE DATE November 22, 2022
LOCATION Cincinnati - Southbound
GPS 36.14798° N / -95.98543° E

CORE LAYER DATA:

Surface Material Type:	☒ A.C.	☒ P.C.C.	☐ Continuously Reinforced Concrete			
Stripping or Separation in Asphalt:		☒ Stripping	☒ Separation	☐ N/A		
Honeycomb or "D" Cracking PCC:		☒ Honeycomb	☒ "D" Cracking	☐ N/A		
Stabilized Subgrade Beneath Pavement or Subbase?		☐ Yes	☒ No	☐ Unknown		

CORE & BASE LAYER DATA (FROM TOP TO BOTTOM):

Core No.	Layer Type	Layer Characteristics	Layer Thickness (in)
A-2	ASPHALTIC CONCRETE	Separation at 4.5 inches	4.5
A-2	PORTLAND CEMENT CONCRETE		6
	Total Core Thickness		**10.5**

SUBGRADE LAYER DATA (FROM BELOW CORES, OR AGGREGATE BASE, IF PRESENT):

Sample No.	Layer Type	Layer Depth (in)
A-2A	Silty CLAY with Sand (CL-ML): brown, moist	0.0 to 6.0
A-2B	Silty CLAY with Sand (CL-ML): brown to reddish brown, moist	6.0 to 36.0

TOP

KLEINFELDER
Bright People. Right Solutions.

PROJECT NO.: 20230052.005A
DRAWN BY: BAG
CHECKED BY: SYW
DATE: 12/13/2022

PAVEMENT CORING LOG A-2

Thunderhead 4th St, Lansing, and Cincinnati
Downtown Tulsa
Tulsa, Oklahoma

CORE
A-2

PROJECT / LOCATION DATA:

CORE DATE November 22, 2022
LOCATION Cincinnati - Southbound
GPS 36.14708° N / -95.98487° E

CORE LAYER DATA:

Surface Material Type:	☒ A.C.	☒ P.C.C.	☐ Continuously Reinforced Concrete			
Stripping or Separation in Asphalt:		☒ Stripping	☒ Separation	☐ N/A		
Honeycomb or "D" Cracking PCC:		☒ Honeycomb	☒ "D" Cracking	☐ N/A		
Stabilized Subgrade Beneath Pavement or Subbase?		☐ Yes	☒ No	☐ Unknown		

CORE & BASE LAYER DATA (FROM TOP TO BOTTOM):

Core No.	Layer Type	Layer Characteristics	Layer Thickness (in)
A-3	ASPHALTIC CONCRETE	Separation at 2 inches and 7 inches	7
A-3	PORTLAND CEMENT CONCRETE		6
	Total Core Thickness		**13**

SUBGRADE LAYER DATA (FROM BELOW CORES, OR AGGREGATE BASE, IF PRESENT):

Sample No.	Layer Type	Layer Depth (in)
A-3A	Lean CLAY with Sand (CL): reddish brown, moist	0.0 to 6.0
A-3B	Lean CLAY with Sand (CL): reddish brown, moist	6.0 to 36.0

TOP

KLEINFELDER
Bright People. Right Solutions.

PROJECT NO.: 20230052.005A
DRAWN BY: BAG
CHECKED BY: SYW
DATE: 12/13/2022

PAVEMENT CORING LOG A-3

Thunderhead 4th St, Lansing, and Cincinnati
Downtown Tulsa
Tulsa, Oklahoma

CORE
A-3

PROJECT / LOCATION DATA:

CORE DATE November 22, 2022
LOCATION Cincinnati - Southbound
GPS 36.14600° N / -95.98444° E

CORE LAYER DATA:

Surface Material Type:	☒ A.C.	☒ P.C.C.	☐ Continuously Reinforced Concrete			
Stripping or Separation in Asphalt:		☒ Stripping	☒ Separation	☐ N/A		
Honeycomb or "D" Cracking PCC:		☒ Honeycomb	☐ "D" Cracking	☐ N/A		
Stabilized Subgrade Beneath Pavement or Subbase?		☐ Yes	☒ No	☐ Unknown		

CORE & BASE LAYER DATA (FROM TOP TO BOTTOM):

Core No.	Layer Type	Layer Characteristics	Layer Thickness (in)
A-4	ASPHALTIC CONCRETE	Separation at 2 inches, 4.75 inches, and 6.5 inches	6.5
A-4	PORTLAND CEMENT CONCRETE		5.5
	Total Core Thickness		**12**

SUBGRADE LAYER DATA (FROM BELOW CORES, OR AGGREGATE BASE, IF PRESENT):

Sample No.	Layer Type	Layer Depth (in)
A-4A	Lean CLAY with Sand (CL): brown, moist	0.0 to 6.0
A-4B	Lean CLAY with Sand (CL): brown to reddish brown, moist	6.0 to 36.0

TOP

KLEINFELDER
Bright People. Right Solutions.

PROJECT NO.: 20230052.005A
DRAWN BY: BAG
CHECKED BY: SYW
DATE: 12/13/2022

PAVEMENT CORING LOG A-4

Thunderhead 4th St, Lansing, and Cincinnati
Downtown Tulsa
Tulsa, Oklahoma

CORE
A-4

PROJECT / LOCATION DATA:

CORE DATE November 22, 2022
LOCATION Cincinnati - Southbound
GPS 36.14507° N / -95.98391° E

CORE LAYER DATA:

Surface Material Type:	☒	A.C.	☒	P.C.C.	☐	Continuously Reinforced Concrete
Stripping or Separation in Asphalt:	☒	Stripping	☒	Separation	☐	N/A
Honeycomb or "D" Cracking PCC:	☒	Honeycomb	☐	"D" Cracking	☐	N/A
Stabilized Subgrade Beneath Pavement or Subbase?	☐	Yes	☒	No	☐	Unknown

CORE & BASE LAYER DATA (FROM TOP TO BOTTOM):

Core No.	Layer Type	Layer Characteristics	Layer Thickness (in)
A-5	ASPHALTIC CONCRETE	Separation at 5.5 inches and 7 inches	7
A-5	PORTLAND CEMENT CONCRETE		6
	Total Core Thickness		**13**

SUBGRADE LAYER DATA (FROM BELOW CORES, OR AGGREGATE BASE, IF PRESENT):

Sample No.	Layer Type	Layer Depth (in)
A-5A	Lean CLAY with Sand (CL): brown, moist	0.0 to 6.0
A-5B	Lean CLAY with Sand (CL): brown to reddish brown, moist	6.0 to 36.0

TOP

KLEINFELDER
Bright People. Right Solutions.

PROJECT NO.: 20230052.005A
DRAWN BY: BAG
CHECKED BY: SYW
DATE: 12/13/2022

PAVEMENT CORING LOG A-5

Thunderhead 4th St, Lansing, and Cincinnati
Downtown Tulsa
Tulsa, Oklahoma

CORE
A-5

PROJECT / LOCATION DATA:

CORE DATE December 2, 2022
LOCATION Lansing - Southbound
GPS 36.15722° N / -95.98099° E

CORE LAYER DATA:

Surface Material Type:	☒ A.C.	☒ P.C.C.	☐ Continuously Reinforced Concrete			
Stripping or Separation in Asphalt:		☒ Stripping	☒ Separation	☐ N/A		
Honeycomb or "D" Cracking PCC:		☒ Honeycomb	☒ "D" Cracking	☐ N/A		
Stabilized Subgrade Beneath Pavement or Subbase?		☐ Yes	☒ No	☐ Unknown		

CORE & BASE LAYER DATA (FROM TOP TO BOTTOM):

Core No.	Layer Type	Layer Characteristics	Layer Thickness (in)
B-1	ASPHALTIC CONCRETE	Separation at 4.5 inches	4.5
B-1	PORTLAND CEMENT CONCRETE		6
	Total Core Thickness		**10.5**

SUBGRADE LAYER DATA (FROM BELOW CORES, OR AGGREGATE BASE, IF PRESENT):

Sample No.	Layer Type	Layer Depth (in)
B-1A	FILL - Lean CLAY (CL): dark gray, moist	0.0 to 6.0
B-1B	FILL - Lean CLAY (CL): dark gray, moist	6.0 to 36.0

TOP

KLEINFELDER
Bright People. Right Solutions.

PROJECT NO.: 20230052.005A
DRAWN BY: BAG
CHECKED BY: SYW
DATE: 12/13/2022

PAVEMENT CORING LOG B-1

Thunderhead 4th St, Lansing, and Cincinnati
Downtown Tulsa
Tulsa, Oklahoma

CORE
B-1

PROJECT / LOCATION DATA:

CORE DATE December 2, 2022
LOCATION Lansing - Northbound
GPS 36.15601° N / -95.98096° E

CORE LAYER DATA:

Surface Material Type:	☒ A.C.	☒ P.C.C.	☐ Continuously Reinforced Concrete			
Stripping or Separation in Asphalt:		☒ Stripping	☒ Separation	☐ N/A		
Honeycomb or "D" Cracking PCC:		☒ Honeycomb	☒ "D" Cracking	☐ N/A		
Stabilized Subgrade Beneath Pavement or Subbase?		☐ Yes	☒ No	☐ Unknown		

CORE & BASE LAYER DATA (FROM TOP TO BOTTOM):

Core No.	Layer Type	Layer Characteristics	Layer Thickness (in)
B-2	ASPHALTIC CONCRETE	Separate @ 2.5 inches	2.5
B-2	PORTLAND CEMENT CONCRETE	Crumbled below 4 inches	6.5
	Total Core Thickness		**9**

SUBGRADE LAYER DATA (FROM BELOW CORES, OR AGGREGATE BASE, IF PRESENT):

Sample No.	Layer Type	Layer Depth (in)
B-2A	Lean CLAY (CL): brown, moist	0.0 to 6.0
B-2B	Lean CLAY with Sand (CL): reddish brown, moist	6.0 to 36.0

TOP

KLEINFELDER
Bright People. Right Solutions.

PROJECT NO.: 20230052.005A
DRAWN BY: BAG
CHECKED BY: SYW
DATE: 12/13/2022

PAVEMENT CORING LOG B-2

Thunderhead 4th St, Lansing, and Cincinnati
Downtown Tulsa
Tulsa, Oklahoma

CORE
B-2

PROJECT / LOCATION DATA:

CORE DATE December 2, 2022
LOCATION 4th Street - Westbound
GPS 36.15521° N / -95.98271° E

CORE LAYER DATA:

Surface Material Type:	☒ A.C.	☒ P.C.C.	☐ Continuously Reinforced Concrete			
Stripping or Separation in Asphalt:		☒ Stripping	☒ Separation	☐ N/A		
Honeycomb or "D" Cracking PCC:		☒ Honeycomb	☒ "D" Cracking	☐ N/A		
Stabilized Subgrade Beneath Pavement or Subbase?		☐ Yes	☒ No	☐ Unknown		

CORE & BASE LAYER DATA (FROM TOP TO BOTTOM):

Core No.	Layer Type	Layer Characteristics	Layer Thickness (in)
B-3	ASPHALTIC CONCRETE	Separate and crumbled at 5.5 inches	7
B-3	PORTLAND CEMENT CONCRETE		6
	Total Core Thickness		**13**

SUBGRADE LAYER DATA (FROM BELOW CORES, OR AGGREGATE BASE, IF PRESENT):

Sample No.	Layer Type	Layer Depth (in)
B-3A	Lean CLAY (CL): brown and reddish brown, moist	0.0 to 6.0
B-3B	Lean CLAY (CL): brown and reddish brown, moist	6.0 to 36.0

TOP

KLEINFELDER
Bright People. Right Solutions.

PROJECT NO.: 20230052.005A
DRAWN BY: BAG
CHECKED BY: SYW
DATE: 12/13/2022

PAVEMENT CORING LOG B-3

Thunderhead 4th St, Lansing, and Cincinnati
Downtown Tulsa
Tulsa, Oklahoma

CORE
B-3

PROJECT / LOCATION DATA:

CORE DATE December 2, 2022
LOCATION 4th Street - Eastbound
GPS 36.15475° N / -95.98389° E

CORE LAYER DATA:

Surface Material Type: ☒ A.C. ☒ P.C.C. ☐ Continuously Reinforced Concrete

Stripping or Separation in Asphalt: ☒ Stripping ☒ Separation ☐ N/A

Honeycomb or "D" Cracking PCC: ☒ Honeycomb ☒ "D" Cracking ☐ N/A

Stabilized Subgrade Beneath Pavement or Subbase? ☐ Yes ☒ No ☐ Unknown

CORE & BASE LAYER DATA (FROM TOP TO BOTTOM):

Core No.	Layer Type	Layer Characteristics	Layer Thickness (in)
B-4	ASPHALTIC CONCRETE	Separate at 3.5 inches	3.5
B-4	BRICK	Separate at 7.5 inches	4
B-4	PORTLAND CEMENT CONCRETE		6.5
	Total Core Thickness		**14**

SUBGRADE LAYER DATA (FROM BELOW CORES, OR AGGREGATE BASE, IF PRESENT):

Sample No.	Layer Type	Layer Depth (in)
B-4A	Lean CLAY (CL): brown, moist	0.0 to 6.0
B-4B	Lean CLAY (CL): brown, moist	6.0 to 12.0
B-4C	Sandy Lean CLAY (CL): brown and reddish brown, moist	12.0 to 36.0

TOP

KLEINFELDER
Bright People. Right Solutions.

PROJECT NO.: 20230052.005A
DRAWN BY: BAG
CHECKED BY: SYW
DATE: 12/13/2022

PAVEMENT CORING LOG B-4

Thunderhead 4th St, Lansing, and Cincinnati
Downtown Tulsa
Tulsa, Oklahoma

CORE
B-4

PROJECT / LOCATION DATA:

CORE DATE December 2, 2022
LOCATION 4th Street - Westbound
GPS 36.15436° N / -95.98518° E

CORE LAYER DATA:

Surface Material Type:	☒ A.C.	☒ P.C.C.	☐ Continuously Reinforced Concrete			
Stripping or Separation in Asphalt:		☒ Stripping	☒ Separation	☐ N/A		
Honeycomb or "D" Cracking PCC:		☒ Honeycomb	☒ "D" Cracking	☐ N/A		
Stabilized Subgrade Beneath Pavement or Subbase?		☐ Yes	☒ No	☐ Unknown		

CORE & BASE LAYER DATA (FROM TOP TO BOTTOM):

Core No.	Layer Type	Layer Characteristics	Layer Thickness (in)
B-5	ASPHALTIC CONCRETE	Separate at 4 and 6 inches	6
B-5	PORTLAND CEMENT CONCRETE		5
	Total Core Thickness		**11**

SUBGRADE LAYER DATA (FROM BELOW CORES, OR AGGREGATE BASE, IF PRESENT):

Sample No.	Layer Type	Layer Depth (in)
B-5A	Lean CLAY (CL): brown and reddish brown, moist	0.0 to 6.0
B-5B	Lean CLAY (CL): brown and reddish brown, moist	6.0 to 36.0

TOP

KLEINFELDER
Bright People. Right Solutions.

PROJECT NO.: 20230052.005A
DRAWN BY: BAG
CHECKED BY: SYW
DATE: 12/13/2022

PAVEMENT CORING LOG B-5

Thunderhead 4th St, Lansing, and Cincinnati
Downtown Tulsa
Tulsa, Oklahoma

CORE
B-5

PROJECT / LOCATION DATA:

CORE DATE December 2, 2022
LOCATION 4th Street - Eastbound
GPS 36.15388° N / -95.98638° E

CORE LAYER DATA:

Surface Material Type:	☒ A.C.	☒ P.C.C.	☐ Continuously Reinforced Concrete			
Stripping or Separation in Asphalt:		☒ Stripping	☒ Separation	☐ N/A		
Honeycomb or "D" Cracking PCC:		☒ Honeycomb	☒ "D" Cracking	☐ N/A		
Stabilized Subgrade Beneath Pavement or Subbase?		☐ Yes	☒ No	☐ Unknown		

CORE & BASE LAYER DATA (FROM TOP TO BOTTOM):

Core No.	Layer Type	Layer Characteristics	Layer Thickness (in)
B-6	ASPHALTIC CONCRETE	Separate at 3.75 and 5.25 inches	5.25
B-6	BRICK		4
B-6	PORTLAND CEMENT CONCRETE	Entire concrete section crumbled	4
	Total Core Thickness		**13.25**

SUBGRADE LAYER DATA (FROM BELOW CORES, OR AGGREGATE BASE, IF PRESENT):

Sample No.	Layer Type	Layer Depth (in)
B-6A	Lean CLAY (CL): brown and reddish brown, moist	0.0 to 6.0
B-6B	Lean CLAY (CL): brown and reddish brown, moist	6.0 to 36.0

TOP

KLEINFELDER
Bright People. Right Solutions.

PROJECT NO.: 20230052.005A
DRAWN BY: BAG
CHECKED BY: SYW
DATE: 12/13/2022

PAVEMENT CORING LOG B-6

Thunderhead 4th St, Lansing, and Cincinnati
Downtown Tulsa
Tulsa, Oklahoma

CORE
B-6

KLEINFELDER

Bright People. Right Solutions.

Appendix B

APPENDIX B
LABORATORY TESTING PROGRAM

Laboratory tests were performed on select, representative samples to evaluate pertinent engineering properties of these materials. We directed our laboratory testing program primarily toward classifying the subsurface materials and measuring index values of the on-site materials. Laboratory tests were performed in general accordance with applicable standards. The results of the laboratory tests are presented on the respective coring logs. The laboratory testing program consisted of the following:

- **Moisture content tests**, AASHTO T-265, Standard Test Method for Laboratory Determination of Moisture Content of Soils.
- **Soil Classification**, AASHTO T-87, T-88, T-89 and T-90, Standard Method for Test for Dry preparation of Disturbed Soil and Soil Aggregate Samples of Test, Standard Method for Test for Particle Size Analysis of Soils, Standard Method for Test for Determining the Liquid Limit of Soils, and Standard Method for Test for Determining the Plastic Limit and Plasticity Index of Soils, respectively.
- **Moisture Density Test,** AASHTO T-99, Standard Method for Test for Moisture-Density Relations of Soils Using a 2.5-kg (5.5 lbs.) Rammer and a 305-mm (12-in.) Drop.
- **Resilient Modulus Test,** AASHTO T-307, Standard Method for Test for Determining the Resilient Modulus of Soils and Aggregate Materials.
- **Visual classification**, ASTM D2488, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure).

Field No.	Soil Group	Station	Description	Depth* (in)	LL	PI	Percent Passing						Water Content (%)	Soluble Sulfates (mg/kg)
							Passing 3 in.	Passing 3/4 in.	Passing #4	Passing #10	Passing #40	Passing #200		
A-1A				0 - 6									21.7	
A-1B	A-4		SILTY CLAY WITH SAND	6 - 36	26	6	100	100	100	100	98	84	18.7	
A-2A				0 - 6									19.3	
A-2B	A-4		SILTY CLAY WITH SAND	6 - 36	26	7	100	100	100	100	98	82	18.3	
A-3A				0 - 6									20.4	
A-3B	A-4		LEAN CLAY WITH SAND	6 - 36	29	10	100	100	100	100	97	78	21.8	
A-4A				0 - 6									28.3	
A-4B	A-4		LEAN CLAY WITH SAND	6 - 36	28	10	100	100	99	99	97	80	24.7	
A-5A				0 - 6									23.8	
A-5B	A-6		LEAN CLAY WITH SAND	6 - 36	31	13	100	100	100	99	97	80	24.7	
B-1A				0 - 6									20.4	
B-1B	A-6		LEAN CLAY	6 - 36	39	22	100	100	100	100	99	96	18.4	
B-2A				0 - 6									21.3	
B-2B	A-6		LEAN CLAY WITH SAND	6 - 36	33	16	100	100	100	99	95	79	15.5	
B-3A				0 - 6									20.3	
B-3B	A-6		LEAN CLAY	6 - 36	33	17	100	100	100	99	96	87	18.4	
B-4A				0 - 6									21.5	
B-4B				6 - 12									24.1	
B-4C	A-6		SANDY LEAN CLAY	12 - 36	29	14	100	100	100	86	79	67	18.2	
B-5A				0 - 6									22.6	
B-5B	A-6		LEAN CLAY	6 - 36	40	23	100	100	100	100	97	86	16.4	
B-6A				0 - 6									23.1	
B-6B	A-6		LEAN CLAY	6 - 36	38	20	100	100	100	100	98	90	17.5	
Comp A	A-4		LEAN CLAY WITH SAND	0 - 36	27	8	100	100	99	98	95	78		
Comp B	A-6		LEAN CLAY WITH SAND	0 - 36	33	15	100	100	99	98	94	81		

Refer to the Geotechnical Evaluation Report or the supplemental plates for the method used for the testing performed above.
NP = Nonplastic
NA = Not Available

KLEINFELDER
Bright People. Right Solutions.

PROJECT NO.: 20230052.005A
DRAWN BY: BAG
CHECKED BY: SYW
DATE: 12/13/2022

LABORATORY TEST RESULT SUMMARY

Thunderhead 4th St, Lansing, and Cincinnati
Downtown Tulsa
Tulsa, Oklahoma

TABLE
B-1

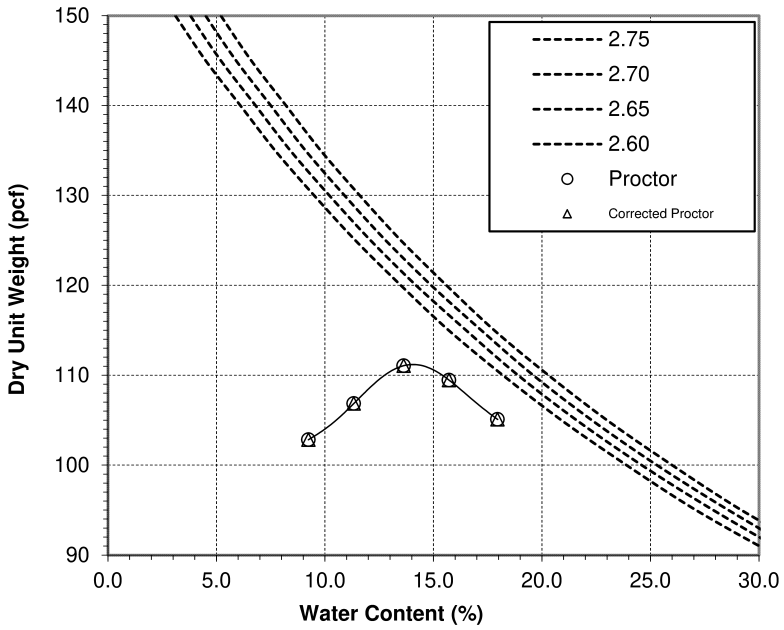
Laboratory Test Report

Client:	**Thunderhead Testing LLC**	Report No.:	**22-TUL-01145 Rev. 0**	Issued:	**12/5/2022**
Project:	**20230052.005A**			Field ID:	**Composite**
	Thunderhead-4th Lansing & Cincinnati	Sampled by:	**B. Goben**	Date:	**11/22/2022**
	01-000L - Lab Testing	Submitted by:	**B. Goben**	Date:	**11/22/2022**

Tested on **11/30/2022** by **S. Williamson**

Material Description: **Lean Clay with Sand, dark brown and tan**

Location: **Composite Borings A-1 through A-5**



Test Method: AASHTO T99 A	Uncorrected	Corrected
Maximum Dry Unit Weight (pcf)	**111.2**	**na**
Optimum Water Content (%)	**14.1**	**na**
Oversize Fraction, retained on No. 4 (%)		**<5**
Bulk Specific Gravity of Oversize Fraction		**na**

Rammer Type: Mechanical

Specimen Preparation: Dry

Sieve Test Method: **AASHTO T88**

US Standard Sieve Size		% Passing
3 Inch	75-mm	**100**
3/4 Inch	19-mm	**100**
3/8 Inch	9.5-mm	**100**
No. 4	4.75-mm	**99**
No. 10	2.00-mm	**98**
No. 40	425-um	**95**
No. 100	150-um	**85**
No. 200	75-um	**78**

Atterberg Limits:

Test Method:	**AASHTO T89/T90**
Liquid Limit, One Point	**27**
Plastic Limit	**19**
Plasticity Index	**8**

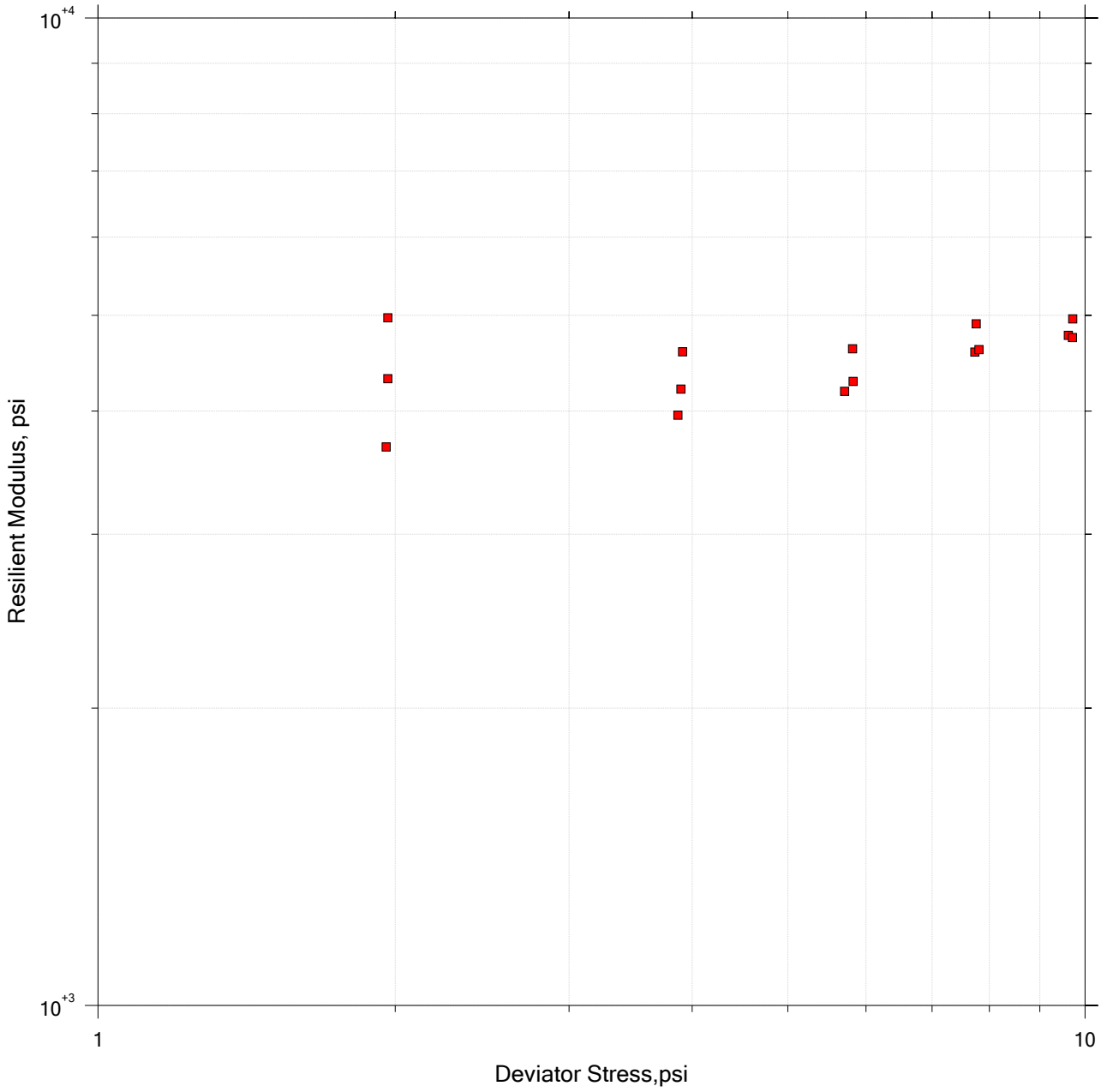
Soil Classification Method:	**AASHTO M145**
Soil Classification	**A-4(5)**

Reviewed on 12/5/2022 by Steve Symsack,
Lab Supervisor

RM TEST

Summary Data

$Mr = 3956.1 * Sd^{0.0764}$ r = 0.51285



KLEINFELDER Bright People. Right Solutions.	Project Name: Cincinnati	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
	Boring Number: "A" Borings	Tester: SS	Checker: SYW
	Sample Number: Composite A	Test Date: 12/13/2022	Depth:
	Test Number: 95% at +2% OMC	Preparation: AASHTO T-307	Elevation: N/A
	Description: Lean Clay with Sand - AASHTO A-4(5) - Type 2 Material		
	Remarks: Remolded Specimen Dry Density 105.6 pcf at 16.1% Moisture		

RM TEST

Summary Data

Confining Stress S3 psi	Nom. Max. Deviator Stress psi	Mean Deviator Stress psi	Std. Dev. Deviator Stress psi	Mean Bulk Stress psi	Mean Resilient Strain %	Std. Dev. Resilient Strain %	Mean Resilient Modulus psi	Std. Dev. Resilient Modulus psi
5.744	2.000	1.966	0.0132	19.20	0.04	0.00	4972.2	109.76
5.754	4.000	3.912	0.0243	21.17	0.08	0.00	4591.1	63.723
5.798	6.000	5.813	0.0166	23.21	0.11	0.00	4623.7	88.938
5.765	8.000	7.759	0.0690	25.05	0.14	0.00	4900.0	64.582
5.740	10.00	9.617	0.1749	26.84	0.18	0.00	4771.4	158.35
3.702	2.000	1.966	0.0126	13.07	0.04	0.00	4311.8	86.102
3.723	4.000	3.895	0.0323	15.06	0.08	0.00	4208.5	80.975
3.760	6.000	5.706	0.1639	16.99	0.12	0.00	4186.7	165.71
3.736	8.000	7.734	0.0770	18.94	0.15	0.00	4587.5	83.782
3.717	10.00	9.719	0.1012	20.87	0.18	0.00	4957.8	88.210
1.730	2.000	1.959	0.0237	7.150	0.05	0.00	3677.6	40.502
1.667	4.000	3.868	0.0209	8.868	0.09	0.00	3960.4	41.546
1.667	6.000	5.821	0.0159	10.82	0.12	0.00	4285.6	54.993
1.690	8.000	7.811	0.0236	12.88	0.15	0.00	4615.8	7.7585
1.690	10.00	9.712	0.0606	14.78	0.18	0.00	4746.5	69.690

KLEINFELDER Bright People. Right Solutions.	Project Name: Cincinnati	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
	Boring Number: "A" Borings	Tester: SS	Checker: SYW
	Sample Number: Composite A	Test Date: 12/13/2022	Depth:
	Test Number: 95% at +2% OMC	Preparation: AASHTO T-307	Elevation: N/A
	Description: Lean Clay with Sand - AASHTO A-4(5) - Type 2 Material		
	Remarks: Remolded Specimen Dry Density 105.6 pcf at 16.1% Moisture		

RM TEST

Results Data

Sequence: 1 of 16
Confining Pressure: 6 psi
Nom. Max. Deviator Stress: 4 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
496	23.963	21.437	2.5257	3.9083	3.4964	0.41194	0.0039754	0.070611	4951.6	0.0065156
497	23.454	20.97	2.4836	3.8253	3.4202	0.40507	0.0041244	0.073257	4668.8	0.0065156
498	23.803	21.363	2.4397	3.8822	3.4843	0.39793	0.0040844	0.072547	4802.8	0.0066345
499	23.958	21.439	2.519	3.9075	3.4967	0.41085	0.0040078	0.071186	4912	0.0067694
500	24.264	21.786	2.4785	3.9575	3.5533	0.40425	0.004092	0.072682	4888.8	0.0070072
AVG	23.888	21.399	2.4893	3.8962	3.4902	0.40601	0.0040568	0.072056	4844.8	0.0066885
SD	0.26384	0.25999	0.031014	0.043033	0.042405	0.0050584	5.5852e-05	0.00099205	100.6	0.00018485

Sequence: 2 of 16
Confining Pressure: 6 psi
Nom. Max. Deviator Stress: 2 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	12.005	10.816	1.1891	1.9581	1.7641	0.19394	0.0019247	0.034187	5160.2	-0.0093394
97	12.009	10.739	1.27	1.9586	1.7515	0.20714	0.0019886	0.035322	4958.7	-0.0097877
98	12.014	10.813	1.2009	1.9595	1.7636	0.19586	0.0019891	0.03533	4991.8	-0.010101
99	12.214	10.894	1.3205	1.9922	1.7768	0.21538	0.0020301	0.036059	4927.4	-0.010101
100	12.02	10.777	1.243	1.9606	1.7578	0.20273	0.002052	0.036448	4822.8	-0.011006
AVG	12.052	10.808	1.2447	1.9658	1.7628	0.20301	0.0019969	0.035469	4972.2	-0.010067
SD	0.081061	0.051347	0.047764	0.013221	0.0083748	0.0077904	4.354e-05	0.00077335	109.76	0.00054601

KLEINFELDER
Bright People. Right Solutions.

Project Name: Cincinnati	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
Boring Number: "A" Borings	Tester: SS	Checker: SYW
Sample Number: Composite A	Test Date: 12/13/2022	Depth:
Test Number: 95% at +2% OMC	Preparation: AASHTO T-307	Elevation: N/A
Description: Lean Clay with Sand - AASHTO A-4(5) - Type 2 Material		
Remarks: Remolded Specimen Dry Density 105.6 pcf at 16.1% Moisture		

RM TEST

Results Data

Sequence: 3 of 16
Confining Pressure: 6 psi
Nom. Max. Deviator Stress: 4 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	23.722	21.284	2.4381	3.869	3.4714	0.39765	0.004194	0.074494	4659.9	-0.00055229
97	23.991	21.557	2.4347	3.913	3.5159	0.3971	0.004349	0.077246	4551.6	-0.00056033
98	23.991	21.555	2.4364	3.913	3.5156	0.39738	0.004368	0.077584	4531.4	-0.0004334
99	24.183	21.749	2.4347	3.9444	3.5473	0.3971	0.0042702	0.075847	4676.9	-0.00016346
100	24.027	21.516	2.5106	3.9188	3.5093	0.40947	0.0043561	0.077373	4535.6	-0.00036591
AVG	23.983	21.532	2.4509	3.9116	3.5119	0.39974	0.0043075	0.076509	4591.1	-0.00041508
SD	0.1487	0.14839	0.029863	0.024253	0.024202	0.0048707	6.6348e-05	0.0011785	63.723	0.00014559

Sequence: 4 of 16
Confining Pressure: 6 psi
Nom. Max. Deviator Stress: 6 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	35.458	31.71	3.7478	5.7833	5.172	0.61126	0.0062336	0.11072	4671.2	0.041037
97	35.768	32.101	3.6669	5.8339	5.2358	0.59807	0.0065123	0.11567	4526.4	0.041426
98	35.689	31.828	3.8607	5.8209	5.1913	0.62969	0.0062427	0.11088	4681.8	0.041367
99	35.65	32.063	3.5876	5.8146	5.2295	0.58515	0.0062246	0.11056	4729.9	0.041823
100	35.649	31.945	3.7039	5.8143	5.2102	0.60412	0.0065056	0.11555	4508.9	0.042188
AVG	35.643	31.93	3.7134	5.8134	5.2077	0.60566	0.0063438	0.11268	4623.7	0.041568
SD	0.10205	0.14544	0.090496	0.016645	0.023721	0.01476	0.00013504	0.0023986	88.938	0.00039783

KLEINFELDER Bright People. Right Solutions.	Project Name: Cincinnati	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
	Boring Number: "A" Borings	Tester: SS	Checker: SYW
	Sample Number: Composite A	Test Date: 12/13/2022	Depth:
	Test Number: 95% at +2% OMC	Preparation: AASHTO T-307	Elevation: N/A
	Description: Lean Clay with Sand - AASHTO A-4(5) - Type 2 Material		
	Remarks: Remolded Specimen Dry Density 105.6 pcf at 16.1% Moisture		

RM TEST

Results Data

Sequence: 5 of 16
Confining Pressure: 6 psi
Nom. Max. Deviator Stress: 8 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	47.174	42.296	4.8788	7.6942	6.8985	0.79573	0.0080383	0.14278	4831.7	0.13858
97	48.376	43.422	4.9546	7.8902	7.0821	0.8081	0.0079381	0.141	5022.9	0.13917
98	47.326	42.372	4.9546	7.719	6.9109	0.8081	0.0079796	0.14173	4876	0.1396
99	47.594	42.641	4.9529	7.7627	6.9548	0.80783	0.0080111	0.14229	4887.7	0.13948
100	47.4	42.488	4.9125	7.7311	6.9298	0.80123	0.0079925	0.14196	4881.4	0.13967
AVG	47.574	42.644	4.9307	7.7594	6.9552	0.8042	0.0079919	0.14195	4900	0.1393
SD	0.42314	0.40612	0.030554	0.069015	0.066239	0.0049833	3.3375e-05	0.00059281	64.582	0.0003974

Sequence: 6 of 16
Confining Pressure: 6 psi
Nom. Max. Deviator Stress: 10 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	59.16	52.957	6.2036	9.6491	8.6373	1.0118	0.0099249	0.17629	4899.6	0.28379
97	60.165	53.887	6.2778	9.813	8.7891	1.0239	0.010173	0.1807	4863.9	0.28447
98	57.335	48.5	8.8348	9.3514	7.9105	1.441	0.0099185	0.17617	4490.2	0.28914
99	58.186	51.989	6.1969	9.4902	8.4795	1.0107	0.01015	0.18029	4703.2	0.28604
100	59.97	53.81	6.1598	9.7811	8.7764	1.0047	0.010083	0.1791	4900.3	0.28691
AVG	58.963	52.229	6.7346	9.617	8.5186	1.0984	0.01005	0.17851	4771.4	0.28607
SD	1.0725	1.9869	1.0508	0.17492	0.32407	0.17139	0.00010898	0.0019356	158.35	0.0018912

KLEINFELDER
Bright People. Right Solutions.

Project Name: Cincinnati	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
Boring Number: "A" Borings	Tester: SS	Checker: SYW
Sample Number: Composite A	Test Date: 12/13/2022	Depth:
Test Number: 95% at +2% OMC	Preparation: AASHTO T-307	Elevation: N/A
Description: Lean Clay with Sand - AASHTO A-4(5) - Type 2 Material		
Remarks: Remolded Specimen Dry Density 105.6 pcf at 16.1% Moisture		

RM TEST

Results Data

Sequence: 7 of 16
Confining Pressure: 4 psi
Nom. Max. Deviator Stress: 2 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	12.048	10.857	1.1916	1.9651	1.7707	0.19435	0.0023092	0.041016	4317.2	0.20773
97	12.095	10.818	1.2775	1.9728	1.7644	0.20837	0.0023302	0.041388	4263.1	0.20708
98	11.944	10.7	1.2438	1.948	1.7452	0.20287	0.0021947	0.038982	4476.9	0.20703
99	12.173	10.855	1.318	1.9854	1.7705	0.21497	0.0023454	0.041658	4250	0.20709
100	12.015	10.737	1.2775	1.9596	1.7512	0.20837	0.0023188	0.041186	4252	0.20717
AVG	12.055	10.793	1.2617	1.9662	1.7604	0.20578	0.0022996	0.040846	4311.8	0.20722
SD	0.076963	0.063744	0.042202	0.012553	0.010397	0.0068832	5.3851e-05	0.00095649	86.102	0.00025987

Sequence: 8 of 16
Confining Pressure: 4 psi
Nom. Max. Deviator Stress: 4 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	23.798	21.243	2.5552	3.8815	3.4648	0.41676	0.004576	0.081279	4262.8	0.21752
97	23.566	21.049	2.5164	3.8436	3.4332	0.41043	0.004483	0.079626	4311.6	0.21751
98	23.874	21.361	2.5131	3.8939	3.484	0.40988	0.0046318	0.082271	4234.8	0.21738
99	24.029	21.594	2.4355	3.9192	3.522	0.39724	0.0048507	0.086157	4087.8	0.21694
100	24.142	21.671	2.4709	3.9376	3.5346	0.40301	0.0048002	0.085261	4145.6	0.21699
AVG	23.882	21.384	2.4982	3.8952	3.4877	0.40746	0.0046683	0.082919	4208.5	0.21727
SD	0.19823	0.22755	0.041166	0.032332	0.037114	0.0067142	0.00013773	0.0024463	80.975	0.00025099

KLEINFELDER
Bright People. Right Solutions.

Project Name: Cincinnati	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
Boring Number: "A" Borings	Tester: SS	Checker: SYW
Sample Number: Composite A	Test Date: 12/13/2022	Depth:
Test Number: 95% at +2% OMC	Preparation: AASHTO T-307	Elevation: N/A
Description: Lean Clay with Sand - AASHTO A-4(5) - Type 2 Material		
Remarks: Remolded Specimen Dry Density 105.6 pcf at 16.1% Moisture		

RM TEST

Results Data

Sequence: 9 of 16
Confining Pressure: 4 psi
Nom. Max. Deviator Stress: 6 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	35.422	31.712	3.7098	5.7774	5.1723	0.60508	0.0067411	0.11974	4319.7	0.2389
97	32.978	29.27	3.7081	5.3787	4.7739	0.6048	0.0068336	0.12138	3933.1	0.23903
98	35.538	31.597	3.9407	5.7963	5.1536	0.64274	0.006736	0.11964	4307.4	0.23885
99	35.535	27.604	7.9305	5.7958	4.5023	1.2935	0.0062682	0.11134	4043.9	0.24735
100	35.456	31.677	3.7789	5.7829	5.1665	0.61635	0.0067188	0.11934	4329.3	0.23911
AVG	34.986	30.372	4.6136	5.7062	4.9537	0.75249	0.0066595	0.11829	4186.7	0.24065
SD	1.0049	1.6658	1.6606	0.1639	0.2717	0.27084	0.00019971	0.0035473	165.71	0.0033531

Sequence: 10 of 16
Confining Pressure: 4 psi
Nom. Max. Deviator Stress: 8 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	47.753	42.876	4.8779	7.7886	6.9931	0.79559	0.0084515	0.15012	4658.5	0.26536
97	47.442	42.486	4.9554	7.7378	6.9296	0.80824	0.0084104	0.14939	4638.7	0.26624
98	47.91	42.842	5.0684	7.8142	6.9876	0.82666	0.0086031	0.15281	4572.8	0.26572
99	47.442	42.528	4.9133	7.7378	6.9364	0.80137	0.0084209	0.14957	4637.5	0.26584
100	46.547	41.596	4.9504	7.5918	6.7844	0.80741	0.0086216	0.15314	4430.3	0.2663
AVG	47.419	42.466	4.9531	7.7341	6.9262	0.80785	0.0085015	0.151	4587.5	0.26589
SD	0.47228	0.46256	0.064094	0.077029	0.075444	0.010454	9.17e-05	0.0016288	83.782	0.00034754

KLEINFELDER
Bright People. Right Solutions.

Project Name: Cincinnati	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
Boring Number: "A" Borings	Tester: SS	Checker: SYW
Sample Number: Composite A	Test Date: 12/13/2022	Depth:
Test Number: 95% at +2% OMC	Preparation: AASHTO T-307	Elevation: N/A
Description: Lean Clay with Sand - AASHTO A-4(5) - Type 2 Material		
Remarks: Remolded Specimen Dry Density 105.6 pcf at 16.1% Moisture		

RM TEST

Results Data

Sequence: 11 of 16
Confining Pressure: 4 psi
Nom. Max. Deviator Stress: 10 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	59.625	53.425	6.1994	9.7249	8.7138	1.0111	0.0097395	0.17299	5037.1	0.3552
97	59.468	53.23	6.2381	9.6993	8.6819	1.0174	0.0097623	0.1734	5006.9	0.35576
98	60.238	54.157	6.0814	9.825	8.8331	0.99188	0.0099781	0.17723	4984	0.35588
99	60.122	54.041	6.0814	9.806	8.8141	0.99188	0.0099756	0.17719	4974.5	0.35625
100	58.492	52.338	6.1539	9.5401	8.5364	1.0037	0.01004	0.17833	4786.8	0.35683
AVG	59.589	53.438	6.1508	9.7191	8.7158	1.0032	0.0098991	0.17583	4957.8	0.35599
SD	0.62046	0.65315	0.062663	0.1012	0.10653	0.01022	0.00012343	0.0021924	88.21	0.00054206

Sequence: 12 of 16
Confining Pressure: 2 psi
Nom. Max. Deviator Stress: 2 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	11.85	10.622	1.2278	1.9328	1.7325	0.20026	0.0026652	0.047339	3659.8	0.27272
97	11.968	10.663	1.3054	1.952	1.7391	0.2129	0.0026938	0.047847	3634.7	0.27259
98	12.275	11.01	1.2649	2.0021	1.7958	0.20631	0.0027595	0.049014	3663.8	0.27253
99	11.926	10.702	1.2245	1.9452	1.7454	0.19971	0.0026176	0.046494	3754.1	0.27253
100	12.039	10.815	1.2245	1.9636	1.7639	0.19971	0.0027018	0.04799	3675.5	0.27246
AVG	12.012	10.762	1.2494	1.9591	1.7553	0.20378	0.0026876	0.047737	3677.6	0.27257
SD	0.14516	0.13948	0.03188	0.023677	0.022749	0.0051996	4.6484e-05	0.00082564	40.502	8.8247e-05

KLEINFELDER
Bright People. Right Solutions.

Project Name: Cincinnati	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
Boring Number: "A" Borings	Tester: SS	Checker: SYW
Sample Number: Composite A	Test Date: 12/13/2022	Depth:
Test Number: 95% at +2% OMC	Preparation: AASHTO T-307	Elevation: N/A
Description: Lean Clay with Sand - AASHTO A-4(5) - Type 2 Material		
Remarks: Remolded Specimen Dry Density 105.6 pcf at 16.1% Moisture		

RM TEST

Results Data

Sequence: 13 of 16
Confining Pressure: 2 psi
Nom. Max. Deviator Stress: 4 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	23.688	21.167	2.5206	3.8635	3.4524	0.41112	0.0048297	0.085785	4024.5	0.286
97	23.765	21.324	2.4414	3.8762	3.478	0.39819	0.0049527	0.08797	3953.6	0.2858
98	23.492	20.857	2.6352	3.8316	3.4018	0.42981	0.0048092	0.08542	3982.5	0.28582
99	23.765	21.364	2.4009	3.8762	3.4846	0.3916	0.0049775	0.08841	3941.4	0.28598
100	23.878	21.285	2.5931	3.8946	3.4716	0.42294	0.0050114	0.089013	3900.2	0.28567
AVG	23.718	21.2	2.5183	3.8684	3.4577	0.41073	0.0049161	0.08732	3960.4	0.28585
SD	0.12809	0.18349	0.088273	0.020891	0.029927	0.014397	8.1362e-05	0.0014451	41.546	0.00012021

Sequence: 14 of 16
Confining Pressure: 2 psi
Nom. Max. Deviator Stress: 6 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	35.787	31.989	3.7983	5.8369	5.2174	0.6195	0.0069844	0.12406	4205.6	0.30592
97	35.667	31.753	3.9146	5.8174	5.1789	0.63847	0.0067025	0.11905	4350.2	0.30575
98	35.59	31.869	3.7207	5.8047	5.1979	0.60686	0.0067469	0.11984	4337.4	0.30513
99	35.586	31.908	3.6786	5.8042	5.2042	0.59998	0.0069058	0.12266	4242.8	0.30648
100	35.819	32.179	3.6398	5.8421	5.2484	0.59366	0.0068845	0.12228	4292.1	0.30581
AVG	35.69	31.939	3.7504	5.821	5.2093	0.6117	0.0068448	0.12158	4285.6	0.30582
SD	0.097305	0.14193	0.097472	0.015871	0.023149	0.015898	0.0001045	0.0018562	54.993	0.00042989

KLEINFELDER
Bright People. Right Solutions.

Project Name: Cincinnati	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
Boring Number: "A" Borings	Tester: SS	Checker: SYW
Sample Number: Composite A	Test Date: 12/13/2022	Depth:
Test Number: 95% at +2% OMC	Preparation: AASHTO T-307	Elevation: N/A
Description: Lean Clay with Sand - AASHTO A-4(5) - Type 2 Material		
Remarks: Remolded Specimen Dry Density 105.6 pcf at 16.1% Moisture		

RM TEST

Results Data

Sequence: 15 of 16
Confining Pressure: 2 psi
Nom. Max. Deviator Stress: 8 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	47.992	42.995	4.9967	7.8275	7.0126	0.81497	0.0085565	0.15198	4614.1	0.33274
97	47.874	42.916	4.9579	7.8083	6.9997	0.80865	0.0085494	0.15185	4609.5	0.33288
98	48.066	43.071	4.995	7.8396	7.0249	0.8147	0.0085456	0.15179	4628.2	0.33301
99	47.64	42.801	4.8383	7.7701	6.981	0.78913	0.0085317	0.15154	4606.7	0.33306
100	47.869	42.877	4.9917	7.8075	6.9933	0.81415	0.0085214	0.15136	4620.4	0.33373
AVG	47.888	42.932	4.9559	7.8106	7.0023	0.80832	0.0085409	0.1517	4615.8	0.33308
SD	0.14475	0.093439	0.060523	0.023608	0.01524	0.0098715	1.2658e-05	0.00022483	7.7585	0.00034145

Sequence: 16 of 16
Confining Pressure: 2 psi
Nom. Max. Deviator Stress: 10 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	58.849	52.686	6.1631	9.5983	8.5931	1.0052	0.010497	0.18644	4608.9	0.39627
97	59.621	53.538	6.0822	9.7242	8.7322	0.99202	0.010306	0.18305	4770.4	0.3962
98	59.929	53.693	6.2356	9.7745	8.7575	1.017	0.010301	0.18296	4786.6	0.39691
99	59.771	53.537	6.2339	9.7487	8.7319	1.0168	0.010245	0.18197	4798.6	0.3974
100	59.573	53.382	6.1918	9.7165	8.7066	1.0099	0.010281	0.18261	4767.9	0.39752
AVG	59.548	53.367	6.1813	9.7124	8.7042	1.0082	0.010326	0.18341	4746.5	0.39686
SD	0.37144	0.3548	0.056527	0.060582	0.057868	0.0092196	8.8184e-05	0.0015663	69.69	0.00055123

KLEINFELDER
Bright People. Right Solutions.

Project Name: Cincinnati	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
Boring Number: "A" Borings	Tester: SS	Checker: SYW
Sample Number: Composite A	Test Date: 12/13/2022	Depth:
Test Number: 95% at +2% OMC	Preparation: AASHTO T-307	Elevation: N/A
Description: Lean Clay with Sand - AASHTO A-4(5) - Type 2 Material		
Remarks: Remolded Specimen Dry Density 105.6 pcf at 16.1% Moisture		

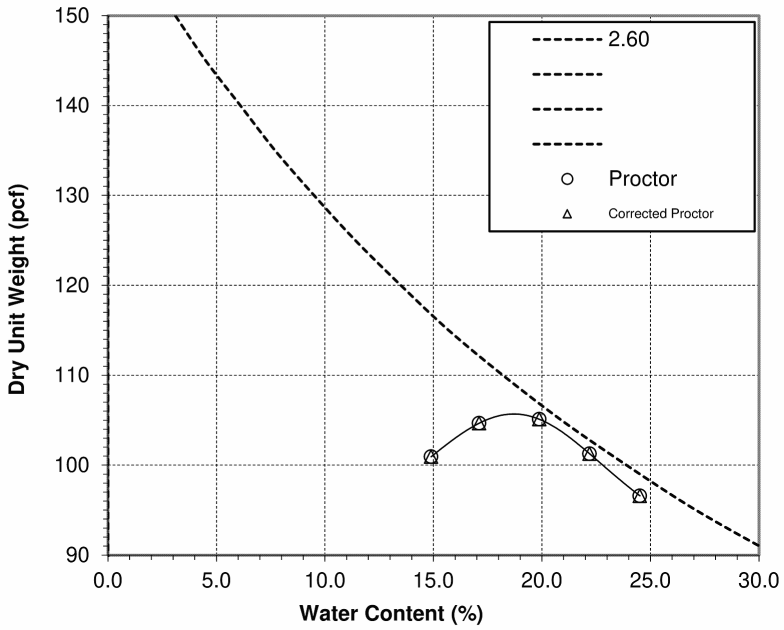
Laboratory Test Report

Client:	**Thunderhead Testing LLC**	Report No.:	**22-TUL-01168 Rev. 0**	Issued:	**12/9/2022**
Project:	**20230052.005A**			Field ID:	**Composite B**
	Thunderhead-4th Lansing & Cincinnati	Sampled by:	**B. Goben**	Date:	**12/2/2022**
	01-000L - Lab Testing	Submitted by:	**B. Goben**	Date:	**12/2/2022**

Tested on **12/6/2022** by **S. Williamson**

Material Description: **Lean Clay with Sand, brown and orange**

Location: **4th Street - Composite "B" Borings**



Sieve Test Method:		**AASHTO T88**
US Standard Sieve Size		% Passing
3 Inch	75-mm	**100**
3/4 Inch	19-mm	**100**
3/8 Inch	9.5-mm	**100**
No. 4	4.75-mm	**99**
No. 10	2.00-mm	**98**
No. 40	425-um	**94**
No. 100	150-um	**85**
No. 200	75-um	**81**

Test Method: AASHTO T99 A	**Uncorrected**	**Corrected**
Maximum Dry Unit Weight (pcf)	**105.7**	**na**
Optimum Water Content (%)	**18.7**	**na**
Oversize Fraction, retained on No. 4 (%)		**<5**
Bulk Specific Gravity of Oversize Fraction		**na**

Rammer Type: Mechanical

Specimen Preparation: Dry

Atterberg Limits:	
Test Method:	**AASHTO T89/T90**
Liquid Limit, One Point	**33**
Plastic Limit	**18**
Plasticity Index	**15**

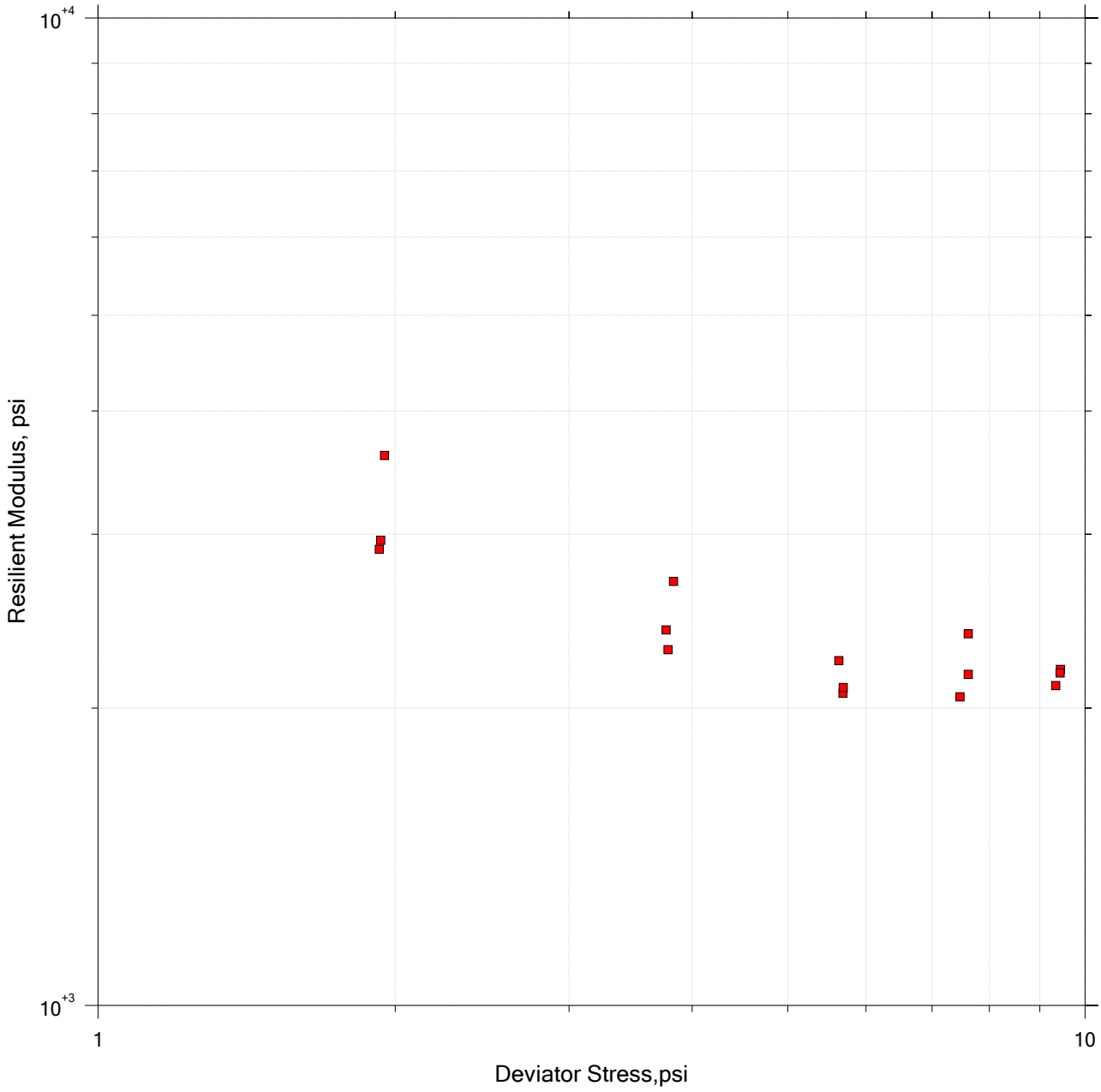
Soil Classification Method:	**AASHTO M145**
Soil Classification	**A-6(11)**

Reviewed on 12/9/2022 by Steve Symsack,
Lab Supervisor

RM TEST

Summary Data

$Mr = 3520.8 * Sd^{-0.243}$ r = -0.85822



KLEINFELDER Bright People. Right Solutions.	Project Name: 4th Street	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
	Boring Number: "B" Borings	Tester: SS	Checker: SYW
	Sample Number: Composite B	Test Date: 12/13/2022	Depth:
	Test Number: 95% on Wet Side	Preparation: AASHTO T-307	Elevation: N/A
	Description: Lean Clay with Sand - AASHTO A-6(11) - Type 2 Material		
	Remarks: Remolded Specimen Dry Density 100.1 pcf at 23.4% Moisture		

RM TEST

Summary Data

Confining Stress S3 psi	Nom. Max. Deviator Stress psi	Mean Deviator Stress psi	Std. Dev. Deviator Stress psi	Mean Bulk Stress psi	Mean Resilient Strain %	Std. Dev. Resilient Strain %	Mean Resilient Modulus psi	Std. Dev. Resilient Modulus psi
5.803	2.000	1.952	0.0204	19.36	0.05	0.00	3604.5	102.04
5.868	4.000	3.829	0.0191	21.43	0.13	0.00	2687.6	109.02
5.815	6.000	5.631	0.0484	23.08	0.23	0.01	2234.4	85.018
5.855	8.000	7.473	0.0713	25.04	0.33	0.01	2053.8	66.735
5.799	10.00	9.341	0.0285	26.74	0.40	0.01	2107.4	50.044
3.804	2.000	1.934	0.0138	13.35	0.06	0.00	2959.2	32.687
3.800	4.000	3.781	0.0196	15.18	0.15	0.00	2292.1	93.267
3.772	6.000	5.687	0.0315	17.00	0.25	0.00	2071.1	29.705
3.793	8.000	7.617	0.0516	19.00	0.28	0.05	2379.0	325.42
3.809	10.00	9.441	0.0693	20.87	0.39	0.01	2189.7	20.120
1.744	2.000	1.927	0.0160	7.158	0.06	0.00	2897.2	140.33
1.740	4.000	3.763	0.0355	8.981	0.14	0.00	2400.2	47.747
1.759	6.000	5.688	0.1700	10.97	0.24	0.00	2098.1	67.407
1.780	8.000	7.617	0.0518	12.96	0.31	0.00	2164.0	4.9700
1.741	10.00	9.437	0.0301	14.66	0.39	0.01	2170.8	38.231

KLEINFELDER Bright People. Right Solutions.	Project Name: 4th Street	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
	Boring Number: "B" Borings	Tester: SS	Checker: SYW
	Sample Number: Composite B	Test Date: 12/13/2022	Depth:
	Test Number: 95% on Wet Side	Preparation: AASHTO T-307	Elevation: N/A
	Description: Lean Clay with Sand - AASHTO A-6(11) - Type 2 Material		
	Remarks: Remolded Specimen Dry Density 100.1 pcf at 23.4% Moisture		

RM TEST

Results Data

Sequence: 1 of 16
Confining Pressure: 6 psi
Nom. Max. Deviator Stress: 4 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
496	22.722	20.351	2.3707	3.7113	3.3241	0.38722	0.0071747	0.12762	2604.7	0.22298
497	23.112	20.702	2.4095	3.7749	3.3814	0.39355	0.0066849	0.11891	2843.7	0.22293
498	22.955	20.547	2.4078	3.7493	3.356	0.39328	0.0066158	0.11768	2851.9	0.22299
499	23.186	20.82	2.3657	3.787	3.4006	0.38639	0.0066824	0.11886	2861	0.22355
500	23.388	20.857	2.5308	3.8201	3.4067	0.41337	0.0068886	0.12253	2780.3	0.22298
AVG	23.072	20.656	2.4169	3.7685	3.3738	0.39476	0.0068093	0.12112	2788.3	0.22308
SD	0.2238	0.18661	0.059793	0.036555	0.030479	0.0097664	0.00020436	0.0036349	96.09	0.00023571

Sequence: 2 of 16
Confining Pressure: 6 psi
Nom. Max. Deviator Stress: 2 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	11.926	10.661	1.2649	1.9479	1.7413	0.20661	0.0027418	0.048768	3570.6	0.20275
97	11.928	10.624	1.3037	1.9482	1.7353	0.21294	0.0027279	0.048522	3576.3	0.20264
98	11.963	10.739	1.2245	1.954	1.754	0.2	0.0028391	0.0505	3473.3	0.20247
99	12.157	10.975	1.1824	1.9857	1.7925	0.19312	0.0027862	0.049558	3617	0.20185
100	11.766	10.545	1.2211	1.9218	1.7223	0.19945	0.002558	0.045499	3785.5	0.20301
AVG	11.948	10.709	1.2393	1.9515	1.7491	0.20242	0.0027306	0.04857	3604.5	0.20254
SD	0.12485	0.1469	0.041468	0.020393	0.023995	0.0067731	9.4656e-05	0.0016837	102.04	0.00038973

KLEINFELDER
Bright People. Right Solutions.

Project Name: 4th Street	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
Boring Number: "B" Borings	Tester: SS	Checker: SYW
Sample Number: Composite B	Test Date: 12/13/2022	Depth:
Test Number: 95% on Wet Side	Preparation: AASHTO T-307	Elevation: N/A
Description: Lean Clay with Sand - AASHTO A-6(11) - Type 2 Material		
Remarks: Remolded Specimen Dry Density 100.1 pcf at 23.4% Moisture		

RM TEST

Results Data

Sequence: 3 of 16
Confining Pressure: 6 psi
Nom. Max. Deviator Stress: 4 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	23.231	20.549	2.6825	3.7945	3.3563	0.43815	0.007239	0.12876	2606.6	0.21921
97	23.46	21.014	2.4466	3.8319	3.4323	0.39961	0.0073199	0.1302	2636.2	0.21922
98	23.577	21.053	2.5241	3.8509	3.4386	0.41227	0.0072886	0.12964	2652.4	0.21909
99	23.42	20.817	2.6033	3.8253	3.4001	0.42521	0.0072424	0.12882	2639.4	0.2192
100	23.513	21.091	2.4212	3.8404	3.445	0.39547	0.0066702	0.11864	2903.6	0.21889
AVG	23.44	20.905	2.5355	3.8286	3.4145	0.41414	0.007152	0.12721	2687.6	0.21912
SD	0.11696	0.20158	0.097273	0.019103	0.032926	0.015888	0.00024277	0.0043183	109.02	0.00012512

Sequence: 4 of 16
Confining Pressure: 6 psi
Nom. Max. Deviator Stress: 6 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	34.359	30.665	3.6939	5.6121	5.0087	0.60334	0.011923	0.21208	2361.7	0.4561
97	34.877	31.206	3.6702	5.6966	5.0971	0.59948	0.012411	0.22076	2308.9	0.45575
98	33.983	30.279	3.7039	5.5507	4.9457	0.60498	0.012964	0.23059	2144.8	0.45682
99	34.6	30.898	3.7023	5.6514	5.0467	0.60471	0.012994	0.23113	2183.5	0.45791
100	34.56	30.782	3.7781	5.6448	5.0277	0.6171	0.013008	0.23137	2173	0.45843
AVG	34.476	30.766	3.7097	5.6311	5.0252	0.60592	0.01266	0.22519	2234.4	0.457
SD	0.29643	0.30285	0.036273	0.048418	0.049465	0.0059247	0.00043118	0.0076694	85.018	0.0010276

KLEINFELDER
Bright People. Right Solutions.

Project Name: 4th Street	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
Boring Number: "B" Borings	Tester: SS	Checker: SYW
Sample Number: Composite B	Test Date: 12/13/2022	Depth:
Test Number: 95% on Wet Side	Preparation: AASHTO T-307	Elevation: N/A
Description: Lean Clay with Sand - AASHTO A-6(11) - Type 2 Material		
Remarks: Remolded Specimen Dry Density 100.1 pcf at 23.4% Moisture		

RM TEST

Results Data

Sequence: 5 of 16
Confining Pressure: 6 psi
Nom. Max. Deviator Stress: 8 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	45.489	40.748	4.7406	7.4299	6.6556	0.7743	0.017626	0.31352	2122.9	1.4024
97	45.334	40.514	4.8198	7.4046	6.6174	0.78724	0.018909	0.33634	1967.5	1.4074
98	46.571	41.596	4.9749	7.6067	6.7941	0.81257	0.018373	0.32681	2078.9	1.4123
99	45.561	40.666	4.8957	7.4418	6.6421	0.79963	0.017627	0.31354	2118.4	1.4163
100	45.792	40.86	4.9327	7.4795	6.6738	0.80569	0.018936	0.33682	1981.4	1.421
AVG	45.75	40.877	4.8727	7.4725	6.6766	0.79589	0.018294	0.32541	2053.8	1.4119
SD	0.43654	0.37695	0.083455	0.071302	0.061568	0.013631	0.00058084	0.010332	66.735	0.0065138

Sequence: 6 of 16
Confining Pressure: 6 psi
Nom. Max. Deviator Stress: 10 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	57.161	51.133	6.0283	9.3365	8.3518	0.98464	0.021746	0.3868	2159.2	3.5513
97	57.092	50.941	6.1514	9.3252	8.3204	1.0047	0.021872	0.38904	2138.7	3.5602
98	57.519	51.293	6.2255	9.3948	8.378	1.0168	0.023391	0.41606	2013.7	3.5757
99	57.166	50.67	6.4969	9.3373	8.2761	1.0612	0.022048	0.39217	2110.3	3.5837
100	57.008	50.901	6.1076	9.3114	8.3138	0.99758	0.022096	0.39303	2115.3	3.5949
AVG	57.189	50.987	6.2019	9.341	8.328	1.013	0.022231	0.39542	2107.4	3.5732
SD	0.17441	0.21236	0.16073	0.028488	0.034686	0.026253	0.00059346	0.010556	50.044	0.015719

KLEINFELDER
Bright People. Right Solutions.

Project Name: 4th Street	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
Boring Number: "B" Borings	Tester: SS	Checker: SYW
Sample Number: Composite B	Test Date: 12/13/2022	Depth:
Test Number: 95% on Wet Side	Preparation: AASHTO T-307	Elevation: N/A
Description: Lean Clay with Sand - AASHTO A-6(11) - Type 2 Material		
Remarks: Remolded Specimen Dry Density 100.1 pcf at 23.4% Moisture		

RM TEST

Results Data

Sequence: 7 of 16
Confining Pressure: 4 psi
Nom. Max. Deviator Stress: 2 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	11.79	10.585	1.2051	1.9258	1.729	0.19684	0.0033023	0.058739	2943.5	3.3795
97	11.905	10.587	1.3181	1.9445	1.7292	0.21529	0.0033237	0.05912	2924.9	3.3793
98	11.881	10.627	1.254	1.9407	1.7358	0.20482	0.0032833	0.058401	2972.3	3.3793
99	11.699	10.509	1.1899	1.9109	1.7166	0.19435	0.0031989	0.0569	3016.8	3.3789
100	11.925	10.622	1.3028	1.9478	1.735	0.2128	0.0033195	0.059045	2938.5	3.3789
AVG	11.84	10.586	1.254	1.9339	1.7291	0.20482	0.0032855	0.058441	2959.2	3.3792
SD	0.084202	0.042195	0.050964	0.013753	0.0068919	0.0083243	4.5613e-05	0.00081133	32.687	0.00022566

Sequence: 8 of 16
Confining Pressure: 4 psi
Nom. Max. Deviator Stress: 4 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	23.343	20.972	2.3715	3.8128	3.4254	0.38735	0.0080734	0.1436	2385.3	3.4
97	23.151	20.742	2.4086	3.7814	3.388	0.39341	0.0084635	0.15054	2250.5	3.4004
98	23.084	20.085	2.9985	3.7704	3.2806	0.48977	0.0083916	0.14926	2197.9	3.4006
99	23.175	20.781	2.3934	3.7852	3.3943	0.39092	0.0078813	0.14019	2421.3	3.3995
100	22.977	20.469	2.508	3.753	3.3434	0.40965	0.0085227	0.15159	2205.5	3.3997
AVG	23.146	20.61	2.536	3.7806	3.3663	0.41422	0.0082665	0.14704	2292.1	3.4001
SD	0.12005	0.30757	0.23594	0.019608	0.050237	0.038538	0.00024728	0.0043985	93.267	0.00042968

KLEINFELDER
Bright People. Right Solutions.

Project Name: 4th Street	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
Boring Number: "B" Borings	Tester: SS	Checker: SYW
Sample Number: Composite B	Test Date: 12/13/2022	Depth:
Test Number: 95% on Wet Side	Preparation: AASHTO T-307	Elevation: N/A
Description: Lean Clay with Sand - AASHTO A-6(11) - Type 2 Material		
Remarks: Remolded Specimen Dry Density 100.1 pcf at 23.4% Moisture		

RM TEST

Results Data

Sequence: 9 of 16
Confining Pressure: 4 psi
Nom. Max. Deviator Stress: 6 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	34.606	30.935	3.6711	5.6524	5.0528	0.59961	0.013877	0.24683	2047	3.4631
97	34.876	31.131	3.7452	5.6964	5.0847	0.61173	0.013433	0.23894	2128	3.4631
98	34.64	30.974	3.666	5.6579	5.0591	0.59879	0.013884	0.24696	2048.5	3.4633
99	34.832	31.168	3.6643	5.6893	5.0908	0.59851	0.01388	0.24689	2061.9	3.4638
100	35.144	31.249	3.8952	5.7402	5.104	0.63623	0.013862	0.24656	2070	3.4639
AVG	34.82	31.091	3.7284	5.6872	5.0783	0.60897	0.013787	0.24524	2071.1	3.4634
SD	0.19304	0.11859	0.08878	0.03153	0.01937	0.014501	0.00017717	0.0031513	29.705	0.00032672

Sequence: 10 of 16
Confining Pressure: 4 psi
Nom. Max. Deviator Stress: 8 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	46.425	41.48	4.9453	7.5829	6.7751	0.80775	0.018168	0.32316	2096.5	3.6082
97	46.619	41.637	4.9824	7.6145	6.8007	0.81381	0.018182	0.3234	2102.9	3.6088
98	47.236	42.257	4.9791	7.7153	6.902	0.81326	0.017997	0.32012	2156.1	3.6091
99	46.346	37.762	8.5845	7.5699	6.1678	1.4021	0.012965	0.23061	2674.5	3.7017
100	46.535	38.031	8.5036	7.6008	6.2118	1.3889	0.012189	0.2168	2865.2	3.7021
AVG	46.632	40.233	6.399	7.6167	6.5715	1.0452	0.0159	0.28282	2379	3.646
SD	0.3159	1.9275	1.7517	0.051597	0.31484	0.28611	0.0027254	0.048477	325.42	0.045652

KLEINFELDER Bright People. Right Solutions.	Project Name: 4th Street	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
	Boring Number: "B" Borings	Tester: SS	Checker: SYW
	Sample Number: Composite B	Test Date: 12/13/2022	Depth:
	Test Number: 95% on Wet Side	Preparation: AASHTO T-307	Elevation: N/A
	Description: Lean Clay with Sand - AASHTO A-6(11) - Type 2 Material		
	Remarks: Remolded Specimen Dry Density 100.1 pcf at 23.4% Moisture		

RM TEST

Results Data

Sequence: 11 of 16
Confining Pressure: 4 psi
Nom. Max. Deviator Stress: 10 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	58.635	52.492	6.1438	9.5772	8.5737	1.0035	0.022292	0.39652	2162.2	4.2842
97	57.702	51.521	6.1809	9.4247	8.4151	1.0096	0.021804	0.38784	2169.7	4.2887
98	57.622	51.482	6.1404	9.4118	8.4088	1.0029	0.021493	0.3823	2199.6	4.2945
99	57.582	51.443	6.1387	9.4052	8.4025	1.0027	0.021445	0.38144	2202.8	4.3
100	57.464	51.325	6.1387	9.3859	8.3832	1.0027	0.021285	0.37861	2214.2	4.3053
AVG	57.801	51.653	6.1485	9.4409	8.4367	1.0043	0.021664	0.38534	2189.7	4.2945
SD	0.42417	0.42461	0.016285	0.069281	0.069354	0.0026598	0.00035654	0.0063419	20.12	0.0076087

Sequence: 12 of 16
Confining Pressure: 2 psi
Nom. Max. Deviator Stress: 2 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	11.95	10.781	1.1689	1.9518	1.7609	0.19092	0.0035761	0.063608	2768.3	4.1115
97	11.69	10.196	1.4941	1.9094	1.6654	0.24405	0.003351	0.059605	2794	4.1118
98	11.813	10.585	1.2278	1.9295	1.729	0.20055	0.0031545	0.05611	3081.3	4.1112
99	11.695	10.429	1.2666	1.9102	1.7033	0.20688	0.003134	0.055745	3055.6	4.1111
100	11.849	10.624	1.2245	1.9353	1.7353	0.2	0.0035008	0.062269	2786.7	4.1107
AVG	11.799	10.523	1.2764	1.9272	1.7188	0.20848	0.0033433	0.059468	2897.2	4.1112
SD	0.097988	0.19822	0.11325	0.016005	0.032376	0.018498	0.00017803	0.0031668	140.33	0.00038054

KLEINFELDER
Bright People. Right Solutions.

Project Name: 4th Street	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
Boring Number: "B" Borings	Tester: SS	Checker: SYW
Sample Number: Composite B	Test Date: 12/13/2022	Depth:
Test Number: 95% on Wet Side	Preparation: AASHTO T-307	Elevation: N/A
Description: Lean Clay with Sand - AASHTO A-6(11) - Type 2 Material		
Remarks: Remolded Specimen Dry Density 100.1 pcf at 23.4% Moisture		

RM TEST

Results Data

Sequence: 13 of 16
Confining Pressure: 2 psi
Nom. Max. Deviator Stress: 4 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	23.287	20.781	2.5055	3.8035	3.3943	0.40923	0.0079295	0.14104	2406.6	4.132
97	23.206	20.621	2.5847	3.7903	3.3682	0.42217	0.0079281	0.14102	2388.4	4.1325
98	22.975	20.55	2.4246	3.7526	3.3566	0.39602	0.0079185	0.14085	2383.1	4.132
99	23.049	20.547	2.5021	3.7647	3.356	0.40868	0.0075943	0.13508	2484.4	4.1318
100	22.661	20.201	2.46	3.7014	3.2996	0.4018	0.0079333	0.14111	2338.3	4.132
AVG	23.036	20.54	2.4954	3.7625	3.3549	0.40758	0.0078608	0.13982	2400.2	4.132
SD	0.21723	0.18951	0.053648	0.035481	0.030954	0.0087626	0.00013329	0.002371	47.747	0.00022737

Sequence: 14 of 16
Confining Pressure: 2 psi
Nom. Max. Deviator Stress: 6 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	35.418	31.715	3.7022	5.7849	5.1802	0.6047	0.013662	0.24301	2131.7	4.1807
97	35.296	31.633	3.6635	5.7651	5.1668	0.59837	0.013526	0.24058	2147.6	4.1807
98	32.815	29.115	3.7005	5.3599	4.7554	0.60443	0.013589	0.24171	1967.4	4.1809
99	35.721	31.903	3.8185	5.8345	5.2108	0.6237	0.013667	0.2431	2143.5	4.1811
100	34.868	31.053	3.8152	5.6952	5.072	0.62315	0.013577	0.2415	2100.3	4.1809
AVG	34.824	31.084	3.74	5.6879	5.0771	0.61087	0.013604	0.24198	2098.1	4.1808
SD	1.0409	1.0246	0.064279	0.17002	0.16736	0.010499	5.3741e-05	0.00095591	67.407	0.00015351

KLEINFELDER Bright People. Right Solutions.	Project Name: 4th Street	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
	Boring Number: "B" Borings	Tester: SS	Checker: SYW
	Sample Number: Composite B	Test Date: 12/13/2022	Depth:
	Test Number: 95% on Wet Side	Preparation: AASHTO T-307	Elevation: N/A
	Description: Lean Clay with Sand - AASHTO A-6(11) - Type 2 Material		
	Remarks: Remolded Specimen Dry Density 100.1 pcf at 23.4% Moisture		

RM TEST

Results Data

Sequence: 15 of 16
Confining Pressure: 2 psi
Nom. Max. Deviator Stress: 8 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
96	47.196	42.181	5.0153	7.7088	6.8897	0.81917	0.017925	0.31884	2160.8	4.2773
97	46.266	41.561	4.7051	7.5569	6.7883	0.76852	0.017656	0.31405	2161.5	4.2776
98	46.613	41.675	4.9378	7.6136	6.8071	0.80651	0.01772	0.3152	2159.6	4.2785
99	46.689	41.714	4.9748	7.626	6.8134	0.81257	0.017625	0.31349	2173.4	4.2795
100	46.418	41.483	4.9344	7.5816	6.7757	0.80596	0.017599	0.31304	2164.5	4.2803

AVG	46.636	41.723	4.9135	7.6174	6.8148	0.80254	0.017705	0.31492	2164	4.2786
SD	0.31685	0.2433	0.10822	0.051753	0.039739	0.017676	0.00011732	0.0020867	4.97	0.0011221

Sequence: 16 of 16
Confining Pressure: 2 psi
Nom. Max. Deviator Stress: 10 psi

Cycle	Applied Maximum Deviator Load lb	Applied Cyclic Deviator Load lb	Applied Contact Deviator Load lb	Applied Maximum Deviator Stress psi	Applied Cyclic Deviator Stress psi	Applied Contact Deviator Stress psi	Recoverable Deformation in	Resilient Strain %	Resilient Modulus psi	Permanent Strain %
19	57.633	51.406	6.2272	9.4135	8.3964	1.0171	0.021599	0.38419	2185.5	4.4038
20	57.595	51.524	6.0704	9.4072	8.4157	0.99151	0.021482	0.38211	2202.5	4.4104
21	57.669	51.519	6.1497	9.4193	8.4149	1.0045	0.022573	0.4015	2095.8	4.4149
22	57.942	51.135	6.807	9.4639	8.3521	1.1118	0.021543	0.38319	2179.6	4.4209
23	58.055	51.87	6.1851	9.4824	8.4721	1.0102	0.021743	0.38674	2190.6	4.4254

AVG	57.779	51.491	6.2879	9.4373	8.4102	1.027	0.021788	0.38755	2170.8	4.4151
SD	0.18435	0.23638	0.26463	0.030111	0.038609	0.043224	0.00040171	0.0071453	38.231	0.0076241

KLEINFELDER Bright People. Right Solutions.	Project Name: 4th Street	Location: Tulsa Co., Oklahoma	Project Number: 20230052.005
	Boring Number: "B" Borings	Tester: SS	Checker: SYW
	Sample Number: Composite B	Test Date: 12/13/2022	Depth:
	Test Number: 95% on Wet Side	Preparation: AASHTO T-307	Elevation: N/A
	Description: Lean Clay with Sand - AASHTO A-6(11) - Type 2 Material		
	Remarks: Remolded Specimen Dry Density 100.1 pcf at 23.4% Moisture		

KLEINFELDER

Bright People. Right Solutions.

Appendix C

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. *Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept*

responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are not final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for information purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration*** by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GEOPROFESSIONAL BUSINESS ASSOCIATION

Telephone: 301/565-2733
e-mail: info@geoprofessional.org www.geoprofessional.org