GEOTECHNICAL ENGINEERING REPORT
PAVEMENT REHABILITATION
ON SOUTH UNION PLACE
BETWEEN SOUTHWEST BOULEVARD
AND WEST 41ST STREET
TULSA, OKLAHOMA
KLF PROJECT NO. 20161079

August 5, 2015

A Report Prepared for:

Mr. Paul M. Hames, PE
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1350 South Boulder Avenue, Suite 600
Tulsa, Oklahoma 74119

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August 5, 2015
Kleinfelder Project No. 20161079

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August 5, 2015
Project No.: 20161079

Mr. Paul M. Hames, PE
Dewberry Engineers, Inc.
1350 South Boulder Avenue, Suite 600
Tulsa, Oklahoma 74119

Subject: **Geotechnical Engineering Report**
Pavement Rehabilitation on South Union Place
Between Southwest Boulevard and West 41st Street
Tulsa, Oklahoma

Dear Mr. Hames:

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 soil properties and subsurface conditions on South Union Place between Southwest Boulevard and West 41st Street 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 06/30/17

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GEOTECHNICAL ENGINEERING REPORT
PAVEMENT REHABILITATION ON SOUTH UNION PLACE
BETWEEN SOUTHWEST BOULEVARD AND WEST 41ST STREET
TULSA, OKLAHOMA

1. INTRODUCTION

1.1 GENERAL

Kleinfelder has completed the authorized subsurface exploration and geotechnical engineering evaluation for the proposed South Union Place Pavement Rehabilitation project located in Tulsa County, Oklahoma. The services provided were in general accordance with our proposal No. TUL14P10283 dated December 4, 2014. 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 Your 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

The proposed project is located on South Union Place between Southwest Boulevard and West 41st Street in Tulsa, Oklahoma. We understand that the proposed project consists of full depth reconstruction of the existing pavement. We also understand that South Union Place may be realigned by moving the western edge of the roadway five to ten feet eastwards to allow for construction of a sidewalk on the North bound side. The intersection at South Union Place and West 41st Street is also proposed to be improved with full depth reconstruction as part of this project.

The field investigations were performed for the purpose of determining the existing pavement thickness, subgrade soil properties and subsurface conditions below the existing pavement.
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 site is located on South Union Place, starting from Southwest Boulevard and extending south approximately 0.5 mile to West 41st Street in Tulsa, Oklahoma. The general location of the site is shown in Figure 1, Site Location Diagram. The existing South Union Place is a four-lane asphaltic concrete over Portland cement concrete road with little to no shoulder. The surrounding areas were mostly residential properties with few commercial properties. Existing overhead and underground utilities were noted within the existing right-of-way. Additional utilities may be anticipated within the proposed construction area.

2.2 SUBSURFACE CONDITIONS

Kleinfelder explored the subsurface conditions at the site by drilling and sampling 7 borings (P-1 through P-7) on June 19, 2015. Approximate boring locations are shown on Figure 2 Boring Location Diagram. The field exploration and laboratory testing programs are presented in APPENDIX A and APPENDIX B, respectively.

In general, the pavement cores consisted of approximately 1½ to 3¼ inches of Asphalt Concrete (AC) pavement over 6½ to 10⅝ inches of Portland Cement Concrete (PCC) pavement. In boring P-7, approximately 7 inches of PCC pavement was encountered over 7¼ inches of AC pavement. Beneath the pavement surface, approximately 2 to 6 inches of aggregate base materials were encountered in borings P-1, P-2 and P-4. Subsurface materials encountered underneath the pavement surface and aggregate base materials consisted of various combinations of clay, silt and sand. Specific subsurface conditions encountered at the boring locations are presented on the respective coring logs in APPENDIX A for all the borings. The thicknesses indicated on the logs represent the approximate boundaries between material types; in-situ, the transitions may vary or be gradual.

2.3 LABORATORY TESTING

Two samples were collected from each boring. One sample was generally obtained in the top 6 inches, with one additional sample collected in the bottom 60 inches provided the material had similar composition and consistency. Atterberg limit tests were performed on selected samples in each boring in accordance with AASHTO T-89 and T-90. Sieve analyses were performed on the same samples in accordance with AASHTO T-88. The soils were classified in accordance to the Unified Soil Classification System (USCS) (ASTM D2487), and the American Association of State Highway and Transportation Officials (AASHTO) soil classification system (AASHTO M-145) and are presented on the Summary of Laboratory Testing, included in APPENDIX B.

One composite sample, based on soil classifications, were prepared from the soils obtained from the borings. Moisture-Density relationship tests (Standard Proctor test) were performed in accordance with AASHTO T-99 on the composite sample of the materials encountered in the borings. The moisture-density test report, including curve, is included in APPENDIX B.

Resilient modulus tests were performed in accordance with AASHTO T-307 on the composite samples collected from the borings. Two tests were performed on the composite sample collected from the borings as follows:

- At approximately 95% of Standard Proctor moisture-density relationship maximum dry density and at optimum moisture content; and
- At approximately 95% of Standard Proctor moisture-density relationship maximum dry density and at wet side of the optimum moisture content.

A total of two resilient modulus tests were performed for this project. All the soils tested were Type 2, according to the test specification, and were tested with confining pressures of approximately 6.0, 4.0 and 2.0 psi. The results of the resilient modulus testing are included in APPENDIX B.

2.4 GROUNDWATER OBSERVATIONS

Groundwater observations were made both during and immediately following completion of drilling operations and no groundwater seepage was observed during our exploration. The materials encountered in the test borings have a wide range of permeability 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, creek level, 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

Based on the results of our evaluation, generally, approximately 1½ to 3¼ inches of AC pavement over 6½ to 10⁵/₈ inches of PCC pavement was encountered in the boring locations. Beneath the pavement surface, approximately 2 to 6 inches of aggregate base materials were encountered in some of the borings. Subsurface materials encountered underneath the pavement surface and aggregate base materials consisted of various combinations of clay, silt and sand. Geotechnical considerations identified for this project are the demolition of existing pavements and various thicknesses of pavement along the proposed alignment. Recommendations addressing the considerations 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 exploration. 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 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 GEOTECHNICAL CONSIDERATIONS

3.2.1 Demolition of Existing Pavement

Demolition of the existing pavements will be required during the initial phase of development. All debris associated with the demolition phase of the project should be removed from the site. Soil disturbed during demolition of the existing pavement will require undercutting to stable material prior to recompaction.

3.2.2 Various Thicknesses of Pavement

Various thicknesses/conditions of pavement were encountered in the borings. Approximately 1½ to 3¼ inches of AC pavement over 6½ to 10⁵/₈ inches of PCC pavement was encountered in the boring locations. . In boring P-7, approximately 7 inches of PCC pavement was encountered over

7¼ inches of AC pavement. Beneath the pavement surface, approximately 2 to 6 inches of aggregate base materials were encountered in borings P-1, P-2 and P-4. Aggregate base was not encountered at the other locations explored.

3.3 SITE DEVELOPMENT

3.3.1 Demolition

We anticipate initial site preparation for the proposed project will include demolition of the existing pavements down to the soil subgrade within proposed construction areas. All broken AC pavement, PCC pavement, and other debris from demolition should be removed from the site. Areas disturbed during demolition should be thoroughly evaluated by the geotechnical engineer prior to subgrade preparation for reconstruction and/or placement of structural fill. If grade changes are required for the proposed pavement re-construction, placement of structural fill may be needed to reach the final grades. All disturbed soils should be undercut to expose competent, undisturbed soil prior to placement of structural fill.

3.3.2 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. 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 the STRUCTURAL FILL section 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 proofrolling, 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 controlled structural fill.

3.3.3 Scarification, Moisture Conditioning, and Compaction

Prior to placement of structural fill, the moisture content of the exposed 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 proofrolling and/or fill placement. The moisture content of the exposed grade in these fill areas should be adjusted to within the range recommended for structural fill, 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. Suitable structural fill should be placed to design grade as soon as practical after reworking the subgrade to avoid moisture changes in the underlying soils.

3.3.4 Proofrolling

Following moisture conditioning and prior to placement of structural fill, it is recommended that the exposed grade be proofrolled. Proofrolling of the subgrade aids in identifying 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.

3.3.5 Construction Considerations

Soils with high silt contents are likely to become unstable with minor changes in moisture contents and/or repeated construction traffic. Close moisture control during compaction operations will be required to reduce the possibility that the soils will pump or become unstable.

3.4 CLIMATIC CONDITIONS

Weather conditions will influence the site preparation required. 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, removal of the wet materials and replacing them with dry materials, or treating the material with Portland cement, fly ash or cement kiln dust.

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

3.5 STRUCTURAL FILL

3.5.1 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 roadway areas within the upper 8 inches of the pavement subgrade should consist of a non-plastic to lower plasticity, sand, silty sand, clayey sand, silty clay, lean clay, clayey gravel, gravelly clay, or sandy lean clay type of soil with maximum Plasticity Index (PI) of 22 percent, as determined by the Atterberg limits test ASTM D4318, wet preparation procedure.

3.5.2 Compaction Criteria

Fill should be placed in lifts having a maximum loose lift thickness of 8 inches for compaction by self-propelled construction equipment. Thinner lifts will be required for smaller equipment. The lift thickness may need to be reduced, depending upon the type/size of compaction equipment utilized at the site. All fill should be compacted to a minimum of 95 percent of the material's maximum dry density as determined by ASTM D698 (standard Proctor compaction). If the plasticity index of the soils is greater than 12, the moisture content of the fill at time of compaction should be within a range of 0 percent to 4 percent above optimum moisture content as defined by the standard Proctor compaction procedure.

If the plasticity index of the soils is less than or equal to 12, the moisture content of the fill at time of compaction should be within a range of 2 percent below to 2 percent above optimum moisture content as defined by the standard Proctor compaction procedure. Moisture contents should be maintained within this range until completion of the project.

3.6 PAVEMENTS

3.6.1 General

We understand that the proposed new pavement will be designed and constructed in accordance with the traffic information provided and approved Dewberry via e-mail correspondence on July 30, 2015. The improvement program will consist of a new pavement construction. The following traffic information was approved and provided by Dewberry:

Functional Class .... Arterial
Design Life for New Pavement ....20 Years

project to
2016 @ 3% to 2036

Growth Rate 3%
Current Design ADT (2013) 7,600
Total Truck Traffic 3%

Kleinfelder assumed the following traffic data information for the subject project:

Directional Distribution..0.5
Lane Factor 0.75
Terminal Serviceability 2.5
Reliability..95%

The pavement design assumes that at least fair drainage will be provided. Kleinfelder performed the pavement design based on the provided traffic data information and in accordance with the AASHTO Guide for Design of Pavement Structures (1993).

3.6.2 New Pavements

Pavement subgrades should be prepared in accordance with the recommendations presented in the SITE DEVELOPMENT and STRUCTURAL FILL sections of this report. Construction scheduling, involving paving and grading by separate contractors, typically results in a time lapse between the end of grading operations and the commencement of paving. Disturbance, desiccation, and/or wetting of the subgrade between grading and paving can result in deterioration of the previously completed subgrade. A non-uniform subgrade can result in poor pavement performance and local failures relatively soon after pavements are constructed.

3.6.2.1 Flexible Pavement

The flexible pavement analysis is based on the following variables:

Resilient Modulus of Subgrade .... 4,000 psi
Drainage Factor...1.0
Initial Serviceability...4.2
Standard Deviation..0.45
Structural Coefficient of HMA 0.44
Structural Coefficient of Aggregate Base 0.14

Based on the provided traffic information, new flexible pavements should be designed using a total Equivalent Single Axle Load (ESAL) of 2 million for a 20-year design life. Using that design ESAL value and the design variable values stated above, the following pavement sections in Table 3-1 are recommended for the new flexible pavement:

76-28 or 70-28

Table 3-1. Recommended New Flexible Pavement Section			
Subgrade Soil Type	**Type of Flexible Pavement**	**Thickness (inches)**	**ODOT Specifications**
Lean Clay RM = 4,000 psi	AC Type S4 w/ PG-64-22 AC Type S3 w/ PG-64-22 AC Type S3 w/ PG-64-22 ODOT Type "A" Aggregate Base Geotextile Separator Fabric Recompacted Subgrade	2.0 3.0 3.0 12.0 - 8.0	411 & 708 411 & 708 411 & 708 303 & 703 402 & 712 310

The geotextile separator fabric is recommended to prevent loss of aggregate base support caused by the aggregate penetrating the subgrade. Proper care should be taken when placing the geotextile separator to ensure the fabric is not punctured or torn.

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" (2009).

3.6.2.2 Rigid Pavement

The rigid pavement analysis is based on the following variables:

- Resilient Modulus of Subgrade .... 4,000 psi
- Drainage Coefficient 1.0
- Standard Deviation 0.35
- Joint Factor of Rigid Slabs 2.7
- Minimum Flexural Strength of Concrete .... 650 psi
- Modulus of Elasticity of Concrete .... 4,400 ksi

Based on the provided traffic information, new rigid pavements (PCC) should be designed for a total ESAL of 3.4 million for a 20-year design life. Using this total ESAL value and the design variable values stated above, the following pavement section is recommended for the new rigid pavement:

Table 3-2. Minimum Portland Cement Concrete (PCC) Design Thickness, inches
8.0 Jointed Plain Concrete Pavement w/ Dowels (JPCP) 12.0 ODOT Type "A" Aggregate Base Geotextile Separator Fabric 8.0 Recompacted Subgrade

The geotextile separator fabric is recommended to prevent loss of aggregate base support caused by the aggregate penetrating the subgrade. Proper care should be taken when placing the geotextile separator to ensure the fabric is not punctured or torn.

Handling and placing of pavement materials should be performed in accordance to the procedures specified by the Oklahoma Department of Transportation (ODOT) "Standard Specifications for Highway Construction" (2009).

3.6.3 Pavement Construction Considerations

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 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.

CoT typically uses pavement Edge Drain

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 designs should be reconsidered to include the effects of the additional traffic loading.

4. ADDITIONAL SERVICES

4.1 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.

4.2 CONSTRUCTION OBSERVATION AND TESTING

As the geotechnical engineering firm that performed the geotechnical evaluation for this project, Kleinfelder should be retained to confirm that the recommendations of this report are properly incorporated in the design of this project, and properly implemented during construction. This may avoid misinterpretation of the information by other parties and will allow us to review and modify our recommendations if variations in the soil conditions are encountered. As a minimum Kleinfelder should be retained to provide the following continuing services for the project:

- Review the project plans and specifications, including any revisions or modifications,
- Observe and evaluate the site earthwork operations to confirm subgrade soils are suitable for construction of pavements, and placement of engineered fill,
- Confirm engineered fill for the pavement and other improvements is placed and compacted per the project specifications..

5. 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.

FIGURES

FIGURE 1. SITE LOCATION DIAGRAM
FIGURE 2. BORING LOCATION DIAGRAM

Source: USDA

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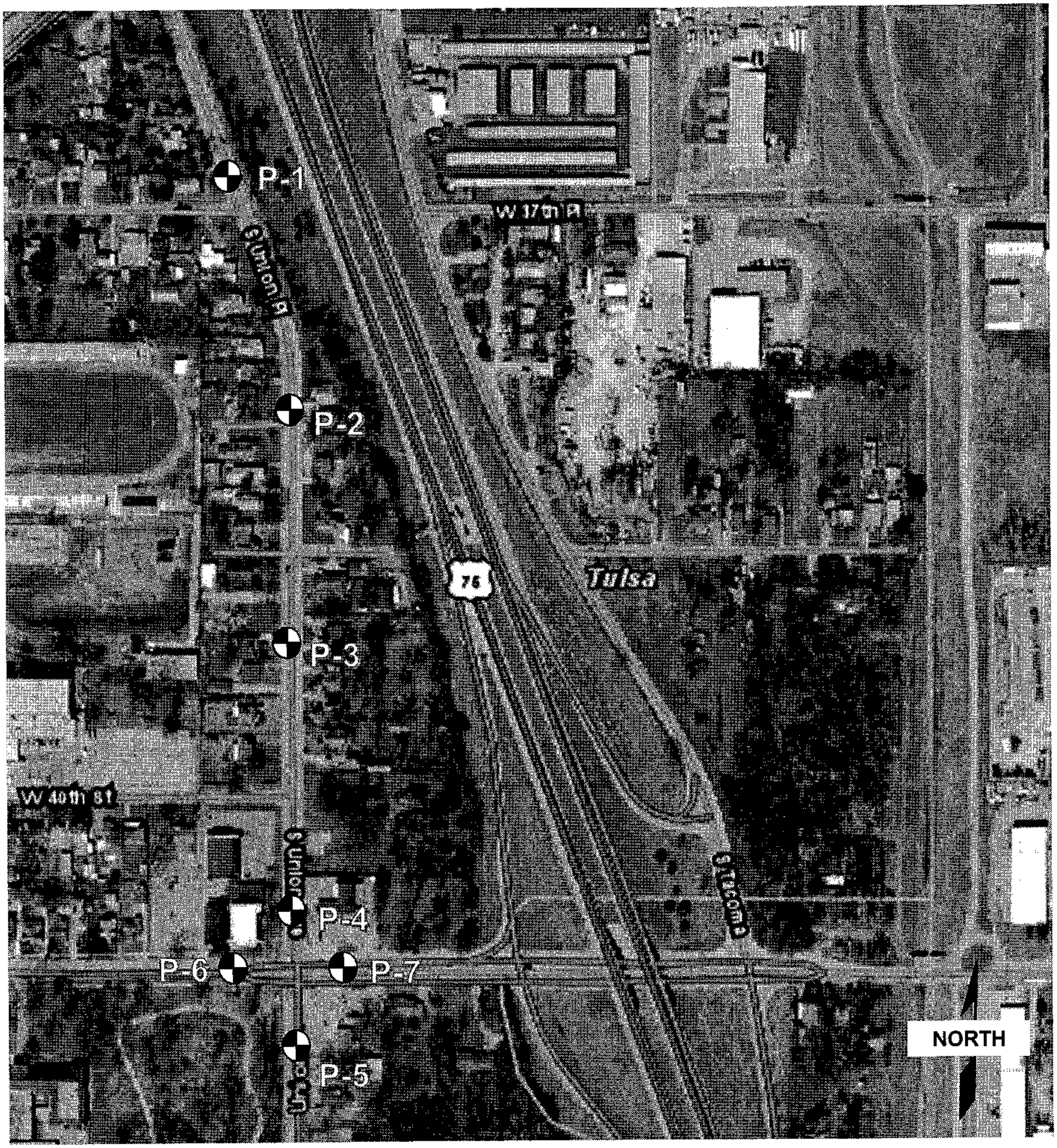
20161079	

SITE LOCATION DIAGRAM

PAVEMENT REHABILITATION ON SOUTH UNION PLACE
BETWEEN SOUTHWEST BOULEVARD
AND WEST 41ST STREET
TULSA, OKLAHOMA

FIGURE

1



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BORING LOCATION DIAGRAM

PAVEMENT REHABILITATION ON SOUTH UNION PLACE
BETWEEN SOUTHWEST BOULEVARD
AND WEST 41ST STREET
TULSA, OKLAHOMA

FIGURE

2

APPENDIX A

FIELD EXPLORATION PROGRAM

APPENDIX A
FIELD EXPLORATION PROGRAM

DRILLING & SAMPLING PROCEDURES

Kleinfelder conducted the field work for this study on June 19, 2015. The exploration consisted of 7 borings drilled near the locations shown on Figure 2, Boring Location Diagram. The borings were terminated at approximate depth of 5 feet below the bottom of pavement. The approximate boring locations are indicated in the following table.

Boring Number	Direction	Approximate Boring Location	GPS Location	
			Latitude	Longitude
P-1	NB Lane	17 ft. E. of CRL, Approx. 100 ft, N. of the Intersection of 37th Pl. & Union Pl.	36.10900	-96.01195
P-2	SB Lane	16 ft. W. of CRL, Approx. 65 ft. N. of the Intersection of 38th St. & Union Pl.	36.10771	-96.01160
P-3	NB Lane	15 ft. E. of CRL, Approx. 325 ft. N. of the Intersection of 40th St. & Union Pl.	36.10625	-96.01152
P-4	SB Lane	16 ft. W. of CRL, Approx. 180 ft. N. of the Intersection of 41st St. & Union Pl.	36.10487	-96.01161
P-5	NB Lane	15 ft. E. of CRL, Approx. 200 ft. S. of the Intersection of 41st St. & Union Pl.	36.10384	-96.01153
P-6	EB Lane on 41st Street	15 ft. S. of CRL, Approx. 225 ft. W. of the Intersection of 41st St. & Union Pl.	36.10439	-96.01234
P-7	WB Lane on 41st Street	30 ft. N. of CRL, Approx. 165 ft. E. of the Intersection of 41st St. & Union Pl.	36.10448	-96.01102

Representatives of Kleinfelder established the boring locations in the field. These locations were identified in the field by using a handheld Global Positioning System (GPS) with an accuracy of 10-foot. 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 then advanced with a solid flight auger to 5 feet below the bottom of the pavement or auger refusal. In boring P-4, a tunnel or storm drain was encountered during the coring operations at a depth of approximately 14 inches below surface. Approximately $3^3/_8$ inches of AC pavement over $10^5/_8$

inches of PCC pavement was encountered in this boring. However, the concrete pavement fell through the void encountered, and therefore, could not be recovered. Coring 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 the drill crew. Field logs included visual classification of the materials encountered during drilling, as well as drilling characteristics. Our final coring logs represent the engineer's interpretation of the field data combined with laboratory observation and testing of the samples. Stratification boundaries indicated on the coring 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 June 19, 2015
GPS 36.10900° N / -96.01195° W

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

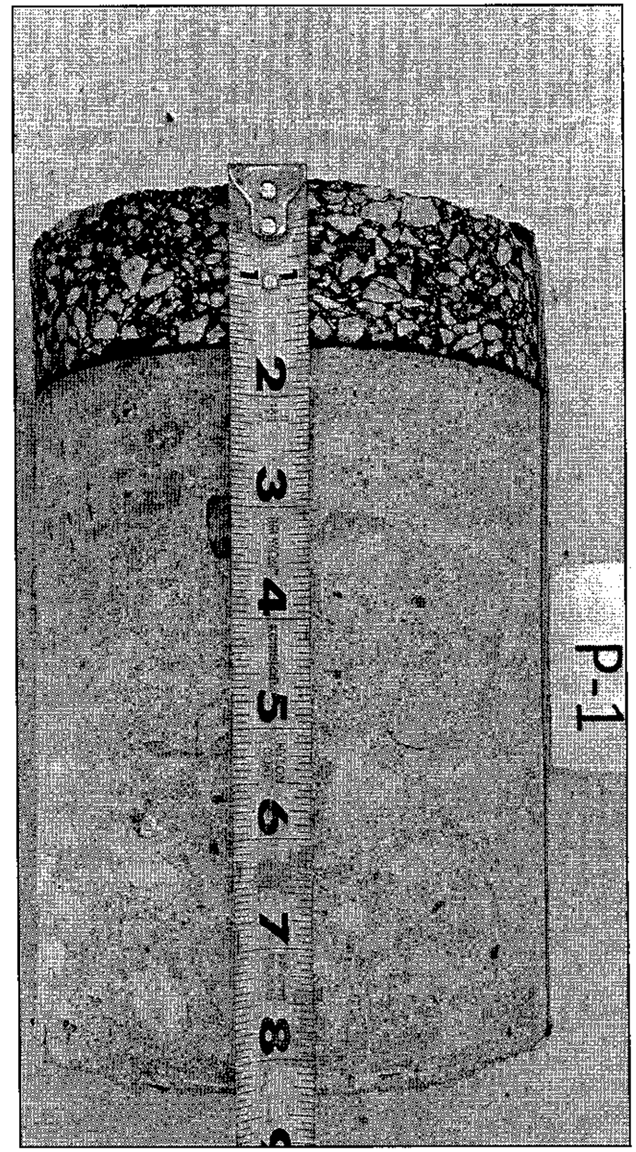
CORE LAYER DATA (FROM TOP TO BOTTOM):

Core No.	Layer Type	Layer Characteristics*	Layer Thickness (in)
P-1	ASPHALTIC CONCRETE		1-1/2
	PORTLAND CEMENT CONCRETE		6-7/8
	Total Core Thickness		**8-3/8**

BASE / SUBGRADE LAYER DATA (FROM BELOW CORES):

Sample No.	Layer Type	Layer Depth (in)
	AGGREGATE BASE:	0 to 6
1A	Lean CLAY with Sand (CL): brown, dark gray and tan LL=34, PL=14, PI=20, #200=78%	6 to 12
1B	Silty CLAY (CL-ML): brown and dark brown	12 to 66

TOP



REMARKS:
- * Asphalt type based on visual observation only.

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PROJECT NO.: 20161079
DRAWN BY: BJM
CHECKED BY: NH
DATE: 6/29/2015
REVISED: -

PAVEMENT CORING LOG P-1

Pavement Rehab. on S. Union Pl.
Between SW Blvd and W. 41st Street
Tulsa, Oklahoma

CORE
P-1

PROJECT / LOCATION DATA:

CORE DATE June 19, 2015
GPS 36.10771° N / -96.01160° W

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

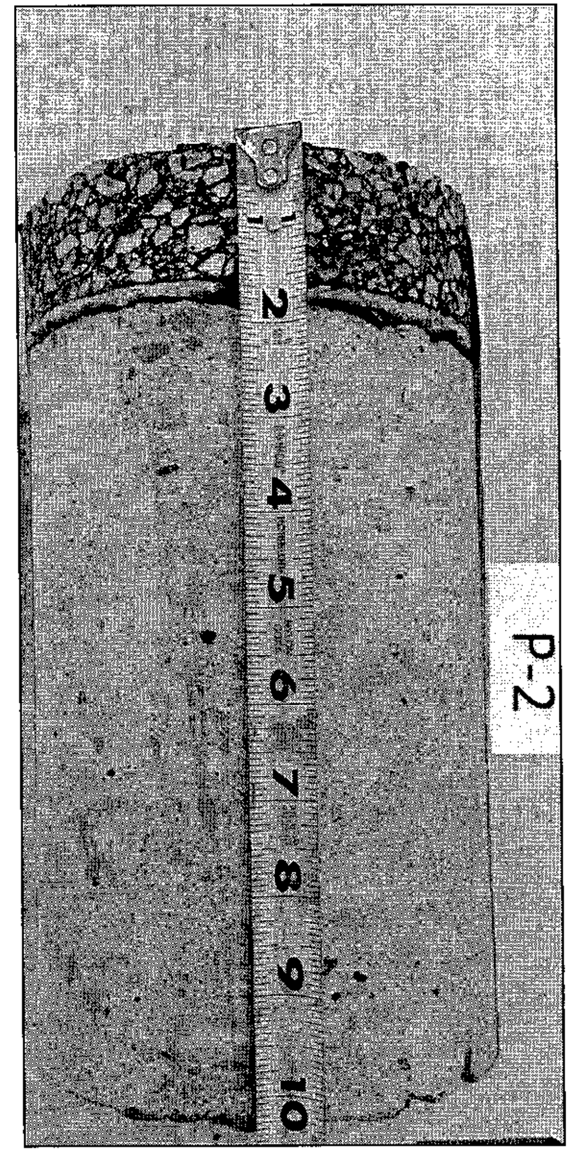
CORE LAYER DATA (FROM TOP TO BOTTOM):

Core No.	Layer Type	Layer Characteristics*	Layer Thickness (in)
P-2	ASPHALTIC CONCRETE		1-1/2
	PORTLAND CEMENT CONCRETE		8-1/2
	Total Core Thickness		**10**

BASE / SUBGRADE LAYER DATA (FROM BELOW CORES):

Sample No.	Layer Type	Layer Depth (in)
	AGGREGATE BASE:	0 to 6
2A	FILL, Lean CLAY: dark brown and dark gray	6 to 12
2B	Lean CLAY (CL): dark brown LL=25, PL=17, PI=8, #200=85%	12 to 66

TOP



REMARKS:
- * Asphalt type based on visual observation only.

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DATE:	6/29/2015
REVISED:	-

PAVEMENT CORING LOG P-2

Pavement Rehab. on S. Union Pl.
Between SW Blvd and W. 41st Street
Tulsa, Oklahoma

CORE
P-2

PROJECT / LOCATION DATA:

CORE DATE June 19, 2015
GPS 36.10625° N / -96.01152° W

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

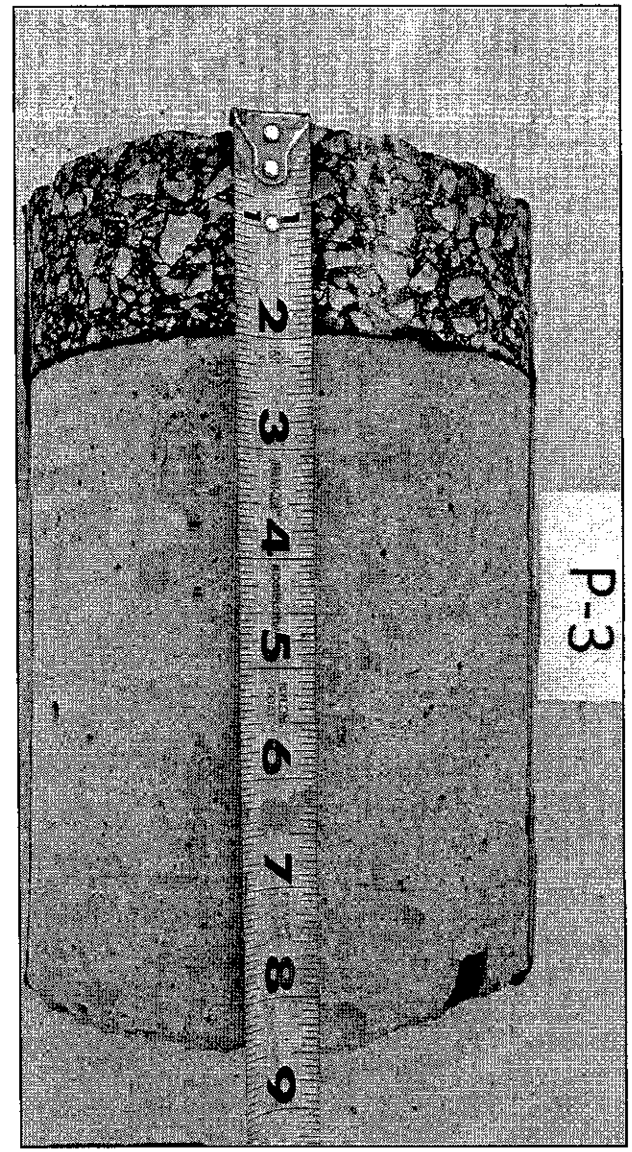
CORE LAYER DATA (FROM TOP TO BOTTOM):

Core No.	Layer Type	Layer Characteristics*	Layer Thickness (in)
P-3	ASPHALTIC CONCRETE		2
	PORTLAND CEMENT CONCRETE		6-1/2
	Total Core Thickness		**8-1/2**

BASE / SUBGRADE LAYER DATA (FROM BELOW CORES):

Sample No.	Layer Type	Layer Depth (in)
3A	FILL, Sandy SILT: tan and brown LL=NP, PL=NP, PI=NP, #200=65%	0 to 6
3B	Lean CLAY with Sand (CL): tan and brown LL=25, PL=15, PI=10, #200=76%	6 to 60

TOP



REMARKS:
- * Asphalt type based on visual observation only.

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PROJECT NO.:	20161079
DRAWN BY:	BJM
CHECKED BY:	NH
DATE:	6/29/2015
REVISED:	-

PAVEMENT CORING LOG P-3

Pavement Rehab. on S. Union Pl.
Between SW Blvd and W. 41st Street
Tulsa, Oklahoma

CORE
P-3

PROJECT / LOCATION DATA:

CORE DATE June 19, 2015
GPS 36.10487° N / -96.01161° W

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

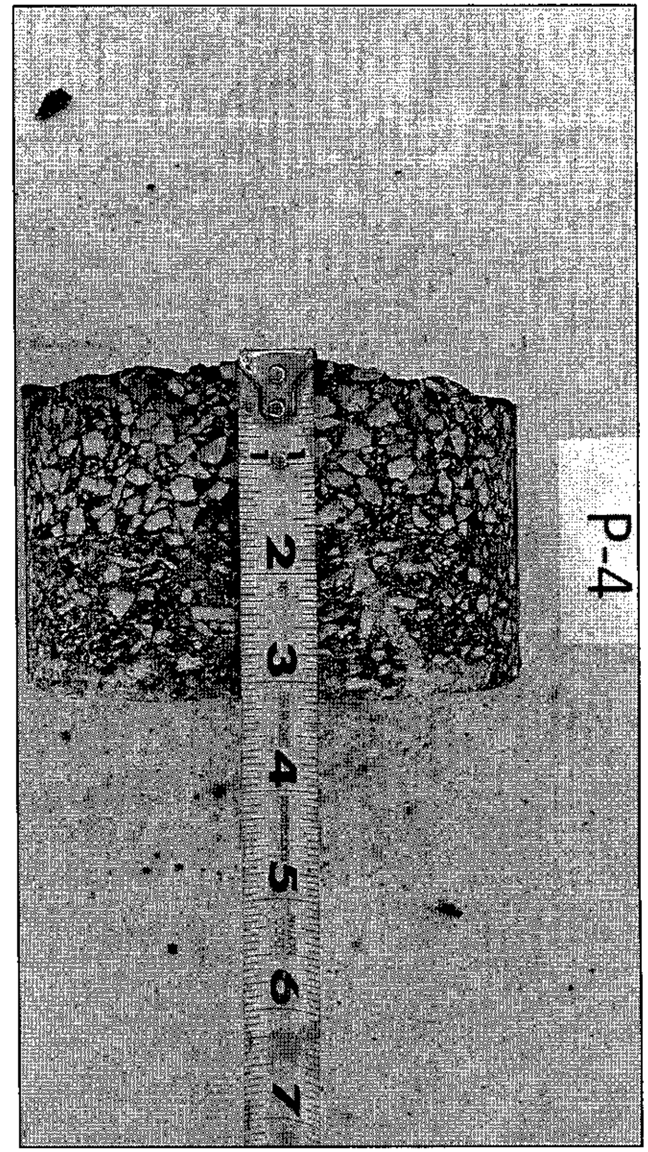
CORE LAYER DATA (FROM TOP TO BOTTOM):

Core No.	Layer Type	Layer Characteristics*	Layer Thickness (in)
P-4	ASPHALTIC CONCRETE		3-1/4
	PORTLAND CEMENT CONCRETE		10-5/8
	Total Core Thickness		**13-7/8**

BASE / SUBGRADE LAYER DATA (FROM BELOW CORES):

Sample No.	Layer Type	Layer Depth (in)
	VOID: tunnel or storm drain	0 to 41

TOP



REMARKS:
- * Asphalt type based on visual observation only.
** The portland cement concrete fell through the void encountered. Therefore it could not be recovered. Thickness of the PCC pavement is estimated from the boring.

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PROJECT NO.:	20161079
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CHECKED BY:	NH
DATE:	6/29/2015
REVISED:	-

PAVEMENT CORING LOG P-4

Pavement Rehab. on S. Union Pl.
Between SW Blvd and W. 41st Street
Tulsa, Oklahoma

CORE
P-4

PROJECT / LOCATION DATA:

CORE DATE June 19, 2015
GPS 36.10384° N / -96.01153° W

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

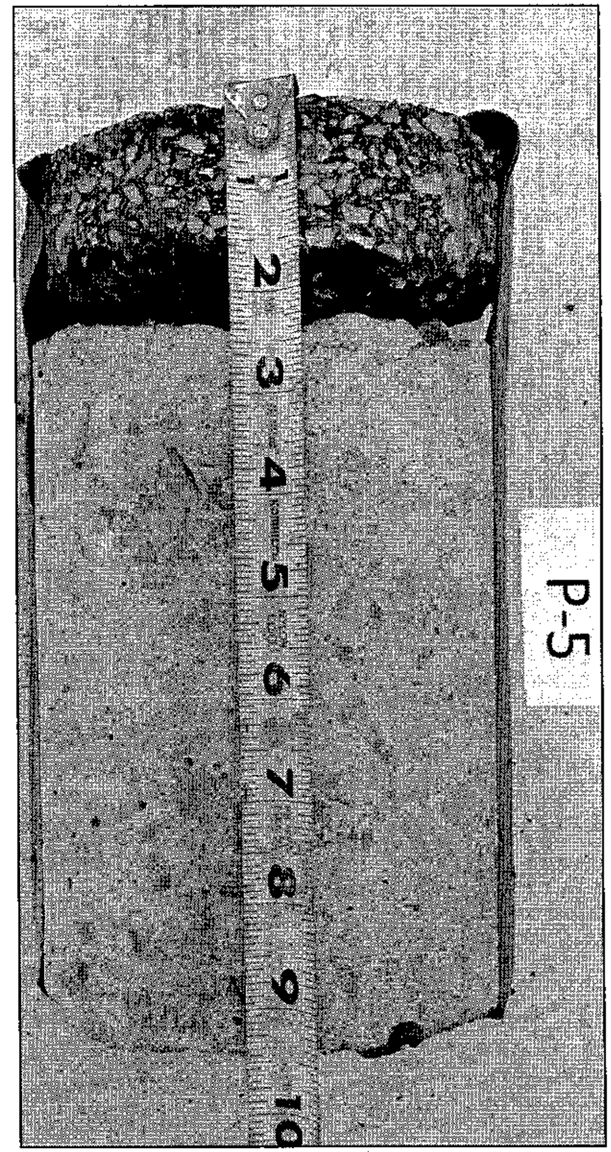
CORE LAYER DATA (FROM TOP TO BOTTOM):

Core No.	Layer Type	Layer Characteristics*	Layer Thickness (in)
P-5	ASPHALTIC CONCRETE		2
	PORTLAND CEMENT CONCRETE		7-1/2
	Total Core Thickness		**9-1/2**

BASE / SUBGRADE LAYER DATA (FROM BELOW CORES):

Sample No.	Layer Type	Layer Depth (in)
	AGGREGATE BASE:	0 to 2
5A	Sandy Lean CLAY (CL): dark gray, brown and dark brown LL=34, PL=16, PI=18, #200=60%	2 to 8
5B	Silty CLAY (CL-ML): dark gray, brown and dark brown	8 to 62

TOP



REMARKS:
- * Asphalt type based on visual observation only.

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PROJECT NO.:	20161079
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CHECKED BY:	NH
DATE:	6/29/2015
REVISED:	-

PAVEMENT CORING LOG P-5

Pavement Rehab. on S. Union Pl.
Between SW Blvd and W. 41st Street
Tulsa, Oklahoma

CORE
P-5

PROJECT / LOCATION DATA:

CORE DATE June 19, 2015
GPS 36.10439° N / -96.01234° W

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

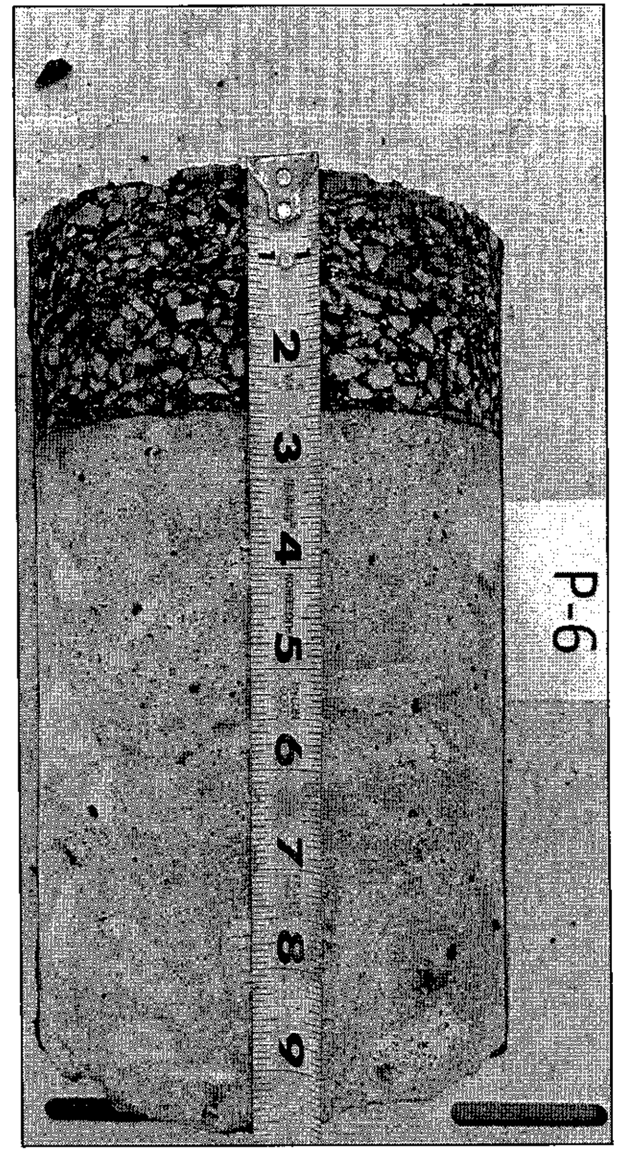
CORE LAYER DATA (FROM TOP TO BOTTOM):

Core No.	Layer Type	Layer Characteristics*	Layer Thickness (in)
P-6	ASPHALTIC CONCRETE		2-3/8
	PORTLAND CEMENT CONCRETE		7
	Total Core Thickness		9-3/8

BASE / SUBGRADE LAYER DATA (FROM BELOW CORES):

Sample No.	Layer Type	Layer Depth (in)
6A	FILL, Lean CLAY: dark brown and dark gray	0 to 6
6B	Lean CLAY (CL): brown, tan and yellowish brown LL=32, PL=17, PI=15, #200=90%	6 to 60

TOP



REMARKS:
- * Asphalt type based on visual observation only.

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CHECKED BY:	NH
DATE:	6/29/2015
REVISED:	-

PAVEMENT CORING LOG P-6

Pavement Rehab. on S. Union Pl.
Between SW Blvd and W. 41st Street
Tulsa, Oklahoma

CORE
P-6

PROJECT / LOCATION DATA:

CORE DATE June 19, 2015
GPS 36.10448° N / -96.01102° W

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

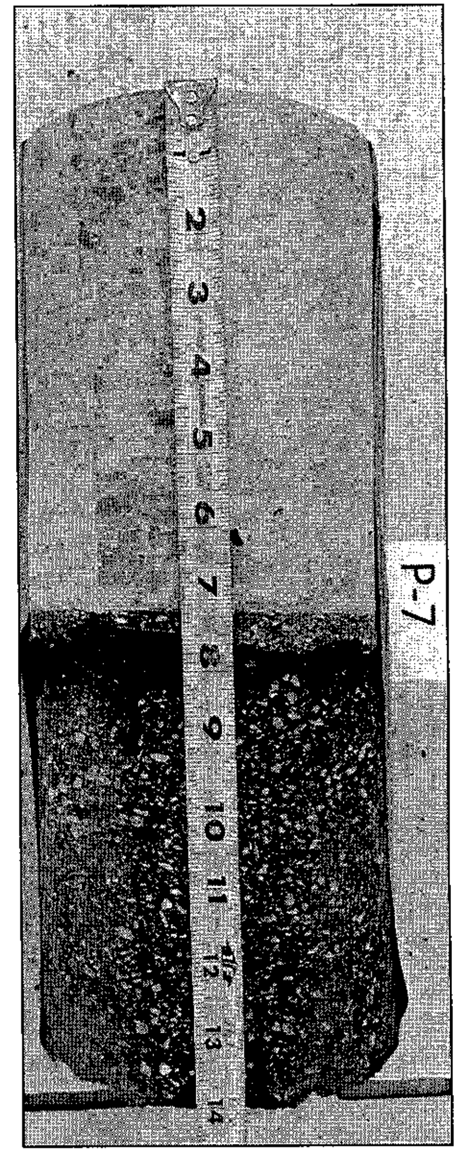
CORE LAYER DATA (FROM TOP TO BOTTOM):

Core No.	Layer Type	Layer Characteristics*	Layer Thickness (in)
P-7	PORTLAND CEMENT CONCRETE		7
	ASPHALTIC CONCRETE		7-1/4
	Total Core Thickness		1□-1/□

BASE / SUBGRADE LAYER DATA (FROM BELOW CORES):

Sample No.	Layer Type	Layer Depth (in)
7A	Lean CLAY with Sand (CL): brown and olive green LL=36, PL=16, PI=20, #200=84%	0 to 6
7B	Lean CLAY (CL): brown and tannish brown	6 to 60

TOP



REMARKS:
- * Asphalt type based on visual observation only.

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PAVEMENT CORING LOG P-7

Pavement Rehab. on S. Union Pl.
Between SW Blvd and W. 41st Street
Tulsa, Oklahoma

CORE
P-7

APPENDIX B

LABORATORY TESTING PROGRAM

APPENDIX B
LABORATORY TESTING PROGRAM

GENERAL

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-lb) 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).

Exploration ID	Depth (ft.)	Sample No.	Sample Description	USCS	AASHTO	OKLAHOMA SOIL INDEX (OSI)	Water Content (%)	Atterberg Limits			Sieve Analysis (%)				
								Liquid Limits	Plastic Limits	Plasticity Index	Passing #4	Passing #10	Passing #40	Passing #100	Passing #200
1	0.5 - 1.0	1A	LEAN CLAY WITH SAND	CL	A-6		21.7	34	14	20	98	96	88	81	78
2	0.8 - 5.3		LEAN CLAY	CL	A-4		18.4	25	17	8	100	99	97	89	85
3	0.0 - 0.5	3A	SANDY SILT	ML	A-4		15.8	NP	NP	NP	99	98	89	68	65
3	0.5 - 5.0	3B	LEAN CLAY WITH SAND	CL	A-4		15.7	25	15	10	100	100	95	82	76
5	0.2 - 0.7	5A	SANDY LEAN CLAY	CL	A-6		22.1	34	16	18	90	84	72	62	60
6	0.5 - 5.0	6B	LEAN CLAY	CL	A-6		19.9	32	17	15	100	99	98	92	90
7	0.0 - 0.5	7A	LEAN CLAY WITH SAND	CL	A-6		25.9	36	16	20	98	95	89	86	84
Composite	1.0		LEAN CLAY	CL	A-6			30	16	14	100	99	96	91	88

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

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PROJECT NO.: 20161079
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DATE: 6/29/2015
REVISED: -

LABORATORY TEST RESULT SUMMARY

Pavement Rehab. on S. Union Pl.
Between SW Blvd and W. 41st Street
Tulsa, Oklahoma

TABLE
B-1

Resilient Modulus of Subgrade Soils (Recompacted Samples)

1. Project Number	Pavement Rehab on South Union Places (btw Southwest Blvd & 41st Street)
2. County//State Name	n/a // Oklahoma
3. Test Date	7/24/2015
4.Sample Number	Mr1 (Compacted @ OMC)
5. Material Type	2
6. Soil Series	n/a
7. Horizon	B

8. Specimen Properties

Compaction Water content, wc, %	15.23
Compaction Dry Density, pcf	106.32
Moisture Content After Mr Test, w(%)	15.02
Permanent Deformation (in)	0.09

9. Soil Properties

Optimum Moisture Content, (%)	15.00
Maximum Dry Density, pcf	111.00
95% MDD (pcf)	105.45

10. Test Information

Preconditioning-Permanent Strain>5%	No
Testing-Permanent Strain >5%	No
Number of Load Sequences Completed	15
Quick Shear Test	No

Column #	1	2	3	4	5	6	7	8	9	10	11	12	13
Parameter	Chamber Confining Pressure	Nominal Maximum Axial Stress	Actual Applied Max. Axial Load	Actual Applied Cyclic Load	Actual Applied Contact Load	Actual Applied Max. Axial Stress	Actual Applied Cyclic Stress	Actual Applied Contact Stress	Recov. Def. LVDT # 1 Reading	Recov. Def. LVDT # 2 Reading	Average Recov. Def. LVDT 1 & 2	Resilient Strain	Resilient Modulus
Designation	S3	Scyclic	Pmax	Pcyclic	Pcontact	Smax	Scyclic	Scontact	H1	H2	Havg	er	Mr
Unit	psi	psi	lbs	lbs	lbs	psi	psi	psi	in	in	in	in/in	psi
Precision	—	—	—	—	—	—	—	—	—	—	—	—	—
Sequence 1	6	2	12.38	11.03	1.36	2.01	1.79	0.22	0.0011	0.0010	0.0011	0.00019	9438
Sequence 2	6	4	24.64	22.11	2.53	4.00	3.59	0.41	0.0025	0.0022	0.0024	0.00043	8427
Sequence 3	6	6	36.96	33.14	3.82	6.00	5.38	0.62	0.0040	0.0036	0.0038	0.00067	8001
Sequence 4	6	8	48.79	44.41	4.37	7.92	7.21	0.71	0.0054	0.0049	0.0052	0.00092	7819
Sequence 5	6	10	61.60	55.50	6.10	10.00	9.01	0.99	0.0072	0.0065	0.0068	0.00122	7399
Sequence 6	4	2	12.38	11.21	1.17	2.01	1.82	0.19	0.0012	0.0011	0.0012	0.00021	8738
Sequence 7	4	4	24.52	22.11	2.40	3.98	3.59	0.39	0.0025	0.0023	0.0024	0.00043	8437
Sequence 8	4	6	36.71	33.14	3.57	5.96	5.38	0.58	0.0041	0.0036	0.0038	0.00068	7891
Sequence 9	4	8	49.03	44.23	4.80	7.96	7.18	0.78	0.0058	0.0052	0.0055	0.00098	7318
Sequence 10	4	10	61.05	55.56	5.48	9.91	9.02	0.89	0.0076	0.0071	0.0073	0.00131	6881
Sequence 11	2	2	12.26	11.03	1.23	1.99	1.79	0.20	0.0013	0.0012	0.0013	0.00023	7889
Sequence 12	2	4	24.70	22.30	2.40	4.01	3.62	0.39	0.0029	0.0026	0.0027	0.00049	7431
Sequence 13	2	6	37.14	33.51	3.63	6.03	5.44	0.59	0.0045	0.0042	0.0043	0.00078	7010
Sequence 14	2	8	49.10	44.29	4.80	7.97	7.19	0.78	0.0061	0.0057	0.0059	0.00105	6819
Sequence 15	2	10	61.35	55.38	5.98	9.96	8.99	0.97	0.0084	0.0076	0.0080	0.00142	6311

* Reported results are based on the average of the last 5 cycles of each load sequence

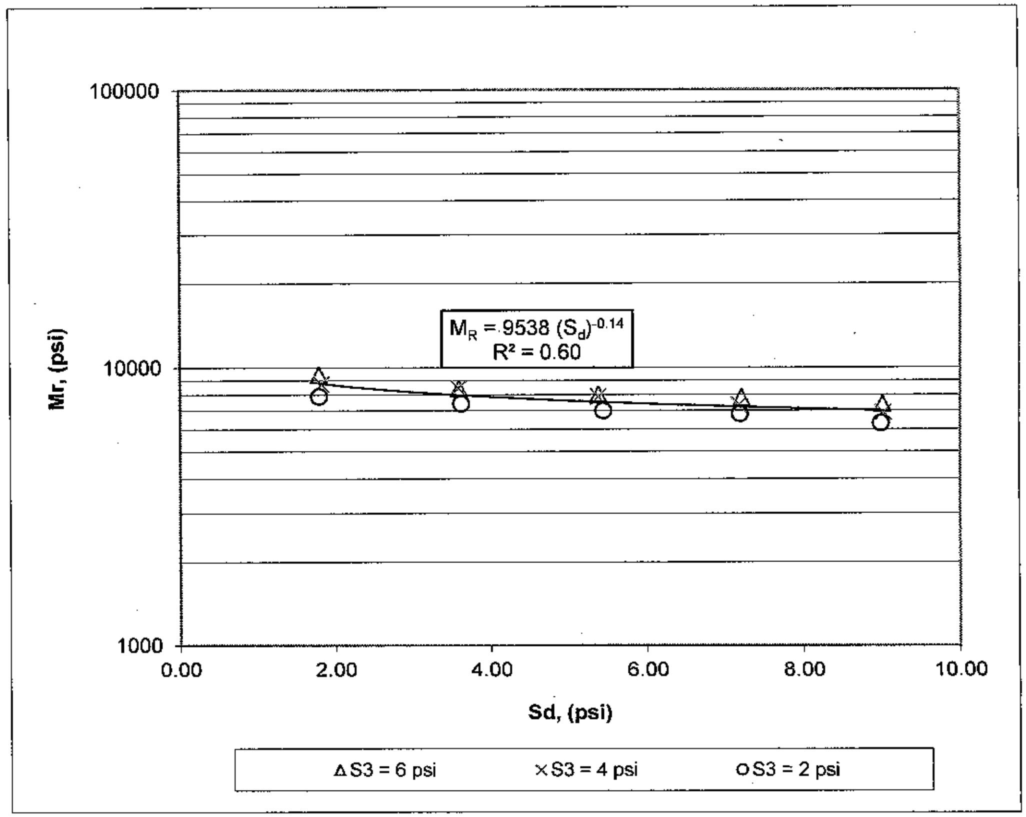
Resilient Modulus of Subgrade Soils (Recompacted Samples)

(Plot)

1. Sample Number	Mr1 (Compacted @ OMC)
2. Material Type	2
3. Soil Series	n/a
4. Horizon	B
5. Test Date	7/24/2015

Column #	1	**2**	3	4	**5**
Parameter	Chamber Confining Pressure	**Desired Applied Cyclic Stress**	Actual Applied Cyclic Stress	Actual Resilient Modulus	**Predicted Resilient Modulus***
Designation	S3	**Scyclic**	Scyclic	Mr	**Mr**
Unit	psi	**psi**	psi	psi	**psi**
Precision	—	—	—	—	—
Sequence 1	6	**1.80**	1.79	9438	**8784**
Sequence 2	6	**3.60**	3.59	8427	**7970**
Sequence 3	6	**5.40**	5.38	8001	**7529**
Sequence 4	6	**7.20**	7.21	7819	**7232**
Sequence 5	6	**9.00**	9.01	7399	**7009**
Sequence 6	4	**1.80**	1.82	8738	**8784**
Sequence 7	4	**3.60**	3.59	8437	**7970**
Sequence 8	4	**5.40**	5.38	7891	**7529**
Sequence 9	4	**7.20**	7.18	7318	**7232**
Sequence 10	4	**9.00**	9.02	6881	**7009**
Sequence 11	2	**1.80**	1.79	7889	**8784**
Sequence 12	2	**3.60**	3.62	7431	**7970**
Sequence 13	2	**5.40**	5.44	7010	**7529**
Sequence 14	2	**5.40**	7.19	6819	**7529**
Sequence 15	2	**5.40**	8.99	6311	**7529**

*Predicted Mr values at the desired applied cyclic stresses using Model



Model #1; $Mr = K1 \times Sd^{K2}$

S3 (psi)	K1	K2	R^2
6	10218	-0.14	0.99
4	9833	-0.15	0.90
2	8631	-0.13	0.94
All	9538	-0.14	0.60

Resilient Modulus of Subgrade Soils (Recompacted Samples)

1. Project Number	Pavement Rehab on South Union Places (btw Southwest Blvd & 41st
2. County//State Name	n/a // Oklahoma
3. Test Date	7/24/2015
4.Sample Number	Mr1 (Compacted Wetter of OMC)
5. Material Type	2
6. Soil Series	n/a
7. Horizon	B

9. Soil Properties

Optimum Moisture Content, (%)	15.00
Maximum Dry Density, pcf	111.00
95% MDD (pcf)	105.45

8. Specimen Properties

Compaction Water content, wc, %	18.01
Compaction Dry Density, pcf	106.58
Moisture Content After Mr Test, w(%)	17.98
Permanent Deformation (in)	0.400

10. Test Information

Preconditioning-Permanent Strain>5%	No
Testing-Permanent Strain >5%	Yes
Number of Load Sequences Completed	15
Quick Shear Test	No

Column #	1	2	3	4	5	6	7	8	9	10	11	12	13
Parameter	Chamber Confining Pressure	Nominal Maximum Axial Stress	Actual Applied Max. Axial Load	Actual Applied Cyclic Load	Actual Applied Contact Load	Actual Applied Max. Axial Stress	Actual Applied Cyclic Stress	Actual Applied Contact Stress	Recov. Def. LVDT # 1 Reading	Recov. Def. LVDT # 2 Reading	Average Recov. Def. LVDT 1 & 2	Resilient Strain	Resilient Modulus
Designation	S3	Scyclic	Pmax	Pcyclic	Pcontact	Smax	Scyclic	Scontact	H1	H2	Havg	er	Mr
Unit	psi	psi	lbs	lbs	lbs	psi	psi	psi	in	in	in	in/in	psi
Precision	—	—	—	—	—	—	—	—	—	—	—	—	—
Sequence 1	6	2	11.95	10.66	1.29	1.94	1.73	0.21	0.0020	0.0017	0.0019	0.00033	5215
Sequence 2	6	4	23.96	21.50	2.46	3.89	3.49	0.40	0.0043	0.0040	0.0042	0.00074	4708
Sequence 3	6	6	35.73	32.71	3.02	5.80	5.31	0.49	0.0070	0.0063	0.0066	0.00118	4494
Sequence 4	6	8	48.85	43.86	4.99	7.93	7.12	0.81	0.0097	0.0095	0.0096	0.00171	4162
Sequence 5	6	10	60.92	54.82	6.10	9.89	8.90	0.99	0.0139	0.0127	0.0133	0.00237	3752
Sequence 6	4	2	12.07	10.78	1.29	1.96	1.75	0.21	0.0022	0.0020	0.0021	0.00037	4701
Sequence 7	4	4	23.78	21.38	2.40	3.86	3.47	0.39	0.0045	0.0041	0.0043	0.00077	4501
Sequence 8	4	6	35.79	32.77	3.02	5.81	5.32	0.49	0.0077	0.0070	0.0073	0.00131	4058
Sequence 9	4	8	47.99	43.67	4.31	7.79	7.09	0.70	0.0110	0.0101	0.0105	0.00188	3765
Sequence 10	4	10	60.49	55.01	5.48	9.82	8.93	0.89	0.0154	0.0137	0.0145	0.00259	3441
Sequence 11	2	2	11.64	10.60	1.05	1.89	1.72	0.17	0.0025	0.0022	0.0024	0.00042	4076
Sequence 12	2	4	24.09	21.93	2.16	3.91	3.56	0.35	0.0056	0.0050	0.0053	0.00095	3761
Sequence 13	2	6	37.58	33.33	4.25	6.10	5.41	0.69	0.0089	0.0083	0.0086	0.00154	3514
Sequence 14**	2	8	48.79	43.80	4.99	7.92	7.11	0.81	0.0134	0.0123	0.0129	0.00230	3094
Sequence 15	2	10	60.61	55.07	5.54	9.84	8.94	0.90	0.0191	0.0174	0.0183	0.00326	2743

* Reported results are based on the average of the last 5 cycles of each load sequence

Permament deformation exceeded 5% - test continued to provide pavement engineer with additional data

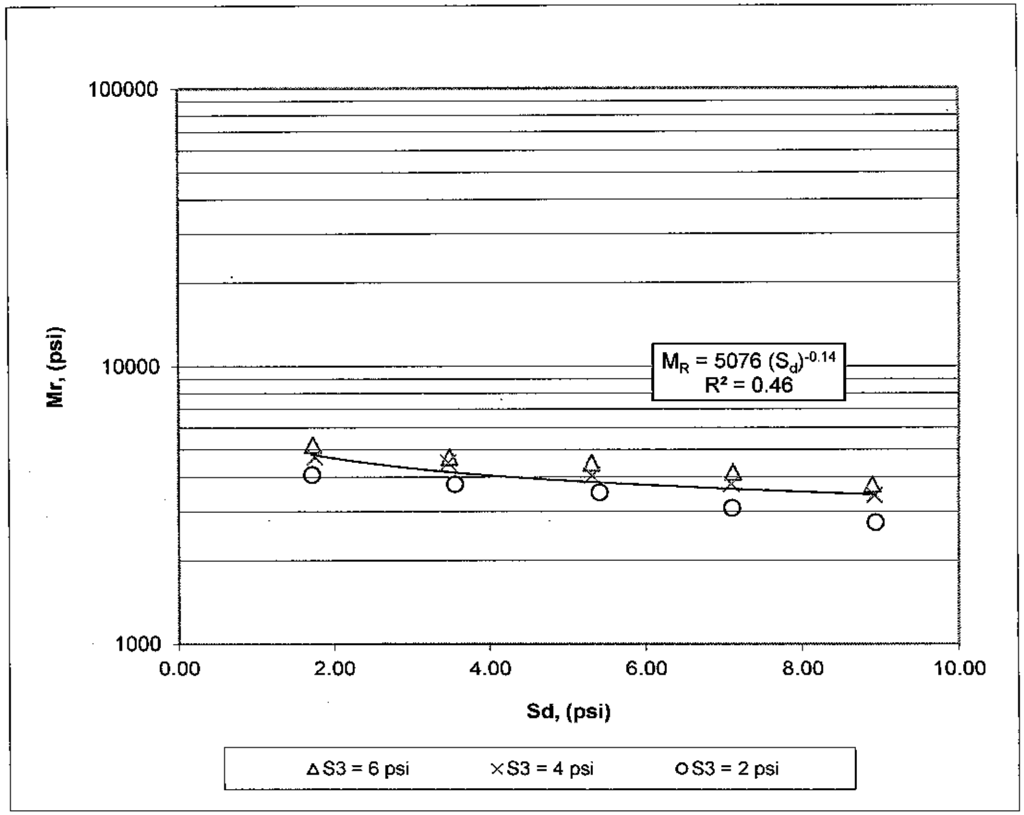
Resilient Modulus of Subgrade Soils (Recompacted Samples)

(Plot)

1. Sample Number	Mr1 (Compacted Wetter of OMC)
2. Material Type	Type 2
3. Soil Series	n/a
4. Horizon	B
5. Test Date	7/24/2015

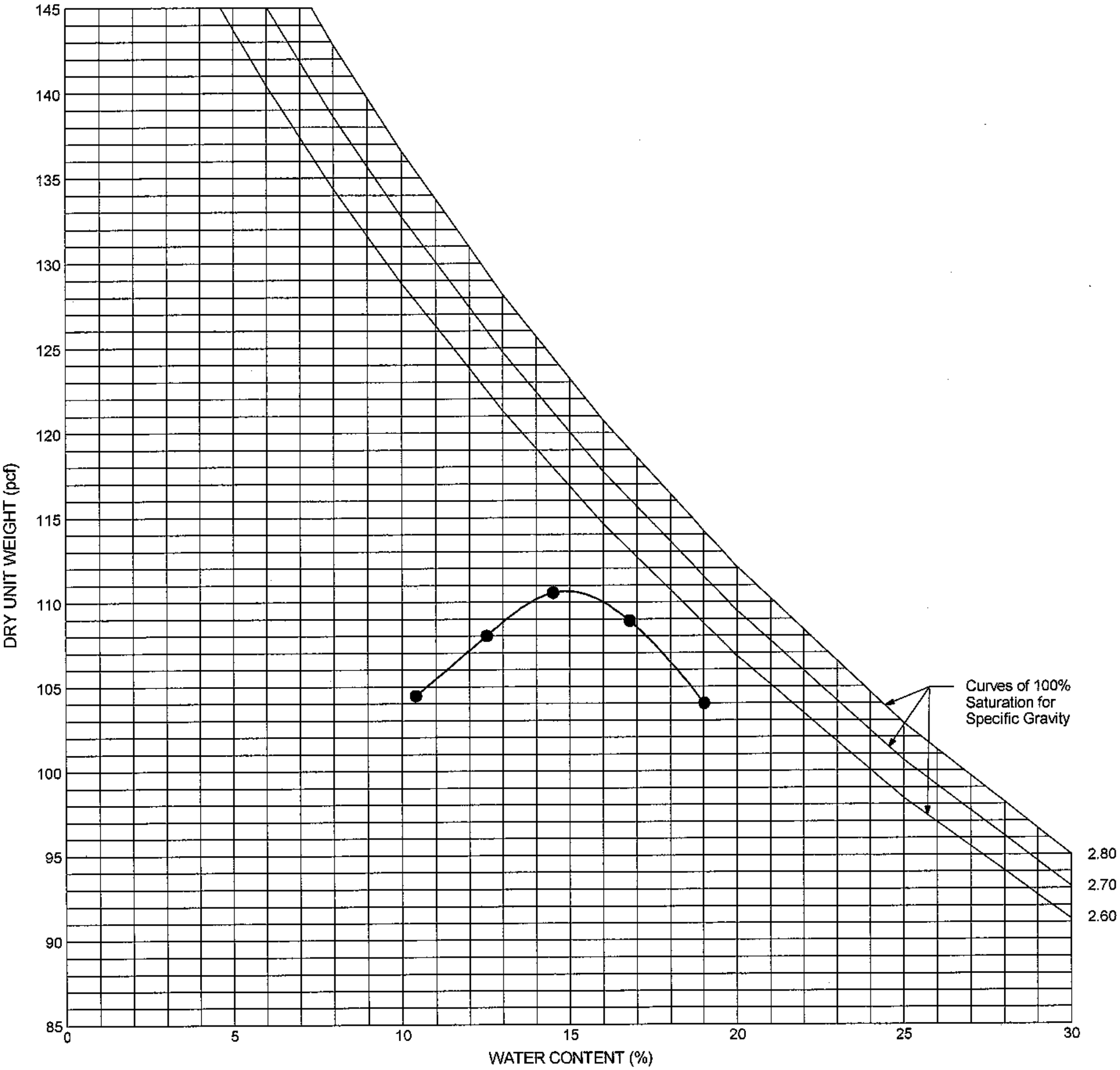
Column #	1	**2**	3	4	**5**
Parameter	Chamber Confining Pressure	**Desired Applied Cyclic Stress**	Actual Applied Cyclic Stress	Actual Resilient Modulus	**Predicted Resilient Modulus***
Designation	S3	**Scyclic**	Scyclic	Mr	**Mr**
Unit	psi	**psi**	psi	psi	**psi**
Precision	—	—	—	—	—
Sequence 1	6	**1.80**	1.73	5215	**4669**
Sequence 2	6	**3.60**	3.49	4708	**4230**
Sequence 3	6	**5.40**	5.31	4494	**3993**
Sequence 4	6	**7.20**	7.12	4162	**3833**
Sequence 5	6	**9.00**	8.90	3752	**3713**
Sequence 6	4	**1.80**	1.75	4701	**4669**
Sequence 7	4	**3.60**	3.47	4501	**4230**
Sequence 8	4	**5.40**	5.32	4058	**3993**
Sequence 9	4	**7.20**	7.09	3765	**3833**
Sequence 10	4	**9.00**	8.93	3441	**3713**
Sequence 11	2	**1.80**	1.72	4076	**4669**
Sequence 12	2	**3.60**	3.56	3761	**4230**
Sequence 13	2	**5.40**	5.41	3514	**3993**
Sequence 14	2	**7.20**	7.11	3094	**3833**
Sequence 15	2	**9.00**	8.94	2743	**3713**

*Predicted Mr values at the desired applied cyclic stresses using Model #1



Model #1; $Mr = K1 \times Sd^{K2}$

S3 (psi)	K1	K2	R^2
6	5887	-0.19	0.93
4	5420	-0.19	0.91
2	4382	-0.13	0.99
All	5076	-0.14	0.46



Exploration ID		Depth (ft.)		Sample Number		Sample Description	
● Composite		1		NA		LEAN CLAY (CL)	
Passing 3/4"	Passing #4	Passing #200	LL	PL	PI	Maximum Dry Unit Weight (pcf)	Optimum Water Content (%)
NM	100	88	30	16	14	110.6	14.9

Testing perfomed in general accordance with ASTM D698 Method A.
NP = Nonplastic
NA = Not Available
NM = Not Measured

KLEINFELDER Bright People. Right Solutions.	PROJECT NO.: 20161079	COMPACTION CURVE	SAMPLE I.D.
	DRAWN BY: BJM		1
	CHECKED BY: NH	Pavement Rehab. on S. Union Pl. Between SW Blvd and W. 41st Street Tulsa, Oklahoma	
	DATE: 8/5/2015		
	REVISED: -		

KLEINFELDER
Bright People. Right Solutions.

APPENDIX C

GBA DOCUMENT

Important Information about Your

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.

Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you*—should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical-engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical-Engineering Report Is Based on a Unique Set of Project-Specific Factors

Geotechnical engineers consider many unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk-management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical-engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical-engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical-engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, droughts, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ—sometimes significantly—from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical-engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical-engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure contractors have sufficient time* to perform additional study. Only then might you be in a position to give contractors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of 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 equipment, techniques, and personnel used to perform a *geoenvironmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical-engineering report does not usually relate any geoenvironmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own geoenvironmental information, ask your geotechnical consultant for risk management guidance. *Do not rely on an environmental report prepared for someone else.*

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold-prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold-prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical-engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold-prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely, on Your GBA-Member Geotechncial Engineer for Additional Assistance

Membership in the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk confrontaton techniques that can be of genuine benefit for everyone involved with a construction project. Confer with your GBA-member geotechnical engineer for more information.

GEOPROFESSIONAL BUSINESS ASSOCIATION

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