Comprehensive Engineering Services

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C.A. 3639, Ren. Date 06/30/2020

December 31, 2020

City of Moore
301 N. Broadway
Moore, Oklahoma 73160

Attn: Mr. Brooks Mitchell

RE: Geotechnical Engineering Services Report
Proposed City of Moore Animal Shelter
1316 SE 34th Street
Moore, Oklahoma
EST Project Number: 6010697

Dear Mr. Mitchell:

EST has completed the geotechnical engineering services for the proposed animal shelter building to be located at 1316 SE 34th Street in Moore, Oklahoma.

The purpose of the subsurface exploration was to estimate the geotechnical engineering properties of the near surface soils for the above referenced project. The laboratory results and engineer's review provide the information needed to evaluate the potential for soil shrink/swell with variation in soil moisture content and to estimate parameters for foundation design. Additionally, we have provided pavement design recommendations for the proposed parking lots and access drives.

This geotechnical report should be read in its entirety prior to utilizing any presented information for design or construction purposes. Additionally, we recommend that EST be retained to provide construction monitoring and testing services to verify that soil conditions are consistent with our geotechnical report. EST will not be responsible for the misinterpretation of the recommendations for this project. Furthermore, EST is not responsible for any conditions that deviate from those described in this report.

Mr. Mitchell, we appreciate the opportunity to work with you on this project, and at your request, we are prepared to provide the proper construction monitoring and testing services. If you have any questions regarding the information contained in this report or if we can be of further assistance, please call us at (405) 815-3600.

Respectfully,
EST, Inc.

Bryce R. Hanlon, P.E.
Geotechnical Engineer

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1.0 Executive Summary

The geotechnical engineering services are complete for the proposed animal shelter building to be located at 1316 SE 34th Street in Moore, Oklahoma. This report describes the subsurface conditions encountered in the borings, furnishes the laboratory data acquired, and provides geotechnical recommendations for building pad development and foundation design. Additionally, we have provided recommended pavement sections for the proposed parking lot and access drives.

Exploration of the subsurface materials at the project site consisted of a total of ten (10) borings located throughout the project site. Six (6) structural building borings (B-01 through B-06) were advanced in the proposed building area to a depth of 20 feet below the existing ground surface elevations. Additionally, four (4) pavement borings (P-01 through P-04) were advanced in the proposed parking and access drive areas to a depth of approximately 5 feet. Samples obtained from the borings were brought to our laboratory for further processing and/or testing. Groundwater was encountered in four of the structural borings at depths ranging from 17.5 to 18 feet below the existing ground surface elevation. The results of the laboratory tests and the final boring logs along with a diagram showing the approximate locations of the borings are included in the appendices of this report.

Evaluation and test results indicate the subsurface materials generally consist of clayey sands and sandy lean clays. Based on the encountered soil conditions, shallow footing foundations with slab-on-grade floors can be used to support the proposed building. Specific geotechnical recommendations are presented further in this report.

2.0 Project Description

We understand that the proposed project consists of constructing a new animal shelter building at 1316 SE 34th Street in Moore, Oklahoma. At the time of this report, no structural loading information was provided. However, we expect the building to be lightly loaded.

3.0 Subsurface Exploration

The subsurface exploration was performed on December 8, 2020. The exploration at the site consisted of ten (10) exploratory borings located by an EST Engineer based on the plans provided.

The project was accessible to a CME-55 track-mounted, rotary drill rig used to perform the borings. The borings were advanced using 4-inch hollow stem augers. Representative soil samples were obtained using the standard penetration test (SPT) sampling procedures in general accordance with ASTM Specifications D-1586.

The SPT sampling process requires a split-barrel (two-piece) sampling tube be used to obtain soil samples. A 2-inch outside diameter sampling tube is hammered, using an automatic drive hammer, into the bottom of the boring with a 140-pound weight falling 30 inches. The number of blows required to advance the tube the last 12 inches of an 18-inch sampling interval or a portion thereof, is recorded as the standard penetration resistance value, N. The in-situ relative density of granular soils, the consistency of cohesive soils, and the hardness of weathered bedrock can be estimated from the N value. The uncorrected, N values recorded for each test are shown on the attached boring logs at their relative sampling depths.

A CME automatic drive hammer was used to perform the standard penetration tests. A greater mechanical efficiency is achieved with the automatic drive hammer when compared to a conventional safety drive hammer operated with a cathead and rope. The effect of this higher efficiency has on the N-values have been considered in our interpretation and analysis of the subsurface information provided in this report.

The locations of the borings have been identified and are shown on the approximate boring location diagram included in Appendix A of this report.

As part of the drilling operations, the field personnel prepared field boring logs. The field personnel examined the samples retrieved during drilling operations and recorded a soil description on the field logs. The split-barrel samples were packaged in plastic bags to reduce moisture loss, tagged for identification and transported to our laboratory for further evaluation. The field logs also include visual classifications of the materials encountered during drilling and the engineer's interpretation of the subsurface conditions between samples. This report contains the final boring logs that represent modifications based on the engineer's review and laboratory test results.

4.0 Subsurface Conditions

4.1 Soil Conditions

The near-surface soils generally consist of clayey sands and sandy lean clays. It should be noted that concrete and asphalt debris was encountered in borings B-01 and B-02 at depths between 1 to 5 feet beneath the existing surface. We recommend this debris be removed within the proposed structural areas prior to building construction.

4.2 Seismic Classification

Based on the subsurface materials encountered during our investigation and Table 1613.5.2 entitled "Site Class Definitions" in the 2012/2015 International Building Code, we recommend using a seismic site classification for the project of Site Class "D". The geotechnical parameters presented in Table I can be used, and were estimated based on the 2015 International Building Code (IBC).

TABLE I

Seismic Site Class (Table 1613.5.2 of the 2015 IBC)		D
Estimated Site Coordinates	Latitude	35.303984°N
	Longitude	97.489049°W
S_s – Short Period Spectral Acceleration		0.273g
S_{MS} – Short Period, Site Class Modified Spectral Acceleration		0.432g
S_{DS} – Short Period, Five Percent Damping, Spectral Acceleration		0.288g
S_1 – 1 Second Period Spectral Acceleration		0.079g
S_{M1} – 1 Second Period, Site Class Modified Spectral Acceleration		0.189g
S_{D1} – 1 Second Period, Five Percent Damping, Spectral Acceleration		0.126g
F_a		1.6
F_v		2.4
Seismic Design Category		B

4.3 Groundwater Conditions

Groundwater was encountered in B-01, B-02, B-05, and B-06 at depths ranging from 17.5 to 18 feet below the existing grade. Groundwater level fluctuations and/or perched water conditions may occur due to seasonal variations in the amount of rainfall and other factors such as drainage characteristics. To obtain more accurate groundwater level information, long-term observations in a monitoring well or piezometer that is sealed from the influence of surface water would be needed. The possibility of groundwater level fluctuations should be considered during the preparation of construction plans. The borings were plugged per Oklahoma Water Resources Board (OWRB) requirements after drilling operations were completed.

4.4 Corrosion Potential/Cement Type

To estimate the corrosion potential of the onsite soils, we utilized the United States Department of Agriculture's (USDA) Web Soil Survey to determine susceptibility of the soil to concrete and steel corrosion. According to the USDA Web Soil Survey, the on-site materials present a high risk of corrosion to steel and a low exposure of concrete to sulfate containing solutions.

Additionally, we tested several samples for Soluble Sulfate Content. The results of these tests are provided in Table II:

TABLE II

Sample ID	Soluble Sulfate Concentration (ppm)
B-02 S-01 (0-1’)	240
B-05 S-01 (0-1’)	240
B-06 S-01 (0-1’)	280
P-01 S-01 (0-2.5’)	267
P-02 S-01 (0-2.5’)	280
P-03 S-01 (0-2.5’)	267
P-04 S-01 (0-2.5’)	280

For steel elements in contact with the on-site soils, we recommend that preventive measures against steel corrosion be considered. In many cases, polyethylene encasement or epoxy-coated resin has been used to protect buried ferrous metals or ductile iron pipes.

For concrete elements in contact with the on-site soils, we recommend using an ASTM C150 Type I Portland cement concrete with a maximum water-to-cement ratio (W/C) of 0.50 and a minimum compressive strength of 3,000 psi. We recommend that routine tests be performed to verify that sulfate concentrations are within acceptable ranges for Type I cement. The USDA Soil Survey output files can be found in Appendix D of this report.

4.5 Potential for Vertical Rise (PVR)

The existing near surface soils generally consist of low to moderate plasticity soils for which volume changes in excess of 1 inch are not expected to occur with variations in soil moisture content.

5.0 Laboratory Evaluation

All samples obtained from the project site were transferred to our laboratory for processing and/or testing. Laboratory tests were performed on select soil samples in agreement and applicable to ASTM, and AASHTO testing procedures. Laboratory tests included estimation of the natural moisture content (ASTM D2216), Atterberg limits (ASTM D4318), sieve analysis (ASTM D2487), and soluble sulfates (OHDL 49). These results are provided in Section 4.4 and Appendix B of this report.

6.0 Evaluation and Recommendations

Based on the subsurface materials encountered a shallow footing foundation system with slab-on-grade floors can be used at this site. The following presents geotechnical recommendations concerning these and other geotechnical issues related to the project.

6.1 Earthwork

Any fill required to develop final grade lines should consist of low volume change (LVC) soils that are free of organic matter and debris. Low PI material would be cohesive materials having a liquid limit less than 35 and a plasticity index between 5 and 17. Fill should be placed in lifts not exceeding 8 to 9 inches in loose thickness and compacted to at least 95 percent of the material's maximum dry density at a moisture content within 2 percent of optimum. Any soft or loose areas observed, or over-saturated, rutting or pumping soils observed during compaction operations should be removed and replaced or stabilized. On-site soils can generally be used as fill material.

During compaction operations, the exposed subgrade and each lift of compacted fill should be tested for moisture and density, and reworked as necessary until that surface is approved by the Geotechnical Engineer's representative prior to the placement of additional lifts. We recommend the scarified surface and each lift of fill be tested for density and moisture content at a rate of one test per 2,000 square feet of compacted area with a minimum of two tests per compacted area. In addition, we recommend one test for every 100 linear feet of compacted utility trench backfill.

6.1.1 General Site Development

We recommend removing all existing trees, vegetation, topsoil, pavements, concrete debris, asphalt debrisand any other unsuitable materials from the construction areas. We also recommend removing any existing stumps, roots larger than 2 inches in diameter, rocks larger than 3 inches in diameter, and any matted roots from the proposed construction area. It should be noted that concrete and asphalt debris was encountered in borings B-01 and B-02 at depths between 1 to 5 feet beneath the existing surface. We recommend this debris be removed within the proposed structural areas prior to building construction.

After removing all the unsuitable materials, we recommend proof-rolling the exposed subgrade. EST should be notified to witness the removal of the unsuitable materials and the proof-rolling process. Proof-rolling should be performed in overlapping passes and in mutually perpendicular directions using equipment with a minimum subgrade loading of 25 tons. After the exposed subgrade is approved by an EST representative, additional recommendations provided in the following sections should be observed.

6.1.2 Floor Slab Development

After performing any required cuts, the exposed subgrade should be scarified to a minimum depth of 8 inches and re-compacted to at least 95 percent of the material's maximum dry density as determined by the test method ASTM D-698 at a moisture content of within two percent above optimum. The recompacted and tested subgrade should be proof-rolled as described in the previous section to ensure compaction. The pad preparation should extend at least 5 feet laterally from the building pad edges. If proper compaction and pad preparation of the on-site soils cannot be achieved due to pumping or wet conditions, then we recommend either using LVC soil instead of native on-site soils or stabilizing the existing subgrade soils.

The ground surface should be sloped away from the building on all sides to prevent water from collecting near the building. Water should not be allowed to pond near the building during or after construction. In addition, the moisture content of the soil should be maintained until the slab is constructed. Therefore, the building pad should always contain enough moisture so that surface cracks do not develop. We recommend the moisture content of the building pad be evaluated just before concrete for the slab is placed.

We recommend placing a waterproof membrane (15-mil Polyethylene) on top of 2 inches of clean sand immediately below the floor slab for a vapor barrier. The slab should be designed using a modulus of subgrade reaction, k_1, of 80 pci for the on-site soils based on a 1 foot by 1 foot plate load test. For different floor slab sizes, we recommend using the following equations:

$k_s = \frac{k_1}{B}$ (cohesive materials)

$k_s = \frac{k_1(1+B)^2}{2B}$ (cohesionless materials)

Where,

k_s = the desired modulus of subgrade reaction for the actual slab size
k_1 = the modulus of subgrade reaction from a 1 foot by 1 foot plate load test
B = the actual slab width in feet

To help minimize moisture migration, we recommend using a low-slump concrete designed with a water-to-cement ratio of 0.50 or less for the slab. Water curing the slab will help the curing process and should help reduce shrinkage cracks and slab curling. Before the floor covering is placed, we recommend slab moisture emission tests be conducted to confirm that moisture discharge levels are within the floor covering manufacturer's recommendation. These tests should be conducted after the building is considerably complete and the HVAC is operational. The tests should be run when the HVAC has been operating enough to provide typical temperature and humidity conditions representative of what the floor covering will be susceptible to under normal conditions.

6.2 Shallow Footing Foundations

Shallow footing foundations can be used to support the proposed building. A reinforced continuous footing, with isolated column footings bearing at least 24 inches below final outside grades will provide a system sufficient to carry the required loads. It is important to reinforce the footings to minimize the effects of movement within the foundation system. For the design of footings bearing in native soils, a maximum allowable net bearing pressure of 1,500 pounds per square foot can be used. This bearing pressure is the pressure that can be applied to the soil at the base of the footings in excess of the minimum surrounding overburden pressure.

To provide frost heave protection, reduce the amount of shrink/swell potential, and provide adequate confinement of the bearing materials, footings should be located at least 24 inches below final outside grade. Continuous footings should have a minimum width of 16 inches. Isolated column footings should have a minimum width of 30 inches.

Caution should be taken to prevent wetting or drying of the bearing materials. This can be accomplished by placing concrete into the footings as soon as they are excavated and approved by the Geotechnical Engineer's representative. Surface run-off water should drain away from the excavated areas. If the footing materials should become wet or dry and/or loose or disturbed, then this material should be removed before placing concrete. Any soft or loose areas observed should also be removed before placing concrete. If unsuitable material is encountered, the material should be removed and replaced with compacted fill or concrete. The footing excavation should not be allowed to remain open for more than 8 hours without approval of the Geotechnical Engineer. Shallow foundations constructed as recommended are expected to have long-term movements less than 1 inch. The differential movement across the structure may approach half of the long-term movement.

6.3 Pavement Design

The existing near surface soils encountered in the borings generally consists of low- to moderate-plasticity soils. The parking and access drive areas are expected to support both light duty and minor heavy duty traffic. After moisture-conditioning and compacting the subgrade and proof rolling the site as previously recommended in this report, one or more of the following pavement sections can be adopted.

TABLE III

MINIMUM PAVEMENT RECOMMENDATIONS (AGGREGATE BASE)		
	RIGID PAVEMENT	**FLEXIBLE PAVEMENT**
STANDARD DUTY PAVEMENT	4" of Portland Cement Concrete over 6" ODOT Type "A" Aggregate Base (compacted to 98% Std. Proctor) over 8" ODOT Subgrade Method "B" (Compacted to 95% Std. Proctor)	2" Superpave Type 'S4' Asphalt Concrete (PG 64-22 OK) over 3" Superpave Type 'S3' Asphalt Concrete (PG 64-22 OK) over 6" ODOT Type "A" Aggregate Base (compacted to 98% Std. Proctor) over 8" ODOT Subgrade Method "B" (Compacted to 95% Std. Proctor)
HEAVY-DUTY PAVEMENT	6" of Portland Cement Concrete over 6" ODOT Type "A" Aggregate Base (compacted to 98% Std. Proctor) over 8" ODOT Subgrade Method "B" (Compacted to 95% Std. Proctor)	2" Superpave Type 'S4' Asphalt Concrete (PG 64-22 OK) over 2.5" Superpave Type 'S3' Asphalt Concrete (PG 64-22 OK) over 2.5" Superpave Type 'S3' Asphalt Concrete (PG 64-22 OK) over 6" ODOT Type "A" Aggregate Base (compacted to 98% Std. Proctor) over over 8" ODOT Subgrade Method "B" (Compacted to 95% Std. Proctor)

TABLE IV

MINIMUM PAVEMENT RECOMMENDATIONS (SOIL STABILIZATION)		
	RIGID PAVEMENT	**FLEXIBLE PAVEMENT**
STANDARD DUTY PAVEMENT	4" of Portland Cement Concrete over 8" Stabilized Subgrade	2" Superpave Type 'S4' Asphalt Concrete (PG 64-22 OK) over 3" Superpave Type 'S3' Asphalt Concrete (PG 64-22 OK) over 8" Stabilized Subgrade
HEAVY-DUTY PAVEMENT	6" of Portland Cement Concrete over 8" Stabilized Subgrade	2" Superpave Type 'S4' Asphalt Concrete (PG 64-22 OK) over 2.5" Superpave Type 'S3' Asphalt Concrete (PG 64-22 OK) over 2.5" Superpave Type 'S3' Asphalt Concrete (PG 64-22 OK) over 8" Stabilized Subgrade
* Based on the soil classifications at the site, we estimate 3 to 4 percent Portland cement will be required to adequately stabilize the subgrade. The actual percentages should be determined at the time of construction via mix design.		

The maximum control joint spacing for the 5 inch and 7 inch thick Portland cement concrete pavements should be 15 feet. All materials and construction should be in accordance with the ODOT, "2009 Standard Specification for Highway Construction" and the latest special provisions adopted by ODOT to supplement the Standard Specifications.

All fill required to develop final grade lines in the proposed paving area should consist of on-site soils that are free of organic matter and debris. Fill should be placed in lifts not exceeding 9 inches in loose thickness and compacted to at least 95 percent of the maximum dry density at a moisture content within 2 percent of optimum. Any soft or loose areas observed or over-saturated, rutting or pumping soils observed during compaction operations should be removed and replaced.

During compaction operations, each lift of compacted fill should be tested for moisture and density and reworked as necessary until that surface is approved by the geotechnical engineer's representative prior to the placement of additional lifts. We recommend aggregate base, and each lift of fill, be tested for density and moisture content at a rate of one test per 5,000 square feet of compacted area with a minimum of two tests per compacted area. In addition, we recommend one test per lift for every 100 linear feet of compacted utility trench backfill. The moisture content of the aggregate base should be maintained near optimum during construction. A prime coat can be used to help retain moisture within the exposed materials. As a check, we recommend the moisture content be evaluated immediately before pavements are placed.

Minimizing subgrade saturation is an important factor in maintaining subgrade strength. Water allowed to pond on or adjacent to the pavements could saturate the subgrade and cause premature pavement deterioration. The pavement and subgrade should be sloped approximately 1/8 inch per foot to provide surface drainage, and positive surface drainage should be maintained away from the edge of the paved areas. Maintenance of the pavements will be required to obtain satisfactory design life. Maintenance should include crack sealing, surface patching of any deteriorated areas. Thicker pavements could also be used to reduce the required maintenance and extend the service life of the pavement.

7.0 General

This report was prepared for the City of Moore in reference to the Proposed Animal Shelter Building to be located at 1316 SE 34th Street in Moore, Oklahoma. This report provides geotechnical recommendations based on the subsurface conditions encountered in the borings. It is not practical or economical to perform enough subsurface investigation borings to identify all conditions at the site. Subsurface conditions may vary with distance away from the borings completed for this report. Conditions that may affect the recommendations contained within the geotechnical report may exist and may not become known until construction. If variations appear during construction, it may be necessary to revise the recommendations contained in this report. Therefore, monitoring of subsurface conditions during construction should be performed by a geotechnical engineer or his representative to verify that conditions are consistent with the geotechnical report.

EST warrants that the findings and recommendations contained herein have been made with generally accepted professional geotechnical practices in the local area. No other warranties are implied or expressed. The scope of services and recommendations contained in this report do not include any environmental assessment or identification of contaminated or hazardous materials. Any statements in this report or in the boring logs concerning suspicious odors, colors, irregular textures or abnormal conditions are for informational purpose only and have not been verified by the engineer or testing.

Appendix A

Approximate Boring Location Diagrams

Appendix B

Boring Logs

Appendix C

General Notes
Boring Log Acronym Library
General Notes for Rock Classification

Appendix D

Web Soil Survey Corrosion Maps