Geotechnical Report

Boone County – Support Services Building – ECC/BCSD Campus
2145/2111 East County Drive
Boone County, Missouri

October 30, 2018

Project No. 18224.01

For
Mr. Erik Miller AIA, CDT
PW Architects, Inc.

Prepared By:

ALLSTATE
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October 30, 2018

Mr. Erik Miller AIA, CDT
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RE: Geotechnical Report
Proposed Boone County-Support Services Building
ECC/BCSD Campus
2145/2111 East County Drive
Columbia, Missouri
Allstate Project No. 18224.01

Dear Mr. Miller;

We have completed the subsurface exploration, laboratory testing and geotechnical engineering report for the Proposed Boone County – Support Services Building to be constructed on an upland site located on the ECC/BCSD Campus at 2145/2111 East County Drive in in Columbia, Missouri. The accompanying geotechnical report presents the findings of the subsurface exploration, the results of the laboratory tests and our engineering recommendations regarding design and construction of the earthwork, foundations, floor slabs and pavement subgrades for the proposed facility.

It has been a pleasure to be of service to you during the initial phase of this project. If you have any questions regarding this geotechnical report, or if we may be of further service during the design or construction phases, please feel free to contact our office.

Sincerely,
Allstate Consultants, LLC

Cassidy Mathews

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ECC/BCSD CAMPUS
2145/2111 EAST COUNTY DRIVE
BOONE COUNTY, MISSOURI

ALLSTATE PROJECT NO. 18224.01
OCTOBER 30, 2018

INTRODUCTION

Allstate Consultants, LLC has completed the subsurface exploration for the Proposed Boone County Support Services Building to be constructed on an upland site located to the northwest of the existing Boone County Emergency Communications Center in Columbia, Missouri.

Nine (9) test borings, designated TB-1 through TB-9, were performed to depths ranging from approximately 5 feet to 20 feet below the existing ground surface in the proposed building and parking lot areas. Laboratory tests were performed on soil samples recovered from the test borings and the soil samples were visually classified. The Test Boring Logs and Test Boring Location Plan are included in the Appendix to this report.

The purpose of this geotechnical engineering report is to describe the subsurface conditions encountered in the borings, evaluate the field and laboratory test data and provide recommendations regarding the design and construction of earthwork, foundations, floor slabs and pavement subgrades for the proposed facility.

PROJECT DESCRIPTION

The Proposed Boone County Support Services Building will consist of a single story, slab on grade, metal building with associated pavement areas as shown on the Test Boring Location Plan in the Appendix.

The proposed building will have approximate plan dimensions of 60 feet by 190 feet and a footprint of approximately 12,000 square feet. Preliminary plans indicate a partial mezzanine with dimensions of approximately 20 feet by 120 feet will be located on the west side of the building. A future building expansion, having approximate plan dimensions of 60 feet by 110 feet, is planned for the north side of the proposed building. Additional parking and access pavements will be located on the east side of the building and east of the existing access drive.

The project is in the early stages of development and site grading plans and structural information are not yet available. However, based on our cursory observations while drilling we assume minor cuts and extensive fills in the range of 10 feet to 15 feet may be required to develop the floor slab subgrade for the proposed building and future north expansion. We estimate the finished floor slab will be established between approximate elevations 770 to 772 feet. We also assume maximum building column and wall loads will be less than 50 kips and 2 kip/lineal foot, respectively. We should be advised if building loads will be higher.

FIELD EXPLORATION AND LABORATORY TESTING PROCEDURES

Building area borings were located and ground surface elevations at these locations were determined by an Allstate Consultants survey crew using traditional surveying methods. Approximate boring locations are shown on the Test Boring Location Plan in the Appendix.

Test borings were performed using a truck-mounted, Mobile B47 rotary drilling rig. Hollow stem augers with a center plug were used to advance the borings. At relatively close vertical intervals, the center plug was removed from the augers and samples of the subsurface materials were obtained using thin-walled tube and split barrel sampling methods.

As the borings were advanced, an Allstate geotechnical engineer recorded the results of the subsurface exploration on field boring logs. Information reported on the field boring logs included, the number, type, depth, recovery, Standard Penetration Test blow counts, and/or calibrated hand penetrometer reading for each sample. The field logs also included visual descriptions of the recovered samples; the driller and field engineers' interpretation of subsurface conditions between samples based on drilling observations and the geotechnical engineer's groundwater observations. Recovered soil samples were sealed to reduce moisture loss and transported to the laboratory for further testing and classification.

Thin-walled tube samples were tested in the laboratory to determine the field water content, dry unit weight and unconfined compressive strength. The unconfined compressive strength of some of the samples was estimated using a calibrated hand penetrometer. The strength estimated using this device is approximate and was considered accordingly. Split-barrel samples were tested in the laboratory to determine the field water content and approximate unconfined compressive strength by use of a calibrated hand penetrometer.

On completion of laboratory testing, the soil samples were described and classified in general accordance with the Unified Soil Classification System (USCS) using visual-manual procedures. USCS Group Letter Symbols and Group Names were also assigned based on visual-manual estimates. Atterberg limit tests were also performed on selected samples to assist in soil classification and in evaluating the engineering characteristics of the site soils. The results of these tests are shown on the Test Boring Logs.

The final Test Boring Logs included in this report present the results of the field exploration and the laboratory testing program. The final logs delineate the soil and rock strata encountered in the borings and represent the geotechnical engineer's interpretation of subsurface conditions at the boring locations. These interpretations were developed from a review of the field boring logs with modifications based on the laboratory test results and on visual observations of the recovered samples. Graphical symbols depicting the soil and rock strata are shown on the boring logs for illustrative purposes. It should be recognized that differing soil types could be present between samples and between borings.

The Test Boring Log Notes included in the Appendix describe the symbols used on the Test Boring Logs and provide additional information regarding sampling procedures; soil and rock descriptions and classification; Standard Penetration Tests; laboratory test results; the consistency of fine grained soils; the relative density of coarse grained soils; bedrock quality and borehole water level observations.

The Unified Soil Classification System is also described in the Appendix and a legend is included relating graphical symbols used on the boring logs to the USCS Group Letter Symbols and Names and to the principal rock types encountered in the project area.

SITE DESCRIPTION

The proposed site is located immediately northwest of the Boone County Emergency Communications Building in a grass covered area that was gently sloping to the north and west at the time of exploration. The upland site slopes gently from the higher terrain on the south and east at approximate elevation 780 feet to the lower terrain on the northwest at approximate elevation 755 feet as shown on the Test Boring Location Plan.

It appears significant grading has been performed on the site. Past grading activities associated with the development of the tract for the Boone County Emergency Communications building have been completed in the immediate area of the proposed Support Services Building. Visual observations indicated that fill was likely placed in the southern portion of the site. It appears the existing fill placed in the vicinity of the proposed Support Services Building may not have been placed under controlled conditions and we are not aware of any previous testing records being available.

SUBSURFACE CONDITIONS

Subsurface conditions encountered at the individual boring locations are indicated on the Test Boring Logs. Stratification lines shown on these logs represent approximate boundaries between soil and rock types. In-situ, the change between material types may be more gradual. Based on a review of the Test Boring Logs, subsurface conditions at the project site can be characterized as follows:

Soil and Rock Conditions

Test borings, TB-1 to TB-9, encountered little to no topsoil over what appeared to be uncontrolled fill over post-glacial and glacial soil deposits and Pennsylvanian aged bedrock. The building area borings, TB-1 to TB-7, were terminated in weathered shale at depths of approximately 16 to 20 feet beneath the existing ground surface while pavement area test borings, TB-8 and TB-9, were terminated in post-glacial soil deposits at depths of approximately 5 feet below the existing ground surface.

The existing fill material encountered in the borings, generally extended to depths of about 3 to 8 feet beneath the existing ground surface and appeared to increase in thickness to the south and west. These materials typically consisted of a variety of lean clays, lean to fat clays and fat clays with zones of crushed limestone in some borings. The existing variable fill was generally moist and very stiff to hard in consistency with occasional medium and stiff consistency zones.

Beneath the existing fill material, building area borings TB-1 to TB-6 and pavement area boring TB-8, encountered post-glacial soil deposits that generally consisted of lean clays and fat clays that were stiff to very stiff in consistency. Test boring TB-9 encountered silty, hard post glacial material consisting of lean clay overlying very stiff to hard consistency lean clay.

In TB-1 to TB-7, in the vicinity of the proposed building and future north addition and at depths ranging from 3 feet to 12 feet below the existing ground surface, the undocumented fill and/or post-glacial soils were underlain by highly weathered claystone. The upper several feet of the claystone was jointed and had the consistency of a stiff to hard, clay soil. Some of the upper claystone was also high in plasticity.

Beneath the highly weathered claystone in these borings, weathered shale was encountered. The upper shale had the consistency of a very stiff to hard clay soil and the lower shale had the consistency of a soft to medium hard rock. TB-1 to TB-7 in the building area were terminated in the underlying weathered shale.

Groundwater Conditions

Field observations were periodically made during drilling and sampling, immediately after boring completion and several hours after completion to measure borehole water levels. Groundwater was observed at a depth of approximately 16 feet during drilling of TB-5 and was not observed at these times in the other borings.

It should be recognized that short term water level observations in open boreholes, drilled into low permeability soil and rock, may not represent actual groundwater conditions in these materials. In fact, a considerable length of time may be required for a groundwater level to be detected and to stabilize in an open borehole extending into materials similar to those encountered in the test borings at this site.

Installation and long term observation of piezometers or groundwater observation wells, screened in the hydrologic units of interest and sealed to prevent the entrance of surface water, would be required to more accurately characterize and evaluate groundwater levels and fluctuations in these levels in this geologic setting. While these services can be provided if requested, they are beyond the scope of this investigation.

Groundwater levels often vary across a project site and typically fluctuate at individual locations with variations in seasonal and climatological conditions. Perched water tables can develop and groundwater levels can be influenced by alterations in site grades, other construction activities, modifications to adjacent sites, leaking utility piping, water following utility trench backfill, and other factors not readily evident at the time the borings are performed.

During construction and at other times during the life of the proposed development, groundwater levels may be higher or lower than the levels reported on the boring logs. The likelihood of fluctuating groundwater levels and the potential occurrence of seasonally perched groundwater in the near surface soils should be appropriately considered during development of design and construction plans for this project.

GEOTECHNICAL EVALUATION AND RECOMMENDATIONS

Geotechnical Evaluation

Borings TB-1 to TB-8 encountered previously placed fill over native post-glacial soils and/or weathered claystone and shale, while test boring TB-9 encountered post-glacial soils. The existing fill was composed of a mixture of lean clay, lean to fat clay, and fat clay. The clayey fill contained variable zones of material and ranged from medium to hard in consistency. Pockets of construction debris composed of crushed limestone gravel were encountered in test borings TB-1, TB-2 and TB-4.

The existing fill generally appeared to thicken toward the south, as was expected, and extended to depths of about 5 feet to 8 feet beneath the surface in building area borings TB-1 to TB-3 on the south and to depths of approximately 3 feet to 5 feet in TB-4 to TB-7 on the north.

The existing fill was variable in engineering properties and we are not aware of any records regarding placement and compaction of the fill. Based on our findings we are of the opinion the much of the existing fill was placed under uncontrolled conditions.

Atterberg limits tests performed on samples of the suspected uncontrolled fill materials consisting of lean clays, lean to fat clays, and fat clays obtained from the upper 3 to 10 feet of the soil profile indicated these site soils were moderately to highly plastic having liquid limits of approximately 41 to as high as 58 and plasticity indices (PI's) of about 25 to 39.

Past experience with similar soils indicates the fat clays and lean to fat clays may have a moderate to high volume change potential. The lean clays may have a low to moderate swell potential when moist, but may also have a high volume change potential when low in moisture content. Additionally, seasonal drying prior to construction may result in higher swelling tendencies in each of these type materials.

The native post-glacial soils encountered below the existing fill generally consisted of stiff to very stiff, lean clays and fat clays with occasional hard consistency materials.

In our opinion, the uncontrolled existing fill could experience continued consolidation under its own weight and under the structural loads that will be added within the building footprint. Consolidation of the uncontrolled fill could result in unacceptable building settlements and significant differential settlement between building foundations and the floor slab. For these reasons, we recommend the existing uncontrolled fill within and to a horizontal distance of 8 feet outside the building footprint be removed and replaced with moisture conditioned, controlled, compacted fill. Over-excavation of the existing fill would need to extend to significant depths of about 8 feet in the area of borings TB-1 and TB-2 and to depths of about 3 to 5 feet in the area of borings TB-3 to TB-7 on the north. Suitable fill material would need to be imported to the building site for use in the moisture conditioned, controlled, compacted fill for the building pad.

Based on our findings and evaluation, we are of the opinion that the most feasible approach for this project would involve removing the existing highly variable fill materials to stiff, native materials in the building area and replacing it with moisture conditioned, controlled, compacted fill. Detailed recommendations for design and construction of earthwork, foundations, and floor slab subgrades are provided below based on removing and replacing the uncontrolled fill with moisture conditioned, controlled, compacted fill in the building area.

Considering the type of facility planned and our experience with expansive soils in the project area, we recommend the owner consider establishing a 24 inch thick, low volume change zone beneath the proposed building floor slab to reduce future floor slab heave to tolerable levels. While a less substantial low volume change zone, such as one having thickness of 12 to 18 inches, could be used, there is a potential that building floor movements would be more significant and more noticeable with a thinner low volume change zone.

The lean clays, lean to fat clays, and fat clays that will be removed from site excavations do not appear to be suitable for re-use in controlled compacted fills below the proposed low volume change zone in the building area and immediately beneath the pavement sections. These materials are suitable for use as controlled compacted fill material in lawn areas at least 8 feet outside the building footprint, if these materials are free of organic matter and debris and are reworked, moisture conditioned and compacted as recommended in this report. If close attention to moisture and density control is not exercised, the on-site materials could develop a higher potential for volume change.

In our opinion, the proposed Support Services Building can be supported on shallow foundations and a floor slab on grade can be utilized in the building area, if the variable, undocumented soils encountered in the upper 3 to 8 feet of the soil profile in the proposed building area are removed and replaced with moisture conditioned, controlled, compacted fill and a low volume change zone is established beneath the entire building floor slab as recommended in this report. Detailed earthwork, foundation, and floor slab recommendations are as follows:

Earthwork

Prior to placement of moisture conditioned, controlled, compacted fill, any remaining vegetation and any topsoil, low strength or otherwise unsuitable material that may be present should be removed from the proposed building area. Generally this would include the upper 3 to 8 feet of variable fill encountered in the building area borings. Unsuitable material would also include any low strength existing site soil lying beneath the uncontrolled fill that is identified during the over-excavation.

The building area undercut should extend laterally beyond the building perimeter for a horizontal distance of at least 5 feet on the north and to at least 8 feet on the south where the existing fill appears to be the thickest. Exposed native soils in the bottom of the undercut should be carefully probed and thoroughly proof-rolled with a loaded tandem axle dump truck, scraper, or other approved rubber tired construction equipment in the presence of the geotechnical engineer of record or his on-site representative. If unsuitable materials are identified in the bottom of the building area undercut, these unsuitable materials should also be removed to stiff native clay as determined by the geotechnical engineer of record or his on-site representative. Moisture deficient soils should be scarified to a minimum depth of at least 6 inches, moisture conditioned to the optimum moisture content or above and recompacted and the entire undercut should be backfilled with moisture conditioned, controlled, compacted clay fill up to the bottom of the low volume change zone.

Lean clay soils, having a liquid limit of 50 or less and a plasticity index (PI) of 30 or less, obtained from off-site excavations that are free of organic matter and debris are suitable for re-use as moisture conditioned, controlled, compacted fill in the building area up to the bottom of the low volume change zone if these soils are placed, moisture conditioned and compacted as recommended in this report.

Controlled, compacted fill should be placed in lifts having a maximum loose thickness of 8 inches. Lean clay soils, suitable for use as controlled, compacted fill, should be placed and moisture conditioned to within the range of 1 percent above the optimum moisture content to 4 percent above the optimum moisture content and compacted to at least 95 percent of the standard Proctor maximum dry density (ASTM D698). Any fat clay soils with a liquid limit of 55 or less and deemed suitable for use as controlled, compacted fill by the geotechnical engineer of record, should be placed and moisture conditioned to within the range of 2 percent above to 5 percent above the optimum moisture content and should be compacted to the same requirements. Silty lean clay soils, suitable for use as controlled, compacted fill that have liquid limits less than 40, should be placed and moisture conditioned to within the range of optimum moisture content to 2 percent above the optimum moisture content and compacted to at least 95 percent of the standard Proctor maximum dry density (ASTM D698). Sheepsfoot and/or padfoot rollers are recommended for compaction of clay soils.

The existing site soils that will need to be over-excavated from the building area undercut are unsuitable for re-use in the building area beneath the low volume change zone due to the variable nature of the materials.

To provide more uniform floor slab support and to reduce the magnitude of future floor slab movements due to potential subgrade volume change, we recommend that any controlled, compacted fill placed inside the building area, for a lateral distance of 5 feet beyond the building footprint and within 24 inches of the bottom of the floor slab consist of low volume change material placed and compacted as described in this report.

We recommend, the low volume change zone in the building area consist of approved densely graded granular materials containing at least 15 percent low plasticity fines passing the No. 200 sieve such as MODOT Type 1 crushed limestone, limestone screenings or wastelime. Approved granular materials should be compacted at workable moisture contents to at least 95 percent of the standard Proctor maximum dry density (ASTM D698). Vibratory rollers are recommended for compaction of granular soils in the low volume change zone.

We recommend all new fill in pavement areas and adjacent slopes be placed on stripped, proof rolled and observed surfaces and consist of controlled compacted fill meeting the requirements of this report. In cut or shallow fill areas, we recommend the upper 2 feet of the subgrade consist of controlled compacted fill. This may require some shallow undercutting and replacement with excavated material in these areas.

Cut and fill slopes located outside the building and pavement areas should be constructed no steeper than 3 horizontal to 1 vertical. Compacted fills placed on terrain having a slope steeper than 6 horizontal to 1 vertical should be placed in relatively horizontal lifts and should be suitably benched into the existing site materials.

Samples of off-site granular or select clay materials proposed for use in controlled compacted fills or in the low volume change zone should be obtained by the geotechnical engineer for evaluation prior to being used at the site.

Each lift of controlled, compacted fill and/or low volume change fill should be observed during placement and compaction and should be subjected to in-place field density testing by the geotechnical engineer of record's on-site representative. Should the field density test results indicate the recommended moisture and compaction levels have not been achieved, the area(s) represented by the test(s) should be reworked and/or recompacted and retested until the moisture and compaction requirements are met.

New utility trench backfill located within 5 feet of the outside of buildings should consist of clay soils placed and compacted at the optimum moisture content or above and to the compaction requirements described in this report for controlled, compacted fill.

We recommend the geotechnical engineer of record be retained by the owner during earthwork construction to perform necessary tests and observations during removal of unsuitable materials, exposure and proof-rolling of subgrades, placement and compaction of controlled, compacted clay fills and/or low volume change zones, backfilling of utility trench, foundation and other excavations and final subgrade preparation just prior to floor slab construction.

Foundations

In our opinion, the proposed Support Services Building can be supported on shallow foundations, if earthwork is constructed as recommended in the ***Earthwork*** section of this report.

Shallow foundations supported on controlled compacted subgrades prepared as recommended in this report should be proportioned using a net allowable total load design bearing pressure of 2500 psf. The net allowable bearing pressure refers to the pressure at the footing bearing level in excess of the minimum surrounding overburden pressure.

Footings beneath unheated areas and footings around the perimeter of the buildings should extend a minimum depth of 36 inches below the lowest adjacent finished grade for frost protection and to reduce the effects of seasonal, moisture-related, volume change in the supporting soils. We recommend isolated footings have a minimum width of 30 inches and continuous formed footings a minimum width of at least 16 inches. Frost walls constructed in earth formed trenches should have a minimum width of at least 12 inches.

Foundations may be subjected to lateral loads. For lateral loads of short duration, we recommend sliding be resisted by an allowable base adhesion of 400 psf acting on the bottom contact area of the foundation that is in compression or by an allowable passive resistance of 800 psf acting on the vertical face of the foundation element in the direction perpendicular to the lateral load. Passive resistance should not be relied upon within 3 feet of finished grade. For any sustained lateral loads of long duration, we recommend an ultimate coefficient of friction of 0.3 be used on the bearing area of the foundation that is in compression. An appropriate factor of safety should be applied to the ultimate base resistance calculated using this ultimate value.

Surface water and/or perched groundwater may enter foundation excavations during construction. In our opinion, water entering foundation excavations from these sources should be promptly removed using sump pumps or gravity drainage ditches.

The bearing surface of all foundation excavations should be free of water and loose or unsuitable soil prior to placing concrete. Reinforcement and concrete should be placed soon after excavation to minimize disturbance of the bearing surface and supporting soils. Should the bearing soils become dry, disturbed, frozen or saturated, the impacted soil should be removed to suitable material prior to placing concrete. The geotechnical engineer of record should be retained to observe and test the foundation bearing materials during construction.

Use of the site preparation procedures recommended in this report will greatly reduce the potential that unsuitable soils will be encountered in foundation excavations. However, if unsuitable bearing materials are identified by the geotechnical engineer of record or his on-site representative, the foundation excavations should be extended deeper to suitable soils. Foundations could bear directly on these deeper suitable materials or on lean concrete backfill placed in the excavations. Foundations could also bear on controlled compacted clay fill extending down to the suitable materials and placed and compacted as recommended in this report. Over-excavations for placement of compacted backfill below foundations should extend at least 1 foot horizontally beyond all footing edges for each foot of over-excavation depth below the footing bearing elevation. Where controlled compacted backfill is placed in confined spaces and compacted with hand operated equipment, the lift thickness may need to be reduced to 4 inches to achieve the recommended compaction levels.

Foundations designed and constructed on subgrades prepared as recommended in this report are expected to experience total settlements on the order of 1 inch or less and differential settlements between adjacent foundation elements of approximately ½ of an inch or less.

Seismicity

Building foundations should be capable of supporting earthquake loads as stipulated in the International Building Code (IBC) or other such applicable code as determined by the structural engineer of record. Based on the results of the subsurface exploration and our experience with geologic conditions in the project area, we recommend the proposed site be classified as Site Class C as defined in Table 20.3-1 and Section 20.3 of the ASCE *Minimum Design Loads for Buildings and Other Structures* if IBC, 2016 governs the design.

Floor Slab Subgrades

After floor slab subgrade construction is complete, care should be taken to maintain the recommended subgrade moisture and density prior to placement of the building floor slab. Completed subgrades that become dry, saturated, frozen, disturbed or altered by plumbing installations or other construction activity should be reconditioned to meet the recommendations of this report prior to floor slab placement.

We recommend a free-draining, compacted, granular leveling course be placed below the floor slab to provide a capillary break and uniform floor slab support. The thickness of this layer should be at least 4 to 6 inches and the layer can be considered a part of the 24 inch thick low volume change zone. For floor slab subgrades prepared as recommended in this report, the concrete slab can be designed using a modulus of subgrade reaction, k, of 125 pounds per square inch per inch (psi/in).

Pavement Subgrades

Pavement subgrades should be developed and prepared as recommended in the ***Earthwork*** section of this report. Fill should consist of moisture conditioned, controlled compacted lean clay fill free of organic matter and debris. Existing site fill is not considered suitable for pavement fill and subgrades. We recommend that at least the upper 12 inches of the soil subgrade in cut and fill areas consist of moisture conditioned, controlled compacted lean clay fill placed and compacted at the optimum moisture content to 4 percent above the optimum moisture content and to at least 95 percent of the standard Proctor maximum dry density (ASTM D698).

Pavement subgrades prepared properly during the early stages of construction may be altered by the passage of time, weather and ongoing construction activities. These subgrades should be carefully evaluated by the geotechnical engineer or his on-site representative and should be properly reconditioned prior to base course placement and paving. Close attention should be paid to restoration of heavily traveled areas that were rutted and disturbed during construction and to areas where utility trenches have been backfilled. We recommend these areas and all other pavement subgrades be moisture conditioned and re-compacted to meet the requirements of controlled compacted fill just prior to finish grading, base course placement and paving. Unsuitable subgrades identified in this process should be reworked and re-compacted or removed and replaced with materials meeting the requirements of controlled compacted fill.

Based on the results of the test borings and our previous experience with the types of soils encountered at the project site and proposed in this report for use in the moisture conditioned, controlled compacted subgrades, we recommend a soaked CBR value of about 2 to 3 or a resilient modulus, M_r, of about 3500 to 4000 psi be used to develop any flexible asphalt pavement sections. A modulus of subgrade reaction, k, of about 75 to 100 psi/in can be used to develop rigid pavement designs. Geogrids such as Tensar TX 140 used in conjunction with nonwoven geotextiles and crushed stone base material are recommended to remediate soft subgrades; enhance pavement performance and to reduce the overall thickness of the pavement sections. If pavement subgrade preparation does not follow the recommendations of this report, lower CBR values and subgrade reaction moduli may be encountered and unsatisfactory pavement performance may develop.

Lateral Earth Pressures and Drains for Below Grade Walls

We understand exposed concrete foundation walls could retain up to 8 to 10 feet of backfill and additional floor surcharge loads. Walls retaining earth backfill and surcharge loads on one side will be subjected to lateral earth pressures. Concrete walls that are provided with appropriate lateral support at the top and bottom are commonly designed for the "at rest" lateral earth pressure. This earth pressure is the minimum lateral pressure that should be used to design restrained walls that will experience essentially no wall rotation. Cantilever retaining walls founded on soil typically experience a small amount of rotation and are typically designed for the "active" lateral earth pressure. Additional lateral earth pressures can develop that exceed the "at rest" and "active" earth pressures. The actual earth pressures developed will depend on the structural design, wall bracing and restraint, construction sequence and methods, backfill compaction procedures and the shear strength of the wall backfill.

For the "at rest" condition and granular backfill, we recommend exposed concrete foundation walls be designed for an earth pressure equivalent to that of a fluid exerting a lateral pressure of at least 60 pounds per cubic foot (pcf) per foot of wall height. For the "active" condition and granular backfill, we recommend any exterior site cantilever retaining walls be designed for an earth pressure equivalent to that of a fluid exerting a lateral pressure of at least 45 pounds per cubic foot (pcf) per foot of wall height.

The above minimum design earth pressures do not include a factor of safety and assume the wall backfill will consist of controlled, compacted, granular fill placed in horizontal lifts as recommended in this report. The recommended minimum design earth pressures do not include the additional lateral stresses that can develop during compaction of the wall backfill or due to heavy construction equipment that may be operated too close to walls or other surcharge loads that may be present above or below finished grade. The minimum design earth pressures also do not account for possible hydrostatic forces that may develop on the walls due to the presence of groundwater. In our opinion, the backfill placed behind these type walls should consist of granular fill. The design earth pressures recommended for granular backfill are only valid if the granular backfill extends out from the heel of the wall footing at an angle of 45 degrees or less from the horizontal.

We recommend exposed concrete foundation walls and any site retaining walls be provided with wall drains to reduce the potential that hydrostatic loads will be applied to the walls. Slotted or perforated rigid plastic drain piping should be installed on top of the footing beneath the back side of these walls. These drainage systems should be independent from roof drainage systems and reverse flow into the wall drainage systems should not be permitted.

Drainage piping should provide positive gravity drainage and should be surrounded by clean, free draining granular material graded to prevent plugging due to intrusion of fines. If well graded filter materials are not preferred, clean, free draining gravel may be used if the gravel is surrounded with a suitable nonwoven geotextile designed to prevent migration of fines into the drainage material. Prefabricated drainage products protected with geotextiles and designed for the intended use can also be used if appropriately selected.

We recommend the backfilled side of exposed concrete foundation walls be provided with wall drains installed above the drainage piping and surrounding drainage material. The wall drains should consist of clean, free draining material protected from plugging due to intrusion of fines. The wall drains should be at least 2 feet thick and should extend to finished subgrade level when located inside the building and to within 2 feet of finished grade for walls located outside the building. Protected wall drains located outside the building should be capped with 2 feet of compacted clay fill. The independent wall drainage systems should discharge into independent, non-perforated or non-slotted discharge piping sloped to drain away from the building by gravity.

Exterior cantilever retaining walls and pavements may experience differential movements with respect to the building foundations. For this reason, we recommend isolation joints be provided between building foundations and the adjacent pavements and exterior retaining walls to allow these structural elements to move independently.

Surface Drainage and Plantings

We recommend final grading plans rapidly direct surface run-off away from building and pavement areas. Roof gutter and downspout discharge should be channeled well away from the building and pavement areas to reduce the potential that water will accumulate adjacent to these facilities. Future foundation and/or utility trench backfill settlement around the perimeter of the building should be corrected to prevent ponding of water in these areas. We recommend that plants and trees with significant moisture requirements not be located adjacent to buildings.

Additional Considerations

The clay soils in the project area are prone to shrinkage and swelling with variations in moisture content. High plasticity soils such as fat clay generally have a greater potential for moisture induced volume change than less plastic materials such as lean clay. However, even lean clay can shrink and swell significantly with variations in moisture levels. We recommend subgrades be constructed as recommended in this report and that close attention be paid to maintaining moisture levels in subgrades prior to installation of floor slabs and sidewalks; providing adequate surface drainage and keeping plants and trees well outside the area where they can adversely influence building performance.

The procedures recommended in this report may not eliminate all future subgrade volume change and resultant foundation and floor slab movement. However, the recommendations described in this report should reduce the potential for consolidation settlement, subgrade volume change and future building movements to reasonably uniform and tolerable levels. If minor floor movements and occasional cosmetic cracks are not tolerable, then other site preparation procedures would need to be implemented. Pavement design, stability of earth slopes and the local and global stability of any site retaining walls are outside the scope of this report. If these additional services are required they can be provided under a separate scope of work.

CONCLUSION AND LIMITATIONS

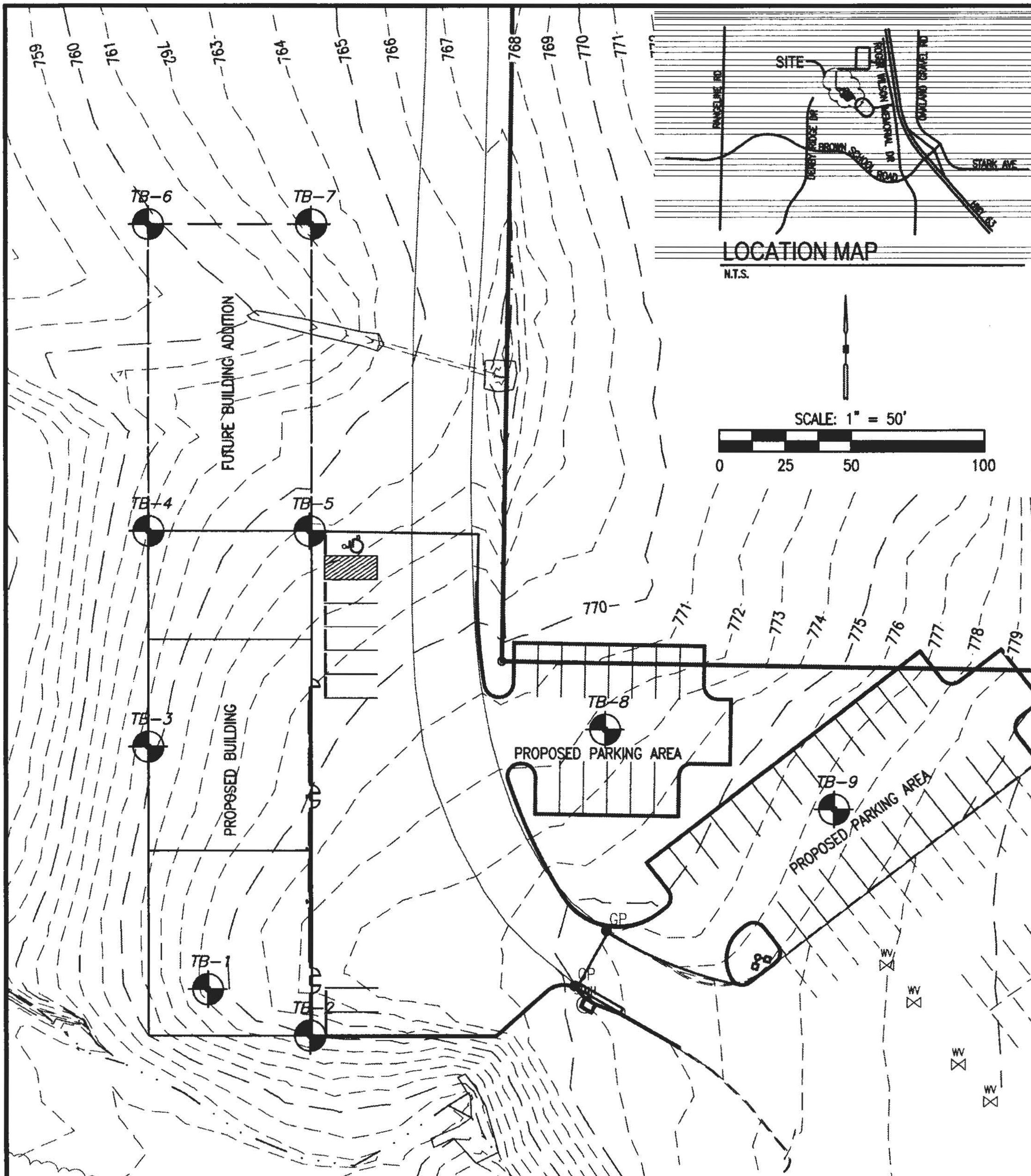
The authorized geotechnical engineering services have been completed. The resulting geotechnical recommendations included in this report provide a basis for development of earthwork, foundation, floor slab and pavement designs for the proposed facility. We recommend that Allstate Consultants be retained to review the final project plans and specifications so that we can comment on and assist in the interpretation and implementation of our geotechnical recommendations.

Allstate Consultants should be retained during construction of this project to provide geotechnical observation and testing services for earthwork, foundation, floor slab and pavement construction.

The evaluations, analyses and recommendations provided in this report are based on the subsurface conditions encountered in the test borings performed at the locations indicated on the Test Boring Location Plan and from other information discussed in this report. Our geotechnical report does not consider variations that could occur between boring locations or changes that may occur due to the passage of time, the modifying effects of weather or adjacent construction activities. The character and extent of such variations may not become evident until during or after construction. Should variations be identified, we should be notified immediately so that further evaluations and additional recommendations can be developed.

The scope of our geotechnical engineering services does not include either specifically or by implication any environmental evaluation of this site nor identification of contaminated or hazardous materials or conditions. Further, we have performed no assessment of the possible presence of bacteria or fungi nor the potential for development of problems associated with mold. If the owner or client is concerned about the potential for such issues, other environmental studies should be performed.

This geotechnical report has been prepared for the exclusive use of our client for specific application to this project only and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either expressed or implied, are intended to be made. During construction, site safety, excavation support, and dewatering will be the responsibility of others. Should changes occur in the nature, design or location of the proposed building and pavements, as described in this report, the evaluations, recommendations and conclusions contained herein shall not be considered valid unless Allstate Consultants reviews the changes and provides written verification or modification of the conclusions of this report.



ALLSTATE CONSULTANTS

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TEST BORING LOCATION PLAN
PROPOSED BOONE COUNTY EMERGENCY COMMUNICATION CENTER STORAGE BUILDING

COLUMBIA, MISSOURI

PROJECT NUMBER:	SCALE	DATE
18224.01	1"=50'	10-23-2018

TEST BORING LOG

TEST BORING NO. 1

ALLSTATE CONSULTANTS

PROJECT: BCECC STORAGE BUILDING

SITE LOCATION: COLUMBIA, MO

CLIENT: PWARCHITECTS

PROJECT NO: 18224.01

DEPTH (feet)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY (inches)	USCS SYMBOL	MATERIAL DESCRIPTION (surface elev. 769.5)	Strata depth / elev.	SPT BLOW COUNTS (Blows/6")	FIELD WATER CONTENT (PL / LL scale 10–60)	DRY UNIT WEIGHT pcf	UNCONFINED COMPRESSIVE STRENGTH psf
	1	3ST	19	CL	FILL, LEAN CLAY, With Sand & Gravel, Gray Mottled Tan, Hard, CL			15.1		*9000+
5	2	3ST	13	CL	Grading Crushed Limestone Gravel, Tan Mottled Gray, Very Stiff			21.2	106	4760
	3	3ST	12	CL	Grading Brown Mottled Gray, Stiff	8 / 761.5		23.1	102	3440
10	4	3ST	20	CH	FAT CLAY, Trace Sand, Gray Mottled Tan, Very Stiff, Jointed, CH	12 / 757.5		22.6	102	4590
15	5	SS	16		HIGHLY WEATHERED CLAYSTONE, Tan Mottled Gray	17 / 752.5	5/7/8	24.6		*4000
20	6	SS	11		WEATHERED SHALE, Tan to Orange	20 / 749.5	26/50-5"	12.5		*9000+
					BOTTOM OF BORING AT 20 FT.					
25										
30										
35										

Note: Stratification lines represent approximate boundaries between soil and rock types. In-situ, the transition between strata may be gradual. Rock classification estimated from disturbed samples. Coring may reveal other rock types. * Based on Calibrated Hand Penetrometer.

DRILLING CONTRACTOR: ALLSTATE CONSULTANTS LLC	**ALLSTATE CONSULTANTS, LLC**
DRILLING METHOD: MOBILE B47 W/6" HSA	**BORING** / **COLUMBIA, MISSOURI**
DEPTH WATER FIRST ENCOUNTERED: NONE ▽	**STARTED:** 10/2/2018
DEPTH TO WATER AFTER BORING COMPLETION (AB): NONE ▼	**COMPLETED:** 10/2/2018 — **TEST BORING NO. 1**
DEPTH TO WATER DAYS AFTER BORING COMPLETION: ▼	**LOG APPROVED BY:** CCM — **PAGE 1 OF 1**

TEST BORING LOG

TEST BORING NO. 2

ALLSTATE CONSULTANTS

PROJECT: BCECC STORAGE BUILDING
CLIENT: PWARCHITECTS

SITE LOCATION: COLUMBIA, MO
PROJECT NO: 18224.01

DEPTH (feet)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY (inches)	USCS SYMBOL	MATERIAL DESCRIPTION (770.0)	SPT BLOW COUNTS (Blows/6")	PLASTIC LIMIT (PL) / FIELD WATER CONTENT / LIQUID LIMIT (LL)	DRY UNIT WEIGHT pcf	UNCONFINED COMPRESSIVE STRENGTH psf
0–8	1	3ST	10	CL	**FILL,** LEAN CLAY, Crushed Limestone Gravel, Brown Mottled Gray, Hard, CL		PL 16, 18.3, LL 41	106	*8000
	2	3ST	16	CL CH	**FILL,** LEAN TO FAT CLAY, Gray Mottled Tan, Medium, CL/CH		25.7	104	1850
	3	3ST	19	CH	**FILL,** FAT CLAY, Trace Sand, Brown Mottled Gray, Stiff, CH (8 — 762.0)		PL 19, 25.4, LL 58	100	2630
8–12	4	3ST	17	CH	**FAT CLAY,** Trace Sand, Gray Mottled Orange, Very Stiff, CH (12 — 758.0)		26.8	98	6100
12–17	5	SS	18		**HIGHLY WEATHERED CLAYSTONE,** Tan to Gray (17 — 753.0)	6/8/15	20.2		*9000
17–20	6	SS	13		**WEATHERED SHALE,** Gray (20 — 750.0)	26/50-3"	13.5		*9000+
					BOTTOM OF BORING AT 20 FT.				

Note: Stratification lines represent approximate boundaries between soil and rock types. In-situ, the transition between strata may be gradual. Rock classification estimated from disturbed samples. Coring may reveal other rock types. * Based on Calibrated Hand Penetrometer.

DRILLING CONTRACTOR: ALLSTATE CONSULTANTS LLC
DRILLING METHOD: MOBILE B47 W/6" HSA
DEPTH WATER FIRST ENCOUNTERED: NONE
DEPTH TO WATER AFTER BORING COMPLETION (AB): NONE
DEPTH TO WATER DAYS AFTER BORING COMPLETION:

ALLSTATE CONSULTANTS, LLC
COLUMBIA, MISSOURI

BORING STARTED: 10/1/2018
COMPLETED: 10/1/2018
LOG APPROVED BY: CCM

TEST BORING NO. 2

TEST BORING LOG

TEST BORING NO. 3

ALLSTATE CONSULTANTS

PROJECT: BCECC STORAGE BUILDING **CLIENT:** PWARCHITECTS

SITE LOCATION: COLUMBIA, MO **PROJECT NO:** 18224.01

DEPTH (feet)	SAMPLE NUMBER	TYPE	RECOVERY (inches)	USCS SYMBOL	STRATUM DEPTH (ft)	MATERIAL DESCRIPTION	ELEVATION	SPT BLOW COUNTS (Blows/6")	FIELD WATER CONTENT (%)	DRY UNIT WEIGHT pcf	UNCONFINED COMPRESSIVE STRENGTH psf
0							764.7				
	1	3ST	20	CL CH		**FILL,** LEAN TO FAT CLAY, With Sand & Gravel, Tan to Brown, Hard, CL/CH			15.2	118	*9000+
5	2	3ST	13	CL CH	5	Grading Brown Mottled Gray, Very Stiff	759.7		20.4	108	6100
	3	3ST	17	CH	8	**FAT CLAY,** Trace Sand, Gray Mottled Orange, Very Stiff, Jointed, CH	756.7		25.2	101	4390
10	4	3ST	24		12	**HIGHLY WEATHERED CLAYSTONE,** Tan, Jointed	752.7		14.9	121	5710
15	5	SS	18			**WEATHERED SHALE,** Gray		22/25/50-4"	13.3		*9000+
	6	SS	10		16.3	Grading Tan	748.4	44/50-4"	11.8		*8000
						AUGER REFUSAL AT 16.3 FT.					

Water content scale: PLASTIC LIMIT (PL) — FIELD WATER CONTENT — LIQUID LIMIT (LL): 10, 20, 30, 40, 50, 60

Depth scale: 5, 10, 15, 20, 25, 30, 35

Note: Stratification lines represent approximate boundaries between soil and rock types. In-situ, the transition between strata may be gradual. Rock classification estimated from disturbed samples. Coring may reveal other rock types. * Based on Calibrated Hand Penetrometer.

DRILLING CONTRACTOR: ALLSTATE CONSULTANTS LLC

DRILLING METHOD: MOBILE B47 W/6" HSA

DEPTH WATER FIRST ENCOUNTERED: NONE ▽

DEPTH TO WATER AFTER BORING COMPLETION (AB): NONE ▼

DEPTH TO WATER DAYS AFTER BORING COMPLETION: ▼

ALLSTATE CONSULTANTS, LLC
COLUMBIA, MISSOURI

BORING STARTED: 10/1/2018

COMPLETED: 10/1/2018

TEST BORING NO. 3

LOG APPROVED BY: CCM

TEST BORING LOG
TEST BORING NO. 4

ALLSTATE CONSULTANTS

PROJECT: BCECC STORAGE BUILDING
SITE LOCATION: COLUMBIA, MO
CLIENT: PWARCHITECTS
PROJECT NO: 18224.01

DEPTH (feet)	SAMPLE NUMBER	TYPE	RECOVERY (inches)	USCS SYMBOL	MATERIAL DESCRIPTION (Surface Elev. 762.2)	Depth	Elev.	SPT BLOW COUNTS (Blows/6")	PLASTIC LIMIT (PL) / FIELD WATER CONTENT / LIQUID LIMIT (LL)	DRY UNIT WEIGHT pcf	UNCONFINED COMPRESSIVE STRENGTH psf
	1	3ST	10	CL	**FILL, LEAN CLAY,** With Crushed Limestone Gravel, Tan, Hard, CL	3	759.2		12.6		*9000+
5	2	3ST	24	CH	**FAT CLAY,** Trace Sand, Gray, Very Stiff, CH	5	757.2		PL 16, 21.4, LL 51	107	4450
	3	3ST	24	CL	**LEAN CLAY,** Tan Mottled Gray, Very Stiff, Jointed, CL	8	754.2		20.1	111	5950
10	4	3ST	17		**HIGHLY WEATHERED CLAYSTONE,** Gray Mottled Tan	12	750.2		16.0	117	3220
15	5	SS	13		**WEATHERED SHALE,** Gray Mottled Tan			20/50-5"	11.6		
	6	SS	10		Grading Gray	19.3	742.9	46/50-4"	9.6		
20					**BOTTOM OF BORING AT 19.3 FT.**						

Water content scale: 10, 20, 30, 40, 50, 60

Depth scale: 5, 10, 15, 20, 25, 30, 35

Note: Stratification lines represent approximate boundaries between soil and rock types. In-situ, the transition between strata may be gradual. Rock classification estimated from disturbed samples. Coring may reveal other rock types. * Based on Calibrated Hand Penetrometer.

DRILLING CONTRACTOR: ALLSTATE CONSULTANTS LLC
DRILLING METHOD: MOBILE B47 W/6" HSA
DEPTH WATER FIRST ENCOUNTERED: NONE ∇
DEPTH TO WATER AFTER BORING COMPLETION (AB): NONE
DEPTH TO WATER DAYS AFTER BORING COMPLETION:

BORING STARTED: 10/1/2018
COMPLETED: 10/1/2018
LOG APPROVED BY: CCM

ALLSTATE CONSULTANTS, LLC
COLUMBIA, MISSOURI
TEST BORING NO. 4
PAGE 1 OF 1

TEST BORING LOG

TEST BORING NO. 5

ALLSTATE CONSULTANTS

PROJECT: BCECC STORAGE BUILDING **CLIENT:** PWARCHITECTS

SITE LOCATION: COLUMBIA, MO **PROJECT NO:** 18224.01

DEPTH (feet)	SAMPLES NUMBER	SAMPLES TYPE	RECOVERY (inches)	USCS SYMBOL	GRAPHICAL SYMBOL	MATERIAL DESCRIPTION (766.2)	SPT BLOW COUNTS (Blows/6")	FIELD WATER CONTENT (PL–LL, 10–60)	DRY UNIT WEIGHT pcf	UNCONFINED COMPRESSIVE STRENGTH psf
						FILL, LEAN CLAY,				
	1	3ST	23	CL		Trace Sand, Tan Mottled Gray, Hard, CL		17.2	113	13380
5	2	3ST	24	CL		With Sand, Trace Gravel, Very Stiff, Jointed (5) 761.2		18.7	108	4480
	3	3ST	11	CH		FAT CLAY, Trace Sand, Tan Mottled Gray, Stiff, Jointed, CH (8) 758.2		23.8	102	2450
10	4	3ST	20			HIGHLY WEATHERED CLAYSTONE, Gray to Tan (12) 754.2		15.7	119	6400
15	5	SS	18			WEATHERED SHALE, Gray	19/34/41	13.1		*9000+
						AUGER REFUSAL AT 16.3 FT. ▽				
	6	SS	12			17.5 Grading Tan 748.7	30/49/50-2"	10.0		
						BOTTOM OF BORING AT 17.5 FT.				
20										
25										
30										
35										

Note: Stratification lines represent approximate boundaries between soil and rock types. In-situ, the transition between strata may be gradual. Rock classification estimated from disturbed samples. Coring may reveal other rock types. * Based on Calibrated Hand Penetrometer.

DRILLING CONTRACTOR: ALLSTATE CONSULTANTS LLC

DRILLING METHOD: MOBILE B47 W/6" HSA

DEPTH WATER FIRST ENCOUNTERED: 16 FT ▽

DEPTH TO WATER AFTER BORING COMPLETION (AB): NONE ▼

DEPTH TO WATER DAYS AFTER BORING COMPLETION: ▼

ALLSTATE CONSULTANTS, LLC
COLUMBIA, MISSOURI

BORING STARTED: 10/2/2018

COMPLETED: 10/2/2018

LOG APPROVED BY: CCM

TEST BORING NO. 5

TEST BORING LOG
TEST BORING NO. 6

ALLSTATE CONSULTANTS

PROJECT: BCECC STORAGE BUILDING | **CLIENT:** PWARCHITECTS
SITE LOCATION: COLUMBIA, MO | **PROJECT NO:** 18224.01

DEPTH (feet)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY (inches)	USCS SYMBOL	GRAPHICAL SYMBOL	MATERIAL DESCRIPTION (759.8)	SPT BLOW COUNTS (Blows/6")	PLASTIC LIMIT (PL) / FIELD WATER CONTENT / LIQUID LIMIT (LL) (10 20 30 40 50 60)	DRY UNIT WEIGHT pcf	UNCONFINED COMPRESSIVE STRENGTH psf
						FILL, SILTY LEAN CLAY,				
	1	3ST	10	CL		Brown, Very Stiff, CL		23.5		*6500
3						756.8				
	2	3ST	10	CH		**FAT CLAY,** Tan Mottled Gray, Stiff, CH		28.9	95	2340
5	3	3ST	15	CH		Grading Very Stiff		22.2	107	4380
8						751.8				
10	4	3ST	14			**HIGHLY WEATHERED CLAYSTONE,** Gray Mottled Tan		14.7	120	5020
12						747.8				
15	5	SS	18			**WEATHERED SHALE,** Gray	29/49/50-4"	11.7		
18.9	6	SS	5			740.9	50-5"	9.5		
20						**BOTTOM OF BORING AT 18.9 FT.**				
25										
30										
35										

Note: Stratification lines represent approximate boundaries between soil and rock types. In-situ, the transition between strata may be gradual. Rock classification estimated from disturbed samples. Coring may reveal other rock types. * Based on Calibrated Hand Penetrometer.

DRILLING CONTRACTOR: ALLSTATE CONSULTANTS LLC
DRILLING METHOD: MOBILE B47 W/6" HSA
DEPTH WATER FIRST ENCOUNTERED: NONE ▽
DEPTH TO WATER AFTER BORING COMPLETION (AB): NONE ▼
DEPTH TO WATER DAYS AFTER BORING COMPLETION: ▼

ALLSTATE CONSULTANTS, LLC
COLUMBIA, MISSOURI
BORING STARTED: 10/2/2018
COMPLETED: 10/2/2018
LOG APPROVED BY: CCM
TEST BORING NO. 6
PAGE 1 OF 1

TEST BORING LOG
TEST BORING NO. 7

ALLSTATE CONSULTANTS

PROJECT: BCECC STORAGE BUILDING | **CLIENT:** PWARCHITECTS
SITE LOCATION: COLUMBIA, MO | **PROJECT NO:** 18224.01

DEPTH (feet)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY (inches)	USCS SYMBOL	GRAPHICAL SYMBOL	MATERIAL DESCRIPTION (763.4)	SPT BLOW COUNTS (Blows/6")	PLASTIC LIMIT PL / FIELD WATER CONTENT / LIQUID LIMIT LL (10 20 30 40 50 60)	DRY UNIT WEIGHT pcf	UNCONFINED COMPRESSIVE STRENGTH psf
						FILL, FAT CLAY,				
	1	3ST	19	CH		Trace Sand, Brown, Hard, CH		23.1	98	8210
3						760.4				
	2	3ST	23			**HIGHLY WEATHERED CLAYSTONE,**		20.5	107	3270
5						Gray to Tan 758.4				
	3	3ST	24			**WEATHERED SHALE,** Gray Mottled Tan		15.0	121	4600
10	4	3ST	16					15.0	121	6540
						Grading Tan				
15	5	SS	18				25/50-3"	13.2		*9000+
19.3	6	SS	14			Grading Gray 744.1	38/50-3"	10.8		
						BOTTOM OF BORING AT 19.3 FT.				

Note: Stratification lines represent approximate boundaries between soil and rock types. In-situ, the transition between strata may be gradual. Rock classification estimated from disturbed samples. Coring may reveal other rock types. * Based on Calibrated Hand Penetrometer.

DRILLING CONTRACTOR: ALLSTATE CONSULTANTS LLC
DRILLING METHOD: MOBILE B47 W/6" HSA
DEPTH WATER FIRST ENCOUNTERED: NONE ▽
DEPTH TO WATER AFTER BORING COMPLETION (AB): NONE ▽
DEPTH TO WATER DAYS AFTER BORING COMPLETION: ▼

ALLSTATE CONSULTANTS, LLC
COLUMBIA, MISSOURI

BORING
STARTED: 10/2/2018
COMPLETED: 10/2/2018
LOG APPROVED BY: CCM

TEST BORING NO. 7

TEST BORING LOG

TEST BORING NO. 8

ALLSTATE CONSULTANTS

PROJECT: BCECC STORAGE BUILDING

SITE LOCATION: COLUMBIA, MO

CLIENT: PWARCHITECTS

PROJECT NO: 18224.01

DEPTH (feet)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY (inches)	USCS SYMBOL	GRAPHICAL SYMBOL	MATERIAL DESCRIPTION (772.5)	SPT BLOW COUNTS (Blows/6")	PLASTIC LIMIT (PL) / FIELD WATER CONTENT / LIQUID LIMIT (LL) (10 20 30 40 50 60)	DRY UNIT WEIGHT pcf	UNCONFINED COMPRESSIVE STRENGTH psf
3	1	SS	15	CL		FILL, LEAN CLAY, Trace Sand, Brown, Hard, CL 769.5	5/5/8	15.9		*9000+
5	2	SS	16	CL		LEAN CLAY, With Sand, Sand Lenses, Gray, Very Stiff, CL 767.5	6/6/7	17.4		*8000
						BOTTOM OF BORING AT 5 FT.				

Note: Stratification lines represent approximate boundaries between soil and rock types. In-situ, the transition between strata may be gradual. Rock classification estimated from disturbed samples. Coring may reveal other rock types. * Based on Calibrated Hand Penetrometer.

DRILLING CONTRACTOR: ALLSTATE CONSULTANTS LLC
DRILLING METHOD: MOBILE B47 W/6" HSA
DEPTH WATER FIRST ENCOUNTERED: NONE ▽
DEPTH TO WATER AFTER BORING COMPLETION (AB): NONE ▼
DEPTH TO WATER DAYS AFTER BORING COMPLETION: ▼

ALLSTATE CONSULTANTS, LLC
COLUMBIA, MISSOURI

BORING STARTED: 10/2/2018
COMPLETED: 10/2/2018
LOG APPROVED BY: CCM

TEST BORING NO. 8
PAGE 1 OF 1

TEST BORING LOG
TEST BORING NO. 9

ALLSTATE CONSULTANTS

PROJECT: BCECC STORAGE BUILDING
CLIENT: PWARCHITECTS
SITE LOCATION: COLUMBIA, MO
PROJECT NO: 18224.01

DEPTH (feet)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES RECOVERY (inches)	USCS SYMBOL	GRAPHICAL SYMBOL	MATERIAL DESCRIPTION (777.6)	SPT BLOW COUNTS (Blows/6")	PLASTIC LIMIT PL / FIELD WATER CONTENT / LIQUID LIMIT LL (10 20 30 40 50 60)	DRY UNIT WEIGHT pcf	UNCONFINED COMPRESSIVE STRENGTH psf
	1	SS	17	CL	▨	SILTY LEAN CLAY, Brown, Hard, CL — 3 — 774.6	5/3/3	● 21.3		*9000+
5	2	SS	15	CL	▨	LEAN CLAY, Tan Mottled Gray, Very Stiff to Hard, CL — 5 — 772.6	4/5/7	● 19.1		*8000
						BOTTOM OF BORING AT 5 FT.				

Depth scale: 5, 10, 15, 20, 25, 30, 35

Note: Stratification lines represent approximate boundaries between soil and rock types. In-situ, the transition between strata may be gradual. Rock classification estimated from disturbed samples. Coring may reveal other rock types. * Based on Calibrated Hand Penetrometer.

DRILLING CONTRACTOR: ALLSTATE CONSULTANTS LLC
DRILLING METHOD: MOBILE B47 W/6" HSA
DEPTH WATER FIRST ENCOUNTERED: NONE ▽
DEPTH TO WATER AFTER BORING COMPLETION (AB): NONE ▼
DEPTH TO WATER DAYS AFTER BORING COMPLETION: ▼

ALLSTATE CONSULTANTS, LLC
COLUMBIA, MISSOURI

BORING STARTED: 10/2/2018
COMPLETED: 10/2/2018
LOG APPROVED BY: CCM

TEST BORING NO. 9

TEST BORING LOG NOTES

SAMPLE TYPE

3ST	SHELBY TUBE SAMPLE –	Obtained by pushing a standard 3 inch OD thin-walled tube sampler using the hydraulic stroke of the drilling rig.
S S	SPLIT-SPOON SAMPLE –	Obtained by driving a standard 2 inch OD by 1 3/8 inch ID split-barrel sampler during performance of a Standard Penetration Test (SPT).
C S	CONTINUOUS SAMPLE -	Obtained by inserting a 3 inch OD by 2 ¼ ID continuous split-barrel sampler into the lead section of a hollow stem auger string and advancing the sampler with the hollow stem auger as the auger penetrates into the underlying soil.
N X	ROCK CORE SAMPLE -	Obtained by coring the rock with an NX size core barrel and diamond bit. The NX size core is approximately 2 1/8 inches in diameter. An NQ size core is approximately 2 inches in diameter.

SOIL AND ROCK DESCRIPTIONS AND CLASSIFICATION

Soil samples are described and classified in general accordance with the Unified Soil Classification System (USCS) using visual-manual procedures. All USCS Group Letter Symbols and Group Names are based on visual-manual estimates except where accompanied by results of Atterberg limits tests and grain size analyses. A brief description of the USCS is attached.

Fine-grained soils are also described in terms of their consistency and coarse-grained soils in terms of their in-place relative density. For fine-grained soils, the consistency is based on the unconfined compressive strength (Table 1). For coarse-grained soils the relative density is related to the N value determined from the Standard Penetration Test (Table 2).

Rock strata penetrated by flight augers or rock bits and intermittently sampled with a split-barrel sampler are described and classified based on drilling performance and visual observation of disturbed samples. Rock cores may reveal other rock types.

Rock core samples, obtained with a core barrel and diamond bit, are visually described and classified based on lithology, bedding, structure, degree of weathering, and hardness. All rock descriptions and classifications are based on visual observations. Petrographic analyses may indicate other rock types. Rock core recovery is expressed as the ratio of the length of core recovered to the length of the core run. Rock Quality Designation (RQD) is the ratio of the total length of the pieces of core that are hard, sound and 4 inches or longer to the length of the core run. Both core recovery and RQD are expressed as a percentage.

Soil and rock strata, delineated on the boring log, represent the geotechnical engineer's interpretation of subsurface conditions at the boring location. The interpretation is developed from the field boring log with modifications based on the laboratory test results and visual observations of the soil and rock samples. Graphical symbols depicting the soil and rock strata are shown on the boring logs for illustrative purposes. Different soil or rock types could be present between samples. A legend relating the graphical symbols to the USCS Group Letter Symbols and Group Names and the principal rock types encountered in the project area is attached. Stratification lines shown on the boring logs represent approximate boundaries between the various soil and rock types. In-situ, the transition between the soil and rock strata may be gradual.

STANDARD PENETRATION TEST

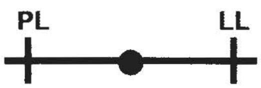
A standard split-barrel sampler (2 inch OD by 1 3/8 inch ID) is driven 18 inches into the soil by a 140 pound hammer repeatedly dropped from a height of 30 inches. The hammer blows are recorded for each 6 inches of penetration and the penetration resistance or N Value is considered the number of blows required for the final 12 inches of sampler penetration. Blows per 6 inch interval are recorded as 8/18/23 etc. under the Test Boring Log heading *SPT Blow Counts.* Where the sampler penetrated less than 6 inches under 50 hammer blows for one of the intervals, the results are recorded as 8/18/50-3".

LABORATORY TEST RESULTS AND SYMBOLS

PLASTIC LIMIT (PL) - Water content at which a soil will just begin to crumble when rolled into a thread approximately 1/8 inch in diameter. Generally represents the water content below which the soil develops cracks upon significant deformation.

LIQUID LIMIT (LL) - Water content at which a pat of soil, cut by a groove of standard dimensions, will flow together for a distance of ½ inch under the impact of 25 blows in a standard liquid limit apparatus. Generally represents the water content above which the soil is in suspension and has minimal shear strength.

FIELD WATER CONTENT - Water content of the soil or rock at depth indicated at time of exploration. The water content may fluctuate with seasonal and climatological conditions and may be altered by excavation, exposure and other construction activities or by conditions not apparent during exploration.



- Relationship between plastic limit (PL), field water content, and liquid limit (LL). The plasticity index, (PI), is the difference between the liquid and plastic limits. In general, the higher the liquid limit and PI, the more a soil is inherently prone to volume change. However, soils with lower liquid limits and PI's can also experience volume change.

Soils having field water contents approaching the liquid limit typically have low shear strength and high compressibility. Soils having water contents near the plastic limit typically have higher shear strength and lower compressibility.

UNCONFINED COMPRESSIVE STRENGTH _ The load per unit area at which an unconfined cylindrical specimen of soil will fail in a simple, quick compression test without lateral support. Expressed in pounds per square foot on the boring log.
* Indicates unconfined compressive strength estimated using a calibrated hand penetrometer.

TABLE 1

CONSISTENCY OF FINE-GRAINED SOILS

UNCONFINED COMPRESSIVE STRENGTH, Qu, psf	CONSISTENCY
Less than 500 psf	Very Soft
500 - 1,000	Soft
1,000 - 2,000	Medium
2,000 - 4,000	Stiff
4,000 - 8,000	Very Stiff
Above - 8,000	Hard

TABLE 2

RELATIVE DENSITY OF COARSE-GRAINED SOILS

SPT N VALUE Blows/ft.	RELATIVE DENSITY
0 - 4	Very Loose
4 - 10	Loose
10 - 30	Medium Dense
30 - 50	Dense
Above 50	Very Dense

TABLE 3

ROCK QUALITY DESIGNATION RQD

RQD (%)	ROCK QUALITY
0 - 25	Very Poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 – 100	Excellent

WATER LEVEL SYMBOLS AND OBSERVATIONS:

WS or WD - Borehole water level observation *While Sampling* or *While Drilling* - ∇

AB - Borehole water level observation *After Boring* completion - ▼

24 Hrs AB – Water level observation *24 Hrs After Boring* completion - ▼
or other such time as recorded on the boring log.

WCI - *Wet Cave In*

DCI - *Dry Cave In*

Borehole water level measurements were made at the times and under the conditions indicated on the boring logs. Groundwater levels may vary across the site and will fluctuate with seasonal and climatological conditions. Groundwater levels may also be altered by site grading and/or other construction activities. Borehole water level measurements in highly pervious soils may represent groundwater conditions in these units at the time of the observations. In semi-pervious and fine-grained soils, short term water level measurements in borings may not represent actual groundwater conditions. Long term observations of piezometers, screened in the hydrologic units of interest, and sealed from the influence of surface water are typically required to evaluate groundwater conditions and fluctuations in groundwater levels in low permeability soils.

SOIL AND ROCK SYMBOLS FOR BORING LOGS

SOIL SYMBOLS

GRAPHICAL SYMBOL	USCS Group Symbol	USCS Group Name
	GW	Well-graded gravel
	GP	Poorly graded gravel
	GM	Silty gravel
	GC	Clayey gravel
	SW	Well-graded sand
	SP	Poorly graded sand
	SM	Silty sand
	SC	Clayey sand
	CL	Lean clay
	ML	Silt
	CL-ML	Silty Clay
	OL	Organic clay
		Organic silt
	CH	Fat clay
	MH	Elastic silt
	OH	Organic clay
		Organic silt
	PT	Peat

ROCK SYMBOLS

GRAPHICAL SYMBOL	MAJOR ROCK TYPE
	SILTSTONE
	SHALE
	SANDSTONE
	LIMESTONE
	DOLOMITE
	COAL
	UNDERCLAY
	CLAYSTONE

OTHER SYMBOLS

	CL	Lean Clay, with Sand and Gravel (Glacial Drift)
	CH	Fat Clay, with Sand and Gravel (Glacial Drift)

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UNIFIED SOIL CLASSIFICATION SYSTEM

Soil Classification Chart

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: Group Name
COARSE-GRAINED SOILS More than 50% retained on No. 200 sieve	**Gravels** More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]	GW	Well-graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]	GP	Poorly graded gravel[F]
		Gravels with Fines More than 12% fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]	SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3$[E]	SP	Poorly graded sand[I]
		Sands with Fines More than 12% fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
FINE-GRAINED SOILS 50% or more passes the No. 200 sieve	**Silts and Clays Liquid limit less than 50**	inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	OL	Organic clay[K,L,M,N]; Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	OH	Organic clay[K,L,M,P]; Organic silt[K,L,M,Q]
HIGHLY ORGANIC SOILS			Primarily organic matter, dark in color, and organic odor	PT	Peat

Footnotes

[A] Based on the material passing the 3-in. (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols:
- GW-GM well-graded gravel with silt
- GW-GC well-graded gravel with clay
- GP-GM poorly graded gravel with silt
- GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12% fines require dual symbols:
- SW-SM well-graded sand with silt
- SW-SC well-graded sand with clay
- SP-SM poorly graded sand with silt
- SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200, predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.

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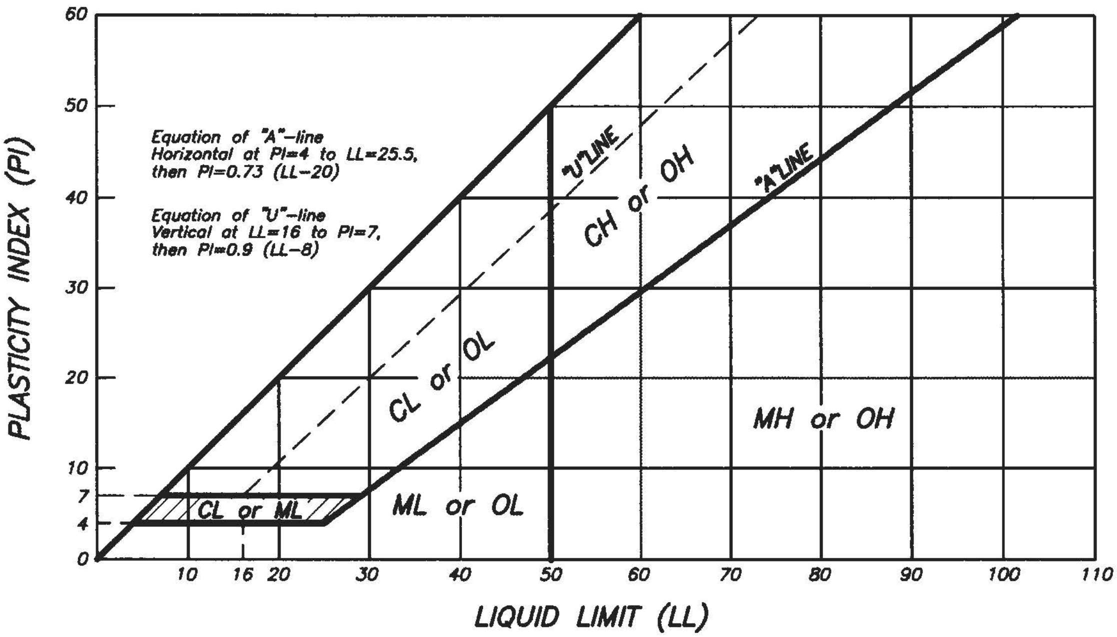
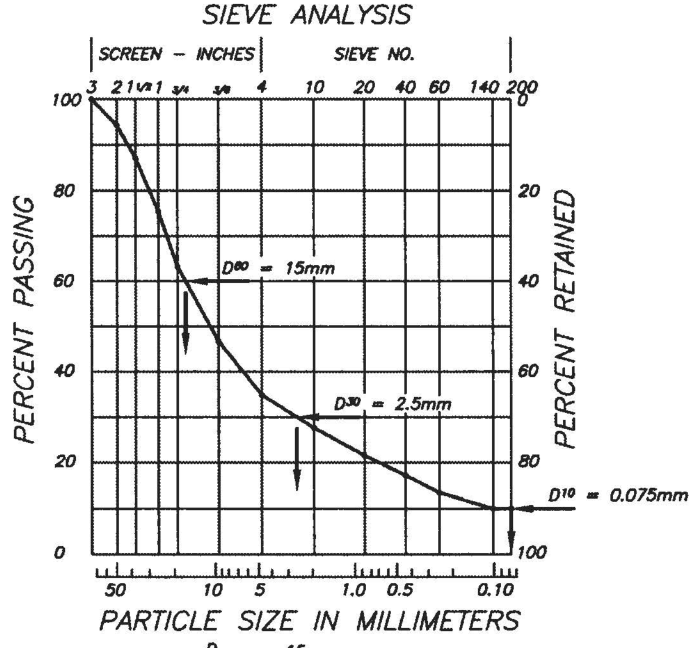


PLASTICITY CHART FOR CLASSIFICATION OF FINE-GRAINED SOILS AND FINE-GRAINED FRACTION OF COARSE-GRAINED SOILS.



$$Cu = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200$$

$$Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{(2.5)^2}{0.075 \times 15} = 5.6$$

Cumulative Particle-Size Plot

FOR CLASSIFICATION OF COARSE-GRAINED SOILS WITH 12% OR LESS FINES.

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