

Exhibit Y.

Chennault Airport #8 Site Preliminary Geotechnical Engineering Report



Chennault Airport #8 Site Preliminary Geotechnical Engineering Report

**Air Cargo Building and Infrastructure
Chennault International Airport
Lake Charles, Louisiana**

for

Chennault International Airport Authority

c/o

**Vincent Shows Architects
1502 South Huntington Street
Sulphur, LA 70663**

prepared by

**Daniel J. Holder, P.E., Inc.
Consulting Civil / Geotechnical Engineer
2767 Scarborough Drive
Lake Charles, LA 70615**

**DJH File 14-046
29 August 2014**

Daniel J. Holder, P.E., Inc.
Consulting Civil / Geotechnical Engineer

2767 Scarborough Drive
Lake Charles, LA 70615
dan@danholderpe.com
337-274-4125

29 August 2014

Chennault International Airport Authority

c/o Vincent Shows Architects
1502 South Huntington Street
Sulphur, LA 70663

Attn: Mr. Steven D. Shows, A.I.A.

RE: Geotechnical Engineering Report
Air Cargo Building and Infrastructure
Chennault International Airport
Sen. J. Bennett Johnston Drive
Lake Charles, Louisiana
DJH File 14-046

Dear Mr. Shows:

I have completed the Geotechnical Engineering Report for the referenced project, and am submitting the same herewith. This work was performed in general accordance with my written scope of work dated 14 April 2014, and was authorized by you in an e-mail dated 24 April 2014.

Please advise if you have any questions regarding this information, or if I may be of any additional assistance. It has been a pleasure working with you on this project.

Sincerely,



Daniel J. Holder, P.E.
Louisiana P.E. Reg. No. 26532



Report Distribution:

Mr. Steven D. Shows, A.I.A., Vincent Shows Architects: 2 copies, 1 electronic file (.PDF)

Geotechnical Engineering Report

Air Cargo Building and Infrastructure Chennault International Airport Lake Charles, Louisiana

DJH File 14-046; 29 August 2014

PROJECT INFORMATION

1. Description of Project. Based on the information provided, it is understood that that this project will consist of a new, one-story, 9,700 square foot (in plan) Air Cargo Building with a recessed loading dock, a new concrete apron, a new 1,150 foot long 2 lane road, and automobile/truck parking. Building loads are expected to be on the order of 2 to 3 kips per foot for walls and 20 to 35 kips for columns. The loading dock will be recessed about 4 feet to accommodate 18 wheeler type tractor trailers. The new apron will be subject to Boeing 757-300 traffic. Site pavements are expected to consist of Portland cement concrete.

The site is located in an unpaved, grassy area in the Chennault International Airport facility, on Sen. J. Bennett Johnston Drive, in Lake Charles, Louisiana. Refer to the Site Vicinity Map (Figure 1), the Google Earth Aerial Photograph (Figure 2), and the Boring Location Plan (Figure 3) in the Appendix.

RESULTS OF INVESTIGATION

2. General. This investigation included the following work activities.

- a review of available geologic information;
- a site reconnaissance by the project engineer;
- three (3) soil borings to the 10 to 25 foot depth in the building area, two (2) soil borings to the 10 foot depth in the apron area, and three (3) soil borings to the 6 foot depth for the proposed road;
- laboratory testing of selected soil samples
- engineering analyses and evaluations; and,
- the preparation of this report by the Geotechnical Engineer.

The approximate boring locations are shown on Figures 2 and 3 in the Appendix.

3. Site Conditions. The building site for this project consists of a grass covered area bordered by Taxi Lane 'G' to the south, Mallard Cove Street to the west, Chennault Parkway to the north, and Compass Rose to the east. A small drainage swale runs west from Compass Rose across the site to a large drainage ditch that runs parallel to

Mallard Cove Street on the west side of the site. The site appears to be relatively flat and level, with several low spots. Drainage appears to be poor to very poor. The airport once served as a United States Air Force base, and thus has a long history of significant construction and earthwork activities.

According to historic aerial photographs available on Google Earth (e.g., Figure 2), the eastern half or so of the building site (immediately west of the Compass Rose) was once occupied by four (4) ball fields (in a circular footprint) until at least March 2006. No other significant changes are evident since February 1998, except minor grading for drainage and the construction of the large drainage ditch on the west side of the site sometime between February 1998 and September 2003.

According to the Geologic Map of Louisiana (*Pope, et al, 1984*), the site is underlain by the Prairie Formation of Pleistocene Age. These soils are described as "*Light gray to light brown clay, sandy clay, silt, sand, and some gravel.*" A portable GPS unit indicated that the center of the site is located at an approximate latitude and longitude of N 30° 12' 45.5" and W 93° 09' 32.1," respectively. The appropriate U.S.G.S. Topographic Map indicates that the site is at an elevation of about +15 MSL. Refer to Figures 1, 2, and 3 in the Appendix.

4. Soil and Ground Water Conditions. In general, the soils encountered in the borings made for this project may be described as follows.

Generalized Soil Stratification

<u>Depth (ft)</u>	<u>Soil Description</u>
0 to 4 (or less)	Firm to hard dark brown, dark gray, or brownish gray CLAYEY to fine SANDY SILT (CL-ML), w/ roots (sometimes fill)
4 to 10	Stiff or firm light gray w/ tan SILTY to SANDY CLAY (CL), grading to reddish brown w/ light gray
10 to 25	Stiff reddish brown w/ light gray CLAY (CH), grading to dark gray & dark brown below about the 17 foot depth

The borings were advanced using dry auger methods to determine the presence of and the hydrostatic conditions of ground water in the boreholes. Ground water was not encountered at any time in the borings. The depth to ground water can fluctuate with seasonal variations in rainfall and evaporation, etc. The actual depth to ground water should be determined more accurately at the time of construction, but, based on historical experience at Chennault, long term ground water levels should be at about the 8 to 10 foot depth.

The information contained in this section has been generalized from the data obtained from all of the soil borings made for this investigation, and is meant to provide the reader with a general overview of the soil and ground water conditions. For more specific information, refer to the Boring Logs in the Appendix.

GEOTECHNICAL RECOMMENDATIONS

5. General Considerations. The silty natural soils and fills encountered to about the 4 foot depth (sometimes as shallow as 2 feet) in the borings made for this investigation appear to be relatively stiff; however, this material will lose strength when wetted or disturbed, and should not be used for the support of building foundations, floor slabs, or pavements. This material should be completely removed from the building areas and replaced with new select fill, or the foundations should extend deeper into the underlying stiff clayey soils.

In the apron and roadway areas, and under the floor slabs, it may be possible to leave some of this material in place, if desired, as long as it provides a firm surface for the placement and compaction of new select fill, and that a buffer of at least 2 feet of new select fill is placed and compacted below the bottom of the pavement section or floor slab. If, however, the silty material is wet or deflects excessively under the earthwork operations or is otherwise unsuitable, it will have to be completely removed and replaced with select fill as described above.

In lieu of completely (or partially) removing the silty soils as described above, it may be possible to stabilize these soils, once the vegetation and all organic material has been completely removed. This option would be most likely to be suitable under the pavements and floor slabs; foundations should not bear in this silty material whether stabilized or not.

Recommendations for site preparation and earthwork activities are provided in Section 6.

Once the undercutting and earthwork activities described above and in Section 6 are completed, shallow foundations should be suitable for the support of the new building for this project, provided some nominal soil movements can be tolerated. If any such movements occur, they should be relatively minor, causing only aesthetic damages (e.g., minor cracks in brick and masonry exteriors, minor cracks in interior finishes, slight unlevelness of floors and other horizontal surfaces, and door and window jambs that “stick” or become slightly out of square); serious structural damage would not be likely. The use of a reinforced slab foundation (i.e., a “ribbed” slab) is recommended to provide rigidity in the slab to help resist differential settlements. The slab may be conventionally reinforced or post-tensioned with high strength steel tendons. In general, the higher the quality of the earthwork operations, and the stiffer the foundation is

constructed, the less likely are the chances for soil movements to cause any signs of building distress. Recommendations for shallow foundations are provided in Section 7.

Alternately, the new building for this project may be supported upon drilled, cast-in-place, concrete shafts. Drilled shafts are especially suitable for supporting large column loads and resisting lateral loads and overturning moments, and will greatly reduce the potential for soil movements. If drilled shafts are used to support the building, the site preparation and earthwork activities described above and in Section 6 are still recommended for the support of slab-on-grade floors. Alternately, a structural floor slab system supported by the drilled shafts may be considered, in which case virtually no site preparation or earthwork activities would be required beneath the floor slab except as necessary to establish the desired subgrade elevation. (A structural floor slab supported by drilled shafts, however, will be significantly more substantial than a slab-on-grade floor slab, and will require the shafts to carry significant additional loading.) Recommendations for drilled shafts are provided in Section 8.

It is understood that the building will include a recessed loading dock about 4 feet or so in height. The below grade portion of the wall will act as a retaining wall, and will be subject to lateral earth pressures from the retained earth and any surcharge loads on the floor of the building. Recommendations for the loading dock retaining wall are provided in Section 9.

Once the site preparation and earthwork activities described above and in Section 6 are completed, the finished subgrade surface should be suitable for the support of pavements for the apron and roadway. Recommendations for site pavements are provided in Section 10.

6. Site Preparation and Earthwork Activities. The shallow, unsuitable silty soils should be removed to expose the firm, stable tan and gray sandy clay subgrade (or, at least as required to provide the recommended buffer of new select fill beneath the pavements and/or floor slabs, as described in Section 5). A minimum undercut of 2 to 4 feet should be anticipated, with deeper excavations required for any isolated poor conditions, or to help provide the recommended buffer of new select fill.

The exposed subgrade surface should be inspected to ensure that a suitable surface exists upon which to place select fill. This inspection may include proofrolling the subgrade with a loaded, tandem-axle dump truck or other means as determined by the inspector. Any areas that are determined to be unsuitable for fill placement should be further undercut or stabilized to achieve a stable subgrade surface. The subgrade surface may become soft and yield under wet conditions or if overloaded by construction traffic, and may require further undercutting and/or stabilization. Proper subgrade preparation and inspection is essential for the development of this project.

Once a firm subgrade exists upon which to conduct fill operations, select fill may be placed to achieve the desired building pad and pavement subgrade elevations, if required. The new building pad should extend a minimum horizontal distance of 10 feet outside the exterior building lines, if possible, and be sloped at a minimum of 10 Horizontal to 1 Vertical (10H:1V) to facilitate drainage away from the building foundations and pavement areas.

Select fill should consist of a silty or sandy clay with a Liquid Limit of 30 to 42 and a Plasticity Index of 12 to 22. The fill should be placed in 6 inch thick loose lifts or less and compacted to 95% of the Standard Proctor Maximum Dry Density at $\pm 2\%$ of the Optimum Moisture Content (ASTM D 698). Each lift should be tested to ensure compliance with these recommendations prior to placing subsequent lifts. A minimum testing frequency of one test per 2,500 square feet, but not less than 3 tests, per lift is recommended. All subgrade preparation and earthwork activities should be observed and tested by qualified personnel experienced in earthwork inspection.

Good surface drainage should be established prior to and during the earthwork activities. Standing water on the subgrade or in any excavations should be promptly drained or pumped off. Standing water on the subgrade for the new building and pavement areas and/or in any excavations should be promptly drained or pumped off.

7. Shallow Foundations. Following the completion of the Site Preparation and Earthwork activities described in Section 6, shallow foundations should be suitable for the support of the new building, provided some settlement and/or other minor soil movements can be tolerated, as previously described. A reinforced slab foundation is recommended for the building for this project to help accommodate soil movements.

7.1 Reinforced Slab (or "Ribbed") Foundation. A reinforced slab foundation consists of a monolithic slab-on-grade with turned-down edges (perimeter grade beams); interior grade beams may be included if required by the building loads and/or stiffness considerations. The perimeter grade beams function as shallow foundations to carry the exterior wall loads and serve to cutoff moisture fluctuations in the soils supporting the slab from the surrounding environment. Interior grade beams serve to stiffen the slab system, allowing it to better accommodate movements in the supporting soils. Interior grade beams should be located beneath any load bearing interior walls and/or columns, in which case they should be designed as a shallow foundation. The spacing of the interior grade beams should be determined by the structural engineer; typically, a maximum spacing of 15 feet or less (each way) is utilized. Adequate reinforcement, as determined by the structural engineer, should be provided in the slab-on-grade foundation and grade beams. The entire slab system should be placed monolithically (in one pour), or dowelled to provide equivalent rigidity.

The slab foundation may be reinforced with conventional reinforcing steel (rebar) or post tensioned steel tendons (i.e., a post-tensioned slab). The grade beam dimensions and reinforcement of either foundation system should be determined by a qualified design professional knowledgeable in the design of slabs-on-grade.

The slab section should be underlain by a suitable polyethylene vapor barrier (e.g., Visqueen) and a granular leveling layer. The vapor barrier should extend beneath the grade beams and/or shallow foundation elements; the granular layer is typically located just beneath the slab-on-grade.

7.2 Bearing Capacity and Soil Movements. Shallow foundations or load bearing grade beams should bear within the new, properly placed and compacted fill. Shallow foundations or load bearing grade beams bearing designed in accordance with these recommendations may be designed for a maximum net allowable soil bearing capacity of 2,000 pounds per square foot (psf); capacities for column footings may be increased to 2,600 psf. The exterior grade beams should extend to a depth of at least 2 feet below finished exterior grades to help minimize moisture fluctuations in the foundation soils. In the case of any grade beams or footings near the edge of a slope, the bottom of the grade beams or footings should be at least 10 feet from the face of the slope (measured horizontally).

Net allowable soil capacities take into account the weight of the concrete and backfill below grade; thus, no adjustments to the design loads are necessary. The bearing capacities provided in this section include a factor of safety of at least 2 against shear failure of the bearing soils. A minimum footing or grade beam width of 18 inches (24 inches for column footings) is recommended to minimize the possibility of shear “punch” failure of the bearing soils.

Post-construction soil movements from normal foundation settlements are expected to be on the order of one inch or less. Differential movements should be about one-half to two-thirds of the total observed movement.

7.3 Rectangular Footings and Overturning. Capacities for rectangular footings may be increased according to the following formula:

$$q_r = q_w (1 + 0.3 B/L)$$

where q_r = net allowable bearing pressure for rectangular footings (psf)
 q_w = net allowable bearing pressure for continuous footings given in Section 7.2 (psf)
 B = footing width
 L = footing length ($L > B$)

Resistance to overturning loads should only consider the **effective** footing area, i.e., the portion of the footing centered beneath and effective in carrying the load. The equivalent footing dimensions B' and L' of the effective footing area are defined as:

$$B' = B - 2e_B \quad \text{and} \quad L' = L - 2e_L$$

where e_B and e_L are the eccentricity in each direction. Eccentricity is defined as the moment (M) divided by the axial load (P), or

$$e_B = M_B / P_B \quad \text{and} \quad e_L = M_L / P_L$$

7.4 Lateral Loads. Lateral loads on the foundation will be resisted by sliding resistance between the base of the foundation and the underlying soil and by lateral earth pressure against the side of the foundation; the latter should be neglected for shallow foundations for this project. The allowable sliding resistance, $f_{s, all}$, may be taken as 0.2 times the applied bearing pressure, not to exceed a value of 250 psf. This is an allowable value; a safety factor of about 1½ to 2 against sliding resistance has already been included.

7.5 Uplift Loads. Foundations placed to depths of about 4 feet or less should be designed for uplift by taking into account the dead weight of the concrete and any overlying backfill. A typical unit weight of 120 pounds per cubic foot (pcf) should be utilized for the soil backfill if properly placed and compacted (refer to Section 6). Granular soils should not be used for backfill over foundations subject to uplift because the soils could become saturated if poor drainage exists. Buoyant unit weights (i.e., subtract the unit weight of water, 62.4 pcf) should be used for uplift calculations if proper drainage cannot be assured.

7.6 Construction Considerations. Shallow excavations (i.e., 4 to 6 feet deep or less) for foundations in stiff natural soils at this site should remain stable (i.e., should not cave) for short periods of time, particularly in the absence of surface or ground water. Excavations that remain open for longer periods of time will be subject to significant ground water intrusion. The reinforcing steel and concrete for the foundations should be placed expeditiously following the completion of the excavation. The excavations should not be permitted to stand open any longer than necessary. Any water that may accumulate in the excavations should be pumped out immediately.

The foundation excavations should be inspected by the geotechnical engineer's representative to ensure that the bearing surface is properly prepared prior to placing the reinforcing steel or concrete for the foundation. The soils at this site can become significantly weaker if wetted or disturbed during the construction operations. Traffic in the excavations should be prohibited, and drainage should

be provided to direct surface and ground water (if any) away from the excavations. If the concrete for the foundation will not be placed on the same day as the excavation, a “mud mat” of lean concrete should be placed to protect the bearing surface.

According to OSHA regulations (CFR 1926.650 through 1926.652, and Appendix A to Subpart P), the contractor is responsible for developing and maintaining the appropriate safety systems for excavations on the project. The soils should be classified as Type C for this purpose. Recommendations for temporary slopes and/or shoring are beyond the scope of this investigation, but can be provided upon request once more specific design details are available.

8. Drilled Shaft Foundations. As noted in Section 5, drilled shafts may also be considered for the support of this project. Straight-sided drilled shafts should be utilized for this project; belled (underreamed) shafts will likely experience construction difficulties and are not recommended for use on this project. Excavations for drilled shafts may require temporary steel casing and/or full depth drilling slurry. The contractor should be thoroughly experienced with the use of these drilling techniques or significant construction difficulties and/or inadequate shaft sections could result. Refer to Section 8.5 for construction considerations.

8.1 Axial Capacity. The compressive axial capacity of drilled shafts is derived from skin friction at the soil-shaft interface and end bearing. Uplift resistance is provided by skin friction and the buoyant weight of the shaft.

Numerous shaft diameters and embedment depths were considered in order to allow the project designer to select the most suitable shaft geometry for the specific loading conditions. These values are tabulated below. The allowable shaft capacities include factors of safety of 2 and 2.5 for skin friction and end bearing in compression, respectively, and 2.5 for skin friction in uplift. The upper 6 feet of skin friction has been neglected due to a pile cap and/or potential surface effects, and the potential undercut expected for the existing drainage ditch. The buoyant unit weight of the shaft is also included in the provided uplift capacities, along with a factor of safety of 1.1. Capacities for intermediate diameters and/or depths may be interpolated from the table. Extrapolation beyond the specified diameters and depths is not recommended without further consultation.

Allowable Compression/Uplift Loads for Single Drilled Shaft Foundations (kips)

<u>Depth (ft)</u>	<u>18 Inch Dia.</u>	<u>24 Inch Dia.</u>	<u>30 Inch Dia.</u>	<u>36 Inch Dia.</u>
10	25 / 15	36 / 21	50 / 27	65 / 33
15	39 / 27	55 / 27	73 / 47	93 / 58
20	53 / 39	74 / 53	97 / 68	121 / 84

All shaft capacities cited above are based on good quality construction procedures being utilized. Sufficient full depth reinforcement, as determined by the structural engineer, is required to develop the full tensile capacity of the shaft.

8.2 Settlement. Total settlements for drilled shaft foundations designed and constructed in accordance with these recommendations are estimated to be about one-half inch or less. Differential settlements between adjacent shafts should be about one-half to three-quarters of the observed total settlement.

8.3 Lateral Loads and Overturning Moments. It is not known if the tops of the drilled shafts will be subject to lateral loads and/or overturning moments, or if these forces will be resisted by the structure itself. The evaluation of lateral loading and overturning moments on drilled shafts can be complex and time consuming for a large number of shaft geometries, such as that provided in this report. Once the final loading conditions on the drilled shafts are known, this office should be contacted for further evaluation.

8.4 Shaft Spacing and Group Effects. Shafts should be spaced a minimum of 2.5 to 3 diameters center-to-center or 5% of the shaft length, whichever is greater. Large groups of shafts are not anticipated; however, if groups of 5 or more shafts are utilized, the Geotechnical Engineer should be permitted to evaluate group efficiencies.

8.5 Construction Considerations. Excavations for drilled shafts may require temporary steel casing and/or full depth drilling slurry to remain stable (i.e., not cave). The contractor should be thoroughly experienced with the use of these drilling techniques or significant construction difficulties and/or inadequate shaft sections could result. Drilling slurry, if utilized, should be introduced into the excavation immediately upon drilling, and maintained at full depth during the drilling and concreting operations. The excavation and concrete placement should proceed as expeditiously as possible. Once the excavation is started, it should be completed and concrete placed without delay. The slurry should be premixed and brought to the proper consistency, etc., before introducing into the excavation. The drilling tools (augers) should be designed such that the slurry can pass freely around or through the tool as the auger is withdrawn, and the auger should be operated slowly enough that suction does not develop beneath the auger and cause caving. The bottom of the excavation should be cleaned out with an air lift pump or similar device; a clean-out bucket is not recommended. Prior to cleanout, the slurry should be allowed to stand undisturbed for about 15 to 30 minutes to allow all suspended solids to settle out.

The reinforcing steel and concrete for the shaft should be placed immediately after the clean out operations are complete. The reinforcing cage should be fixed in place with centralizers or other means so that it is not disturbed by the

concrete placement. If temporary steel casing is used to achieve a dry excavation, the concrete may be dropped freely through the excavation, provided it is not permitted to strike any obstructions on the way down and does not land in standing water. If this cannot be achieved, a full depth tremie should be utilized to place the concrete. A "head" of concrete of at least 5 feet above the bottom of the casing should be maintained while the temporary casing is withdrawn.

If drilling slurry is utilized, the concrete should be placed by means of a full depth, water-tight tremie with a valve or other means of separating the slurry from the concrete (e.g., a pig). The concrete should be proportioned so that it has the proper strength as determined by the project designers, while maintaining a slump of 6 to 8 inches at the time of placement. This is critical to ensure that the slurry is completely displaced, and that no voids remain within the completed shaft. All drilling and concreting operations should be observed by qualified personnel experienced in drilled shaft inspection techniques.

9. Lateral Earth Pressures on Retaining Walls. As noted in Section 1, the building will include a recessed loading dock with a 4 to 5 foot high retaining wall. The retaining wall will be subject to lateral earth pressures from the retained soil and the surcharge loads carried by the floor slab. It is expected that the walls will be rigid; that is, unable to rotate at the top. This will result in an "at-rest" earth pressure condition, which is slightly higher than the "active" pressure condition that results when the top of the wall is able to rotate. If the dock is cut into the natural, cohesive soils and proper drainage is provided behind the wall, an at-rest earth pressure coefficient of 0.7 should be used for determining the lateral earth pressures. If a free draining, well graded granular soil is used for backfill behind the wall (extending upwards at a 45 degree angle from the base of the wall), then an "at-rest" earth pressure coefficient of 0.5 may be used. These coefficients correspond to Equivalent Fluid Pressures of about 90 and 65 pounds per square foot per foot of depth for the cohesive and granular soils, respectively (not including any surcharge loads). If granular backfill is used, it should be a clean (less than 5 percent passing the No. 200 Sieve) sand or gravel with a gradation meeting the requirements of Sections 1003.02 (a), Concrete Sand, or 1003.03 (b), Base Course Stone, in *Louisiana Standard Specification for Roads and Bridges, 2006 Edition*. A suitable filter fabric should be provided between the aggregate base and the clayey subgrade (if applicable) to prevent the mixing of the base and subgrade. All fill should be placed, compacted, and tested in accordance with the recommendations contained in Section 6 of this report. Extreme caution should be used when compacting against the retaining walls to avoid overstressing and/or causing deflections in the walls, while achieving sufficient compaction to minimize the possibility of soil settlements in the fill.

Proper drainage must be provided behind and in front of the wall so that water cannot accumulate behind the wall or in the recessed dock.

10. Pavements. Following the completion of the Site Preparation and Earthwork activities described in Section 6, the prepared subgrade should be suitable for the support of the project pavements. The success of any pavement system depends primarily on the following factors: traffic volume and wheel (or axle) loadings, drainage, construction quality, and regular inspection and maintenance. These considerations are discussed in Section 10.1.

It has been the experience of this author that Portland cement concrete (PCC) pavements generally perform better than asphaltic concrete (AC) pavements in this area, and thus are recommended for use on this project. PCC pavements generally require a larger initial investment; however, future maintenance costs are generally less than that of AC pavements. Recommendations for PCC pavements are provided in Section 10.2.

The previous paragraph notwithstanding, properly designed and maintained asphalt pavements can also perform satisfactorily for projects of this type, and are discussed for the project designer's consideration. AC pavements generally involve less initial investment, although greater future maintenance costs are involved. Recommendations for AC pavements can be provided upon request.

10.1 General Considerations for Pavement Systems.

- Traffic Loading Conditions. Pavement sections should be designed to accommodate the anticipated traffic volume and loadings. Overloading pavement sections through excessive wheel loads and/or repetitions will lead to premature pavement failure.

It is understood that traffic loading conditions for this project will consist of two distinct cases, as described below.

- Road, Driveway, and Parking. The new road, driveway, and parking areas are expected to be subject to heavy and medium trucks and light passenger car and truck traffic and parking. Traffic frequencies have not been specified, but it is expected that several large trucks a day might utilize the pavements, as well as unlimited light passenger car and truck traffic and parking.
- Apron. The new apron is expected to be subject to Boeing 757-300 traffic. Again, the traffic frequencies have not been specified, but it is expected that several aircraft per day might travel across the apron for loading and unloading.
- Drainage. Establishing and maintaining good drainage is essential to the successful performance of pavements. Without good drainage conditions, premature pavement failure can be expected. The final subgrade surface

should be contoured to channel surface and subsurface water away from the pavements. If site grades allow, the pavement sections should be elevated so that an aggregate base course can drain freely. Otherwise, a soil-cement base or other such base that will not trap water beneath the pavements should be utilized.

- Construction Quality. Quality construction practices and inspection services are essential for the successful installation and performance of pavements. Construction inspection services by Geotechnical Engineer's representative are considered essential for this phase of the project.
- Inspection and Maintenance. A regular inspection and maintenance program should be conducted to ensure that the pavement is maintained in good operating condition. The pavements should be inspected regularly to verify that adequate drainage is maintained and that all joints are properly sealed and free of vegetation or debris. When pavement distress is noted, the appropriate measures (e.g., patching, sealing, resurfacing, etc.) should be performed to keep the pavements in good operating condition.

10.2 Portland Cement Concrete (PCC) Pavements. PCC pavements subject to heavy and medium truck traffic should consist of at least 8 inches of concrete with a minimum compressive strength of 4,000 psi (other thicknesses may be considered, as noted below). PCC pavements subject to light passenger car and traffic only can be reduced to 5 inches. PCC pavements for the apron should be at least 12 inches thick.

The pavements should be underlain by 4 inches of crushed aggregate or 6 inches of soil-cement base. The aggregate should meet the gradation requirements of LA DOTD Section 1003.03(b). Locally available products known as 610 Road Base or No. 57 Stone, although not strictly meeting 1003.03 (b), should be suitable for use as base material.

A suitable non-woven geotextile (US Fabrics US 160NW, or equal) should be provided between the aggregate base and the subgrade to prevent the mixing of the base and subgrade. If suitable drainage cannot be provided for a granular base, a 6 inch thick soil-cement base should be utilized. The soil-cement base, if utilized, should be constructed in accordance with *LA DOTD Standard Specifications for Roads and Bridges* Section 303. A treatment percentage of 10% cement (by volume) may be used for planning purposes; however, the appropriate treatment percentage should be determined by additional laboratory testing prior to construction using *LA DOTD Testing Procedure Manual* TR 432.

Appropriate reinforcement, as determined by the project designers, should be used and adequate control joint spacing (15 feet or less is suggested) should be

observed. Pavements should be isolated from other structures (e.g., the building and the existing pavements) by means of suitable expansion and/or control joints. Connections to the existing pavements should be dowelled to maintain alignment.

All aspects of the pavement design and construction should conform to the American Concrete Institute (ACI) *Standard 325.12R-02: Guide for Design of Jointed Concrete Pavements for Streets and Local Roads*, the *LA DOTD Standard Specifications for Roads and Bridges, Section 601 - Portland Cement Concrete*, and all other applicable engineering specifications.

In addition to the minimum specified pavement thicknesses given above, other thicknesses have been evaluated using the methodologies of the 1993 AASHTO Guide for the Design of Pavement Structures. These computations assumed a terminal serviceability index (p_t) of 2.0 (typical of secondary roads), a modulus of subgrade reaction (k) of 75 pci, and a concrete strength of 4,000 psi. The computed total equivalent 18 kip axle load (EAL) applications over the pavement lifetime for each pavement section thickness are summarized as follows:

Estimated Total EAL Applications Over Pavement Lifetime

<u>PCC Pavement Thickness (in)</u>	<u>EALs</u>
5	50,000
6	125,000
8	700,000
10	3,000,000
12	10,000,000

10.3 General. Note that the pavement sections provided in this report were derived from the experience of this firm based on similar projects that have been observed to perform satisfactorily over the last 15 years. Rigorous pavement designs have not been performed because traffic data was not provided for that purpose. Minor deviations from the pavement sections provided in this section should not necessarily be detrimental to the performance of the pavements at this site, provided traffic is limited to light passenger traffic, a good subgrade is established and fill placement is of high quality, and good construction practices are utilized when constructing the pavements (especially observing minimum specified pavement thicknesses). I will be happy to provide additional analyses for the pavement sections if requested.

OTHER GEOTECHNICAL CONSIDERATIONS

11. Drainage and Landscaping. Proper long term drainage should be provided to direct surface water away from the completed building foundations and pavements. Gutters and downspouts, as well as positive site grading, should be utilized for this purpose as required. Landscaping near the building foundations should be avoided to minimize fluctuations in the moisture contents of the surrounding soils, or a suitable drainage barrier (e.g., geosynthetic liner) should be utilized. Trees should be located no closer to the building foundations than the drip line of the mature tree canopy.

12. Additional Consulting Services. The Geotechnical Engineer should be kept informed of and permitted to address all aspects of the soils-related aspects of the project. Often, concerns may arise that are not specifically addressed by the Geotechnical Engineering Report. A brief conference can often address any such concerns, and can identify any other issues not anticipated by the design team.

Upon completion of design, and prior to the start of construction, the Geotechnical Engineer should be provided with the opportunity to review the design drawings and specifications to assure compliance with the Geotechnical Engineering Report. Such review is considered to be an integral part of the recommendations of this report.

13. Construction Inspection Services. Construction inspection services for this project are essential to assure that the soil conditions do not vary from that assumed in this report and to ensure that the recommendations in this report are followed. These services should be retained by the owner to assure that unbiased reporting is provided. The Geotechnical Engineer should be provided with timely copies of all test results.

14. Limitations. This report is based upon the information provided by the owner's representative, as well as the soil and ground water conditions encountered during the field investigation. Variations may occur away from or between the borehole locations. If such variations become apparent, or if the nature of the project changes significantly, the Geotechnical Engineer should be consulted for additional recommendations.

The recommendations in this report pertain only to the soils-related aspects of the project. The structural design of the building foundations is beyond the scope of these services. Likewise, this report does not address the environmental aspects of the project. We would be pleased to assist with these additional services if requested.

APPENDIX

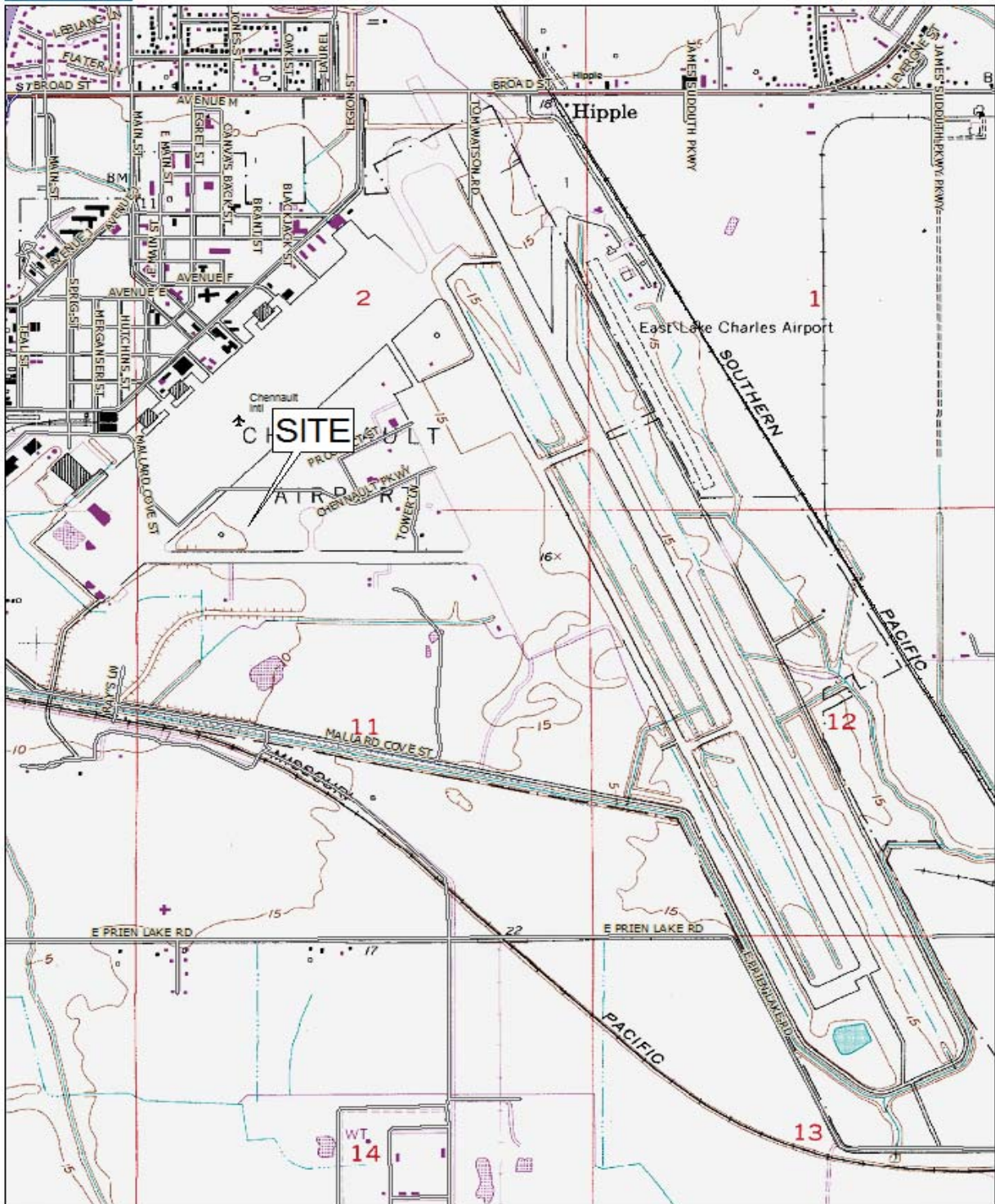
U.S.G.S. Topographic Map / Site Vicinity Map (Figure 1)

Google Earth Aerial Photograph (Figure 2)

Boring Location Plan (Figure 3)

Soil Boring Logs (8)

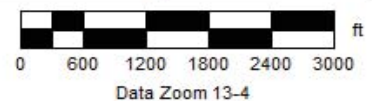
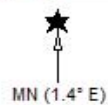
Description of Field and Laboratory Testing Procedures



Data use subject to license.

© DeLorme. Topo North America™ 9.

www.delorme.com



Daniel J. Holder, P.E., Inc.
 Consulting Civil / Geotechnical Engineer
 2767 Scarborough Drive
 Lake Charles, LA 70615
 (337) 274-4125 dan@danholderpe.com

Air Cargo Building & Infrastructure
 Lake Charles, Louisiana
 for
 Chennault International Airport Authority
 c/o Vincent Shows Architects

Project Engineer: DJH	DJH File No. 14-046
Drawn By: dan	Date: 28 Aug 14
Checked By: <i>[Signature]</i>	Figure No. 1
Site Vicinity Map / U.S.G.S. Topographic Map	

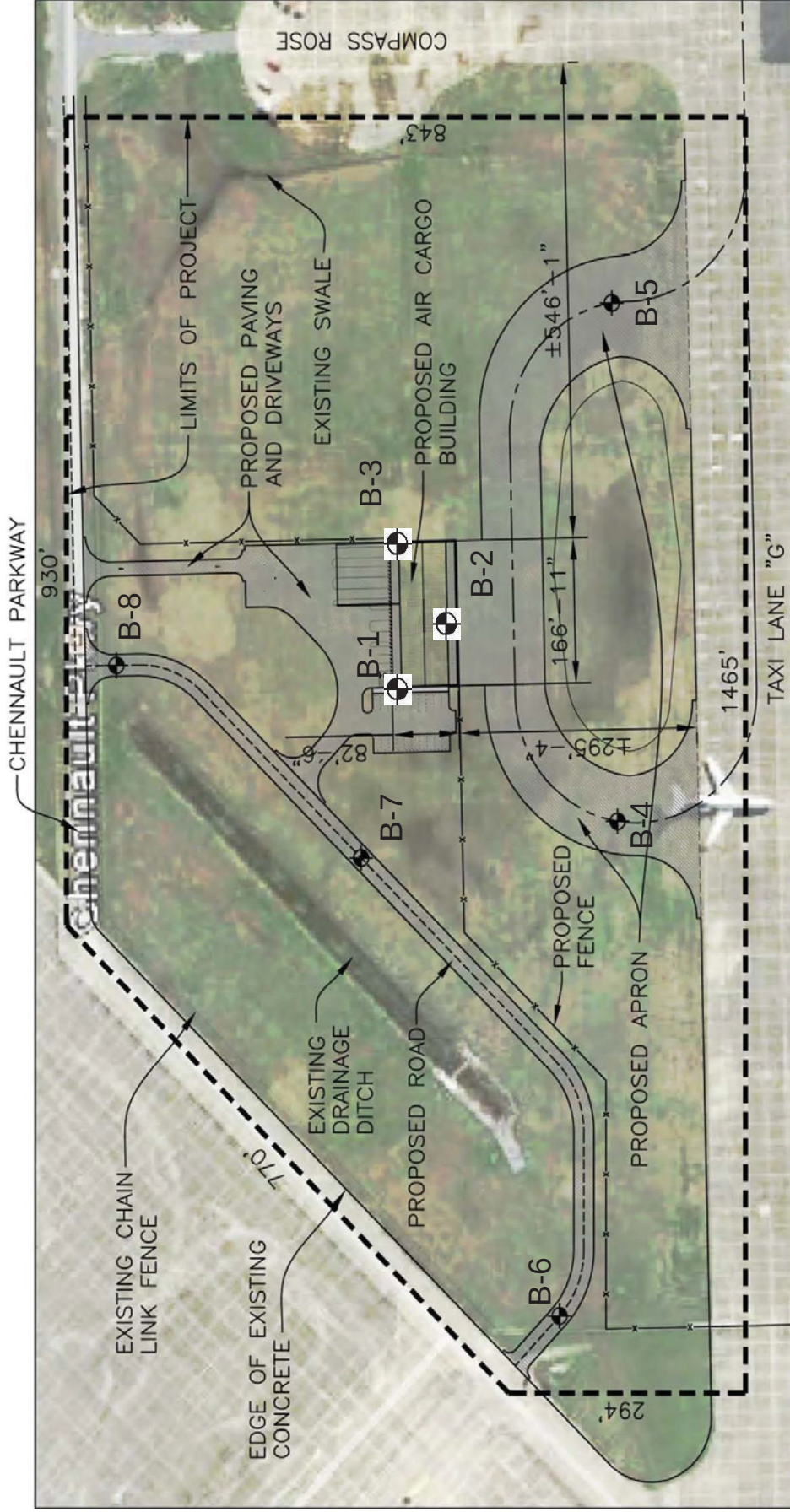
Source: U.S.G.S. 7.5 Minute Topographic Map, 1999 (3-D TopoQuads, DeLorme)



Imagery Date: 5/5/2013 30°12'45.93" N 93°09'31.60" W elev

Daniel J. Holder, P.E., Inc. Consulting Civil / Geotechnical Engineer 2767 Scarborough Drive Lake Charles, LA 70615 (337) 274-4125 dan@danholderpe.com	Air Cargo Building & Infrastructure Lake Charles, Louisiana for Chennault International Airport Authority c/o Vincent Shows Architects	Project Engineer: DJH	DJH File No. 14-046
		Drawn By: dan	Date: 28 Aug 14
		Checked By: <i>[Signature]</i>	Figure No. 2
		Google Earth Aerial Photograph	

Source: Google Earth Aerial Photograph dated 5/05/2013



Daniel J. Holder, P.E., Inc.
 Consulting Civil / Geotechnical Engineer
 2767 Scarborough Drive
 Lake Charles, LA 70615
 (337) 274-4125
dan@danholderpe.com

Air Cargo Building & Infrastructure
 Lake Charles, Louisiana
 for
 Chennault International Airport Authority
 c/o Vincent Shows Architects

Project Engineer: DJH
 Drawn By: dan
 Checked By: *[Signature]*

DJH File No. 14-046
 Date: 28 Aug 14
 Figure No. 3

Boring Location Plan

Source: Site Plan Provided by Vincent Shows Architects

SOIL BORING LOG

Boring No. B-1

Page 1 of 1

Project: Air Cargo Building & Infrastructure
 Location: Chennault International Airport
 Lake Charles, Louisiana
 Client: Chennault International Airport Authority
 c/o Vincent Shows Architects

DJH File No: 14-046
 Date Drilled: 5/09/2014
 Logged By: Nathan Pettit
 Drilled By: Triangle Resources, Inc.
 Equipment: Ardco Top Drive (Buggy)

Depth (ft)	Field Tests			Laboratory Tests							Symbol	Description				
	Sample Type	Penetrometer (tsf) or SPT (bpf)	Ground Water	Qu / UU (tsf)	Dry Density, γ _d (pcf)	Moisture Content, w (%)	Atterberg Limits			Notes / Other Tests						
							Liquid Limit, %	Plastic Limit, %	Plasticity Index, %							
1	ST	3½ tsf	★													Firm dark gray fine SANDY SILT (ML), w/ roots
2																
3	ST	1½ tsf														Firm dark gray CLAYEY SILT (CL-ML)
4																
5	ST	3 tsf		1.5	115	19	29	17	12	ε _f = 10%						-ditto, w/ brown & black oxides
6																
7	ST	½ tsf		1.3	110	20				ε _f = 10%						Stiff light gray w/ reddish brown SANDY CLAY (CL), w/ brown & black oxides
8																
9	ST	¾ tsf														Firm to stiff reddish brown w/ light gray CLAY (CH), w/ black oxides & light gray silt pockets
10																
11	ST	2½ tsf		1.5	100	27	51	22	29	ε _f = 6.4%						-ditto, w/ silt lenses
12																
13	ST	3½ tsf		2.1	99	29				ε _f = 4.3%						-ditto, very stiff
14																
15																
16																
17																
18	ST	2½ tsf		1.7	91	34	66	26	40	ε _f = 4.3%						Stiff brown CLAY (CH), w/ lots of light gray silt laminations
19																
20																
21																
22																
23	ST	2¼ tsf		1.9	98	31				ε _f = 4.3%						Stiff brown w/ light gray CLAY (CH), w/ brown oxides & light gray silt pockets
24																
25																
Boring Data						Ground Water Data					Notes / Other Tests					
Boring Advancement: Dry Auger: 0' - 25' Rotary Wash: n/a						★ No Ground Water Encountered					ε _f = Failure Strain					
Boring Abandonment: Boring Backfilled w/ Soil Cuttings Upon Completion						Sample Type: ST: Shelby Tube (ASTM D 1587) SS: Split Spoon (ASTM D 1586)					Soil Stratification is Approximate					

Daniel J. Holder, P.E., Inc.
 Consulting Civil / Geotechnical Engineer

2767 Scarborough Drive
 Lake Charles, LA 70615

(337) 274-4125
dan@danholderpe.com

SOIL BORING LOG

Boring No. B-2

Page 1 of 1

Project: Air Cargo Building & Infrastructure
 Location: Chennault International Airport
 Lake Charles, Louisiana
 Client: Chennault International Airport Authority
 c/o Vincent Shows Architects

DJH File No: 14-046
 Date Drilled: 5/09/2014
 Logged By: Nathan Pettit
 Drilled By: Triangle Resources, Inc.
 Equipment: Ardco Top Drive (Buggy)

Depth (ft)	Field Tests			Laboratory Tests							Symbol	Description	
	Sample Type	Penetrometer (tsf) or SPT (bpf)	Ground Water	Qu / UU (tsf)	Dry Density, γ _d (pcf)	Moisture Content, w (%)	Atterberg Limits			Notes / Other Tests			
							Liquid Limit, %	Plastic Limit, %	Plasticity Index, %				
1	ST	4½+ tsf	★										FILL - Stiff dark brown CLAYEY to SANDY SILT (CL-ML), w/ light gray & brown silty clay pockets Stiff dark brown very SILTY CLAY (CL) Stiff gray w/ brown SILTY CLAY (CL), w/ brown oxides & light gray silt pockets Stiff reddish brown & light gray SANDY CLAY (CL), w/ black oxide nodules & light gray silt pockets/ lenses
2													
3	ST	4½ tsf											
4	ST	1¾ tsf		1.4	114	19	33	18	15	ε _f = 10%			
5													
6	ST	2¾ tsf											
7													
8	ST	2½ tsf		1.2	105	24	40	22	18	ε _f = 5.0%			
9													
10													Boring Completed At 10' Depth
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
25													
Boring Data						Ground Water Data					Notes / Other Tests		
Boring Advancement: Dry Auger: 0' - 10' Rotary Wash: n/a						★ No Ground Water Encountered					ε _f = Failure Strain		
Boring Abandonment: Boring Backfilled w/ Soil Cuttings Upon Completion						Sample Type: ST: Shelby Tube (ASTM D 1587) SS: Split Spoon (ASTM D 1586)					Soil Stratification is Approximate		

Daniel J. Holder, P.E., Inc.
 Consulting Civil / Geotechnical Engineer

2767 Scarborough Drive
 Lake Charles, LA 70615

(337) 274-4125
dan@danholderpe.com

SOIL BORING LOG

Boring No. B-3

Page 1 of 1

Project: Air Cargo Building & Infrastructure
 Location: Chennault International Airport
 Lake Charles, Louisiana
 Client: Chennault International Airport Authority
 c/o Vincent Shows Architects

DJH File No: 14-046
 Date Drilled: 5/09/2014
 Logged By: Nathan Pettit
 Drilled By: Triangle Resources, Inc.
 Equipment: Ardco Top Drive (Buggy)

Depth (ft)	Field Tests			Laboratory Tests							Symbol	Description																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
	Sample Type	Penetrometer (tsf) or SPT (bpf)	Ground Water	Qu / UU (tsf)	Dry Density, γ _d (pcf)	Moisture Content, w (%)	Atterberg Limits			Notes / Other Tests																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
							Liquid Limit, %	Plastic Limit, %	Plasticity Index, %																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									
1	ST	2 tsf	★																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															

Daniel J. Holder, P.E., Inc.
 Consulting Civil / Geotechnical Engineer

2767 Scarborough Drive
 Lake Charles, LA 70615

(337) 274-4125
dan@danholderpe.com

SOIL BORING LOG

Boring No. B-4

Page 1 of 1

Project: Air Cargo Building & Infrastructure
 Location: Chennault International Airport
 Lake Charles, Louisiana
 Client: Chennault International Airport Authority
 c/o Vincent Shows Architects

DJH File No: 14-046
 Date Drilled: 5/09/2014
 Logged By: Nathan Pettit
 Drilled By: Triangle Resources, Inc.
 Equipment: Ardco Top Drive (Buggy)

Depth (ft)	Field Tests			Laboratory Tests							Symbol	Description	
	Sample Type	Penetrometer (tsf) or SPT (bpf)	Ground Water	Qu / UU (tsf)	Dry Density, γ _d (pcf)	Moisture Content, w (%)	Atterberg Limits			Notes / Other Tests			
							Liquid Limit, %	Plastic Limit, %	Plasticity Index, %				
1	ST	No Test	★										FILL - Hard brown SILTY CLAY (CL), w/ small shells, dry
2													
3	ST	2¾ tsf											-ditto, w/ small shells & roots, dry
4													
5	ST	2¼ tsf		1.2	113	19				ε _f = 9.3%			Stiff light gray w/ tan SILTY CLAY (CL), w/ brown oxides, black oxide nodules, & light gray silt streaks
6													
7	ST	2½ tsf											
8													
9	ST	4½+ tsf		1.6	104	25	42	22	20	ε _f = 5.7%			Stiff reddish brown SILTY CLAY (CL), w/ black oxides & silt pockets / lenses
10													
11													Boring Completed At 10' Depth
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
25													
Boring Data						Ground Water Data					Notes / Other Tests		
Boring Advancement: Dry Auger: 0' - 10' Rotary Wash: n/a						★ No Ground Water Encountered					ε _f = Failure Strain		
Boring Abandonment: Boring Backfilled w/ Soil Cuttings Upon Completion						Sample Type:					Soil Stratification is Approximate		
						ST: Shelby Tube (ASTM D 1587) SS: Split Spoon (ASTM D 1586)							

Daniel J. Holder, P.E., Inc.
 Consulting Civil / Geotechnical Engineer

2767 Scarborough Drive
 Lake Charles, LA 70615

(337) 274-4125
dan@danholderpe.com

SOIL BORING LOG

Boring No. B-5

Page 1 of 1

Project: Air Cargo Building & Infrastructure
 Location: Chennault International Airport
 Lake Charles, Louisiana
 Client: Chennault International Airport Authority
 c/o Vincent Shows Architects

DJH File No: 14-046
 Date Drilled: 5/09/2014
 Logged By: Nathan Pettit
 Drilled By: Triangle Resources, Inc.
 Equipment: Ardco Top Drive (Buggy)

Depth (ft)	Field Tests			Laboratory Tests							Symbol	Description																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
	Sample Type	Penetrometer (tsf) or SPT (bpf)	Ground Water	Qu / UU (tsf)	Dry Density, γ _d (pcf)	Moisture Content, w (%)	Atterberg Limits			Notes / Other Tests																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																	
							Liquid Limit, %	Plastic Limit, %	Plasticity Index, %																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
1	ST	No Test	★																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								

Daniel J. Holder, P.E., Inc.
 Consulting Civil / Geotechnical Engineer

2767 Scarborough Drive
 Lake Charles, LA 70615

(337) 274-4125
dan@danholderpe.com

SOIL BORING LOG

Boring No. B-6

Page 1 of 1

Project: Air Cargo Building & Infrastructure
 Location: Chennault International Airport
 Lake Charles, Louisiana
 Client: Chennault International Airport Authority
 c/o Vincent Shows Architects

DJH File No: 14-046
 Date Drilled: 5/09/2014
 Logged By: Nathan Pettit
 Drilled By: Triangle Resources, Inc.
 Equipment: Ardco Top Drive (Buggy)

Depth (ft)	Field Tests			Laboratory Tests							Symbol	Description	
	Sample Type	Penetrometer (tsf) or SPT (bpf)	Ground Water	Qu / UU (tsf)	Dry Density, γ _d (pcf)	Moisture Content, w (%)	Atterberg Limits			Notes / Other Tests			
							Liquid Limit, %	Plastic Limit, %	Plasticity Index, %				
1	ST	4½+ tsf	★										Firm dark brown very SILTY CLAY to CLAYEY SILT (CL-ML)
2													
3	ST	¾ tsf				22	42	19	23				Stiff light gray & brown SILTY CLAY (CL), w/ brown oxides & silt streaks
4													
5	ST	¾ tsf											-bluish gray w/ brown, w/ brown oxides
6													Boring Completed At 6' Depth
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
21													
22													
23													
24													
25													
Boring Data						Ground Water Data					Notes / Other Tests		
Boring Advancement: Dry Auger: 0' - 6' Rotary Wash: n/a						★ No Ground Water Encountered					ε _f = Failure Strain Soil Stratification is Approximate		
Boring Abandonment: Boring Backfilled w/ Soil Cuttings Upon Completion						Sample Type:							
						ST: Shelby Tube (ASTM D 1587) SS: Split Spoon (ASTM D 1586)							

Daniel J. Holder, P.E., Inc.
 Consulting Civil / Geotechnical Engineer

2767 Scarborough Drive
 Lake Charles, LA 70615

(337) 274-4125
dan@danholderpe.com

SOIL BORING LOG

Boring No. B-7

Page 1 of 1

Project: Air Cargo Building & Infrastructure
 Location: Chennault International Airport
 Lake Charles, Louisiana
 Client: Chennault International Airport Authority
 c/o Vincent Shows Architects

DJH File No: 14-046
 Date Drilled: 5/09/2014
 Logged By: Nathan Pettit
 Drilled By: Triangle Resources, Inc.
 Equipment: Ardco Top Drive (Buggy)

Depth (ft)	Field Tests			Laboratory Tests							Symbol	Description																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
	Sample Type	Penetrometer (tsf) or SPT (bpf)	Ground Water	Qu / UU (tsf)	Dry Density, γd (pcf)	Moisture Content, w (%)	Atterberg Limits			Notes / Other Tests																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
							Liquid Limit, %	Plastic Limit, %	Plasticity Index, %																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
1	ST	4½+ tsf	★																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									

Daniel J. Holder, P.E., Inc.
 Consulting Civil / Geotechnical Engineer

2767 Scarborough Drive
 Lake Charles, LA 70615

(337) 274-4125
dan@danholderpe.com

SOIL BORING LOG

Boring No. B-8

Page 1 of 1

Project: Air Cargo Building & Infrastructure
 Location: Chennault International Airport
 Lake Charles, Louisiana
 Client: Chennault International Airport Authority
 c/o Vincent Shows Architects

DJH File No: 14-046
 Date Drilled: 5/09/2014
 Logged By: Nathan Pettit
 Drilled By: Triangle Resources, Inc.
 Equipment: Ardco Top Drive (Buggy)

Depth (ft)	Field Tests			Laboratory Tests							Symbol	Description																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
	Sample Type	Penetrometer (tsf) or SPT (bpf)	Ground Water	Qu / UU (tsf)	Dry Density, γ _d (pcf)	Moisture Content, w (%)	Atterberg Limits			Notes / Other Tests																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
							Liquid Limit, %	Plastic Limit, %	Plasticity Index, %																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
1	ST	4½+ tsf	★																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									

Daniel J. Holder, P.E., Inc.
 Consulting Civil / Geotechnical Engineer

2767 Scarborough Drive
 Lake Charles, LA 70615

(337) 274-4125
dan@danholderpe.com

Description of Field and Laboratory Testing Procedures

Field Testing Procedures. The borings were located in the field using the information provided by the client's representative and standard taping procedures from relevant physical features shown on the site plan provided for our use. The borings were (initially) advanced using dry auger methods. Soil samples were obtained continuously in the upper 10 foot and on 5 foot centers thereafter. The sample depths and types are recorded on the soil boring logs.

In general, relatively undisturbed "Shelby" tube samples (ASTM D 1587) were taken in clays and silty clays. Undisturbed soil samples are required for strength and density tests, and other properties that are dependent upon the soil being close to its natural state. In this procedure, the boring is advanced to the desired sampling depth, then a 3 inch diameter, thin-walled "Shelby" tube is inserted into the borehole. The tube is then pushed hydraulically about 2 feet into the undisturbed soil. The tube is withdrawn, and the sample extruded with a hydraulic piston. The sample is visually classified and tested with a spring loaded penetrometer, which provides a crude estimate of the unconfined compressive strength. The penetrometer test result is recorded on the soil boring log, and a representative portion of the sample is secured for transport to the laboratory.

In sands and silts, Standard Penetration Tests (ASTM D 1586) are generally made. This test provides a measure of the in-situ density or stiffness of the soil and provides a relatively disturbed sample that may be used for classification testing. In this procedure, the boring is advanced to the desired sampling depth, and a relatively heavy walled "split spoon" sampler is inserted into the borehole. The sampler is driven into the soil using a 140 pound "drop" hammer with 30 inch strokes. The number of blows required to drive each 6 inch increment is recorded. The first increment is a seating drive; the number of blows required to drive the second and third increments are added together to determine the "N-value," which has units of blows per foot (bpf). The N-value and the number of blows per increment are recorded on the soil boring log. The sample is visually classified, and a representative portion secured for transport to the laboratory.

Laboratory Testing Procedures. Representative samples from the field investigation were selected by the project engineer for laboratory testing to determine their relevant engineering characteristics. These tests generally fall into one of the following categories.

Strength Tests. Strength tests generally consist of the Unconfined Compressive Strength, or Qu Test, (ASTM D 2166), and the Unconsolidated, Undrained Triaxial Compressive Strength, or UU Test, (ASTM D 2850). In each of these tests, a cylindrical sample of undisturbed soil is subjected to an axial load until failure occurs, yielding the compressive strength of the soil. The principal difference between the two tests is that the Qu is not confined laterally, which can lead to premature failure, and thus, lower compressive strength values. The UU test is confined laterally in a triaxial cell, typically to the lateral stress that the in-situ soil sample was subject to. The compressive strength and axial strain at failure (ϵ_r) are recorded on the soil boring log. The confining stress of UU tests is also recorded.

Classification Tests. Common classification tests include the Atterberg Limit Tests and Particle Size Analyses. Atterberg Limit Tests (ASTM D 4318) are performed to determine the consistency (or "clayeyiness") of a soil. The Atterberg limits consist of the Liquid Limit (LL) and the Plastic Limit (PL), and the Plasticity Index (PI), which is the difference between the LL and the PL. These values are recorded on the soil boring log.

The Particle Size Analysis Test (ASTM D 422) is performed to determine the distribution of the individual particle sizes of a soil sample. The test is typically performed using mechanical sieves for soils containing gravel and sands, or a "hydrometer" for clayey and silty soils. The results of the Particle Size Analysis are typically plotted on a log scale.

Physical Tests. Common physical tests include the Moisture Content Test (ASTM D 2216) and the Dry Density Test. As the names indicate, these tests determine the moisture content and dry density (or dry unit weight) of a soil sample.