Geotechnical Engineering Report

Fitness Center – Phase 1, Aledo Retail

Aledo, Texas

December 22, 2017

Terracon Project No. 95175113

Prepared for:

ALEDO JMD 1, LLC

Austin, Texas

Prepared by:

Terracon Consultants, Inc.

Aledo, Texas

December 22, 2017

ALEDO JMD 1, LLC
11701 Bee Caves Road, Suite 215
Austin, Texas 78738

Attn: Mr. Michael Johnson
P: [515] 524 9651
E: michael@mdjdevelop.com

Re: Geotechnical Engineering Report
Fitness Center – Phase 1, Aledo Retail
Bailey Ranch Road
Aledo, Texas
Terracon Project Number: 95175113

Mr. Johnson:

This report presents the findings of our boring and laboratory testing programs and provides geotechnical recommendations for the design and construction of building foundations, floor slabs, and pavements for the proposed project. This study was performed in general accordance with our proposal number P95175113 dated July 5, 2017 and revised on October 19, 2017.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.
Texas Registration #3272

Simon T. Gilazghi, P.E.
Senior Staff Engineer

Gregory S. Fagan, P.E.
Geotechnical Department Manager

Terracon

TABLE OF CONTENTS

EXECUTIVE SUMMARY

A new Fitness Center is planned in Aledo, Texas. The facility will include a single story building, access drives and associated parking areas. Four borings were drilled to depths of 20 feet in the building area and four borings were drilled to depths of 5 feet in the drive and parking areas.

The following geotechnical considerations were identified:

- Subsurface conditions generally consisted of fat clays and lean clays underlain by tan limestone with clay layers and gray limestone. There is a large variation to top of tan limestone at this site. The depth to top of tan limestone increased quickly west of Boring B-4; increasing in depth from about 4 feet in Boring B-4 to about 18 feet in Boring B-3. Groundwater was not encountered in any of the borings.

- We recommend supporting foundation loads on straight-sided drilled shafts bearing in the tan or gray limestone.

- Grade beams should be supported by the drilled shaft foundations and a minimum void space of 10 inches should be provided between the grade beam and the underlying soil. If limestone is present directly below the grade beams, no void space is required.

- If floor slab movements must be limited to less than ½ inch, a floor system structurally supported above the subgrade is recommended. If potential slab movements of about one inch are acceptable, the floor slab can be supported on a modified subgrade.

- The 2015 International Building Code, Table 1613.5.2 IBC seismic site classification for this site is C.

- Asphaltic concrete pavement or portland cement concrete pavement can be used at this site. These pavements are not equal in performance. The portland cement concrete pavement is expected to require less maintenance.

This summary should be used in conjunction with the entire report for design purposes. It should be recognized that details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The section titled **GENERAL COMMENTS** should be read for an understanding of the report limitations.

GEOTECHNICAL ENGINEERING REPORT
PROPOSED FITNESS CENTER – PHASE 1
ALEDO, TEXAS

Terracon Project No. 951575113
December 22, 2017

1.0 INTRODUCTION

A new Fitness Center is planned for construction in Aledo, Texas. Our scope of services for the project included drilling and sampling eight borings, laboratory testing, and engineering analyses. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- groundwater conditions
- earthwork
- foundation design and construction
- seismic considerations
- floor slabs and building pad preparation
- pavement sections and subgrade preparation

2.0 PROJECT INFORMATION

2.1 Project Description

ITEM	DESCRIPTION		
Proposed improvements	Multi-phase construction over a period of time on 9-acres. The first phase is the construction of a 7,200 square foot single story fitness center within a planned ultimate 23,500 square foot building.		
Building construction	Tilt-wall structure		
Finished floor elevation	±2 feet of existing grade (assumed)		
Maximum loads (assumed)	Columns: 125 kips	Walls: 2 to 3 kips/lf	Slab: 150 psf
Grading	±2 feet of existing grade (assumed)		
Cut and fill slopes	Assumed to be no steeper than 4H:1V (Horizontal to Vertical)		
Pavements	Traffic will include automobile, light trucks, fire trucks, garbage trucks, and tractor-trailers		
Free-standing retaining walls	None		
Below grade areas	None		

2.2 Site Location and Description

ITEM	DESCRIPTION
Location	NEC of Bailey Ranch Road and Creekview Terrace in Aledo, Texas (Approximate GPS coordinates: 32.7107N, 97.6054W)
Existing improvements	None
Current ground cover	Grass and scattered trees
Existing topography	Relatively flat

3.0 SUBSURFACE CONDITIONS

3.1 Soil Borings and Laboratory Tests

Subsurface conditions were explored by drilling eight borings located approximately as shown on Exhibits A-2 and A-3 in Appendix A. A description of the field work is presented in Exhibit A-4. Soil, rock, and groundwater conditions encountered at the boring locations are described on the boring logs included as Exhibits A-5 to A-12. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; in situ, the transition between materials may be gradual.

Laboratory tests were performed to assist with soil classification and to measure soil strength and soil swell potential. Testing procedures are presented in Appendix B. Results of the laboratory tests are listed on the boring log.

3.2 Typical Profile

Based on the results of the borings, subsurface conditions on the project site can be generalized as follows:

Stratum	Approximate Depth to Bottom of Stratum	Material Encountered	LL: Liquid Limit PI: Plasticity Index
1[1]	2 to 18 feet	Very stiff to hard, dark brown, brown, gray and tan fat clay (CH) and lean clay (CL)	LL: 33 – 71% PI: 19 – 45%
2[2]	5 to 17 feet	Tan limestone with clay layers	-

Stratum	Approximate Depth to Bottom of Stratum	Material Encountered	LL: Liquid Limit PI: Plasticity Index
3[3]	Termination depth at 20 feet	Gray limestone	-

1. Present in all borings except B-6.
2. Present in borings B-1, B-4, and termination depth of B-5 and B-6

The following table summarizes the rock profile in the building borings:

Boring	Depth to Top of Tan Limestone (ft)*	Depth to Top of Gray Limestone (ft)*
B-1	12	17
B-2	None present	16
B-3	None present	18
B-4	4	16

*Depths are below existing grade

3.3 Groundwater

The borings were advanced using dry auger drilling techniques that allow short-term groundwater observations to be made while drilling. Groundwater was not encountered in all the borings during and at the completion of drilling.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Highly expansive soils are present on this site. This report provides recommendations to help mitigate the effects of soil shrinkage and expansion associated with these soils. However, even if these procedures are followed, some movement and (at least minor) cracking in the structure should be anticipated. The severity of cracking and other damage such as uneven floor slabs will probably increase if modification of the site results in excessive wetting or drying of the expansive soils. Eliminating the risk of movement and distress may not be feasible, but it may be possible to further reduce the risk of movement if significantly more expensive measures are used during construction. Some of these options such as moisture conditioning of expansive soils or a structural slab are discussed in this report.

At the time of our field operations in December 2017, the overburden soils were at a relatively dry state. Our laboratory absorption swell tests indicated the soil swell potential was as high as 4.1% for samples tested. The resulting moisture induced potential vertical movements are estimated to be greater than 5 inches for in-situ moisture levels.

The depth to limestone from existing ground surface fluctuated significantly across the site in the boring locations. Limestone was encountered at a depth of about 2 to 4 feet in Borings B-4, B-5, and B-6, which are located on the east side of the project (see Exhibit A-3). However, the depth to limestone dropped to about 12 to 18 feet in Borings B-1, B-2, and B-3, which are located west of boring B-4.

Geotechnical recommendations are presented in the following report sections for earthwork, building foundations, floor slab preparation, and pavements.

4.2 Earthwork

Earthwork will include clearing and grubbing, excavations, and fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria as necessary to render the site in the state considered in our geotechnical engineering evaluation for foundations, floor slabs, and pavements.

4.2.1 Site Preparation

Site preparation for the proposed project should include removing vegetation, topsoil, and any other unsuitable surface materials from the areas of new construction. Existing utility lines that are to be abandoned should be removed or fully grouted to prevent moisture intrusion into the site soils.

The exposed subgrade should be proof rolled prior to placing any fill and prior to pavement placement. The proof rolling should be performed with a fully loaded, tandem-axle dump truck or other equipment providing an equivalent subgrade loading. A minimum gross weight of 20 tons is recommended for the proof-rolling equipment.

The proof rolling should consist of several overlapping passes in mutually perpendicular directions over a given area. Any soft or pumping areas should be modified by excavating, drying the soil and placing the processed soil back into the excavated area in a controlled manner.

4.2.2 Suitable Fill

The following soil materials are discussed in the coming sections of this report. The following table summarizes their nomenclature, detailed descriptions, and appropriate usage in the context of this project.

Nomenclature	Technical Requirements	Appropriate Use
On-site soils	Free of vegetation, decomposable organic material, debris, and rocks greater than 4 inches in maximum dimension	1) General site grading 2) Building pad 3) Pavement subgrades 4) Utility trench backfill
Imported fill	Clean clay soil (free of decomposable organic material and debris) with a liquid limit (LL) less than 60 percent, a plasticity index (PI) between 6 and 30, and no rock greater than 4 inches in maximum dimension	
Select fill	Sandy clay to clayey sand with a liquid limit (LL) of less than 35 percent and a plasticity index (PI) between 6 and 15. Site material matching this criterion is acceptable.	1) Upper 1 foot of the building pad
Flexible base	TxDOT* Item 247, Type D, Grade 1 or 2. Recycled concrete meeting this gradation is acceptable.	1) Upper 1 foot of the building pad 2) Below pavement

4.2.3 Compaction Requirements

Recommendations for compaction are presented in the following table. We recommend engineered fill be tested for moisture content and compaction during placement. Should the results of the in-place density tests indicate the specified moisture or compaction limits have not been met, the area represented by the test should be reworked and retested as required until the specified moisture and compaction requirements are achieved.

Item	Compaction	Moisture Content
On-site soils or imported fills outside the moisture conditioned zone[1]	A minimum of 95% maximum standard Proctor dry density (ASTM D 698)	At a minimum of +2 percentage points above optimum moisture
Moisture conditioned soils[1]	In the range of 92% to 98% maximum standard Proctor dry density (ASTM D 698)	At a minimum of +4 percentage points above optimum moisture
Select fill / flexible base[1]	A minimum of 95% maximum standard Proctor dry density (ASTM D 698)	In the range of -2 to +2 percentage points of optimum moisture

Item	Compaction	Moisture Content
Pavement subgrades	A minimum of 95% maximum standard Proctor dry density (ASTM D 698)	In the range of -1 to +3 percentage points of optimum moisture content

1. Fills should be placed in maximum loose lifts of 9 inches or less
2. The compaction criteria in fire lanes and roadways must meet the requirements, if any, as prescribed by the local governing authority.

Note that any material removed and replaced to install utilities, grade beams or other subsurface elements must be placed and compacted to the appropriate criteria above using the required materials.

4.2.4 Drainage and Utilities

The flatwork abutting the structure should be sloped down to provide effective drainage away from the buildings. Where paving or flatwork abuts the structure, the joints should be properly sealed and maintained to prevent the infiltration of surface water. Open ground should be sloped on 5 percent or steeper grades for 10 or more feet away from the building. Roof drains should discharge on paved surfaces or be extended away from the structure. The on-site soils are susceptible to erosion and will require protection.

Care should be taken that utility trenches are properly backfilled. Utility trenches penetrating beneath the building should be effectively sealed to restrict water intrusion and flow through the trenches, which could migrate below the building. The trench should provide an effective trench plug that extends at least 5 feet from the face of the building exterior. The plug material should consist of cementitious flowable fill or low permeability clay. The trench plug material should be placed to surround the utility line. The clay trench plug material should be placed and compacted to comply with the water content and compaction recommendations of section **4.2.3 Compaction Requirements**.

4.2.5 Earthwork Construction Considerations

It is anticipated that excavations in the upper soils for the proposed construction may encounter clay soil, as well as tan limestone with clay seams. Deeper excavation will encounter tan and gray limestone. The limestone is hard and may be difficult to excavate. Excavations extending into the limestone may require breaker hoes, trenchers and milling machines equipped with rock teeth. Line drilling can be used to control over break at the limits of the excavation. The limestone may be very difficult to break down for use as suitable fill in the building and paving areas and may have to be placed in landscape areas (i.e. outside building and pavement areas) or wasted.

Based upon the subsurface conditions determined from the geotechnical exploration, subgrade soils exposed during construction are anticipated to be relatively stable to construction traffic.

However, the stability of the subgrade may be affected by precipitation, repetitive construction traffic, closeness to the groundwater seepage or other factors. If unstable conditions develop, workability may be improved by scarifying and drying. Lightweight excavation equipment may be required to reduce subgrade pumping. The use of remotely operated equipment, such as a backhoe, would be beneficial to perform cuts and reduce subgrade disturbance.

Upon completion of filling and grading, care should be taken to maintain the subgrade moisture content prior to construction of floor slabs and pavements. Construction traffic over the completed subgrade should be avoided to the extent practical. The site should also be graded to prevent ponding of surface water on the prepared subgrades or in excavations. If the subgrade should become frozen, desiccated, saturated, or disturbed, the affected material should be removed or these materials should be scarified, moisture conditioned, and recompacted prior to floor slab and pavement construction.

As a minimum, excavations should be performed in accordance with OSHA 29 CFR, Part 1926, Subpart P, "Excavations" and its appendices, and in accordance with any applicable local, and/or state regulations. The grading contractor, by his contract, is usually responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations as required, to maintain stability of both the excavation sides and bottom. All excavations should comply with applicable local, state and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

The geotechnical engineer, or their representative, should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during subgrade preparation; proof-rolling; placement and compaction of controlled compacted fills; backfilling of excavations into the completed subgrade, and just prior to construction of building floor slabs.

4.3 Foundations

4.3.1 Straight Drilled Shafts

A low risk method of supporting the structure and reducing the risk of foundation movements is to support the loads on drilled shaft foundations. Design recommendations are provided in the following sections for straight drilled shafts bearing in the tan or gray limestone stratum.

Design Parameter	Recommendation	
Bearing stratum	Tan Limestone with clay layers	Gray limestone with shale layers
Allowable end bearing capacity	Not recommended	27,000 psf
Allowable skin friction - compression	1,900 psf	4,000 psf

Design Parameter	Recommendation	
Allowable skin friction - tension	1,500 psf	3,200 psf
Minimum penetration into bearing stratum to develop end bearing	Minimum 2 feet below top of gray limestone	
Minimum penetration into bearing stratum to develop skin friction	Below the surface of the tan limestone/gray limestone or below any temporary casing, whichever is deeper.	
Minimum center to center spacing to develop full skin friction	2.5 times the diameter of the larger shaft. Closer spacing may require some reductions in skin friction and/or changes in installation sequences. Closely spaced shafts should be examined by Terracon on a case-by-case basis. As a general guide, the design skin friction will vary linearly from the full value at a spacing of 2.5 diameters to 50 percent of the design value at 1.0 diameter.	
Groups of 3 or more shafts spaced closer than 2.5 shaft diameters	Should be evaluated by Terracon on a case-by-case basis. Alternative installation sequences may be needed to allow for a minimum of 48 hours concrete curing time, before installation of adjacent shafts.	
Minimum Shaft Diameter	18 inches	
Settlement	Less than one inch for column loads of 125 kips or less	

4.3.2 Lateral Capacity

The drilled shafts may be subject to lateral loads. Parameters for lateral load analysis are provided in the follow tables for use in Ensoft's L-PILE (version 6.0) computer program. Overburden soils should be neglected for lateral analysis.

Soil Type	Tan limestone	Gray limestone
LPILE Material Type	Week Rock (Reese)	Week Rock (Reese)
Effective Soil Unit Weight (pcf)	130	140
Strain Factor, ϵ_{50}	0.001	0.001
Young's Modulus, E_r (psi)	9,500	20,000
Uniaxial Compressive Strength (psi)	95	220
Rock Quality Designation, RQD (%)	65	85
K_{rm}	0.0005	0.0005

4.3.3 Uplift with Drilled Shafts

The drilled shafts will be subject to uplift as a result of heave in the overlying clay soils. The magnitude of these loads varies with the shaft diameter, soil parameters, and particularly the in-situ moisture levels at the time of construction. The shafts must contain sufficient continuous vertical reinforcing and embedment depth into the limestone stratum to resist the net tensile load.

For the conditions encountered at this site, the uplift load can be approximated by assuming a uniform uplift of 1,800 psf over the shaft perimeter for a depth of 10 feet. If the subgrade is moisture conditioned as discussed in section **4.4.2 Floor Slabs/Flatwork on Modified Subgrade**, a uniform uplift of 1,000 psf can be used for a depth of 10 feet.

4.3.4 Drilled Shaft Construction Considerations

The construction of all drilled shafts should be observed by experienced geotechnical personnel during construction to confirm: 1) the bearing stratum; 2) the minimum bearing depth; 3) that groundwater seepage is correctly handled; and 4) that the shafts are within acceptable vertical tolerance.

Recommendations for drilled shaft construction are presented in the following table.

Item	Recommendation
Drilled shaft installation specification	Current version of American Concrete Institute's "Standard Specification for the Construction of Drilled Piers" ACI 336.
Top of shaft completion	Enlarged (mushroom-shaped) top in contact with the clays should not be allowed.
Time to complete	Drilled shaft construction should be completed within 8 hours in a continuous manner to reduce side wall and base deterioration.
Installation methods	Shaft excavations should be installed using dry methods. The concrete should have a slump of 6 inches plus or minus 1 inch and be placed in a manner to avoid striking the reinforcing steel during placement.
Groundwater control	Seepage was not observed in the borings. However, groundwater could be encountered during wet periods of the year. If ground water is encountered, rapid placement of steel and concrete may permit shaft installation to proceed; however, seepage rates could be sufficient to require the use of temporary casing or underwater placement methods.
Special conditions	The limestone layers may be hard and can be difficult to penetrate. A contractor experienced with drilling in hard rock should be retained for this project.

4.3.5 Grade Beams, Wall Panels and Pier Caps with Drilled Shafts

In conjunction with drilled shafts, all grade beams or wall panels should be supported by the drilled shafts. A minimum void space of 10 inches is required between the bottom of grade beams, pier cap extensions, or wall panels and the subgrade where clay soils are present. This void will serve to reduce distress resulting from swell pressures generated by the clay soils. Structural cardboard forms are one acceptable means of providing this void beneath cast-in-place elements. Soil retainers should be used to prevent infilling of the void. Where clay soils are present, the grade beams should be formed rather than cast against earth trenches.

Backfill against the exterior face of grade beams, wall panels and pier caps should be placed and compacted as described in section **4.2.3 Compaction Requirements**.

4.4 Floor System and Flatwork

The potential magnitude of the moisture induced movement is rather indeterminate. It is influenced by the soil properties, overburden pressures, and by soil moisture levels at the time of construction. Based on the soil types encountered in the borings, movements in slabs placed on grade are estimated to be greater than 5 inches for dry soil conditions that could exist prior to construction.

A structural slab is recommended if foundation movements are to be limited to less than one inch. The building slabs can be supported on a modified subgrade that has been prepared to reduce soil movements to about one inch. It should be noted that there is a low risk that even ½ inch of movement can result in unsatisfactory performance. Some of the risks that can affect performance include uneven floors, floor and wall cracking, and sticking doors.

4.4.1 Structural Floor System

The floor systems should be structurally supported above the subgrade if movements of about one inch or more cannot be tolerated. This method does not require modification of the existing subgrade other than grading the surface to drain water away from the building. A minimum void space of 18 inches is recommended beneath the slab. The minimum void space can be provided by the use of cardboard carton forms or a deeper crawl space.

4.4.2 Floor Slabs/Flatwork on Modified Subgrade

Slab on grade construction on modified subgrade should only be considered if slab movements of about one inch are considered acceptable. Reductions in anticipated movements can be achieved by using methods developed in this area to reduce on-grade slab movements. A suitable method for this site consists of moisture conditioning the on-site clays and capping them with select fill or flexible base material. Moisture conditioning can be accomplished using excavation and replacement as described below.

The areas beneath building pads and sensitive flatwork (i.e. adjacent sidewalks and pavement) should be excavated to permit the installation of 12 feet moisture conditioned soils and a 1-foot layer of select fill or flexible base material (section **4.2.2 Suitable Fill**).

The moisture conditioned soils should extend at least 10 feet beyond the buildings perimeters and include entrances, abutting sidewalks, and other flatwork areas sensitive to movement. The excavated soils, except for deleterious materials or rock greater than 4 inches, can then be placed in accordance with section **4.2.3 Compaction Requirements** for moisture conditioned clays. The select fill or flexible base material must be placed above the moisture conditioned soils in a reasonable period of time (i.e. within 48 hours) following completion of the moisture conditioning process to prevent the loss of soil moisture. If the surface of the moisture conditioned soils is allowed to desiccate prior to placement of the cap, the desiccated soils should be reworked and placed in a moisture conditioned state. The select fill cap should not extend beyond the building perimeter.

The use of a vapor retarder should be considered beneath concrete slabs on grade that will be covered with wood, tile, or carpet with a water soluble adhesive. A vapor retarder should be used for other moisture sensitive coverings, impervious coverings, or when the slab will support equipment sensitive to moisture. When conditions warrant the use of a vapor retarder, the slab designer and slab contractor should refer to ACI 302 and/or ACI 360 for procedures and cautions regarding the use and placement of a vapor retarder.

It should be noted that excessive water from any source could result in movements greater than the estimated amounts. For example, should leaks develop in underground water or sewer lines or the grades around the structure allow ponding of water, unacceptable slab movements could develop. The area around the structure must be well drained, landscape beds must not be over watered or allow ponding of water, and utility leaks are promptly repaired. Trees should be planted at least one-mature tree height from the building. Root barriers should be installed if trees are planted closer.

4.5 Seismic Considerations

Code Used	Site Classification
2015 International Building Code (IBC) [1]	C [2]

1. In general accordance with the *2015 International Building Code,* Table 1613.5.2.
2. The 2015 International Building Code (IBC) uses a site soil profile determination extending a depth of 100 feet for seismic site classification. The current scope requested does not include a 100 foot soil profile determination. Borings extended to a maximum depth of approximately 20 feet and this seismic site class definition considers rock extends below the maximum depth of the subsurface exploration. Additional exploration to deeper depths would be required to confirm the conditions below the current depth of exploration. Alternatively, a geophysical exploration could be utilized in order to attempt to justify a higher seismic site class.

4.6 Pavements

4.6.1 Pavement Subgrades

Subgrade materials at this site will consist of clay soils and tan limestone. The clay soils are subject to loss of support with the moisture increases that can occur beneath paving. The clay soils react with hydrated lime, which serves to improve and maintain their support value. Lime treatment is recommended beneath asphaltic concrete pavement sections where clay subgrades are exposed.

For budgeting purposes, a minimum of 8 percent hydrated lime (TxDOT Item 260), by dry weight, is estimated. The lime application rate should be determined by laboratory testing once the pavement subgrade is rough graded. The lime should be thoroughly mixed and blended with the top 6 inches of the subgrade (TxDOT Item 260). Lime treatment should extend a minimum of one foot beyond the edge of the pavement.

The subgrade soils should also be tested for the presence of water soluble sulfates during construction. Sulfates can react with lime to form ettringite crystals that can lead to heave of pavements and premature pavement failure. If lime treatment of the pavement subgrade is performed, additional sulfate tests should be performed on the surface soils after final grading is complete. When the sulfate concentrations are less than 3,000 ppm, the subgrade soils are considered to be suitable for lime treatment in the conventional manner using a single lime application. When sulfate concentrations are higher than about 3,000 ppm, there is risk of lime/sulfate induced heave occurring.

Portland cement concrete pavements may be placed on compacted subgrade without lime treatment or on tan limestone. In some areas excavations to achieve the planned pavement grades might encounter tan limestone and can result in rock breakout. The concrete pavement can crack in irregular patterns due to the constraints to pavement movement caused by the rock breakouts. A bond breaker should be placed between the concrete and the rock subgrade to prevent irregular pavement cracking. This bond breaker is recommended to consist of a six-inch flexible base.

The lime modified or natural subgrade should then be uniformly compacted to the criteria described in section **4.2.3 Compaction Requirements**. It should then be protected and maintained in a moist condition until the pavement is placed. Pavement subgrades should be graded to prevent ponding and infiltration of excessive moisture on or adjacent to the pavement subgrade surface.

Site grading is generally accomplished early in the construction phase. However, as construction proceeds, the subgrade may be disturbed due to utility excavations, construction traffic, desiccation, or rainfall. As a result, the pavement subgrade may not be suitable for pavement construction and corrective action will be required. The subgrade should be carefully evaluated and proof rolled at the time of pavement construction for signs of disturbance or excessive rutting. If disturbance has occurred, pavement subgrade areas should be reworked, moisture conditioned, and properly compacted to the recommendations in this report immediately prior to paving.

4.6.2 Pavement Traffic

Traffic patterns and anticipated loading conditions were not available; however, typical pavement sections with subgrade modification alternatives for 20 year design life are provided. These represent a total of 45,000 18-Kip Equivalent Single Axle Loads (ESALs) for Light Duty pavement and 100,000 18-Kip ESALs for the Medium Duty pavement. The Light Duty pavement is intended for passenger car and pickup trucks and occasional delivery trucks. The Medium Duty pavement is intended for passenger car, pickup trucks, small delivery trucks, and occasional fire trucks.

If the pavements are subject to heavier loading and higher traffic counts than the assumed values, this office should be notified and provided with the information so that we may review these pavement sections and make revisions if necessary.

4.6.3 Pavement Sections

Both asphalt and concrete pavement sections are presented in the following table. They are not considered equal. Over the life of the pavement, concrete sections would be expected to require less maintenance.

The concrete should have a minimum 28-day compressive strength of 3,000 psi in Light Duty areas and 3,500 psi in Medium Duty and dumpster areas. It should contain a minimum of 4.5±1.5 percent entrained air. As a minimum, the section should be reinforced with No. 3 bars on 18-inch centers in both directions. Refer to ACI 330 “Guide for Design and Construction of Concrete Parking Lots” for additional information concerning joint spacing, joint depth, joint location, etc.

Pavements will be subject to differential movement due to heave in the site soils. Flat grades should be avoided with positive drainage provided away from the pavement edges. Backfilling of curbs should be accomplished as soon as practical to prevent ponding of water.

Openings in pavement, such as landscape islands, are sources for water infiltration into surrounding pavements. Water collects in the islands and migrates into the surrounding subgrade soils thereby degrading support of the pavement. This is especially applicable for islands with raised concrete curbs, irrigated foliage, and low permeability near-surface soils. The civil design for the pavements with these conditions should include features to restrict or to collect and discharge excess water from the islands. Examples of features are edge drains connected to the storm water collection system or other suitable outlet and impermeable barriers preventing lateral migration of water such as a cutoff wall installed to a depth below the pavement structure.

Pavement Section		**Pavement Thickness, Inches**		
		Light Duty 45,000 18-kip ESALs	**Medium Duty** 100,000 18-kip ESALs	**Dumpster Area**[1]
Portland Cement Concrete	Concrete	5	6	7
	Compacted Subgrade	6	6	6
	Total Pavement Thickness	**11**	**12**	**13**
Full Depth Asphaltic Concrete	Asphaltic Concrete TxDOT Item 340 Type D	2	2	-
	Asphaltic Concrete TxDOT Item 340 Type A or B	3	4	-
	Lime modified subgrade	6	6	-
	Total Pavement Thickness	**11**	**12**	**-**

1. The dumpster pad should be large enough to support the container and the tipping axle of the collection truck.
2. All materials should meet the TXDOT Standard Specifications for Highway Construction

4.6.4 Pavement Maintenance

The pavement sections provided in this report represent minimum recommended thicknesses and, as such, periodic maintenance should be anticipated. Therefore, preventive maintenance should be planned and provided for through an on-going pavement management program.

Preventive maintenance activities are intended to slow the rate of pavement deterioration, and to preserve the pavement investment. Preventive maintenance consists of both localized maintenance (e.g., crack and joint sealing and patching) and global maintenance (e.g., surface sealing). Preventive maintenance is usually the first priority when implementing a planned pavement maintenance program and provides the highest return on investment for pavements.

Prior to implementing any maintenance, additional engineering observation is recommended to determine the type and extent of preventive maintenance. Even with periodic maintenance, some movements and related cracking may still occur and repairs may be required.

5.0 GENERAL COMMENTS

Terracon should be retained to review the final design plans and specifications so comments can be made regarding interpretation and implementation of our geotechnical recommendations in the design and specifications. Terracon also should be retained to provide observation and testing services during grading, excavation, foundation construction and other earth-related construction phases of the project.

The analysis and recommendations presented in this report are based upon the data obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur between borings, across the site, or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we should be immediately notified so that further evaluation and supplemental recommendations can be provided.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, either express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the conclusions of this report in writing.

APPENDIX A
FIELD EXPLORATION

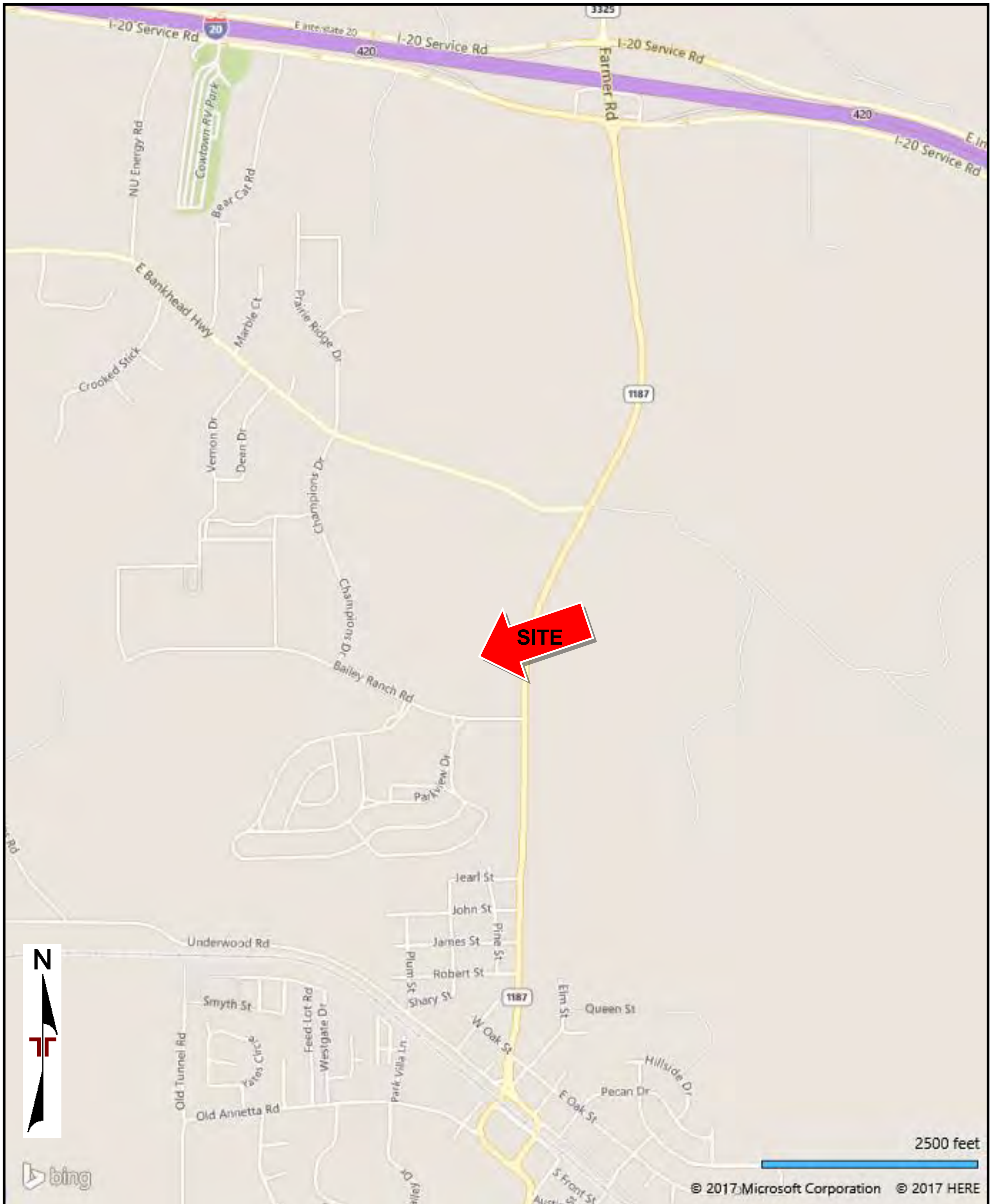


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

Project Manager: GSF	Project No. 95175113	Terracon	SITE LOCATION	Exhibit
Drawn by: STG	Scale: AS SHOWN	2501 E Loop 820 N Fort Worth, TX 76118-6978	FITNESS CENTER - PHASE I, ALEDO RETAIL	A-.
Checked by: GSF	File Name:		**BAILEY RANCH ROAD** **ALEDO, TEXAS**	
Approved by: GSF	Date: 12/15/2017			

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

Project Manager: GSF	Project No. 95175113
Drawn by: STG	Scale: AS SHOWN
Checked by: GSF	File Name:
Approved by: GSF	Date: 12/15/2017

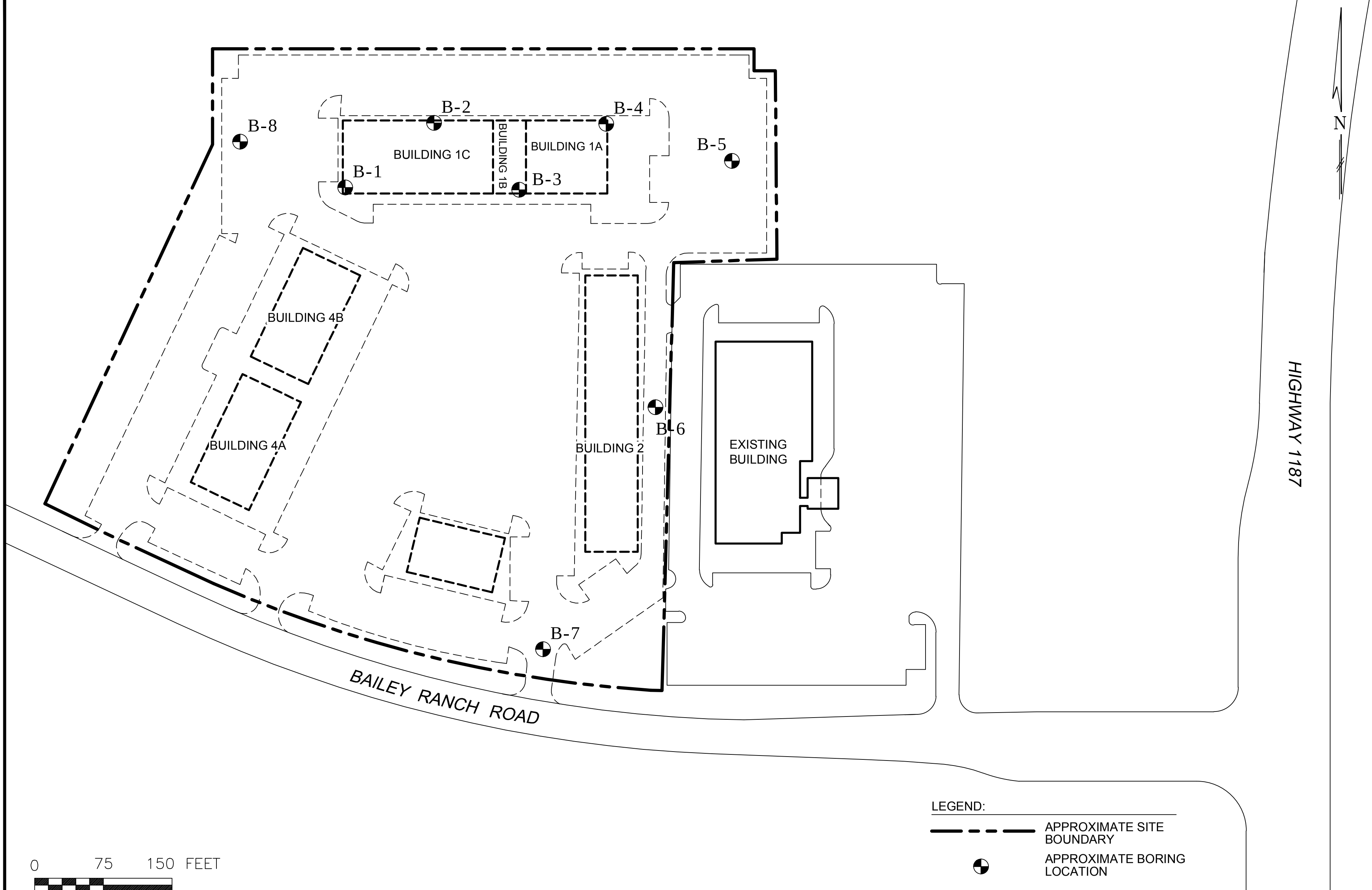
Terracon
2501 E Loop 820 N
Fort Worth, TX 76118-6978

EXPLORATION PLAN

FITNESS CENTER - PHASE I, ALEDO RETAIL
BAILEY RANCH ROAD
ALEDO, TEXAS

Exhibit
A-2

Date: 12/14/17 O:\Drawings\Terracon\Fort Worth\2017\95175113\95175113.dwg Layout: BORINGS Current Layer: 0



THIS DRAWING SHOULD NOT BE USED SEPARATELY FROM ORIGINAL REPORT.

NOTE: ALL BORING LOCATIONS ARE APPROXIMATE.

Project Mngr:	SG	Project No.	95175113
Drawn By:	DLC	Scale:	AS SHOWN
Checked By:	SG	Date:	12/14/2017
Approved By:	SG		

Terracon
Consulting Engineers and Scientists
(Registration No.: F-3272)
2501 EAST LOOP 820 N. FORT WORTH, TX 76118
PH. (817) 268-8600 FAX. (817) 268-8602

BORING LOCATION PLAN

FITNESS CENTER - PHASE 1, ALEDO RETAIL
BAILEY RANCH ROAD
ALEDO, TEXAS

EXHIBIT

A-3

Field Exploration Description

Subsurface conditions were explored by drilling eight borings to depths of about 5 to 20 feet at the approximate locations indicated on the Exploration Plan (Exhibit A-2) and Boring Location Plan (Exhibit A-3) in Appendix A. The field exploration was performed on December 05, 2017. The test locations were established in the field utilizing a hand held GPS unit. The boring locations should be considered accurate only to the degree implied by the methods employed to determine them.

The borings were performed using a truck-mounted drill rig. Samples of the soil encountered in the borings were obtained using thin-walled tube and split-barrel sampling procedures. The samples were tagged for identification, sealed to reduce moisture loss, and taken to the laboratory for further examination, testing, and classification. The load-carrying capacity of the bedrock was evaluated in place by the Texas Department of Transportation (TxDOT) cone penetration test.

Field logs of the borings were prepared by the drill crew. These logs include visual classifications of the materials encountered as well as interpretation of the subsurface conditions between samples. The boring logs included with this report represent the engineer's interpretation of the field logs and include modifications based on visual evaluation of the samples and laboratory test results. The boring logs are presented on Exhibit A-5 through A-12 in Appendix A. General notes to log terms and symbols are presented on Exhibit C-1 in Appendix C.

BORING LOG NO. B-1

PROJECT: Fitness Center - Phase I

CLIENT: ALEDO JMD 1, LLC
Austin, Texas

SITE: Bailey Ranch Road
Aledo, Texas

LOCATION See Exhibits A2 & A3

Latitude: 32.7105° Longitude: -97.6062°

DEPTH	Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	FAT CLAY (CH), dark gray, very stiff to hard				4.5+ (HP)				20		67-24-43
4.0					4.5+ (HP)				23		
	FAT CLAY (CH), with limestone fragments, dark brown, very stiff to hard	5			4.5+ (HP)				16		67-22-45
6.0					1.25 (HP)						
	FAT CLAY (CH), with limestone fragments, brown and tan, stiff to hard				14-17-11 N=28				9		
8.0	**FAT CLAY (CH)**, shaley, with limestone seams, tan and gray, stiff to medium stiff										
		10			1.25 (HP)				20		67-25-42
12.0	**LIMESTONE**, weathered, with clay layers, tan										
		15			100/6.75"						
17.0	**LIMESTONE**, with shale layers, gray										
20.0		20			100/1.875"						
	Boring Terminated at 20 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry Auger

Abandonment Method:
Backfilled with auger cuttings

See Exhibit A-4 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water encountered during drilling

Dry upon completion of drilling

Terracon
2501 E Loop 820 N
Fort Worth, TX

Boring Started: 12-05-2017	Boring Completed: 12-05-2017
Drill Rig:	Driller: StrataBore
Project No.: 95175113	Exhibit: A-5

BORING LOG NO. B-2

PROJECT: Fitness Center - Phase I

CLIENT: ALEDO JMD 1, LLC
Austin, Texas

SITE: Bailey Ranch Road
Aledo, Texas

LOCATION See Exhibits A2 & A3

Latitude: 32.7107° Longitude: -97.6059°

DEPTH	Material Description	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	FAT CLAY (CH), dark brown, stiff to hard				4.0 (HP)				21		
4.0					4.5+ (HP)				18		62-20-42
	LEAN CLAY (CL), with gravel and calcareous nodules, brown, tan and gray, very stiff to hard	5			4.5+ (HP)				17		
					4.5+ (HP)				16		45-19-26
8.0					4.0 (HP)						
	LEAN CLAY (CL), with limestone lenses and fragments, tan and gray, stiff				28-11-6 N=17						
12.0		10									
	FAT CLAY (CH), shaley, tan and gray, very stiff				3.50 (HP)						
16.0		15									
	LIMESTONE, with shale seams, gray				100/1.125"						
20.0	***Boring Terminated at 20 Feet***	20									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry Auger

Abandonment Method:
Backfilled with auger cuttings

See Exhibit A-4 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water encountered during drilling

Dry upon completion of drilling

Terracon
2501 E Loop 820 N
Fort Worth, TX

Boring Started: 12-05-2017	Boring Completed: 12-05-2017
Drill Rig:	Driller: StrataBore
Project No.: 95175113	Exhibit: A-6

BORING LOG NO. B-3

PROJECT: Fitness Center - Phase I

CLIENT: ALEDO JMD 1, LLC
Austin, Texas

SITE: Bailey Ranch Road
Aledo, Texas

LOCATION See Exhibits A2 & A3

Latitude: 32.7105° Longitude: -97.6056°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	FAT CLAY (CH), dark brown, very stiff to hard				4.5+ (HP)						
	4.0				4.5+ (HP)				19		71-26-45
	LEAN CLAY (CL), with calcareous deposits, tan, very stiff to hard	5			4.5+ (HP)						
	6.0										
	LEAN CLAY (CL), with calcareous deposits and gravel, light brown and tan, very stiff to hard				4.5+ (HP)				16		36-17-19
					4.5+ (HP)				12		
		10			60/12"						
	13.0										
	FAT CLAY (CH), shaley, tan and gray, very stiff to hard	15			4.5+ (HP)						
	18.0										
	LIMESTONE, with shale layers, gray				100/3.25"						
	20.0	20									
	Boring Terminated at 20 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry Auger

Abandonment Method:
Backfilled with auger cuttings

See Exhibit A-4 for description of field procedures

See Appendix B for description of laboratory procedures and additional data (if any).

See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water encountered during drilling

Dry upon completion of drilling

Terracon
2501 E Loop 820 N
Fort Worth, TX

Boring Started: 12-05-2017	Boring Completed: 12-05-2017
Drill Rig:	Driller: StrataBore
Project No.: 95175113	Exhibit: A-7

BORING LOG NO. B-4

PROJECT: Fitness Center - Phase I

CLIENT: ALEDO JMD 1, LLC
Austin, Texas

SITE: Bailey Ranch Road
Aledo, Texas

LOCATION See Exhibits A2 & A3

Latitude: 32.7107° Longitude: -97.6053°

GRAPHIC LOG	DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	2.0	**FAT CLAY (CH)**, brown, very stiff to hard				4.5+ (HP)				18		
	4.0	**LEAN CLAY (CL)**, with calcareous deposits, tan, very stiff to hard				4.5+ (HP)						33-13-20
	16.0	**LIMESTONE**, weathered, with clay layers, tan	5			100/3.5"						
			10			100/4.0"						
			15			100/0.5"						
	20.0	**LIMESTONE**, with shale layers, gray	20			100/2.5"						
		Boring Terminated at 20 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry Auger

Abandonment Method:
Backfilled with auger cuttings

See Exhibit A-4 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water encountered during drilling

Dry upon completion of drilling

Terracon
2501 E Loop 820 N
Fort Worth, TX

Boring Started: 12-05-2017	Boring Completed: 12-05-2017
Drill Rig:	Driller: StrataBore
Project No.: 95175113	Exhibit: A-8

BORING LOG NO. B-5

PROJECT: Fitness Center - Phase I

CLIENT: ALEDO JMD 1, LLC
Austin, Texas

SITE: Bailey Ranch Road
Aledo, Texas

LOCATION See Exhibits A2 & A3

Latitude: 32.7106° Longitude: -97.6048°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	FAT CLAY (CH), brown, very stiff to hard				4.5+ (HP)				18		52-22-30
	2.0 **LIMESTONE**, weathered, with clay seams, tan				100/2.0"						
	5.0	5			100/1.75"						
	Boring Terminated at 5 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry Auger

Abandonment Method:
Backfilled with auger cuttings

See Exhibit A-4 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water encountered during drilling

Dry upon completion of drilling

Terracon
2501 E Loop 820 N
Fort Worth, TX

Boring Started: 12-05-2017	Boring Completed: 12-05-2017
Drill Rig:	Driller: StrataBore
Project No.: 95175113	Exhibit: A-9

BORING LOG NO. B-6

PROJECT: Fitness Center - Phase I

CLIENT: ALEDO JMD 1, LLC
Austin, Texas

SITE: Bailey Ranch Road
Aledo, Texas

LOCATION See Exhibits A2 & A3

Latitude: 32.7099° Longitude: -97.6051°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	LEAN CLAY (CL), with limestone fragments and layers, tan, very stiff to hard				4.5+ (HP)						
					4.5+ (HP)				11		
	4.0 **LIMESTONE**, weathered, with clay seams, tan				100/.75"						
	5.0 ***Boring Terminated at 5 Feet***	5									

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry Auger

Abandonment Method:
Backfilled with auger cuttings

See Exhibit A-4 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS
No water encountered during drilling
Dry upon completion of drilling

Terracon
2501 E Loop 820 N
Fort Worth, TX

Boring Started: 12-05-2017	Boring Completed: 12-05-2017
Drill Rig:	Driller: StrataBore
Project No.: 95175113	Exhibit: A-10

BORING LOG NO. B-7

PROJECT: Fitness Center - Phase I

CLIENT: ALEDO JMD 1, LLC
Austin, Texas

SITE: Bailey Ranch Road
Aledo, Texas

LOCATION See Exhibits A2 & A3

Latitude: 32.7091° Longitude: -97.6055°

GRAPHIC LOG	DEPTH	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	FAT CLAY (CH), dark brown, very stiff				2.5 (HP)				29		
	2.0										
	FAT CLAY (CH), brown, medium stiff				1.0 (HP)				26		65-23-42
	4.0										
	FAT CLAY (CH), brown and tan, stiff				2.0 (HP)						
	5.0	5									
	Boring Terminated at 5 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry Auger

Abandonment Method:
Backfilled with auger cuttings

See Exhibit A-4 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS
No water encountered during drilling
Dry upon completion of drilling

Terracon
2501 E Loop 820 N
Fort Worth, TX

Boring Started: 12-05-2017	Boring Completed: 12-05-2017
Drill Rig:	Driller: StrataBore
Project No.: 95175113	Exhibit: A-11

BORING LOG NO. B-8

PROJECT: Fitness Center - Phase I

CLIENT: ALEDO JMD 1, LLC
Austin, Texas

SITE: Bailey Ranch Road
Aledo, Texas

LOCATION See Exhibits A2 & A3

Latitude: 32.7106° Longitude: -97.6066°

GRAPHIC LOG	DEPTH	DESCRIPTION	DEPTH (Ft.)	WATER LEVEL OBSERVATIONS	SAMPLE TYPE	FIELD TEST RESULTS	STRENGTH TEST: TEST TYPE	STRENGTH TEST: COMPRESSIVE STRENGTH (tsf)	STRENGTH TEST: STRAIN (%)	WATER CONTENT (%)	DRY UNIT WEIGHT (pcf)	ATTERBERG LIMITS LL-PL-PI
	2.0	**FAT CLAY (CH)**, dark gray, very stiff to hard				4.5+ (HP)				21		66-27-39
	4.0	**FAT CLAY (CH)**, with calcareous deposits, brown, very stiff to hard				4.5+ (HP)				15		
	5.0	**FAT CLAY (CH)**, with calcareous deposits and gravels, tan and gray, very stiff to hard	5			4.5+ (HP)						
		Boring Terminated at 5 Feet										

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Dry Auger

Abandonment Method:
Backfilled with auger cuttings

See Exhibit A-4 for description of field procedures
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

No water encountered during drilling

Dry upon completion of drilling

Terracon
2501 E Loop 820 N
Fort Worth, TX

Boring Started: 12-05-2017	Boring Completed: 12-05-2017
Drill Rig:	Driller: StrataBore
Project No.: 95175113	Exhibit: A-12

APPENDIX B
LABORATORY TESTING

Laboratory Testing

The boring logs and samples were reviewed by a geotechnical engineer who selected soil samples for testing. Tests were performed by technicians working under the direction of the engineer. A brief description of the tests performed follows.

Liquid and plastic limit tests (ASTM D4318) and moisture content measurements (ASTM D2216) were made to aid in classifying the soils in accordance with the Unified Soil Classification System (USCS). The USCS is summarized on Exhibit C-2 in Appendix C. Absorption swell tests (ASTM D4546) were performed on selected samples of the cohesive materials. These tests were used to quantitatively evaluate volume change potential at in-situ moisture levels. Consistency of cohesive soils was measured by hand penetrometer test.

The results of the swell tests are presented in the following table. The results of the other laboratory tests are presented on the boring logs in Appendix A.

SWELL TEST RESULTS

Boring No.	Depth (feet)	Liquid Limit (%)	Plasticity Index (%)	Initial Moisture (%)	Final Moisture (%)	Surcharge (psf)	Swell (%)
B-1	2 - 4	67	43	23	26	360	3.8
B-2	2 - 4	62	42	18	22	360	3.6
B-4	0 - 2	-	-	20	29	360	4.1

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Auger	Split Spoon
Shelby Tube	Macro Core
Texas Cone	Rock Core
Grab Sample	No Recovery

WATER LEVEL

- Water Initially Encountered
- Water Level After a Specified Period of Time
- Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

(HP)	Hand Penetrometer
(T)	Torvane
(b/f)	Standard Penetration Test (blows per foot)
(PID)	Photo-Ionization Detector
(OVA)	Organic Vapor Analyzer
(TCP)	Texas Cone Penetrometer

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance Includes gravels, sands and silts.			CONSISTENCY OF FINE-GRAINED SOILS (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance			
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength, Qu, tsf**	**Standard Penetration or N-Value Blows/Ft.**	**Ring Sampler Blows/Ft.**
Very Loose	0 - 3	0 - 6	Very Soft	less than 0.25	0 - 1	< 3
Loose	4 - 9	7 - 18	Soft	0.25 to 0.50	2 - 4	3 - 4
Medium Dense	10 - 29	19 - 58	Medium-Stiff	0.50 to 1.00	4 - 8	5 - 9
Dense	30 - 50	59 - 98	Stiff	1.00 to 2.00	8 - 15	10 - 18
Very Dense	> 50	≥ 99	Very Stiff	2.00 to 4.00	15 - 30	19 - 42
			Hard	> 4.00	> 30	> 42

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

Terracon

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification: Group Symbol	Soil Classification: Group Name [B]
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:	Liquid limit - oven dried / 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:	Liquid limit - oven dried / 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

[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] $Cu = D_{60}/D_{10} \qquad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[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 shaded 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] $PI \geq 4$ 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.