Geotechnical Engineering Report

TEXAS HORSE PARK

Dallas County, Texas

February 26, 2013

Terracon Project No. 94135010

Prepared for:

City of Dallas
Dallas, Texas

Prepared by:

Terracon Consultants, Inc.

Terracon

February 26, 2013

City of Dallas
Park and Recreation Department
1500 Marilla Street, 6FS
Dallas, Texas 75201

Attn: Mr. Donald Burns

Re: Geotechnical Engineering Report
Texas Horse Park
Pemberton Hill Road, Dallas, Texas
Dallas, Texas
Terracon Project No. 94135010

Dear Mr. Burns:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the referenced project. This study was performed in general accordance with our proposal number P94130056, dated January 11, 2013. This report presents the findings of the subsurface exploration and provides geotechnical recommendations for the proposed project. Building locations were changed after field exploration was performed. We recommend additional field exploration, laboratory testing and analyses to be performed to confirm recommendations for River Ranch Admin building.

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

STATE OF TEXAS
SIDDHARTH NEEKHRA
102284
LICENSED
PROFESSIONAL ENGINEER
2/26/13

Siddharth Neekhra, P.E.
Project Manager

Tim G. Abrams, P.E.
Senior Principal

TABLE OF CONTENTS

GEOTECHNICAL ENGINEERING REPORT
TEXAS HORSE PARK
DALLAS, TEXAS

Terracon Project No. 94135010
February 25, 2013

1.0 INTRODUCTION

The Texas Horse Park is planned on the west side of Pemberton Hill Road in Dallas, Texas. Our scope of services included drilling and sampling twenty five soil borings to depths of about 10 to 25 feet, laboratory testing, and engineering analysis. 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
- pavement recommendations

Building locations were changed after field exploration was performed. We recommend additional field exploration, laboratory testing and analyses to be performed to confirm geotechnical recommendations for River Ranch Admin building.

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Site layout	See Appendix A, Exhibit A-1, Boring Location Plan.
Planned improvements	Covered arenas, horse barns, office and activity center buildings, feed and equipment storage buildings, drives and parking lots.
Finished floor elevation	See Appendix A, Exhibit A-1, Boring Location Plan.
Maximum loads (assumed)	Columns: 10 to 150 kip (as per RFP) Walls: 0.50 to 2.0 kips per foot Slabs: 125 psf (assumed)

2.2 Site Location and Description

Item	Description
Location	West of Pemberton Hill Road near intersection with Jeane Road, Dallas, Texas
Existing Improvements	Wood frame structures to be demolished
Current ground cover	Wooded areas, grass land and land under cultivation

Item	Description
Existing topography	About 30 to 40 feet of relief
Below grade walls and Retaining Walls	None

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

Based on the results of the borings, subsurface conditions on the project site vary throughout. The Subsurface conditions for each structure location are as follows:

River Ranch Covered Arena – Borings B-6 through B-9

Stratum	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency
1	1 to 4 foot	Brown fat clay (CH)	Soft to very stiff
2	5 to 14 foot	Red and brown Sandy Clay(CL)	Hard
3	Termination depths of 25 feet	Poorly Graded Sand (SP)	Dense to very dense

River Ranch Camp Activities – Borings B-12 through B-13

Stratum	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency
1	2 to 3 feet	Red and brown Sandy Clay (CL)	Medium Stiff to very stiff
2	8 feet in boring B-12	Clayey Sand (SC)	dense
3	Termination depths of 25 feet	Poorly Graded Sand (SP)	Medium dense to very dense

Equest Covered Arena and Horse Barn – Borings B-18 through B-20

Stratum	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency
1	2 feet in B-18 and 6 feet and 23 feet in B-19	Red, brown, and gray Sandy Clay (CL)	Medium Stiff to hard
2	13 to 18, not encountered in B-20	Fat Clay (CH)	Hard
3	Termination depths of 25 feet	Poorly Graded Sand (SP)	Medium dense to very dense

Equest Admin – Borings B-21

Stratum	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency
1	13 feet	Tan and brown Sandy Clay (CL)	Medium Stiff to hard
2	Termination depths of 25 feet	Poorly Graded Sand (SP)	Very dense

River Ranch Horse Barn – Borings B-24

Stratum	Approximate Depth to Bottom of Stratum	Material Encountered	Consistency
1 and 3	8 feet and 20 feet	Tan and brown Sandy Clay (CL)	Medium Stiff to hard
2	12 feet	Fat Clay (CH)	Hard
4	Termination depths of 25 feet	Poorly Graded Sand (SP)	Very dense

Conditions encountered at individual boring locations are indicated on the boring logs. Stratification boundaries on the boring logs represent the approximate location of changes in soil types; in-situ, the transition between materials may be gradual. Details for the boring drilling and sampling can be found in Appendix A of this report. Laboratory test results are present on the Boring logs and in Appendix B

3.2 Groundwater

The borings were advanced dry using auger drilling techniques, which allows short-term groundwater observations to be made while drilling. Groundwater seepage was observed during drilling or at the completion of drilling the borings. The summary of ground water information is presented in the table below.

Boring	Depth During Drilling, feet	Depth After Completion, feet
B-1	24	13
B-3	24	-
B-4	25	-
B-13	24	-
B-18	-	24
B-20	19	21
B-21	13	24

These groundwater observations provide an indication of the groundwater conditions present at the time of drilling. Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff, landscape irrigation 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 project may be higher than the levels indicated on the boring logs. The possibility of groundwater level fluctuation should be considered when developing the design and construction plans for the project.

4.0 RECOMMENDATIONS FOR DESIGN AND CONSTRUCTION

4.1 Geotechnical Considerations

Active clay soils were encountered in the borings and these soils can subject shallow foundations bearing in them to significant differential movements due to moisture fluctuations in the soils. We estimate the potential magnitude of post-construction heave at this site to range from 1 to 5 inches for dry soil conditions that can exist prior to construction.

Auger cast piles and shallow footings are the recommended method of supporting the planned buildings and arena structures. If floor slab movements must be limited to less than one inch, a floor system structurally supported above the subgrade is recommended. If potential slab movements on the order of one inch are acceptable, the floor slab can be supported on a modified subgrade. It should be noted that there is a 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.

Flexible base is planned for interior drives and parking areas. Portland cement concrete pavement is planned for fire lanes.

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

4.2 Earthwork

4.2.1 Site Preparation

Areas to receive new fill should be stripped and grubbed. The exposed subgrade should then be proof rolled. 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 excavated to firm ground. Excavated areas should be backfilled with properly placed and compacted fill as discussed in **Section 4.2.3**.

4.2.2 Suitable Fills

The on-site soils, free of vegetation, debris, in maximum dimension, are generally suitable for site grading. If imported fill materials are used, they should be clean soil with a Liquid Limit less than 50 percent and no rock greater than 4 inches in maximum dimension.

The material used as select fill should be sandy clay to clayey sand with a Liquid Limit (LL) of less than 35 percent and a Plasticity Index (PI) between 6 and 15. Clayey sand encountered during field exploration can be used as select fill material provided they meet the select fill criteria mentioned above. Positive drainage must be provided away from the structure to prevent the ponding of water in the select fill.

As an alternate to select fill, flexible base can be used. The base should meet the requirements of TxDOT Item 247, Type D, Grade 1 or 2. Recycled concrete meeting this gradation is acceptable.

4.2.3 Compaction Requirements

Recommendations for compaction are presented in the following table. We recommend that 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	DESCRIPTION
1. Subgrade preparation to receive fill	Surface scarified to a minimum depth of 6 inches and compacted to criteria in either Items 3 or 4.
2. Clay, select fill, and flexible base loose lift thickness	9-inches or less
3. Subgrades and fills outside moisture conditioned areas	A minimum of 95% maximum standard Proctor dry density (ASTM D 698) at a minimum of -2 to +2 percentage points of optimum moisture content.
4. Moisture conditioned soils	93% to 98% of the maximum standard Proctor dry density (ASTM D 698) at a minimum of +3 percentage points above optimum moisture content.
5. Select fill and flexible base	A minimum of 95% maximum standard Proctor dry density (ASTM D 698) in the range of -2 to +2 percentage points of optimum moisture content.
6. Backfill against grade beams	A minimum of 95% maximum standard Proctor dry density (ASTM D 698) at a minimum of +3 percentage points above optimum moisture content.
7. Pavement subgrades, natural or lime-treated	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.

4.2.4 Drainage and Utilities

All grades must be adjusted to provide positive drainage away from the structures. Water permitted to pond adjacent or near the structures will result in ground movements that exceed those discussed in this report. Open ground should preferably be sloped at a minimum of 5 percent grade for at least 10 feet beyond the perimeter of the structure. Flatwork and pavement will be subject to post construction movement. Maximum grades practical should be used for paving and flatwork to prevent areas where water can pond.

In addition, allowances in final grades should take into consideration post-construction movement of flatwork, particularly if such movement would be critical. Where paving or flatwork abuts the structure, care should be taken that joints are properly sealed and maintained to prevent the infiltration of surface water.

Planters located adjacent to the structure should preferably be self-contained, or at least designed to drain away from the building. Sprinkler mains should be located a minimum of five feet away from the building lines. If heads must be located adjacent to the structures, then service lines off the main should be provided. Roof drains should discharge on pavement or be extended away from the structure.

Care should be taken that utility trenches are not left open for extended periods and they are properly backfilled. Backfilling should be accomplished with properly compacted on-site soils, rather than granular materials. A positive cut-off at the building line is recommended to help prevent water from migrating in the utility trench backfill.

4.2.5 Cut and Fill

The site existing grades range from El. 408 to El. 440 with a general slope towards southwest. Cut and fills are planned to achieve the planned finished grades. Following table provides a summary of approximate maximum cut and fill information for each building. The fill under building slabs must consist of select fill.

Cut and Fill			
Building	**Finished Floor Elevation, feet**	**Maximum Cut, feet**	**Maximum Fill, feet**
River Ranch Covered Arena	438.5	0	4
River Ranch Camp Activities Building	435.5	0	5.5
River Ranch Camp Admin Building	436	0	0
Equest Covered Arena	415.9	2	4

Cut and Fill			
Building	**Finished Floor Elevation, feet**	**Maximum Cut, feet**	**Maximum Fill, feet**
Equest Horse Barn	417.7	2	6.5
Equest Admin	419.5	3	2
River Ranch Horse Barn	434.5	0	0

4.3 Foundations

4.3.1 Shallow Foundations

The perimeter wall for River Ranch Camp Activities building and Admin building can be supported on continuous strip footings and interior columns on square footings supported on structural select fill or moisture conditioned clays. Recommendations for select fill or moisture conditioned depths are presented in report Section 4.5. The arena and barn structures can be supported on shallow footings provided they can tolerate greater than one inch movement otherwise a deep foundation system discusses in next section must be used.

Recommended allowable net bearing pressures for footings founded at least 2 feet below finished floor grade into moisture conditioned onsite clays or select fill are presented in the following table.

SHALLOW FOOTING RECOMMENDATIONS		
Design Element	**Recommendation**	
Bearing Stratum	Compacted Select Fill or moisture conditioned clays	
Strip Footing – Allowable Net Bearing Pressure	Select Fill	2,000 psf, Sustained Loads
	Moisture conditioned clays	1,500 psf Sustained loads
Square Footing – Allowable Net Bearing Pressure	Select Fill	2,350 psf, Sustained Loads
	Moisture conditioned clays	1,800 psf, Sustained Loads

SHALLOW FOOTING RECOMMENDATIONS

Design Element	Recommendation
Minimum Footing Embedment Below Finished Floor	2 feet
Minimum Footing Width	2 feet
Total Estimated Settlement	1.0 inch
Total Differential Settlement	0.5 to 0.75 inches

The allowable net bearing values include a factor of safety of 3 for dead loads. The allowable net bearing values can be increased by 25 percent for dead and live loads.

The footing subgrade must be free of loose material and water when footings are constructed. The footings must be constructed shortly after the footings are excavated to reduce deterioration of the bearing surface.

4.3.2 Auger Cast Piles (ACP) – Design Parameters

Due to seepage observed in the borings and caving potential of non-cohesive soils, auger cast pile shafts extending into the dense sands are considered the most positive deep foundation system for supporting the proposed structures. Design parameters for auger cast pile systems are presented below.

Auger cast piles are installed by advancing a hollow-stem auger to a predetermined depth in the ground, and then pumping high-strength flowable cement grout into the hole through the bottom of the hollow auger as the auger is slowly withdrawn. The grout is pumped under relatively high pressure and a positive head of grout is maintained above the base of the auger during auger extraction. After the auger is completely removed, reinforcing steel is then placed. Full scale, on-site load tests are customarily performed on auger cast pile to verify the desired capacity is achievable prior to construction. Auger cast piles systems have been installed in North Texas. While the foundation system is not commonly used in the area, they have been used for similar soil conditions in other parts of Texas and around the country.

Auger cast pile shafts penetrating the dense sands, cemented sands and sandy clays will use a combination of end bearing and skin friction in developing their load carrying capacity. They should be initially proportioned using an allowable bearing pressures provided in the table below for each building location. This value contains a safety factor of three. Additional load carrying capacity can be gained by utilizing an allowable skin friction for that portion of the shaft embedded in the dense sands. This skin friction value may be used for compressive or tensile loads. The auger cast pile shafts extend a minimum of 22 feet below existing grade. Deeper penetrations may be required to develop additional skin friction and/or uplift resistance. A minimum center to center spacing of 2.5 pile diameters is recommended between adjacent piles.

AUGERCAST PILE BEARING CAPACITY RECOMMENDATIONS			
Structure Location	**Bearing Stratum**	**Allowable End Bearing, psf**	**Allowable Skin Friction, psf**
River Ranch Covered Arena	Sandy Clay	6,750	400
River Ranch Camp Activities Building and River Ranch Admin Building	Dense Sand	15,000	680
Equest Covered Arena	Sandy Clay	3750	225
Equest Horse Barn	Sandy Clay	3750	225
Equest Admin	Dense Sand	15,000	680
River Ranch Horse Barn	Dense Sand	15,000	450

DESIGN NOTES	
Design Parameter	**Recommendation**
Minimum Embedment Depths	Minimum embedment depth 22 feet below existing grade.
Penetration to develop skin friction	Begin including skin friction 10 feet below existing grade
Minimum center to center spacing to develop full skin friction	2.5 times the diameter of the larger shaft. Should be examined case-by-case. General reduction guide: varies linearly from the 100% value at a spacing of 2.5 diameters to 50% of the design value at 1.0 diameter.
Groups of 3 or more shafts spaced closer than 2.5 shaft diameters	Should be evaluated on a case by case basis by Terracon. Alternative installation sequences may be needed to allow for a minimum of 48 hours concrete curing time, before installation of adjacent shafts.
Minimum pile diameter	12 inches
Settlement	Less than 3/4 inch

Ultimate load capacity and settlement of the auger cast piles should be verified using load tests procedures as described in ASTM D1143. Final design auger cast pile capacities and settlements should be based upon field load testing data. A safety factor of 2.5 (allowable capacity reduction) is recommended for auger cast pile shafts after ultimate capacity is determined by the load test (ASTM D1143).

Settlements of properly constructed auger cast pile shafts are anticipated to be minor and primarily elastic.

4.3.3 Auger Cast Piles – Soil Induced Uplift Loads

The auger cast pile 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 piles must contain sufficient continuous vertical reinforcing and embedment depth 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 1,400 psf over the shaft perimeter for a depth provided in the table below for each structure location. If the building pads are prepared as discussed in **Section 4.5.2**, a uniform uplift of 800 psf to a depth of 8 feet where moisture conditioned clays are present.

SOIL INDUCED UPLIFT BELOW FINISHED GRADE

Structure Location	Depth to Uplift
River Ranch Covered Arena	8 feet
River Ranch Camp Activities Building and Admin Building	-
Equest Covered Arena	8 feet
Equest Horse Barn	8 feet
Equest Admin	8 feet
River Ranch Horse Barn	8 feet

4.3.4 L-PILE Parameters

The lateral load parameters for different buildings are provided in the tables below. The values are given for use in Ensoft's L-PILE computer program. Suitable p-y modification factors must be used to account for group effects of closely spaced auger cast piles.

LATERAL DESIGN PARAMETERS - RIVER RANCH COVERED ARENA			
Design Parameter	**Soft Clay**	**Sand**	**Dense Sand**
Depth Range, feet	0 to 8 feet	8 feet to 14 feet	14 to 25 feet
Material Type for L-PILE	Soft Clay	Sand (Reese)	Sand (Reese)
Effective Unit Weight (pci)	0.072	0.072	0.072
Modulus of Subgrade Reaction K (pci)	100	-	125
Soil Undrained Cohesion (psi)	6.94	-	-
Strain Factor, E_{50}	0.02	-	-
Friction Angle, degrees	-	27	30

Design Parameter	**Soft Clay**	**Dense Sand**	**Dense Sand**
Depth Range, feet	0 to 8 feet	14 to 20 feet	20 to 25 feet
Material Type for L-PILE	Soft Clay	Sand (Reese)	Sand (Reese)
Effective Unit Weight (pci)	0.072	0.072	0.072
Modulus of Subgrade Reaction K (pci)	100	225	125
Soil Undrained Cohesion (psi)	6.94	-	-
Strain Factor, E_{50}	0.02	-	-
Friction Angle, degrees	-	30	30

LATERAL DESIGN PARAMETERS – EQUEST ADMIN BUILDING			
Design Parameter	**Soft Clay**	**Sand**	**Dense Sand**
Depth Range, feet	0 to 8 feet	8 feet to 13 feet	13 to 25 feet
Material Type for L-PILE	Soft Clay	Sand (Reese)	Sand (Reese)

LATERAL DESIGN PARAMETERS – EQUEST ADMIN BUILDING

Design Parameter	Soft Clay	Sand	Dense Sand
Effective Unit Weight (pci)	0.072	0.072	0.072
Modulus of Subgrade Reaction K (pci)	100	90	125
Soil Undrained Cohesion (psi)	6.94	-	-
Strain Factor, E_{50}	0.02	-	-
Friction Angle, degrees	-	27	30

LATERAL DESIGN PARAMETERS – RIVER RANCH HORSE BARN

Design Parameter	Soft Clay	Stiff Clay	Dense Sand
Depth Range, feet	0 to 8 feet	8 feet to 13 feet	13 to 25 feet
Material Type for L-PILE	Soft Clay	Sand (Reese)	Sand (Reese)
Effective Unit Weight (pci)	0.072	0.072	0.072
Modulus of Subgrade Reaction K (pci)	100	1,000	125
Soil Undrained Cohesion (psi)	6.94	27.8	-
Strain Factor, E_{50}	0.02	-	-
Friction Angle, degrees	-	-	30

4.3.5 Auger Cast Piles - Construction Considerations

Auger cast piles shall be made by rotating a continuous flight, hollow-shaft auger into the ground to design depth. High strength grout shall then be injected through the auger shaft in such a way as to exert positive upward grout pressure on the auger flights and positive lateral earth pressure shaft walls, as the auger is being withdrawn. Grout used for the auger cast piles should have a flow rate of 10 to 25 seconds when a ¾ inch opening (Modified Corps. of Engineers) flow cone is used.

A minimum of two piles should be tested within the project location prior to commencement of foundation construction using the ASTM D1143 axial pile load test procedure. The tests must be performed at Boring B-6 and B-19 locations. After completion of standard loading cycle of the pile load test, the pile should be reloaded until failure or at least three times the design load, whichever comes first. Test piles loaded to failure should not become part of the permanent foundation system. Load testing should be performed by the auger cast pile contractor in the presence of the geotechnical engineer of record and/or his designee. Cost of the load tests performed by the piling contractor should be included in the base bid price.

Very dense sand layers were encountered in our test borings and were penetrated by our auger drilling rigs. However, harder zones can be encountered and may require special drilling techniques and/or specialized heavy equipment to penetrate the material. Auger cast-in-place pile shaft installations should be performed with equipment suitable to perform this work, by a contractor with experience with subsurface conditions similar to those encountered at this site.

We recommend that Terracon be retained to observe and document the auger cast pile construction. The geotechnical engineer or his representative should document the shaft diameter, drilling elevation, tip elevation, elevation of butt, quantity of grout placed, reinforcement steel, plumbness, and the minimum penetration into the bearing soils. Significant deviations from the specified or anticipated conditions should be reported to the owner's representative, the structural engineer and the geotechnical engineer.

4.3.6 Grade Beams/ Pier Caps

If grade beams are used, they must be supported by the auger cast piles. If no moisture conditioning is performed, a minimum void space of 8 inches is recommended between the bottom of grade beams or pile cap extensions and the subgrade. If moisture conditioning is performed, a minimum void space of 4 inches is recommended between the bottom of grade beams or pile cap extensions and the moisture conditioned subgrade. This void will serve to minimize 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.

The grade beams should be formed rather than cast against earth trenches. Backfill against the exterior face of grade beams, wall panels and pile caps should be on site materials placed and compacted as described in section 4.2.3 Compaction Requirements.

4.4 Seismic Considerations

Code Used	Site Classification
2009 International Building Code (IBC) [1]	D [2]

1. In general accordance with the *2009 International Building Code,* Table 1613.5.2.
2. The 2009 International Building Code (IBC) requires a site soil profile determination extending a depth of 100 feet for seismic site classification. The current scope requested does not include the

Code Used	Site Classification
required 100 foot soil profile determination. The borings extended to a maximum depth of approximately 30 feet and this seismic site class definition considers that stiff soil or bedrock exists 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.	

4.5 Floor System

Lightly loaded floor slabs and flatwork placed on-grade will be subject to movement as a result of moisture induced volume changes in the active soils that can occur following construction. The soils expand (heave) with increases in moisture and contract (shrink) with decreases in moisture. The movement typically occurs as post construction heave.

The potential magnitude of the moisture induced movements is rather indeterminate. It is influenced by the soil properties, overburden pressures, thickness of the clay layers, presence of trees and to a great extent by soil moisture levels at the time of construction. Based on the soil type and thickness encountered in the borings, potential vertical movements in slabs placed on grade are estimated to be on the order of 2 to 5 inches for dry soil moisture conditions that can exist prior to construction. Following table presents the PVR limits at each building location prior for existing conditions.

POTENTIAL VERTICAL MOVEMENTS	
Structure Location	**PVR, inches**
River Ranch Covered Arena	3 to 5
River Ranch Camp Activities Building and River Ranch Admin Building	<1
Equest Covered Arena	3 to 5
Equest Horse Barn	3 to 5
Equest Admin	3 to 5
River Ranch Horse Barn	3 to 5

A structural floor slab is recommended if floor slab movements are to be limited to less than one inch. If floor slab movements of about one inch are acceptable, the building floor slabs can be supported on grade. Moisture conditioning of the existing soils beneath the building pad will be required to reduce movements to about one inch.

4.5.1 Structural Floor Slabs

The building floor slabs should be structurally supported above the subgrade if movements are to be limited to less than one inch. A minimum void space of 8 inches is recommended beneath the structural floor slab.

The minimum void space can be provided by the use of cardboard carton forms, or a deeper crawl space. The bottom of the void should preferably be higher than adjacent exterior grades. A ventilated and drained crawl space is preferred under the building for several reasons, including the following:

- Ground movements will affect the project utilities, which can cause breaks in the lines and distress to interior fixtures.
- A crawl space permits utilities to be hung from the superstructure, which greatly reduces the possibility of distress due to ground movements. It also can provide ready access in the event repairs are necessary.
- Ground movements are uneven. A crawl space can be positively drained preventing the ponding of water and reducing the possibility of distress due to unexpected ground movements.

4.5.2 Floor Slabs/Flatwork on Moisture Conditioned Subgrade

Slab on grade construction should only be considered if slab movements on the order of 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 is moisture conditioning the on-site clays and capping them with one foot of select fill. Any fill required above finished grade must meet the select fill criteria as described in **Section 4.2.2 Suitable Fills.** Water injection is not recommended because of the low moisture contents and high strengths of the clays.

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 one inch. 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 present or planned to be planted closer.

Based on dry soil conditions, it is estimated that movements on the order of one inch can generally be obtained by moisture conditioning of the in-situ soils in conjunction with a minimum one foot cap of select fill. The depth of moisture conditioning for each building location is provided in table below. The depth given in the table includes the one foot select fill layer. The moisture conditioned soils and select fill should extend beyond the building perimeter to include entrances, abutting sidewalks and other flatwork areas sensitive to movement.

MOISTURE CONDITIONING DEPTH

Structure Location	Moisture Conditioning Depth, feet
River Ranch Covered Arena	8
River Ranch Camp Activities Building and River Ranch Admin Building	None
Equest Covered Arena	8
Equest Horse Barn	8
Equest Admin	8
River Ranch Horse Barn	8

The moisture conditioning depth is measured from top of finished slab subgrade

Excavation and Replacement

The soil should be excavated to the depths given in the Moisture Conditioning Depth table in the previous section below the bottom of floor slab. The excavated soils, except for deleterious materials and soils with PI's greater than 35 can be used in accordance with section **4.2.3 Compaction Requirements** for moisture conditioned clays.

One foot of select fill or flexible base material must be placed above the moisture conditioned soils in a short 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.

4.6 Pavement

4.6.1 Pavement Subgrades

Subgrade materials at this site will typically consist of clay soils. These soils are subject to loss of support with the moisture increases that can occur beneath paving. Concrete pavements may be placed on compacted subgrade without lime treatment unless required by City of Dallas Standards.

A flexible base pavement section is planned for drives and parking lots that are not fire lanes. The upper 8 inches of the flexible base subgrade must be lime stabilized to provide sufficient subgrade strength to support the paving equipment and future roadway traffic. Five percent lime can be used to estimate the quantity required for stabilization. The required lime content should be determined after the pavement subgrade is rough graded.

The 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 at the time of pavement construction for signs of disturbance or excessive rutting. If disturbance has occurred, pavement subgrade areas should be reworked, moisture adjusted, 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 concrete pavement sections with subgrade stabilization alternatives are provided. These represent a total of 45,000 18-Kip Equivalent Single Axle Loads (ESALs) for Light Duty PCC pavement and 100,000 18-Kip ESALs for the Medium Duty PCC pavement. The gravel pavement is designed for 5,000 ESALs. The Light Duty pavement is intended for passenger car and pickup trucks. The Medium Duty pavement is intended for passenger car, pickup trucks, small delivery trucks, and 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

Concrete and flexible pavement sections are presented in the following table.

Pavement Section	Pavement Thickness, Inches		
	Light Duty 45,000 18-kip ESALs	**Medium Duty** 100,000 18-kip ESALs	**Dumpster Area**
Portland Cement Concrete	5	6	7
Compacted Subgrade	8	8	8

***All materials should meet the City of Dallas Standard Specifications for Roadway Construction.**

Pavement Section	Pavement Thickness, Inches
Surface Course (3/4" Minus Crushed Limestone Surface Course)	3
Flexible Base (TxDOT Item 247, Type A)	8
Lime Stabilized Subgrade	8

***All materials should meet the City of Dallas Standard Specifications for Roadway Construction.**

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.

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.