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GEOTECHNICAL ENGINEERING STUDY
WOODMEN HILLS FIRE STATION NO. 1
SOUTHWEST OF THE INTERSECTION
OF STAPLETON DRIVE AND
MERIDIAN RANCH BOULEVARD
EL PASO COUNTY, COLORADO

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4/2/09

Prepared for:

COPESTONE GENERAL CONTRACTORS
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Attn: Mr. Kurt Kaltenbacher

Project No. 09-2-127

April 2, 2009

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SUMMARY

1. Beneath a thin layer of topsoil, clayey sand extended to the maximum 5-foot depth of one of the borings and to depths ranging from approximately 1.5 to 8.5 feet in the other four borings. Sandstone bedrock with occasional thin layers of claystone was encountered beneath the clayey sand in three of the borings and extended to the maximum 5-foot depth in one boring and the maximum 20-foot depth in two other borings. In one boring, the sandstone bedrock was determined to be interbedded with a layer of claystone from approximately 13 feet to 16 feet; sandstone bedrock was again encountered beneath the claystone and extended to the 20-foot depth of the boring.

2. Ground water was encountered at a depth of approximately 19 feet in Boring 1 at the time of drilling. When checked six days after drilling, the ground-water level was measured at a depth of approximately 12 feet in Borings 1 and 2. Fluctuations in the ground-water level may occur with time.

3. Considering the subsurface conditions encountered in the exploratory borings and the nature of the proposed construction, we recommend the proposed building be supported on spread footings placed on the native clayey sand or properly compacted structural fill. Sandstone bedrock was encountered within approximately 3 feet of the expected footing bearing elevation. There is a potential in this area for the sandstone to be interbedded with occasional thin layers of expansive sandy claystone. We recommend several test pits be excavated to a depth of 4 feet below the foundation bearing elevation at the time of construction to determine if sandy claystone layers are present. We recommend any claystone material encountered within 4 feet of the foundation bearing elevation be removed and replaced with suitable structural fill.

4. Pavement recommendations for the proposed parking and drive areas restricted from emergency vehicle traffic include full depth asphalt, portland cement concrete and composite sections consisting of asphalt over aggregate base course. In areas subject to the emergency vehicle traffic, we recommend only portland concrete cement pavements be considered. A discussion of our pavement design assumptions and recommendations are presented in the report.

PURPOSE AND SCOPE OF STUDY

This report presents the results of a geotechnical engineering study for the proposed Woodmen Hills Fire Station No. 1 to be located at the southwest corner of Stapleton Drive and Meridian Ranch Boulevard, in El Paso County, Colorado. The project site is shown on Fig. 1. The study was conducted in accordance with our proposal Number C09-122, dated March 9, 2009, to develop foundation and floor slab recommendations for the proposed building, and pavement section thickness design recommendations for the proposed pavement areas.

This report has been prepared to summarize the data obtained during this study, and to present our conclusions and recommendations based on the proposed construction and the subsurface conditions encountered. Design parameters and a discussion of geotechnical engineering considerations related to the proposed construction are included in the report.

PROPOSED CONSTRUCTION

We understand the proposed construction at the site will include a single-story, metal-frame fire-station building with four equipment bays, and will have nominal plan dimensions of approximately 55x225 feet. Foundation loads are anticipated to be light to moderate, typical of the proposed construction type. The site development will also include drive and parking areas west and southwest of the proposed structure, and an apron east and west of the equipment bays. We understand the finished floor slab for the structure is expected to be at an elevation of approximately 7048.5 feet. Based on the estimated finished floor slab elevation, we anticipate grading within the footprint of the proposed structure will consist of cuts ranging to a depth of approximately 1.5 feet on the north side and fill ranging to approximately 2.5 feet in height on the south side. A grading plan was not available at the writing of this report; however, we anticipate grading will consist of minimal amounts of cut and fill in the areas beyond the proposed structure.

If the proposed construction varies significantly from that described above or depicted in this report, we should be notified to reevaluate our recommendations.

SITE CONDITIONS

The subject site generally consists of vacant land that appears to have been previously graded. Based on the surrounding topography, it appears the grading has generally consisted of cuts. The subject site is bound by Stapleton Drive to the north, Meridian Ranch Boulevard to the east, Royal County Down Road to the south and by single-family residential homes to the west. With the exception of the northern and eastern edges of the site, which slope moderately towards the site, the remainder of the property slopes gently to the southeast. Vegetation generally consisted of sparse grasses and weeds. We observed irrigated shrubs and trees along the northern and eastern edges of the property.

SUBSURFACE CONDITIONS

Information of the subsurface conditions was obtained by drilling five exploratory borings at the approximate locations shown on Fig. 1. Borings 1, 2 and 3 were drilled within the footprint of the proposed structure, and Borings 4 and 5 were drilled in the proposed drive/ parking areas west of the proposed structure. The logs of the borings are shown on Fig. 2, and the corresponding legend and notes for the logs are shown on Fig. 3. The results of laboratory testing performed on selected samples from the borings are presented on Figs. 2, 4 through 6, and are summarized on Table I. The laboratory testing was conducted in general accordance with applicable ASTM standards.

Beneath a thin layer of topsoil, clayey sand extended to the maximum 5-foot depth of Boring 5 and to depths ranging from approximately 1.5 to 8.5 feet in the other four borings. Sampler penetration blow counts suggest the clayey sand is very stiff to hard in consistency.

Sandstone bedrock with occasional thin layers of claystone was encountered beneath the clayey sand in Borings 1 through 4 and extended to the maximum 20-foot depth explored in Borings 1 and 2 and the maximum 5-foot depth of Boring 4. In Boring 3, the sandstone bedrock was interbedded with a thicker layer of claystone from approximately 13 feet to 16 feet; sandstone bedrock was again encountered beneath the claystone and extended to the 20-foot depth of the boring. Results of a swell-consolidation test of a sample of claystone collected from Boring 3, presented on Fig. 6, indicates the claystone has a low swell potential when wetted under a 1-ksf load.

At the time of drilling, ground water was encountered at a depth of approximately 19 feet in Boring 1. The ground-water level was measured at a depth of approximately 12 feet in Borings 1 and 2 when checked six days after drilling. Follow up water-level measurements were not performed in Borings 4 and 5 because they were backfilled the day of drilling. Fluctuations in the water level may occur over time.

FOUNDATION RECOMMENDATIONS

Considering the subsurface conditions encountered in the exploratory borings and the nature of the proposed construction, we recommend the proposed building be supported on spread footings placed on the native clayey sand or properly compacted structural fill.

The design and construction criteria presented below should be observed for a spread footing foundation system. The construction details should be considered when preparing project documents.

1. Footings placed on the undisturbed native soils or properly compacted structural fill should be designed for an allowable soil bearing pressure of 2,500 psf.

2. We estimate total settlement for footings designed and constructed as discussed in this section will not exceed 1 inch.

3. Spread footings placed on the native clayey sand or properly compacted structural fill should have a minimum width of 16 inches for continuous footings and 24 inches for isolated pads.

4. Exterior footings and footings beneath unheated areas should be provided with adequate soil cover above their bearing elevation for frost protection. Placement of foundations at least 30 inches below the exterior grade is typically used in this area.

5. The lateral resistance of a spread footing placed on the native soil or new nonexpansive structural fill will be a combination of the sliding resistance of the footing on the foundation materials and the passive earth pressure against the side of the footing. Resistance to sliding at the bottoms of the footings may be calculated based on an allowable coefficient of friction of 0.3. Passive pressure against the sides of the footings may be calculated using an allowable equivalent fluid unit weight of 250 pcf. Compacted fill placed against the sides of the footings to resist lateral loads should be a nonexpansive structural material compacted to at least 95% of the maximum standard Proctor density (ASTM D 698) within two percentage points of the optimum moisture content.

6. Continuous foundation walls should be reinforced top and bottom to span an unsupported length of at least 10 feet.

7. Sandstone bedrock was encountered within approximately 3 feet of the expected footing bearing elevation. There is a potential in this area for the sandstone to be interbedded with occasional thin layers of expansive sandy claystone. We recommend several test pits be excavated to a depth of 4 feet below the foundation bearing elevation at the time of construction to determine if sandy claystone layers are present. We recommend any claystone material encountered within 4 feet of the foundation bearing elevation be removed and replaced with suitable structural fill. New fill should extend down from the edges of the footings at a 1 horizontal to 1 vertical projection.

8. Structural fill should consist of a nonexpansive material having 100% passing the 2-inch sieve, a maximum 30% passing the No. 200 sieve, a maximum liquid limit of 30, and a maximum plasticity index of 15. The tested samples of the on-site clayey sand, minus any organics or other deleterious material, meet these criteria. The geotechnical engineer should evaluate the suitability of proposed fill materials prior to placement.

9. Structural fill placed for support of the foundation should be compacted to at least 98% of the maximum standard Proctor density, at a moisture content within 2% of the optimum.

10. Any existing fill or areas of disturbed, loose or soft material encountered within the foundation excavation should be removed and replaced with structural fill.

11. A representative of the geotechnical engineer should observe all footing excavations prior to fill and concrete placement.

SEISMIC DESIGN CRITERIA

The Colorado Front Range is located in a low seismic activity area. The soil profile generally consists of between 1.5 to 8.5 feet of clayey sand over interbedded sandstone and claystone bedrock. The weighted average for this profile indicates a UBC design Soil Profile Type for the site of SC or an IBC design Site Class C. Based on the subsurface profile and site seismicity, liquefaction is not a design consideration.

FLOOR SLABS

The native on-site soils, exclusive of topsoil, are suitable to support lightly to moderately loaded slab-on-grade construction. Based on the proposed finished floor slab elevation, we anticipate up to approximately 2.5 feet of fill will be required beneath the middle and southern portions of the proposed floor slab. We recommend the new fill meet the specifications for nonexpansive structural fill as presented in the "Foundation Recommendations" section above. We recommend a modulus of subgrade reaction of 130 pci be assumed for slab on grade design. The geotechnical engineer should evaluate the suitability of proposed fill materials. Fill placed for support of floor slabs should be compacted to at least 95% of the maximum standard Proctor density at a moisture content within 2 percentage points of the optimum.

To reduce the effects of some differential movement, floor slabs should be separated from all bearing walls and columns with expansion joints which allow unrestrained vertical movement. Floor slab control joints should be used to reduce damage due to shrinkage cracking. The appropriate joint spacing is dependant on slab thickness, concrete aggregate size and slump, and should be consistent with recognized guidelines such as those of the portland Cement Association (PCA) and American Concrete Institute (ACI). The joint spacing and any requirements for slab reinforcement should be established by the designer based on experience and the intended slab use. Our experience with similar construction suggests operations in the area of the equipment bays include water; therefore, we recommend the joints in the concrete be sealed with a flexible sealant and a maintenance program be established for sealing any future cracks to prevent water from entering the joints or cracks.

If moisture-sensitive floor coverings will be used, mitigation of moisture penetration into the slabs such as by use of a vapor barrier may be required. If an impervious vapor barrier membrane is used, special precautions will be required to reduce potential differential curing problems which could cause the slabs to warp. Section 302.1R of the ACI Manual of Concrete Practice addresses this topic.

WATER SOLUBLE SULFATES

The concentration of water soluble sulfates measured in two samples obtained from the exploratory borings were approximately 0.01% to 0.06%. These concentrations of water soluble sulfates represent a negligible degree of sulfate attack on concrete exposed to these materials. However, our experience in the area indicates soils or bedrock similar to those encountered at the site commonly contain localized concentrations of water soluble sulfates sufficient to cause sulfate attack. Therefore, we recommend all concrete exposed to the on-site materials contain (ASTM C 150) Type II cement. Concrete should have a minimum cement content of 564 pounds (6 sacks) per cubic yard, have a maximum water-cement ratio (by weight) of 0.45, and have air entrainment.

SURFACE DRAINAGE

Proper surface drainage is very important for acceptable performance of the structure during construction and after the construction has been completed. The following recommendations should be used as guidelines and changes should be made only after consultation with the geotechnical engineer.

1. Excessive wetting or drying of the foundation and slab subgrade should be avoided during construction.

2. Exterior backfill should be adjusted to a moisture content within 2 percentage points of the optimum and compacted to at least 95% of the maximum standard Proctor density.

3. Care should be taken when compacting around the foundation walls and underground structures to avoid damage to the structures. Hand compaction procedures, if necessary, should be used to prevent lateral pressures from exceeding the design values.

4. The ground surface surrounding the exterior of the building should be sloped to drain away from the foundation in all directions. We recommend a minimum slope of 6 inches in the first 10 feet in unpaved areas. Site drainage beyond the 10-foot zone should be designed to promote runoff and reduce infiltration. A minimum slope of 3 inches in the first 10 feet is recommended in the paved areas. These slopes may be changed as required for handicap access points in accordance with the Americans with Disabilities Act.

5. Ponding of water should not be allowed in backfill material or in a zone within 20 feet of the foundation walls, whichever is greater.

6. Roof downspouts and drains should discharge well beyond the limits of all foundation backfill.

7. Excessive landscape irrigation should be avoided within 10 feet of the foundation walls.

PAVEMENT DESIGN

Subgrade Materials: Based on the results of the field and laboratory studies, the on-site clayey sand classifies as an A-2-4 soil with a group index of 0 in accordance with the American Association of State Highway and Transportation Officials (AASHTO) classification. The sandstone bedrock classifies as an A-2-4 and A-2-6 with group indices of 0 and 1, respectively. Based on the soil types encountered in the exploratory borings and our experience, we have assumed an R-value of 20 for the design of flexible pavements. For rigid pavements, we have assumed the subgrade soils have a modulus of subgrade reaction of 130 pci for the design of rigid pavements.

Design Traffic: An equivalent 18-kip daily load application (EDLA) of 5 was assumed for areas of the pavement restricted to automobile traffic, and an EDLA of 8 was assumed for areas of automobile and occasional truck traffic, excluding the emergency equipment. Based on our understanding of the proposed construction, these areas would be limited to the parking areas.

Based on our previous experience with similar construction, we understand that emergency equipment typical of fire stations generally range from approximately 40 to 75 kips. For the purpose of calculating the 18-kip single axle equivalency factor for the emergency equipment we have assumed a 20-kip front axle and 55-kip tandem rear axle for the 75-kip trucks, and an 18-kip front axle and 22-kip rear axle for the 40-kip trucks. We have also assumed an average daily traffic of 5 trips of each of two 75-kip three-axle trucks and two 40-kip two-axle trucks.

We have calculated average 20-year, 18-kip equivalent single-axle load (ESAL) values for flexible pavements and 30-year ESALS for rigid pavements in areas restricted from the emergency equipment. We have also calculated a 30-year ESAL for rigid pavements in areas subject to the emergency equipment. The calculated ESALs are presented in the following table:

Areas Subject to:	Avg 20-year ESAL for Flexible Pavement	Avg 30-year ESAL for Rigid Pavement
Automobile Traffic	36,500	54,750
Automobile and Occasional Truck Traffic (excluding emergency equipment)	58,400	87,600
Emergency Equipment Traffic	---	1,356,705

If it is determined that actual traffic is different from that estimated, we should be contacted to reevaluate the pavement thickness design.

Pavement Sections: Recommended pavement sections were determined using the DARWin 3.01 pavement design software based on the 1993 AASHTO pavement design procedures and guidance from Appendix D of the El Paso County Engineering Criteria Manual (dated January 2008). The input parameters used in the pavement design analysis are presented in Table II, and the detailed outputs from the DARWin program are presented in the Appendix.

Areas of the pavement restricted to automobile traffic should consist of a minimum of 5.5 inches of full depth hot mix asphalt. As an alternative, a composite section consisting of a minimum of 4 inches of asphalt over 6 inches of aggregate base course may be considered. Another alternative is a pavement section consisting of a minimum of 6 inches of portland concrete cement (PCC). (Our analysis suggests a portland cement concrete layer less than 6 inches will satisfy the structural requirements of the pavement. However, we recommend that a minimum portland cement concrete thickness of 6 inches be maintained.)

Areas of the pavement restricted to automobile traffic and occasional truck traffic (exclusive of emergency equipment) should consist of a minimum of 6 inches of full depth hot mix asphalt. As an alternative, a composite section consisting of a minimum of 4 inches of asphalt over 7 inches of aggregate base course may be considered. Another alternative is a pavement section consisting of a minimum of 6 inches of PCC.

Truck loading areas, trash pick-up areas and other areas where truck-turning movements are concentrated (exclusive of emergency equipment) should be paved with a minimum of 6 inches of portland cement concrete.

We recommend the drive lanes and apron utilized by the emergency equipment be paved with portland concrete cement rather than asphalt. Based on our experience, a portland concrete cement pavement performs better under heavy equipment traffic. The pavement in the drive lanes and apron subject to traffic by the emergency vehicles should consist of a minimum 8 inches of PCC. The concrete pavement should contain sawed or formed joints to 1/4 of the depth of the slab at a maximum distance of 15 feet on center.

Pavement Materials: The HMA should conform to the requirements presented in the Pikes Peak Region Asphalt Paving Specifications. The binder materials should be PG 64-22 or 58-28 grade. The concrete mix design should meet the requirements of a Colorado Department of Transportation Class "P" mix and the specifications presented in Appendix D.5.5 of the El Paso County Engineering Criteria Manual. Aggregate base course should be a Class 5 or 6 material conforming to the requirements presented in Appendix D.5.5.I of the El Paso County Engineering Criteria Manual.

Subgrade Preparation: Prior to placing the pavement section, the entire subgrade area should be scarified to a depth of 8 inches, adjusted to a moisture content within two percentage points of optimum and compacted to 95% of the maximum standard Proctor density. The pavement subgrade should be proofrolled with a heavily loaded pneumatic-tired vehicle. Pavement design procedures assume a stable subgrade. Areas which deform under heavy wheel loads are not stable and should be removed and replaced to achieve a stable subgrade prior to paving.

Drainage: The collection and diversion of surface drainage away from paved areas is extremely important to the satisfactory performance of pavement. Drainage design should provide for the removal of water from paved areas and prevent wetting of the subgrade soils.

DESIGN AND CONSTRUCTION SUPPORT SERVICES

Kumar & Associates, Inc., should be retained to review the project plans and specifications for conformance with the recommendations provided in this report. We are also available to assist the design team in preparing specifications for geotechnical aspects of the project and, if necessary, perform additional studies to accommodate any changes in the proposed construction.

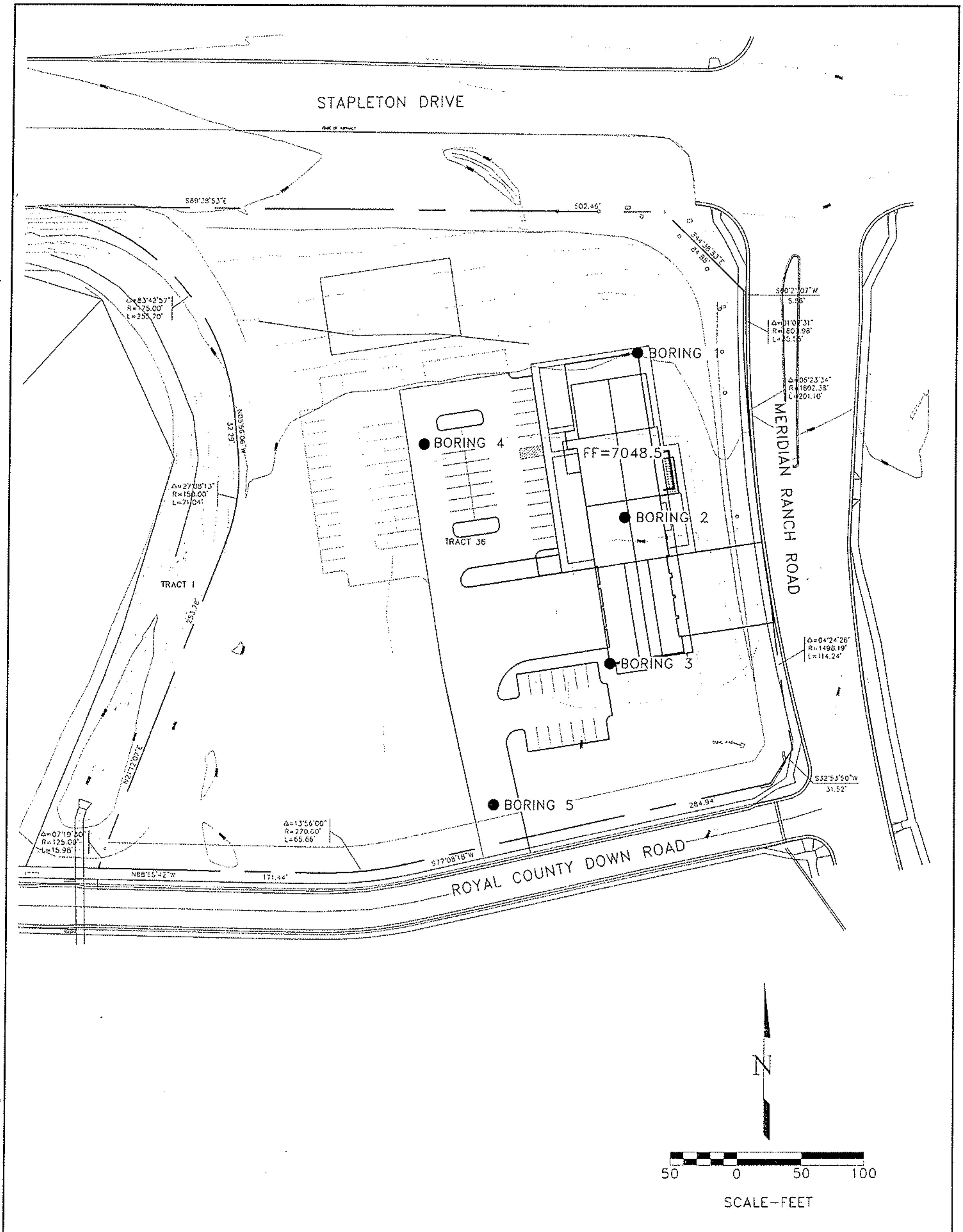
We recommend that Kumar & Associates, Inc., be retained to provide observation and testing services to document that the requirements of the plans and specifications are being followed during construction, and to identify possible variations in subsurface conditions from those encountered in this study.

LIMITATIONS

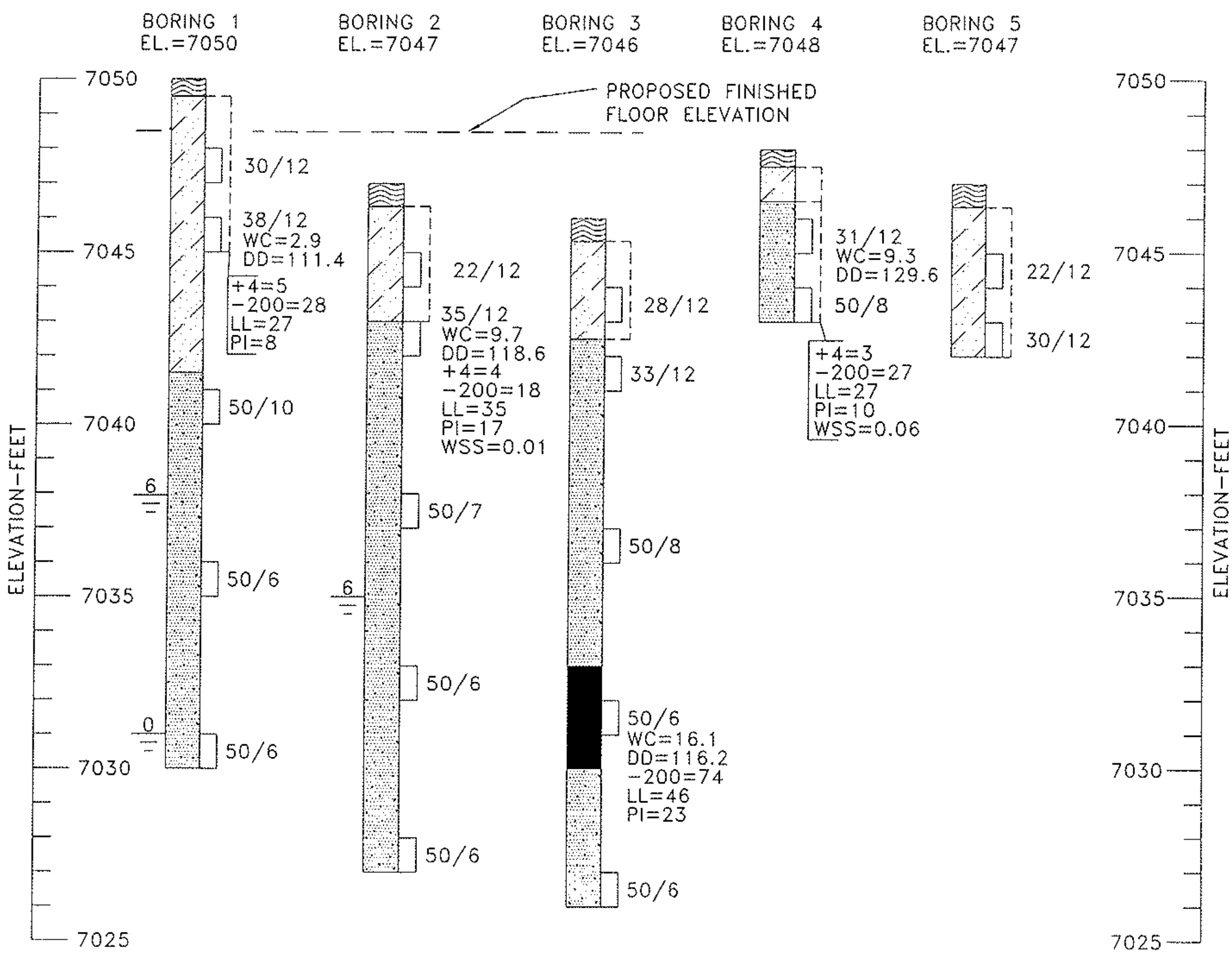
This study has been conducted in accordance with generally accepted geotechnical engineering practices in this area for use by the client for design purposes. The conclusions and recommendations submitted in this report are based upon the data obtained from the exploratory borings drilled at the locations indicated on Fig. 1 and the proposed type of construction. The nature and extent of subsurface variations across the site may not become evident until excavation is performed. If during construction, fill, soil, rock or water conditions appear to be different from those described herein, this office should be advised at once so reevaluation of the recommendations maybe made. We recommend on-site observation of excavations by a representative of the geotechnical engineer.

CAJ:db

cc: HB&A; Attn: Mr. Gene Leavines



09-2-127	Kumar & Associates	LOCATION OF EXPLORATORY BORINGS	Fig. 1



09-2-127	Kumar & Associates	LOGS OF EXPLORATORY BORINGS	Fig. 2

LEGEND

TOPSOIL.

CLAYEY SAND (SC), OCCASIONAL LAYERS OF POORLY-GRADED SAND WITH CLAY (SP-SC), VERY STIFF TO HARD, SLIGHTLY MOIST, LIGHT BROWN.

SANDSTONE, CLAYEY, INTERBEDDED WITH OCCASIONAL LAYERS OF CLAYSTONE, NONCEMENTED, MEDIUM HARD TO VERY HARD, MOIST, OLIVE TO GRAY.

CLAYSTONE, SANDY, VERY HARD, MOIST, GRAY.

DRIVE SAMPLE, 2-INCH I.D. CALIFORNIA LINER SAMPLER.

30/12 DRIVE SAMPLE BLOW COUNT. INDICATES THAT 30 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 12 INCHES.

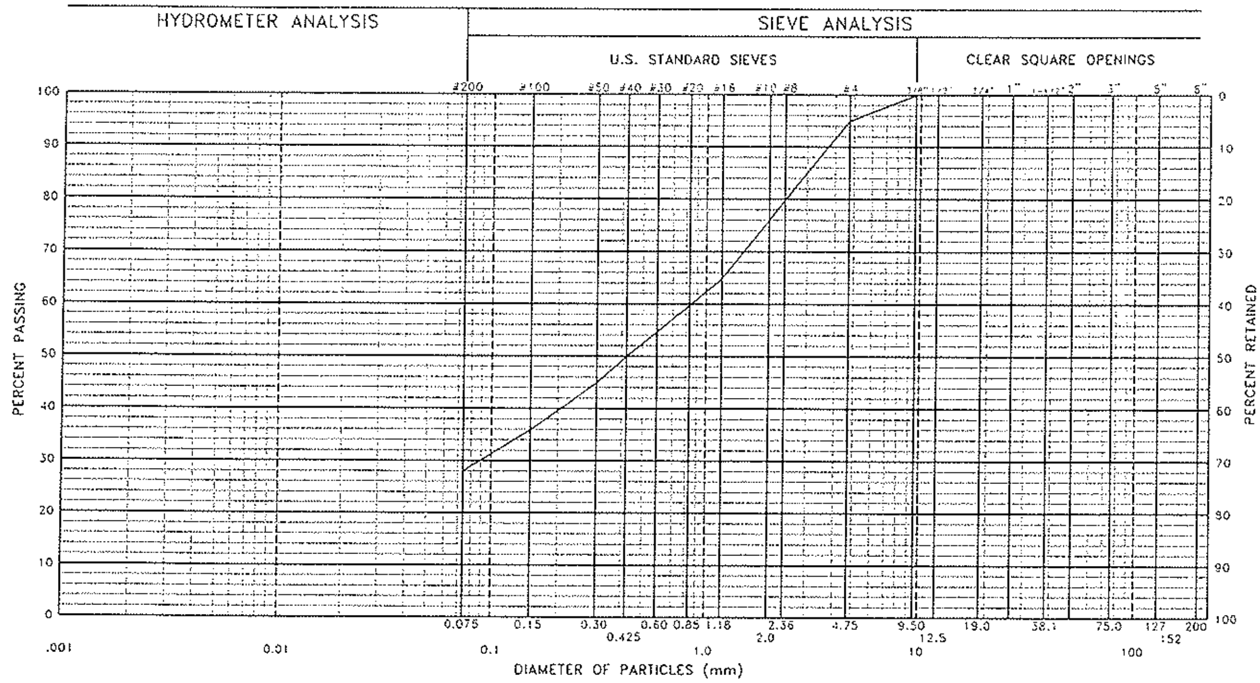
DISTURBED BULK SAMPLE.

6 DEPTH TO WATER LEVEL AND NUMBER OF DAYS AFTER DRILLING MEASUREMENT WAS MADE.

LABORATORY TEST RESULTS
WC = WATER CONTENT (%) (ASTM D 2216);
DD = DRY DENSITY (pcf) (ASTM D 2216);
+4 = PERCENTAGE RETAINED ON NO. 4 SIEVE (ASTM D 422);
-200 = PERCENTAGE PASSING NO. 200 SIEVE (ASTM D 1140);
LL = LIQUID LIMIT (ASTM D 4318);
PI = PLASTICITY INDEX (ASTM D 4318);
WSS = WATER SOLUBLE SULFATES (%) (HACH METHOD).

NOTES
1. THE EXPLORATORY BORINGS WERE DRILLED ON MARCH 13, 2009, WITH A 4-INCH DIAMETER CONTINUOUS FLIGHT POWER AUGER.
2. THE LOCATIONS OF THE EXPLORATORY BORINGS WERE MEASURED APPROXIMATELY BY TAPING FROM FEATURES SHOWN ON THE SITE PLAN PROVIDED.
3. THE ELEVATIONS OF THE EXPLORATORY BORINGS WERE OBTAINED BY INTERPOLATION BETWEEN CONTOURS ON THE PLAN PROVIDED.
4. THE EXPLORATORY BORING LOCATIONS AND ELEVATIONS SHOULD BE CONSIDERED ACCURATE ONLY TO THE DEGREE IMPLIED BY THE METHOD USED.
5. THE LINES BETWEEN MATERIALS SHOWN ON THE EXPLORATORY BORING LOGS REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN MATERIAL TYPES AND THE TRANSITIONS MAY BE GRADUAL.
6. GROUND-WATER LEVELS SHOWN ON THE LOGS WERE MEASURED AT THE TIME AND UNDER CONDITIONS INDICATED. FLUCTUATIONS IN THE WATER LEVEL MAY OCCUR WITH TIME.

09-2-127	Kumar & Associates	LEGEND AND NOTES	Fig. 3

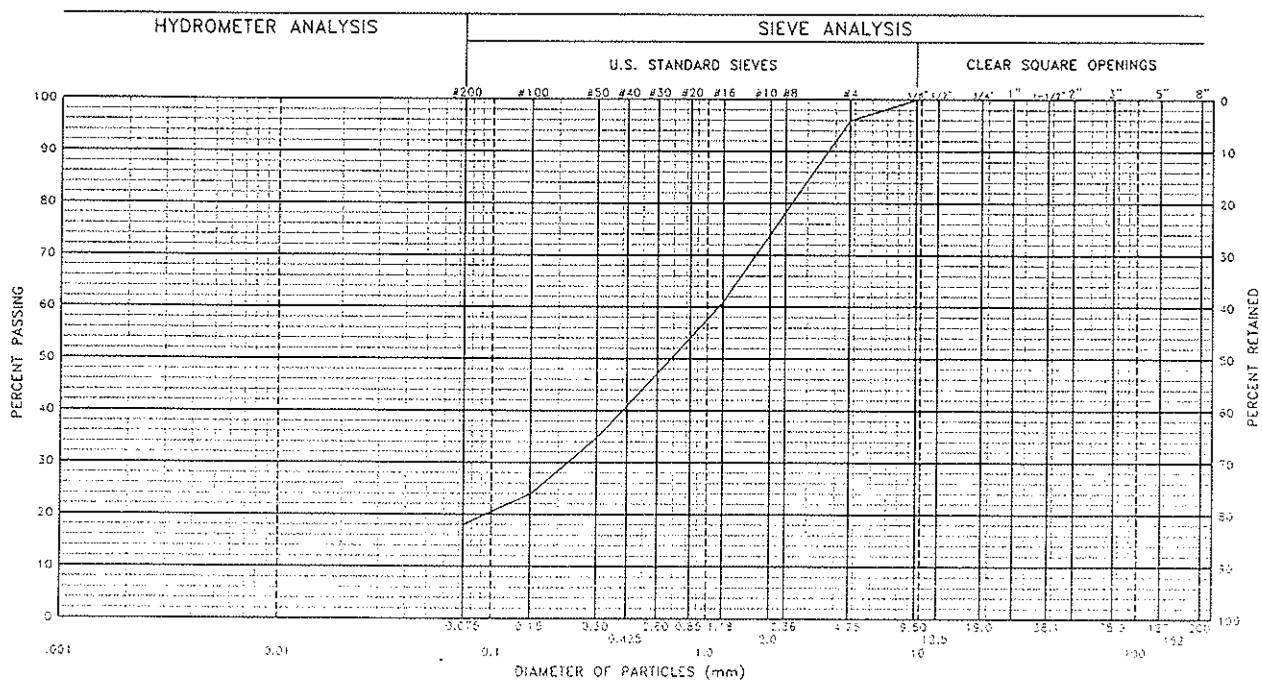


SILT AND CLAY	SAND			GRAVEL		COBBLES
	FINE	MEDIUM	COARSE	FINE	COARSE	

GRAVEL: 5 %
SAND: 67 %
SILT AND CLAY: 28 %

LIQUID LIMIT: 27
PLASTICITY INDEX: 8

SAMPLE OF: Clayey sand (SC)
FROM: Boring 1 @ 0 – 5 feet

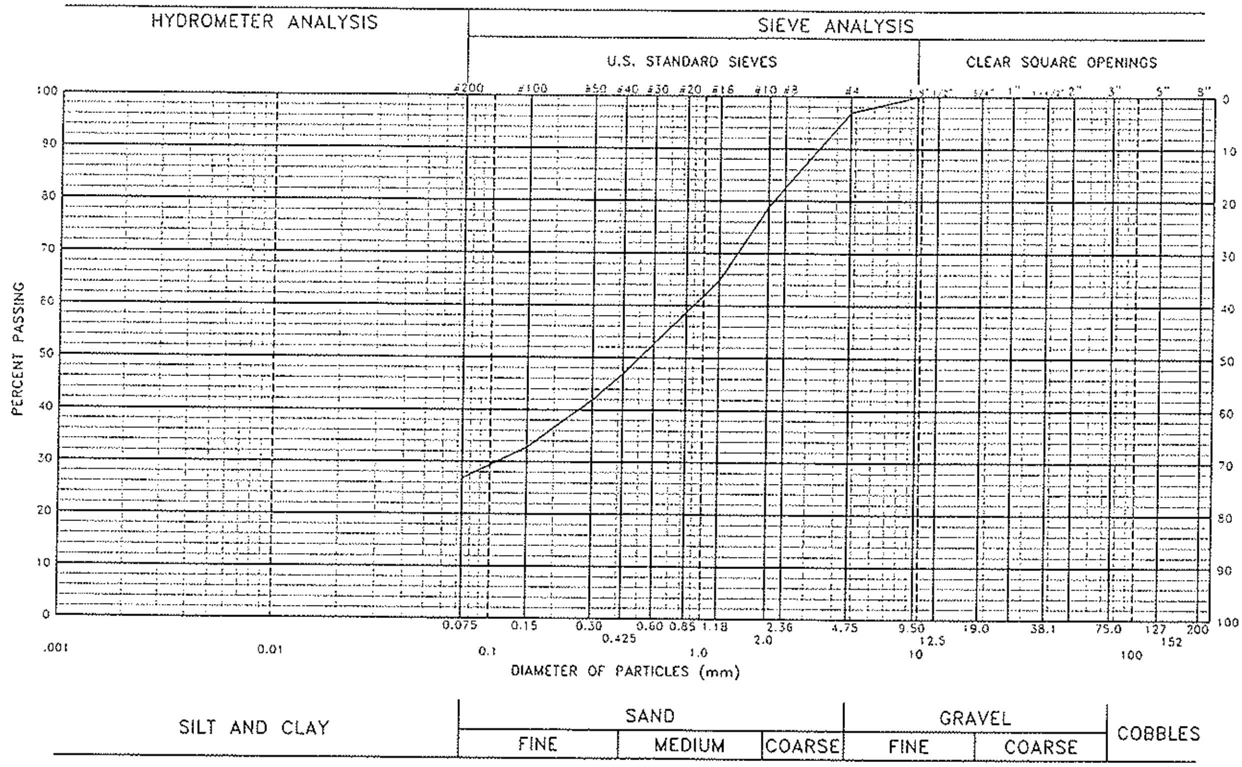


SILT AND CLAY	SAND			GRAVEL		COBBLES
	FINE	MEDIUM	COARSE	FINE	COARSE	

GRAVEL: 4 %
SAND: 78 %
SILT AND CLAY: 18 %

LIQUID LIMIT: 35
PLASTICITY INDEX: 17

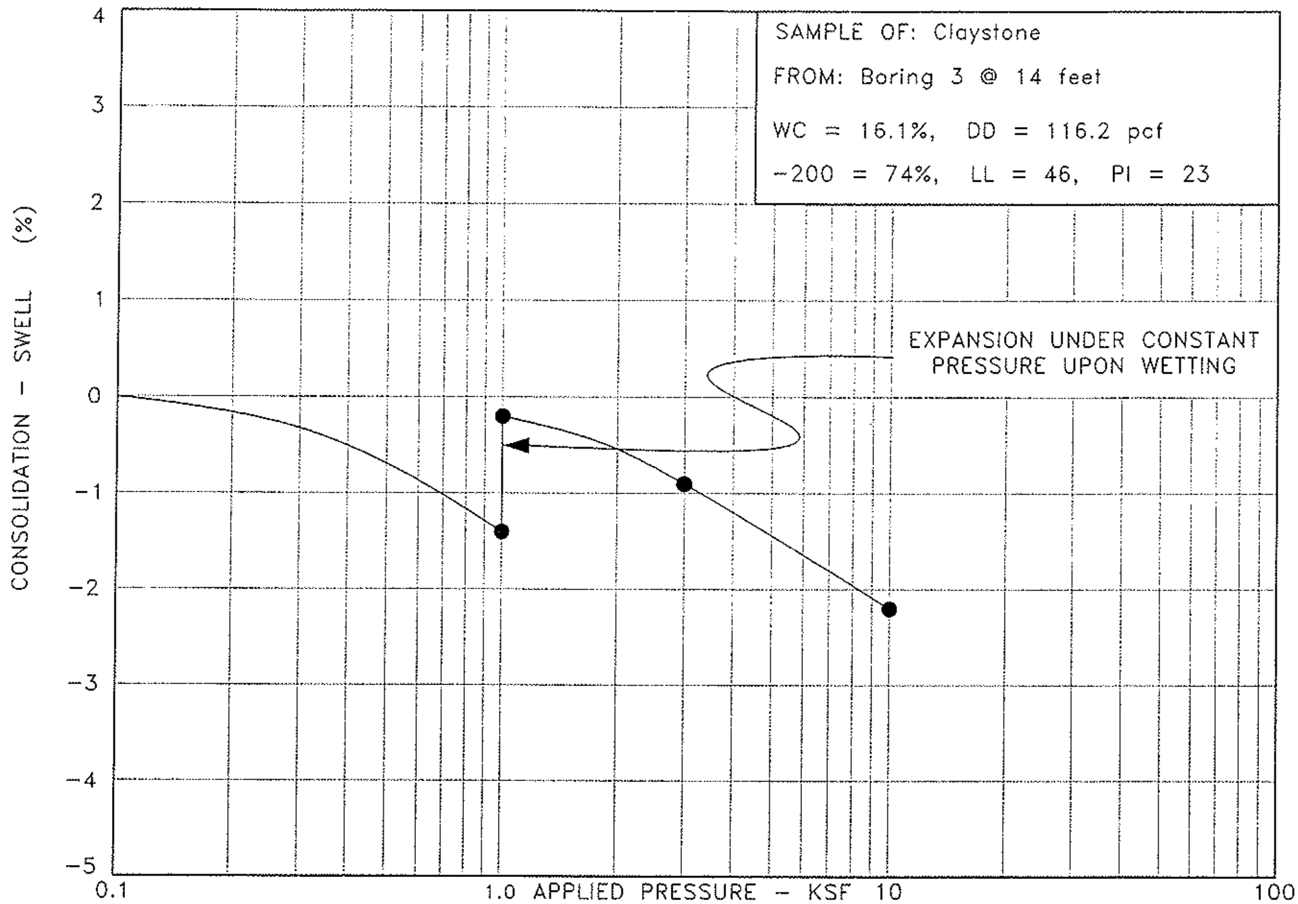
SAMPLE OF: Sandstone
FROM: Boring 2 @ 4 feet



GRAVEL: 3 %
SAND: 70 %
SILT AND CLAY: 27 %

LIQUID LIMIT: 27
PLASTICITY INDEX: 10

SAMPLE OF: Sandstone
FROM: Boring 4 @ 1.5 – 5 feet


SAMPLE OF: Claystone
FROM: Boring 3 @ 14 feet
WC = 16.1%, DD = 116.2 pcf
-200 = 74%, LL = 46, PI = 23
EXPANSION UNDER CONSTANT PRESSURE UPON WETTING
CONSOLIDATION - SWELL (%)
4
3
2
1
0
-1
-2
-3
-4
-5
0.1
1.0
APPLIED PRESSURE - KSF
10
100

Kumar & Associates, Inc.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

Project No.: 09-2-127
Project Name: Woodman Hills Fire Station No. 1
Date Sampled: 3/13/09
Date Received: 3/16/09

SAMPLE LOCATION		DATE TESTED	NATURAL MOISTURE CONTENT (%)	NATURAL DRY DENSITY (pcf)	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		WATER SOLUBLE SULFATES (%)	AASHTO CLASSIFICATION (group index)	SOIL OR BEDROCK TYPE (Unified Soil Classification)
BORING	DEPTH (ft)				GRAVEL (%)	SAND (%)		LIQUID LIMIT	PLASTICITY INDEX			
1	0 - 5	3/17/09			5	67	28	27	8		A-2-4(0)	Clayey sand (SC)
1	4	3/17/09	2.9	111.4								Clayey sand (SC)
2	4	3/17/09	9.7	118.6	4	78	18	35	17	0.01	A-2-6(0)	Sandstone
3	14	3/17/09	16.1	116.2			74	46	23		A-7-6(17)	Claystone
4	1.5 - 5	3/17/09			3	70	27	27	10	0.06	A-2-4(0)	Sandstone
4	2	3/17/09	9.3	129.6								Sandstone

Kumar & Associates, Inc.

TABLE II

SUMMARY OF PAVEMENT DESIGN PARAMETERS

Project No.: 09-2-127

Project Name: Woodmen Hills Fire Station No. 1

Initial Serviceability		4.5
Terminal Serviceability		2.5
Reliability Level		80
Overall Standard Deviation	Flexible Pavement	0.45
	Rigid Pavement	0.35
Roadbed Soil Resilient Modulus		4,938 psi (Equivalent to an R-20 material.
28-day Mean PCC Modulus of Rupture		650 psi
28-day Mean Elastic Modulus of Slab		3,600,000 psi
Mean Effective k-value		28 psi/in
Load Transfer (Edge Reinforcement)		3.6
Structural Coefficients	New Hot Mix Asphalt	0.4
	Aggregate Base Course with a minimum R-value of 78	0.11

APPENDIX

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Kumar & Associates, Inc.
6735 Kumar Heights
Colorado Springs, Colorado
USA

Flexible Structural Design Module

Woodmen Hills Fire Station No. 1
Project No. 09-2-127
Full Depth Asphalt in Parking and Drive Areas restricted to automobiles.

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	36,500
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	80 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	4,938 psi
Stage Construction	1
Calculated Design Structural Number	2.17 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.4	1	5.5	-	2.20
Total	-	-	-	5.50	-	2.20

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Kumar & Associates, Inc.
6735 Kumar Heights
Colorado Springs, Colorado
USA

Flexible Structural Design Module

Woodmen Hills Fire Station No. 1
Project No. 09-2-127
Composite HMA over ABC in Parking and Drive Areas restricted to automobiles.

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	36,500
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	80 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	4,938 psi
Stage Construction	1
Calculated Design Structural Number	2.17 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.4	1	4	-	1.60
2	ABC	0.11	1	6	-	0.66
Total	-	-	-	10.00	-	2.26

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Kumar & Associates, Inc.
6735 Kumar Heights
Colorado Springs, Colorado
USA

Rigid Structural Design Module

Woodmen Hills Fire Station No. 1
Project No. 09-2-127
Traffic restricted to automobiles.

Rigid Structural Design

Pavement Type	JPCP
18-kip ESALs Over Initial Performance Period	54,750
Initial Serviceability	4.5
Terminal Serviceability	2.5
28-day Mean PCC Modulus of Rupture	650 psi
28-day Mean Elastic Modulus of Slab	3,600,000 psi
Mean Effective k-value	28 psi/in
Reliability Level	80 %
Overall Standard Deviation	0.35
Load Transfer Coefficient, J	3.6
Overall Drainage Coefficient, Cd	1
Calculated Design Thickness	4.58 in

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

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Kumar & Associates, Inc.
6735 Kumar Heights
Colorado Springs, Colorado
USA

Flexible Structural Design Module

Woodmen Hills Fire Station No. 1
Project No. 09-2-127
Full Depth Asphalt in Parking and Drive Areas used by automobiles and occasional truck traffic (exclusive of emergency vehicles).

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	58,400
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	80 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	4,938 psi
Stage Construction	1
Calculated Design Structural Number	2.34 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.4	1	6	-	2.40
Total	-	-	-	6.00	-	2.40

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Kumar & Associates, Inc.
6735 Kumar Heights
Colorado Springs, Colorado
USA

Flexible Structural Design Module

Woodmen Hills Fire Station No. 1
Project No. 09-2-127
Composite HMA over ABC in Parking and Drive Areas used by automobiles and occasional truck traffic (exclusive of emergency vehicles).

Flexible Structural Design

18-kip ESALs Over Initial Performance Period	58,400
Initial Serviceability	4.5
Terminal Serviceability	2.5
Reliability Level	80 %
Overall Standard Deviation	0.45
Roadbed Soil Resilient Modulus	4,938 psi
Stage Construction	1
Calculated Design Structural Number	2.34 in

Specified Layer Design

Layer	Material Description	Struct Coef. (Ai)	Drain Coef. (Mi)	Thickness (Di)(in)	Width (ft)	Calculated SN (in)
1	HMA	0.4	1	4	-	1.60
2	ABC	0.11	1	7	-	0.77
Total	-	-	-	11.00	-	2.37

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare Computer Software Product

Kumar & Associates, Inc.
6735 Kumar Heights
Colorado Springs, Colorado
USA

Rigid Structural Design Module

Woodmen Hills Fire Station No. 1
Project No. 09-2-127
Automobiles and occasional truck traffic (excluding emergency equipment).

Rigid Structural Design

Pavement Type	JPCP
18-kip ESALs Over Initial Performance Period	87,600
Initial Serviceability	4.5
Terminal Serviceability	2.5
28-day Mean PCC Modulus of Rupture	650 psi
28-day Mean Elastic Modulus of Slab	3,600,000 psi
Mean Effective k-value	28 psi/in
Reliability Level	80 %
Overall Standard Deviation	0.35
Load Transfer Coefficient, J	3.6
Overall Drainage Coefficient, Cd	1
Calculated Design Thickness	4.96 in

1993 AASHTO Pavement Design

DARWin Pavement Design and Analysis System

A Proprietary AASHTOWare
Computer Software Product

Kumar & Associates, Inc.
6735 Kumar Heights
Colorado Springs, Colorado
USA

Rigid Structural Design Module

Woodmen Hills Fire Station No. 1
Project No. 09-2-127
Area subject to automobiles, occasional trucks and emergency equipment.

Rigid Structural Design

Pavement Type	JPCP
18-kip ESALs Over Initial Performance Period	1,356,705
Initial Serviceability	4.5
Terminal Serviceability	2.5
28-day Mean PCC Modulus of Rupture	650 psi
28-day Mean Elastic Modulus of Slab	3,600,000 psi
Mean Effective k-value	28 psi/in
Reliability Level	80 %
Overall Standard Deviation	0.35
Load Transfer Coefficient, J	3.6
Overall Drainage Coefficient, Cd	1
Calculated Design Thickness	7.87 in