Kumar & Associates, Inc.
Geotechnical and Materials Engineers
and Environmental Scientists

6735 Kumar Heights
Colorado Springs, CO 80918
phone: (719) 632-7009
fax: (719) 632-1049
email: kacolospgs@kumarusa.com
www.kumarusa.com

An Employee Owned Company

Office Locations: Denver (HQ), Colorado Springs, Fort Collins, Glenwood Springs, Parker, and Summit County, Colorado

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GEOTECHNICAL ENGINEERING STUDY
PROPOSED MONUMENT ACADEMY SCHOOL
VICINITY OF SEC OF HWY 83 & HWY 105
EL PASO COUNTY, COLORADO

Prepared By:
Duane P. Craft, P.E.

COLORADO REGISTERED PROFESSIONAL ENGINEER
DUANE P. CRAFT
37553
2/25/19

Reviewed By:
Arben F. Kalaveshi, P.E.

Prepared For:

Monument Academy
c/o CRP Architects
100 E. St. Vrain Street, #300
Colorado Springs, Colorado 80903

Attn: Mr. Brian Risely

Project No. 19-2-112

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SUMMARY

1. The native subsoils encountered in the borings consisted primarily clayey sand, silty sand and poorly to well-graded sand with silt and clay. Cohesive (fine grained) soils consisting of sandy silty clay and sandy lean clay were encountered in one of the borings (Boring 10). The native soils extended to depths ranging from approximately 5 to 18 feet in Borings 1 thru 6, and to the maximum 10 to 20-foot depths explored in Borings 7 thru 11. The overburden soils were underlain by sandstone bedrock in six of the borings, which extended to the maximum 20-foot depth explored.

2. Groundwater was not encountered in the borings at the time of drilling. Fluctuations in the water level may occur with time.

3. Based on the subsurface conditions encountered, it is our opinion spread footings and slab-on-grade floors bearing on the undisturbed native granular soils or properly compacted nonexpansive fill will be suitable for this site.

4. We recommend the clay soils be overexcavated and replaced with a nonexpansive structural fill where present within 5 feet of footing foundations and slab on grade floors, and within 2 feet of the pavement subgrade, to include roadways, parking lots and other areas with exterior concrete flatwork. Based on our current understanding of the site layout, we anticipate overexcavation may be required for a portion of the south parking lot and eastern end of the north parking lot, depending on the final grading planned.

5. We recommend areas of pavement with light duty traffic (parking lot stalls, and areas restricted to automobiles), be paved with a minimum 4 inches of asphalt over 5 inches of Class 6 aggregate base course. Areas with heavy duty traffic (driveways and other areas with occasional truck traffic) should consist of a minimum 5 inches of asphalt over 5 inches of Class 6 aggregate base course. Alternate pavement sections consisting of full depth asphalt and concrete are presented in the report. Trash pickup areas, and other areas where truck turning movements are concentrated, if applicable, be paved with a minimum 6.5 inches of portland cement concrete.

PURPOSE AND SCOPE OF STUDY

This report presents the results of a geotechnical engineering study for the proposed Monument Academy School, to be located southeast of the intersection of State Highway 83 and Highway 105, in El Paso County, Colorado. The project site is shown on Fig. 1. This study was conducted in accordance with our Proposal No. C19-106R, dated January 7, 2019, to develop recommendations for site grading, foundations, floor slabs and pavements.

We previously prepared a geotechnical engineering study for the former proposed school building site, located north and west of the current proposed location (Project No. 18-2-221, dated October 9, 2018). Information from this report was referenced when developing recommendations for the current proposed construction.

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 will consist of a new two-story Grade 6 thru 12 charter school. The school building will have nominal plan dimensions of approximately 290’x480’. We understand a basement level is not planned, and that the building will have a finished floor elevation of approximately 7,422 feet. The building construction is anticipated to consist of a steel frame, stone or stucco exterior walls, with possible masonry bearing walls for the gym portion of the building. Foundation loads are anticipated to be moderate, typical of the proposed construction type.

As part of the project, paved parking lot areas will be constructed north and south of the school building, and a sports field with bleachers will be constructed in the northern portion of the property as generally shown on Fig. 1. Site grading is anticipated to consist of nil to approximately 12 feet of fill within the building footprint. Elsewhere on-site, maximum cuts and fills of about 5 feet have been assumed.

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

SITE CONDITIONS

The site is bound by Highway 105 (aka Walker Road) to the north, residential acreage properties to the south and a small water treatment facility and vacant land to the east and west, respectively. Highway 83 is located nearby, roughly 650 feet to the west. Regionally, the area consists of rolling hills with an overall general slope down towards minor drainages which generally flow to the north. Within the site, the central portion of the property generally includes a roughly defined mesa that slopes gently down towards the north and west. There was about 10 feet of elevation difference within the proposed building footprint area. The site is generally vegetated with natural grasses and weeds, with occasional evergreen trees.

FIELD EXPLORATION

The field exploration of subsurface conditions consisted of drilling a total of 11 borings at the approximate locations shown on Fig. 1. The borings were drilled on February 14, 2019, and the location were measured by taping from the features shown on the site plan provided. The boring logs are presented on Figs. 2 and 3, and the corresponding legend and notes are presented on Fig. 3.

The borings were drilled with 4-inch diameter continuous flight augers and were logged by a representative of Kumar & Associates, Inc. Samples of the soils were taken with a 2-inch I.D. California sampler. The sampler was driven into the various strata with blows from a 140-pound hammer falling 30 inches. Penetration resistance values, when properly evaluated, provide an indication of the relative density or consistency of the soils. Depths at which the samples were taken and the penetration resistance values are shown on the boring logs.

LABORATORY TESTING

Samples obtained from the exploratory borings were visually classified in the laboratory by the project engineer and samples were selected for laboratory testing. Laboratory testing included index property tests such as in-situ moisture content and dry unit weight, grain size analysis, and Atterberg limits. Additional testing performed included swell-consolidation testing and concentration of water soluble sulfates. The testing was conducted in general accordance with recognized test procedures, primarily those of the American Society for Testing of Materials (ASTM). Results of the laboratory testing program are shown on Figs. 2 through 8, are summarized on Table I.

SUBSURFACE CONDITIONS

The following subsurface descriptions are of a generalized nature to highlight the major stratification features encountered in the borings. The boring logs should be referenced for more detailed information at each location.

The native subsoils encountered in the borings consisted primarily clayey sand, silty sand and poorly to well-graded sand with silt and clay. Cohesive (fine grained) soils consisting of sandy silty clay and sandy lean clay were encountered in one of the borings (Boring 10). The native soils extended to depths ranging from approximately 5 to 18 feet in Borings 1 thru 6, and to the maximum 10 to 20-foot depths explored in Borings 7 thru 11. Sampler penetration blow counts indicate the native granular soils are medium dense to very dense and the cohesive soils are very stiff to hard in consistency. Results of swell-consolidation testing are presented on Fig. 4 indicate the tested sample of clayey sand was nonexpansive when wetted under a constant 1-ksf load. Swell-consolidation testing from our 2018 study indicated the tested samples of clay ranged from having a low to high swell potential when wetted under a constant 1-ksf load.

In Borings 1 thru 6, beginning at depths between 5 to 18 feet, the overburden soils were underlain by sandstone bedrock which extended to the maximum 20-foot depth explored at these locations. Sampler penetration blow counts indicate the bedrock is medium hard to very hard.

Groundwater was not encountered in the borings at the time of drilling. Fluctuations in the water level may occur with time. The borings were backfilled upon completion of drilling.

GEOTECHNICAL CONSIDERATIONS

Based on the subsurface conditions encountered, it is our opinion spread footings and slab-on-grade floors bearing on the undisturbed native granular soils or properly compacted nonexpansive fill will be suitable for this site. As discussed, the clay soils in the area exhibited low to high swell potential when wetted. Shallow foundations and slabs placed directly on or near the expansive materials can experience differential movement causing distress if the materials are subjected to changes in moisture content. To reduce the risk of suck distress, we recommend the expansive clay soils be overexcavated and replaced with a nonexpansive structural fill where present within 5 feet of spread footing foundations and slab on grade floors, and within 2 feet of the pavement subgrade, to include roadways, parking lots and other areas with exterior concrete flatwork. Overexcavation and the use of the fill layer is intended to provide separation between the expansive materials and thereby reduce the potential for foundation or slab movement.

Based on our current understanding of the site layout and the subsurface conditions encountered in our borings, we anticipated overexcavation may be required for a portion of the south parking lot and the eastern edge of the northern parking lot, depending on the grading planned. We do not anticipate overexcavation of expansive materials will be required within the building footprint based on our boring logs, however, we recommend potholing be performed to confirm this at the time of construction. Reference the “Site Grading” section of the report for additional discussion.

The clay soils encountered were found to be fairly limited in occurrence, with clay soils encountered in three of the 15 borings from the 2018 study, and in one of the 11 borings for this study. Given the intermittent presence of the clay, it is possible for these materials be present elsewhere within the project area.

Assuming shallow foundations and slabs are properly constructed as described in this report, and provided good surface drainage and irrigation practices are designed, constructed and maintained, we estimate a low risk of heave or settlement related movements beyond about 1 inch in magnitude.

FOUNDATION RECOMMENDATIONS

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. We recommend spread footing foundations bearing on the native granular soils or properly compacted nonexpansive fill be designed for an allowable soil bearing pressure of 3,000 psf.

2. Clay soils encountered with 5 feet of foundation bearing elevations should be removed and replaced with suitable nonexpansive fill. New fill should extend down from the edge of footings at a minimum 1:1 horizontal to vertical projection. Reference the “Site Grading” section of the report for additional discussion.

3. The material and compaction specifications for fill placed for support of foundations are presented in the “Site Grading” section of the report.

4. We estimate total movement for footings designed and constructed as discussed in this section will not exceed 1 inch. Differential settlements across the building footprint are estimated to be approximately ½ to ¾ of the total settlement.

5. Spread footings should have a minimum width of 16 inches for continuous footings and 24 inches for isolated pads.

6. 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 the area.

7. The lateral resistance of a footing placed on native soils or properly compacted structural fill material will be a combination of the sliding resistance of the foundation on the foundation materials and 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 0.35. Passive pressure against the sides of the foundation may be calculated using an allowable equivalent fluid unit weight of 180 pcf.

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

9. Areas of loose material encountered within the foundation excavation should be removed and replaced with properly compacted structural fill.

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

SEISMIC DESIGN CRITERIA

Using estimated shear wave velocities for the subgrade materials encountered based on standard penetration testing, calculations for an assumed 100' profile indicate a design Site Class C per the International Building Code (IBC). Based on the subsurface profile and site seismicity, liquefaction is not a design consideration. Using the USGS National Earthquake Hazard Reduction Program online database, the following probabilistic ground motion values are reported for the project site address.

Intensity Measure Type	Intensity Measure Level 2% in 50 Years
0.2 Sec. Spectral Acceleration S_S	0.181 g
1.0 Sec. Spectral Acceleration S_1	0.060 g

FLOOR SLABS

Based on subsurface conditions encountered, we believe slab-on-ground construction may be used, provided clay soils are removed and replaced with suitable nonexpansive soils within 5 feet of the slab elevation. Assuming floor slabs are properly constructed as described in this report, and provided good surface drainage and irrigation practices are designed, constructed and maintained, we believe the risk of slab movements will be relatively low, with potential movements of about 1 inch or less anticipated. The client/owner should be aware that cracking or other slab distress could occur even with movement of this magnitude.

With slab-on-grade floors, the following measures should be taken to reduce damage which could result from movement should the underslab materials be subjected to moisture changes.

1. We recommend the native clay soils, if present, be overexcavated and replaced with a suitable nonexpansive fill where present within 5 feet of floor slabs. The specifications for

fill materials along with a discussion regarding reuse of the on-site materials and compaction criteria are presented in the "Site Grading" section of the report.

2. We recommend a modulus of subgrade reaction of 125 pci be used for design of slabs.

3. Floor slabs should be separated from all bearing walls and columns with expansion joints which allow unrestrained vertical movement.

4. Interior non-bearing partitions resting on floor slabs should be provided with slip joints at the bottoms so that, if the slabs move, the movement cannot be transmitted to the upper structure. This detail is also important for wallboards, stairways and door frames. Slip joints which will allow at least 1.5 inches of vertical movement are recommended.

5. Floor slabs should not extend beneath exterior doors or over foundation stem walls or grade beams, unless saw cut at the beam after construction.

6. Floor slab control joints should be used to reduce damage due to shrinkage cracking. The appropriate joint spacing is dependent on slab thickness, concrete aggregate size and slump, and should be consistent with recognized guidelines such as those of the Portland Cement Association (PCA) or 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.

7. 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.

8. All plumbing lines should be tested before operation. Where plumbing lines or other slab protrusions enter through the floor, a positive bond break should be provided. Flexible connections should be provided for slab-bearing mechanical equipment.

The precautions and recommendations itemized above will not prevent the movement of floor slabs if the underlying expansive materials are subjected to alternate wetting and drying cycles. However, the precautions should reduce the damage if such movement occurs.

FOUNDATION WALLS AND RETAINING STRUCTURES

Foundation walls which are laterally supported and can be expected to undergo only a moderate amount of deflection should be designed for a lateral earth pressure computed on the basis of an equivalent fluid unit weight of 55 pcf assuming the onsite granular soils are used for backfill, or 45 pcf for an imported Class I structural backfill. Cantilevered retaining structures which can be expected to deflect sufficiently to mobilize the full active earth pressure condition should be designed for a lateral earth pressure computed on the basis of an equivalent fluid unit weight of 45 pcf assuming the onsite clayey sand soils are used for backfill, or 40 pcf for backfill consisting of imported Class I structural backfill.

Retaining structures should be designed for appropriate hydrostatic and surcharge pressures such as adjacent buildings, traffic, construction materials and equipment. The pressures recommended above assume drained conditions behind the walls and a horizontal backfill surface. The buildup of water behind a wall or an upward sloping backfill surface will increase the lateral pressure imposed on the wall.

Import granular soils should meet the requirements of a CDOT Class I structural backfill and contain less than 20% passing the No. 200 sieve. The on-site soils, if used, should consist of the granular materials. Clays and claystone should not be used for wall backfill. Proposed material should be approved by the geotechnical engineer prior to use.

The backfill behind walls should be sloped from the base of the wall at an angle of at least 45 degrees from vertical. The upper 2 feet of the wall backfill should be a relatively impervious on-site soil (or a pavement structure should be provided) to inhibit surface water infiltration into the backfill. Wall backfill should be placed in uniform lifts and compacted to at least 95% of the maximum standard Proctor density, within two percent of the optimum moisture content. Care should be taken not to overcompact the backfill since this could cause excessive lateral pressure on the walls. Some settlement of deep foundation wall backfills will occur even if the material is placed correctly.

UNDERDRAIN SYSTEM

Based on our understanding that there will be no basement or below grade space, it is our opinion an underdrain system will not be necessary. If the proposed construction differs from our assumptions, we should be consulted to reevaluate the recommendations for an underdrain.

WATER SOLUBLE SULFATES

The concentrations of water soluble sulfates measured in samples obtained from the exploratory borings were approximately 0.02% or less. These concentrations of water soluble sulfates represent a Class 0 severity of exposure to sulfate attack on concrete exposed to these materials. The degree of attack is based on a range of Class 0 to Class 3 severity of exposure as presented in ACI 201. Based on this information and our experience with the soil types encountered, we believe special sulfate resistant cement will not be required for concrete exposed to the on-site soils.

SURFACE DRAINAGE

Providing proper surface drainage, both during construction and after the construction has been completed, is very important for acceptable performance of the facility. 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 subgrades should be avoided during construction.

2. Care should be taken when compacting around foundation walls and underground structures to avoid damage to the structure.

3. 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 water 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.

4. Ponding of water should not be allowed on backfill material or within 10 feet of the foundation walls, whichever is greater.

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

6. Lawn sprinkler heads and landscaping which requires typical irrigation should be located at least 10 feet from foundation walls. Irrigation schemes are available which allow placement of lightly irrigated landscape near foundation walls in moisture sensitive soil areas. Drip irrigation heads with main lines located at least 10 feet from the foundation

walls are acceptable provided irrigation quantities are limited.

7. Plastic membranes should not be used to cover the ground surface adjacent to foundation walls. A pervious geotextile may be used to inhibit weed growth.

EXCAVATION CONSIDERATIONS

In our opinion, the overburden soils and near surface bedrock encountered in the exploratory borings drilled for this study can be excavated with heavy-duty construction equipment. Rippers, hydraulic chiseling or other means may be required for deeper excavations that extend into the bedrock, particularly in confined trench excavations.

All excavations should be in accordance with OSHA, state and local requirements. The contractor should follow appropriate safety precautions. In accordance with OSHA guidelines, the native overburden soils should be considered a Type C material, and the bedrock as Type A material. Depending on the fracturing, bedding and the timeframe that the excavation remains unretained, the bedrock may classify as a Type B or C material.

Per OSHA criteria, unless excavations are shored, temporary unretained excavations in Type C materials should have slopes no steeper than 1½:1 (H:V); Type B materials should have slopes no steeper than 1:1; and Type A materials should have slopes no steeper than 3/4:1. Flatter slopes will be required where ground-water seepage is encountered. OSHA regulations require that excavations greater than 20 feet in depth be designed by a professional engineer. The contractor's on-site "competent person" should make decisions regarding necessary slope and shoring. In addition, the slopes should be monitored on a regular basis for signs of movement and safety considerations.

SITE GRADING

<u>Cut and Fill Slopes</u>: We recommend the following criteria be used when preparing site grading plans. Permanent cut and fill slopes should not be steeper than 3:1 (horizontal to vertical). Slopes will generally be stable at 2:1; however, 2:1 slopes will be prone to increased surface erosion and it will be difficult to maintain vegetation on them. The risk of slope instability will be significantly increased if seepage is encountered in cuts. If seepage is encountered in permanent excavations, an investigation should be conducted to determine if the seepage will adversely affect the cut stability. Fills should be benched into hillsides that are steeper than 4:1.

Good surface drainage should be provided for all permanent cuts and fills to direct the surface runoff away from the slope faces. Cut and fill slopes and other stripped areas should be protected against erosion by revegetation or other means. Site grading should be planned to provide positive surface drainage away from all building and pavement areas.

No formal stability analyses were performed to evaluate the slopes recommended above. Published literature and our experience with similar cuts and fills indicate the recommended slopes should have adequate factors of safety. If a detailed stability analysis is required, we should be notified.

<u>Fill Material Specifications</u>: The following material specifications are presented for fills on the project site.

1. *Fill Within Building Footprint*: The onsite granular soils and sandstone will be suitable for reuse as nonexpansive structural fill within the building pad. Any clay or claystone materials encountered within 5 feet of the foundation bearing elevation or within 5 feet of the floor slab elevation should be removed and replaced with nonexpansive structural fill. Imported soils, if required, should consist of a minus 2-inch nonexpansive granular soil having a maximum 35% passing the No. 200 sieve and a maximum plasticity index of 15. (We recognize that some of the tested samples of the onsite granular soils do not meet the specification for plasticity index or percent passing the No. 200 seive; however, give the properties, it is our opinion they would be acceptable for reuse as structural fill, if properly moisture conditioned.) New fill should extend down from the edge of footings at a minimum 1:1 horizontal to vertical projection.

2. *Pavement Areas:* Fill should consist of the onsite granular soils or similar imported nonexpansive soil which meets the minimum R-value used for the pavement design calculation (minimum R value of 15). We recommend the clay and claystone materials not be used as fill within 2 feet below subgrade levels. In pavement areas where shallow clay or claystone is present, overexcavation and replacement will be required to provide for a minimum 2 feet of separation.

3. *Utility Trench Backfill*: Material excavated from the utility trenches may be used for backfill provided it does not contain unsuitable material or particles larger than 2 inches.

4. *Material Suitability*: All fill material should be free of vegetation, brush, sod and other deleterious substances. Fill should not contain concentrations of organic matter or other deleterious substances. The geotechnical engineer should evaluate the suitability of all proposed fill materials prior to placement.

5. *Subgrade Preparation*: The ground surface shall be stripped of vegetation/organics, and overexcavated as required. The resulting ground surface should be scarified to a depth of 12 inches, moisture conditioned as necessary, and compacted in a manner specified below for the subsequent layers of fill. Loose or unstable soils shall be removed, where present, in order to provide a stable platform prior to placement of fill.

Removal and Replacement Requirements: We anticipate potholing of the subgrade will be required at the time of grading to facilitate in determining the limits of where clay and claystone bedrock may be present and the resulting overexcavation that will be required. We should be present during excavation and consulted to assist the contractor in defining the limits of overexcavation required, if applicable. Our previous study of the adjacent site had encountered a few areas with shallow clay soils (Borings 2, 3 and 15), with occasional claystone at depth. For this study, clay soils were only encountered in one of the 11 borings (Boring 10). Given the intermittent presence of the clay and claystone, it is possible for these materials be present elsewhere within the project area.

We recommend the expansive clay and claystone materials be overexcavated and replaced with a nonexpansive structural fill where present within 5 feet of spread footing foundations and slab on grade floors, and within 2 feet of the pavement subgrade, to include roadways, parking lots and other areas with exterior concrete flatwork. Based on our current understanding of the site layout, we anticipated overexcavation may be required for a portion of the south parking lot and the eastern edge of the northern parking lot, depending on the grading planned.

Placement of excavated clay and claystone should be should be limited to nonstructural areas such as landscape areas to the extent practical. If necessary elsewhere, placement of claystone should be limited to deeper fills, and placed at depths 5 feet or greater from the finished grade. Claystone placed as fill should only be used if it is processed into a soil like material, with a maximum particle size of 2 inches.

Subgrade Stabilization: If areas of unstable subgrade are encountered during construction, we anticipate these areas may be stabilized by scarifying/ripping the subgrade and allowing it to dry, or by overexcavation and replacement of the subgrade with suitable, well-graded materials. Other alternatives include the use of geogrid reinforcement with aggregate base course, or placement of a coarse angular aggregate. Specific stabilization requirements should be evaluated at the time of construction.

Compaction Requirements: A representative of the geotechnical engineer should observe fill placement operations on a full-time basis. We recommend the following minimum compaction criteria be used on the project.

Area	Percentage of Standard Proctor Maximum Dry Density (ASTM D 698)
Building Footprint	100%
Fill Adjacent to Foundation Walls & Grade Beams	95%
Beneath Pavement Areas/Exterior Flatwork/Sports Fields	95%
Landscape and Other Misc. Overlot Fill Areas	95%
Compaction of fill materials should be achieved as follows: Granular Soils: at a moisture content within +/- 2% of the optimum moisture content. Cohesive Soils: at a moisture content within –1% to +3% of the optimum moisture content.	

PAVEMENT DESIGN

Subgrade Materials: The upper subgrade soils encountered within the exploratory borings encountered during our study classified as A-2-4, A-2-6, A-4 and A-6, with group indices ranging from 0 to 1 in accordance with the American Association of State Highway Transportation Officials (AASHTO) classification. Based on the soil classifications and our experience, an R-value of 15 was assumed for design of flexible pavements and a subgrade modulus of 125 pci was assumed for rigid pavements, with the assumption that clay or claystone material encountered within 2 feet of the proposed pavement grade be removed and replaced with nonexpansive fill. Reference the “Site Grading” section of the report for additional discussion.

Design Traffic: We understand traffic loading for the parking lot pavements will primarily consist of light duty traffic limited to automobiles. Some areas such as the drive lanes will include occasional delivery trucks, trash trucks and fire vehicle traffic. We understand there will be no bus traffic. Based on this information, an EDLA of 4 was assumed for light duty traffic areas, and an EDLA of 8 was assumed for heavy duty traffic areas. If it is determined that actual traffic is significantly different from that assumed, we should be contacted to reevaluate the pavement thickness design.

Pavement Sections: The recommended sections were determined using the DARWin 3.01 pavement design software based on the 1993 AASHTO pavement design procedures. Based on the subgrade conditions encountered and the traffic information provided, we recommend the following pavement sections:

Traffic		Pavement Section Thickness (in.)		
		Full Depth Asphalt	Composite Asphalt over Base Course	Portland Cement Concrete
Light Duty	*Parking lot stalls restricted to autos*	5	4 over 5	6
Heavy Duty	*Driveways and areas with occasional truck traffic*	6	5 over 5	6.5

We recommend trash pickup areas, and other areas where truck turning movements are concentrated, if applicable, be paved with the 6.5 inch portland cement concrete section rather than an asphalt alternative. The use of a flexible pavement in these areas could result in pavement fatigue cracking and/or rutting/shoving of the pavement due to the concentrated wheel loads.

Pavement Materials: The asphalt pavement should consist of a bituminous material which meets the requirements of the Pikes Peak Region Asphalt Paving Specifications. The mix should meet Grading S or SX requirements and a SuperPave gyratory design revolution (NDES) of 75 should be used in the design process. Based on the assumed traffic loading, we recommend that a PG 58-28 or PG 64-22 asphalt binder is used in the mix. Aggregate base course should meet the requirements of a CDOT Class 6.

Concrete pavement should meet the requirements of a Class P Mix, per Section 601 of the CDOT Standard Specifications, and should be based on a mix design established by a qualified engineer. The concrete should contain transverse joints not greater than 12 to 15 feet on centers and longitudinal joints no greater than 14 feet. A qualified engineer should establish appropriate joint spacing based on the specific location, layout, and usage. The joints should be hand formed, sawed or formed by premolded filler. The joints should be at least 1/4 of the slab thickness. Expansion joints should be provided at the end of each construction sequence and between the concrete slab and adjacent structures. Expansion joints where required, should be filled with a ½ inch-thick asphalt impregnated fiber. Concrete should be cured by protecting against loss of moisture, rapid temperature changes and mechanical injury for at least three days after placement. The concrete sections presented above are assumed to be unreinforced. Providing dowels at construction joints would help reduce the risk of differential movements between panel sections. Providing a grid mat of deformed rebar or welded wire mesh within the concrete pavement section would assist in mitigating corner breaks and differential panel movements. If a rebar mat is installed, we recommend that the bars be placed in the lower half of the pavement section. Also, if reinforcing is used, we have commonly seen No. 4 rebar placed at 24-inch center in each direction, however, we recommend that a structural engineer evaluate the placement and spacing of rebar if needed.

Subgrade Preparation: Reference the "Site Grading" section of the report for recommendations related to fill placement, and overexcavation/replacement of any clay and claystone material.

Prior to placing the pavement section, the entire subgrade area should be thoroughly scarified and well-mixed to a minimum depth of 12 inches, adjusted to within two percentage points of the optimum moisture content, and compacted to a minimum 95% of the maximum standard Proctor density (ASTM D698). The pavement subgrade should be proofrolled with a heavily loaded pneumatic-tired vehicle. Pavement design procedures assume a stable subgrade. Areas that deform excessively 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 the pavement. Drainage design should provide for the removal of water from paved areas and prevent the wetting of the subgrade soils.

Maintenance: Periodic maintenance of paved areas is critical to achieve the design life of the pavement. Crack sealing should be performed annually as new cracks appear. Chip seals, fog seals, or slurry seals applied at approximate intervals of 3 to 5 years are usually necessary for asphalt parking lots. As conditions warrant, it may be necessary to perform patching and overlay at approximate 10-year intervals.

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.

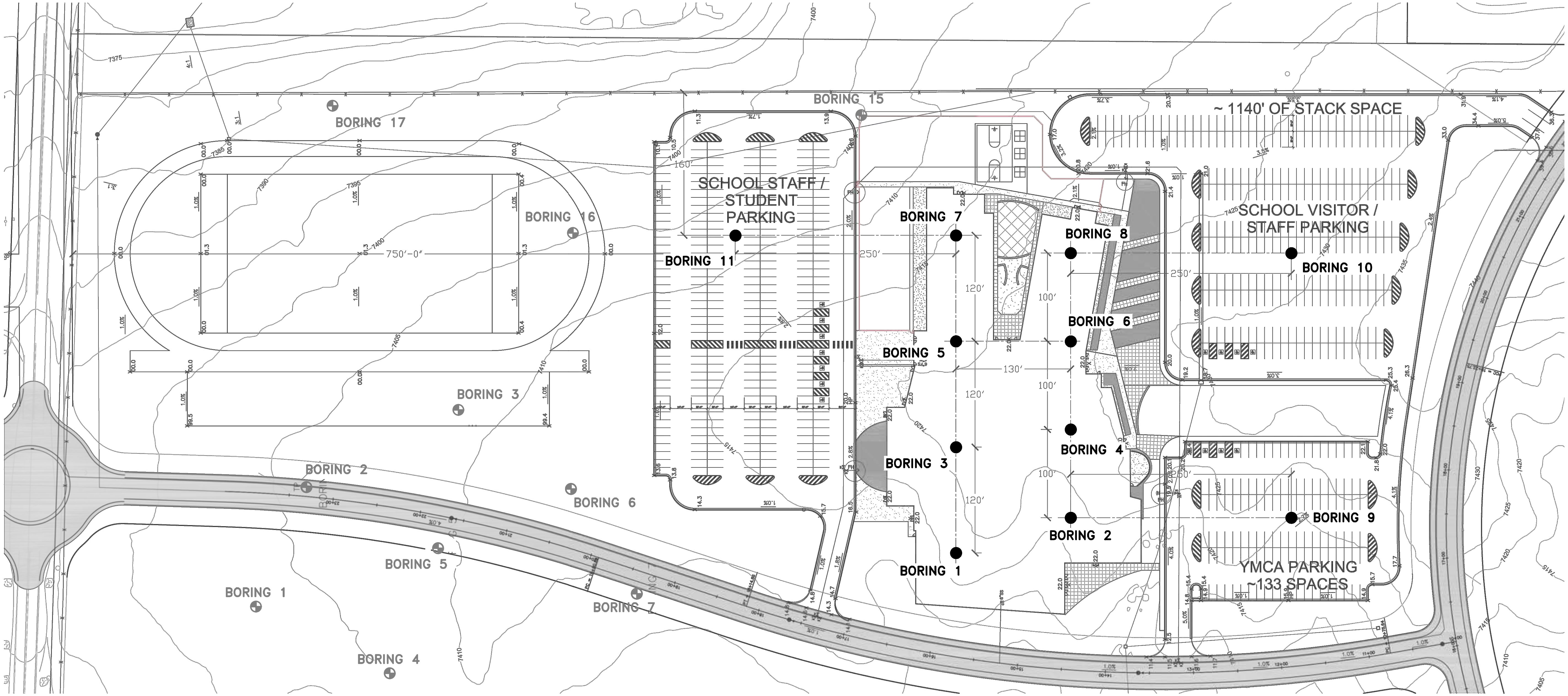
We recommend that Kumar & Associates, Inc., be retained to provide observation and testing services to document that the requirements of the plans and specifications are being followed during construction, and to identify possible variations in subsurface conditions from those encountered in this study.

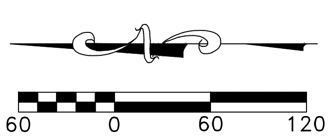
LIMITATIONS

This study has been conducted in accordance with generally accepted geotechnical engineering practices in this area for exclusive use by the client for design purposes. The conclusions and recommendations submitted in this report are based upon data obtained from the exploratory borings at the locations indicated on Fig. 1, and the proposed construction. This report may not reflect subsurface variations that occur between the borings, and the nature and extent of variations across the site may not become evident until site grading and excavations are performed. If during construction, fill, soil, rock or water conditions appear to be different from those described herein, Kumar & Associates, Inc. should be advised at once so that a re-evaluation of the recommendations presented in this report can be made. Kumar & Associates, Inc. is not responsible for liability associated with interpretation of subsurface data by others.

The scope of services for this project does not include any environmental assessment of the site or identification of contaminated or hazardous materials or conditions. If the owner is concerned about the potential for such contamination, other studies should be undertaken.

DPC:bj





LEGEND

- BORINGS DRILLED FOR PREVIOUS STUDY, PROJECT NO. 18-2-221, DATED 10/9/18
- BORINGS DRILLED FOR THIS STUDY

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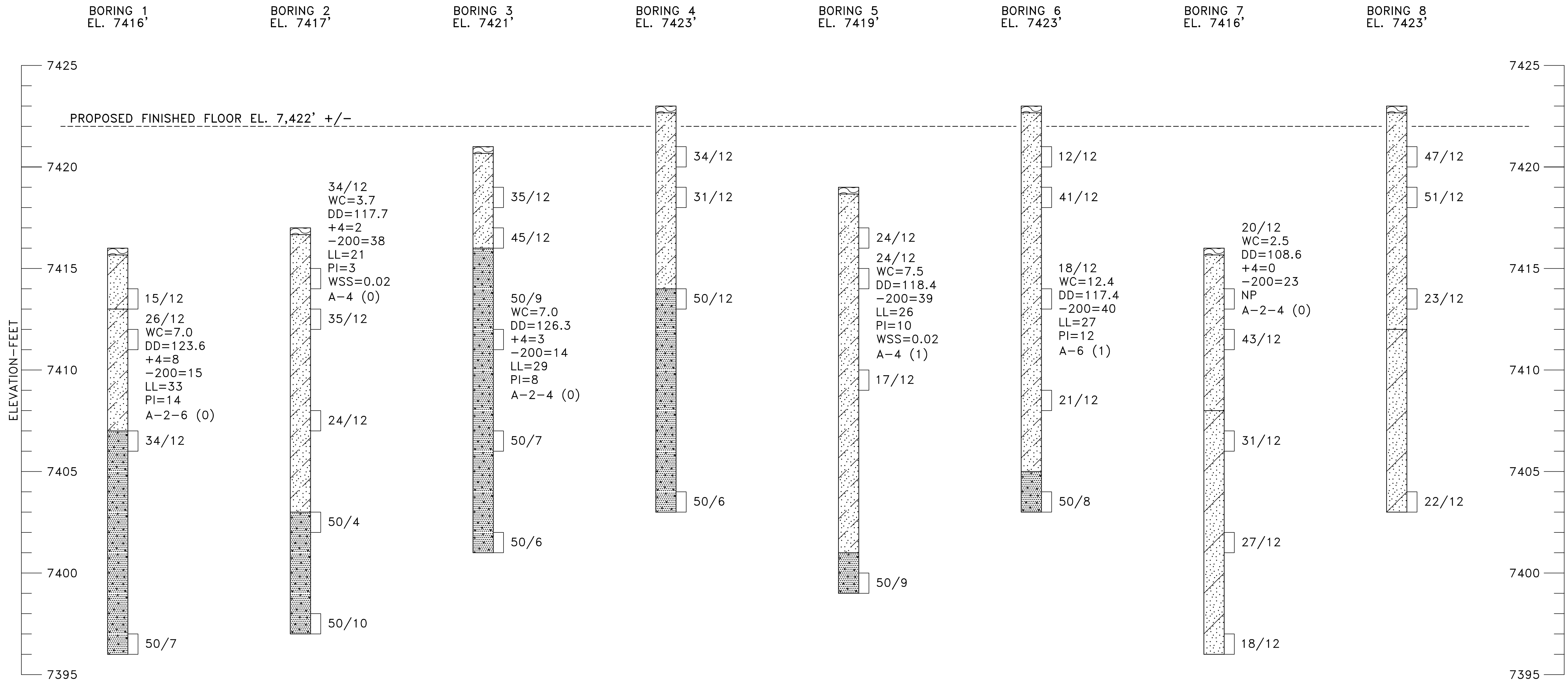
19-2-112	Kumar & Associates		LOCATION OF EXPLORATORY BORINGS	Fig. 1



19-2-112	Kumar & Associates		LOGS OF EXPLORATORY BORINGS	Fig. 2

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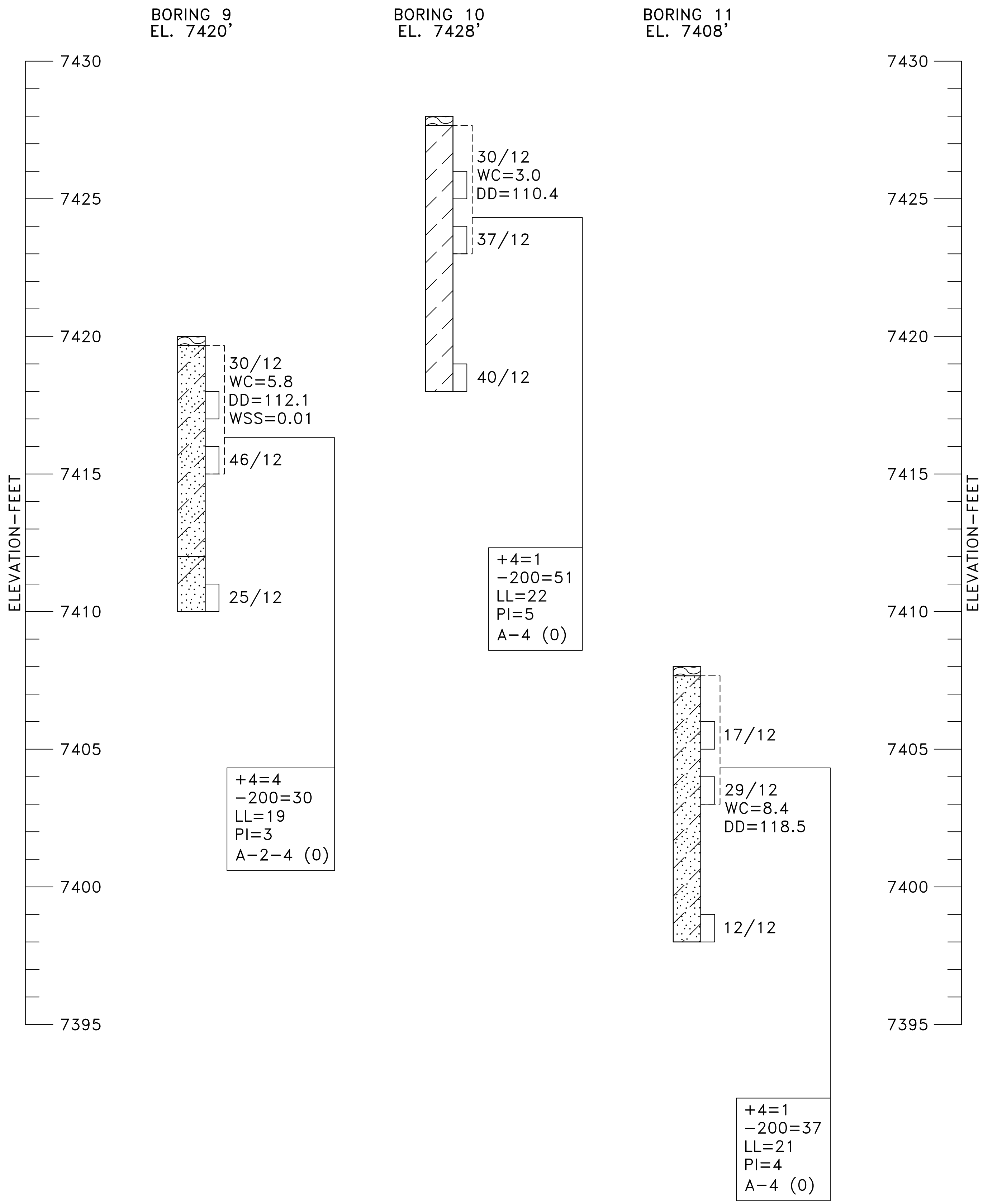

LEGEND

TOPSOIL.

POORLY TO WELL−GRADED SAND WITH SILT OR CLAY (SP−SM, SW−SM, SP−SC, SW−SC), AND SILTY SAND (SM), WITH OCCASIONAL GRAVEL, MEDIUM DENSE TO DENSE, SLIGHTLY MOIST TO MOIST, BROWN, REDDISH−BROWN AND GRAY.

CLAYEY SAND (SC), AND SILTY−CLAYEY SAND (SC−SM), WITH OCCASIONAL SILTY SAND (SM), MEDIUM DENSE TO VERY DENSE, SLIGHTLY MOIST TO MOIST, BROWN AND GRAY.

SANDY LEAN CLAY (CL), SANDY SILTY CLAY (CL−ML), AND SANDY SILT (ML), VERY STIFF TO HARD, SLIGHTLY MOIST TO MOIST, BROWN.

SANDSTONE BEDROCK, NON CEMENTED, OCCASIONAL CLAYEY, MEDIUM HARD TO VERY HARD, SLIGHTLY MOIST TO MOIST, GRAY.

DRIVE SAMPLE, 2−INCH I.D. CALIFORNIA LINER SAMPLE.

DISTURBED BULK SAMPLE.

15/12 DRIVE SAMPLE BLOW COUNT. INDICATES THAT 15 BLOWS OF A 140−POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 12 INCHES.

NOTES

1. THE EXPLORATORY BORINGS WERE DRILLED ON FEBRUARY 14, 2019 WITH A 4−INCH DIAMETER CONTINUOUS FLIGHT POWER AUGER.
2. THE LOCATIONS OF THE EXPLORATORY BORINGS WERE MEASURED APPROXIMATELY BY PACING FROM FEATURES SHOWN ON THE SITE PLAN PROVIDED.
3. THE ELEVATIONS OF THE EXPLORATORY BORINGS WERE OBTAINED BY INTERPOLATION BETWEEN CONTOURS ON THE SITE 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. GROUNDWATER WAS NOT ENCOUNTERED IN THE BORINGS AT THE TIME OF DRILLING. FLUCTUATIONS IN THE WATER LEVEL MAY OCCUR WITH TIME.
7. 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);
   NP = NON−PLASTIC (ASTM D 4318);
   WSS = WATER SOLUBLE SULFATES (%) (CP−L 2103);
   A−2−6 (0) = AASHTO CLASSIFICATION (GROUP INDEX) (AASHTO M 145).

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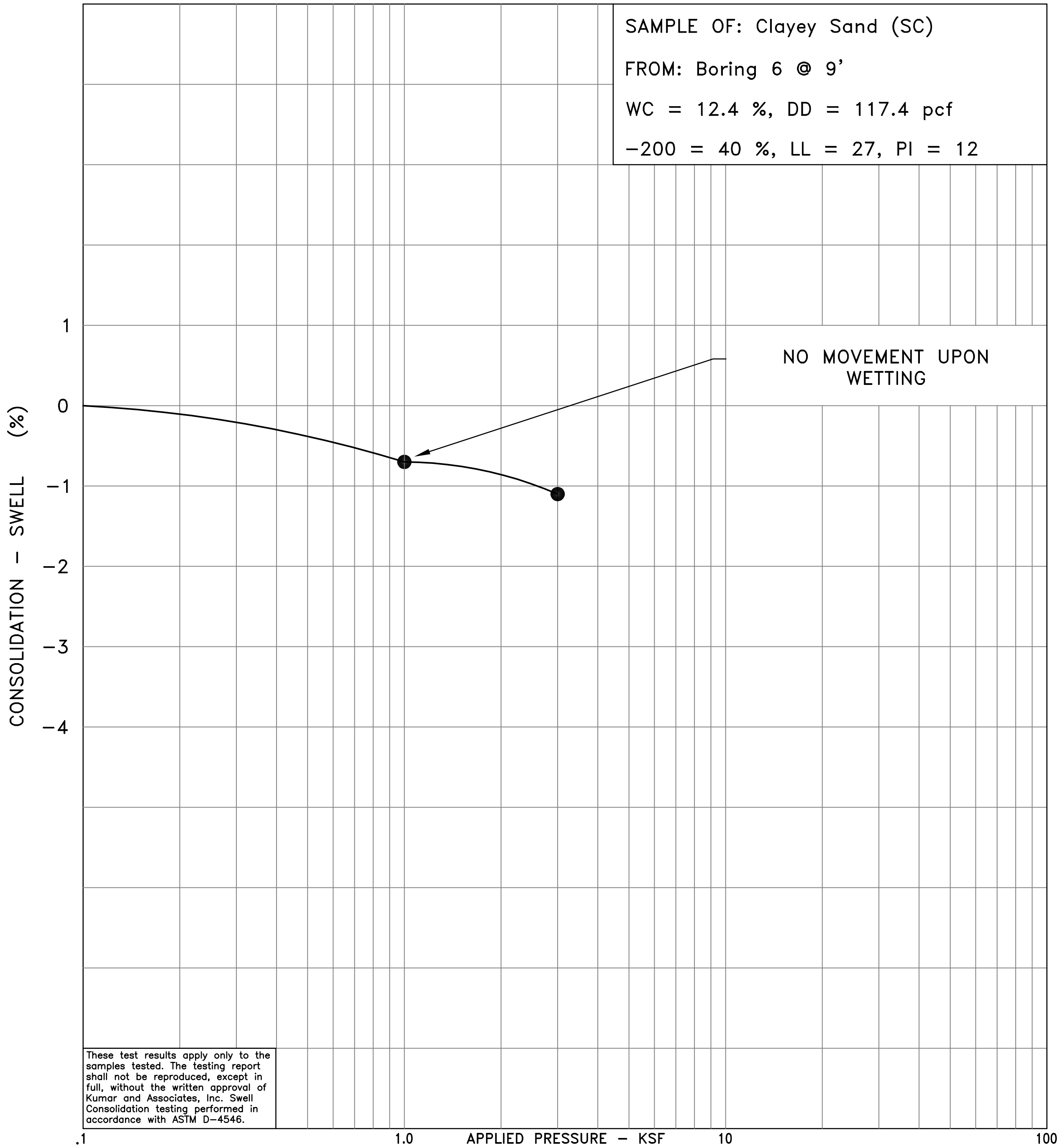
19−2−112	Kumar & Associates		LOGS, LEGEND AND NOTES OF EXPLORATORY BORINGS	Fig. 3



19-2-112	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 4

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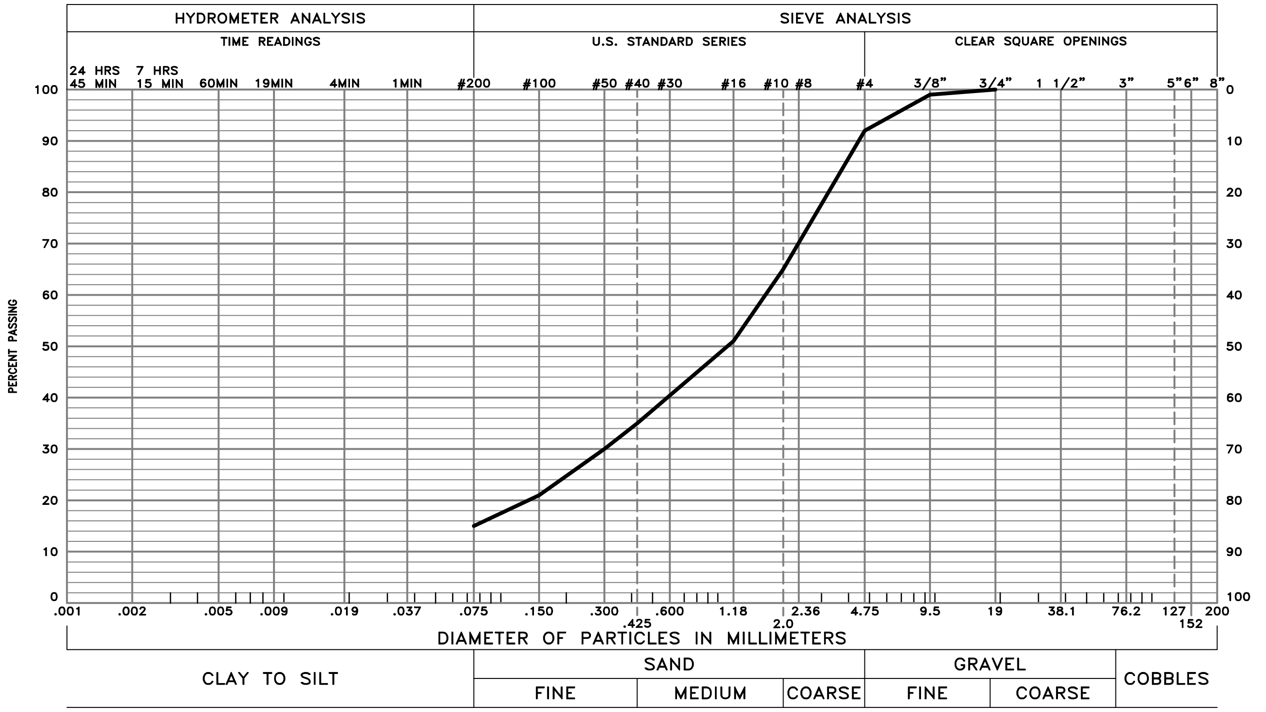
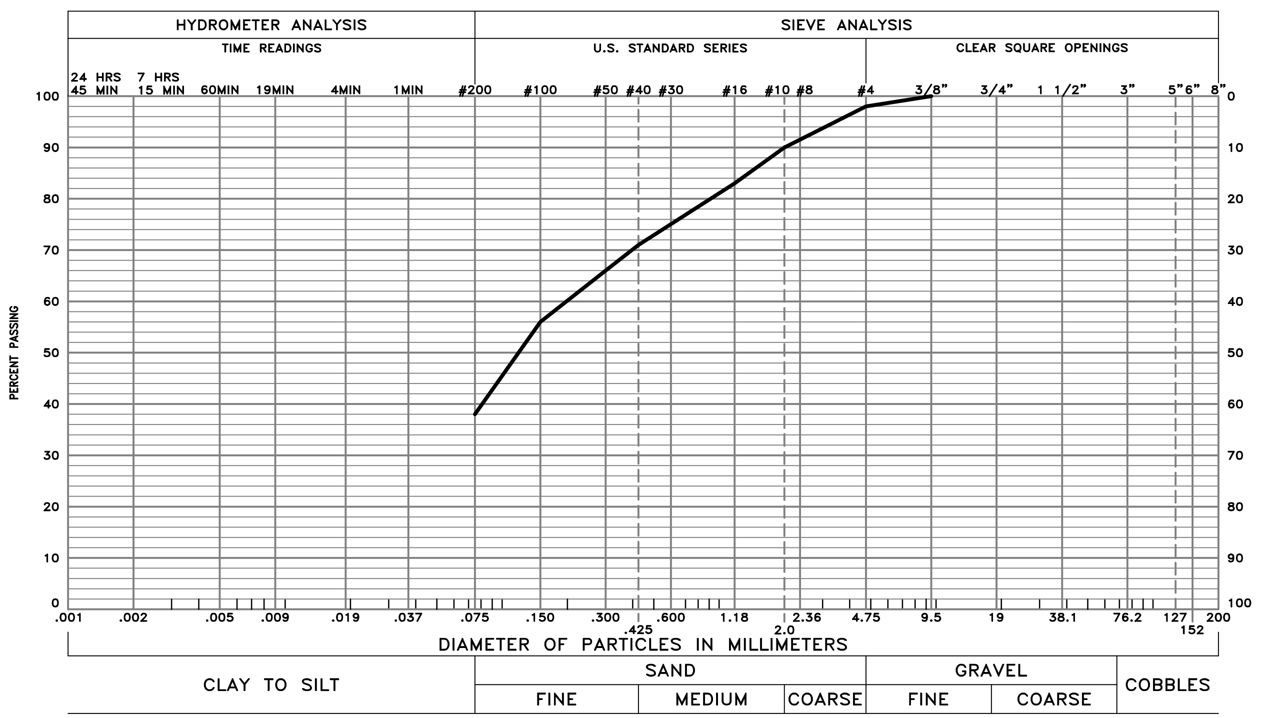


GRAVEL 8 % SAND 77 % SILT AND CLAY 15 %

LIQUID LIMIT 33 PLASTICITY INDEX 14

SAMPLE OF: Clayey Sand (SC) FROM: Boring 1 @ 4'



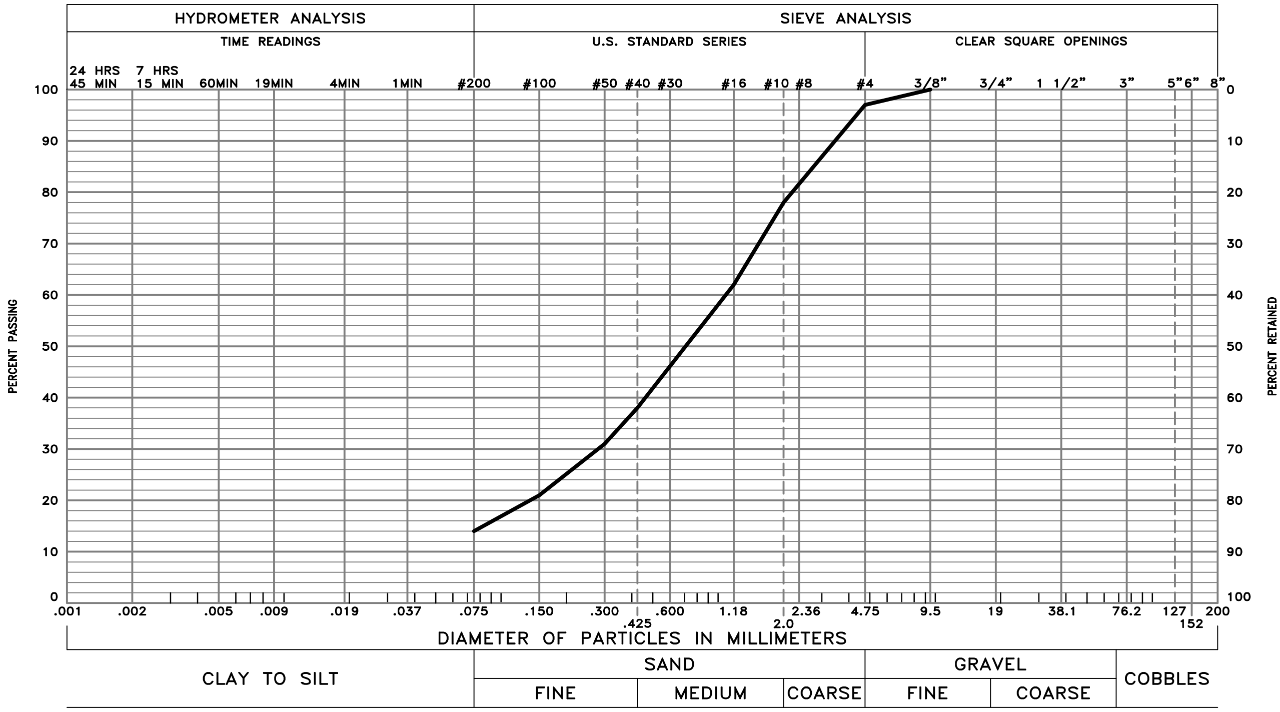
GRAVEL 2 % SAND 60 % SILT AND CLAY 38 %

LIQUID LIMIT 21 PLASTICITY INDEX 3

SAMPLE OF: Silty Sand (SM) FROM: Boring 2 @ 2'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D422, ASTM C136 and/or ASTM D1140.

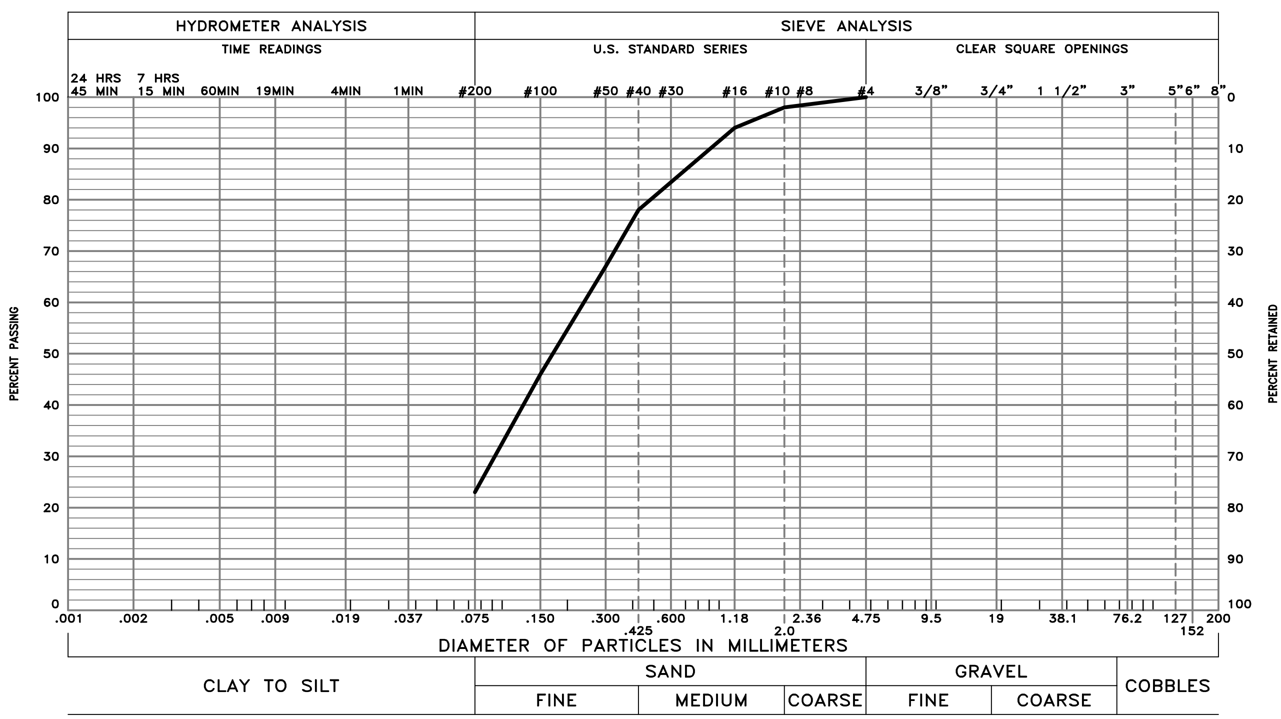
19-2-112	Kumar & Associates	GRADATION TEST RESULTS	Fig. 5



GRAVEL 3 % SAND 83 % SILT AND CLAY 14 %

LIQUID LIMIT 29 PLASTICITY INDEX 8

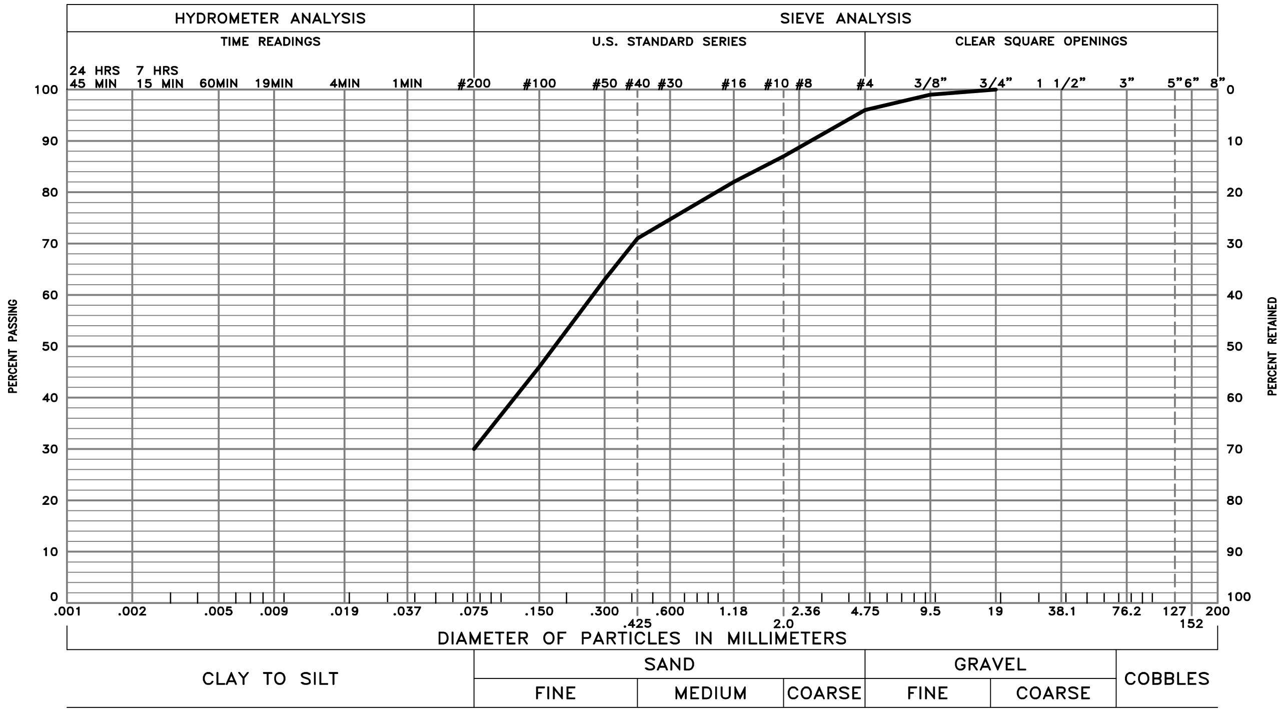
SAMPLE OF: Sandstone FROM: Boring 3 @ 9'



GRAVEL 0 % SAND 77 % SILT AND CLAY 23 %

LIQUID LIMIT PLASTICITY INDEX NP

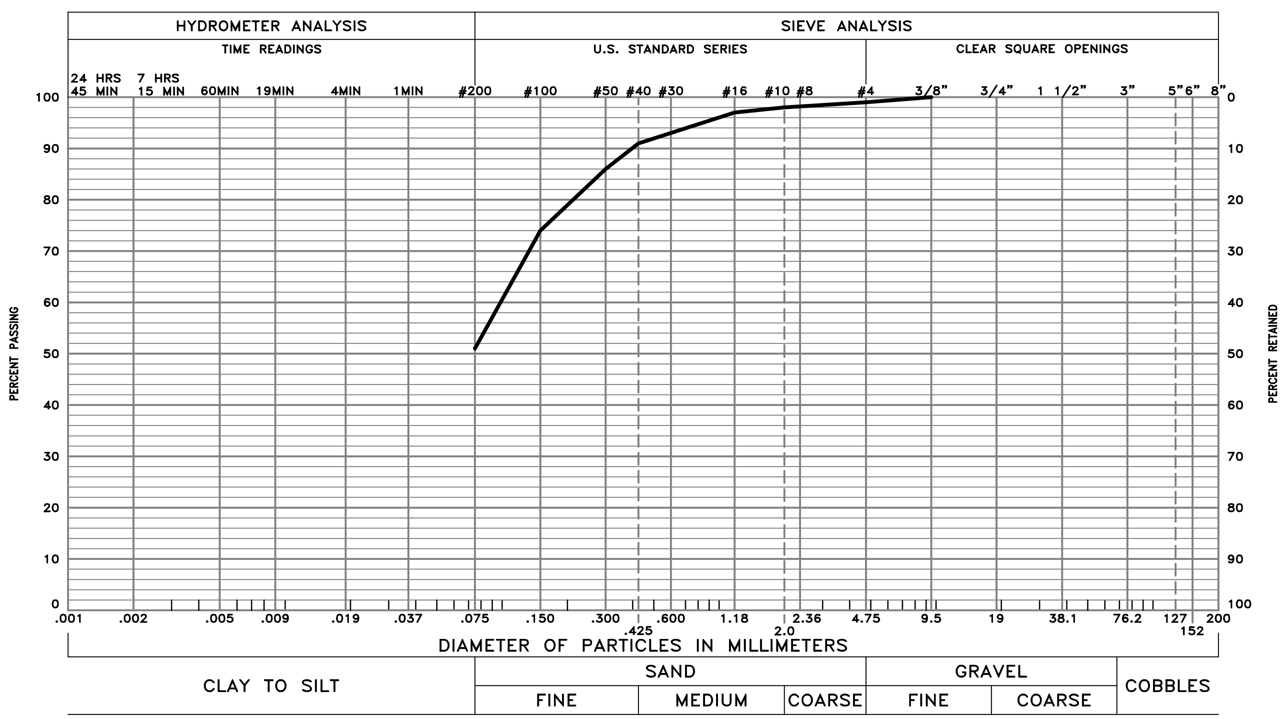
SAMPLE OF: Silty Sand (SM) FROM: Boring 7 @ 2'



GRAVEL 4 % SAND 66 % SILT AND CLAY 30 %

LIQUID LIMIT 19 PLASTICITY INDEX 3

SAMPLE OF: Silty Sand (SM) FROM: Boring 9 @ 4"–5'



GRAVEL 1 % SAND 48 % SILT AND CLAY 51 %

LIQUID LIMIT 22 PLASTICITY INDEX 5

SAMPLE OF: Sandy Silty Clay (CL–ML) FROM: Boring 10 @ 4"–5'

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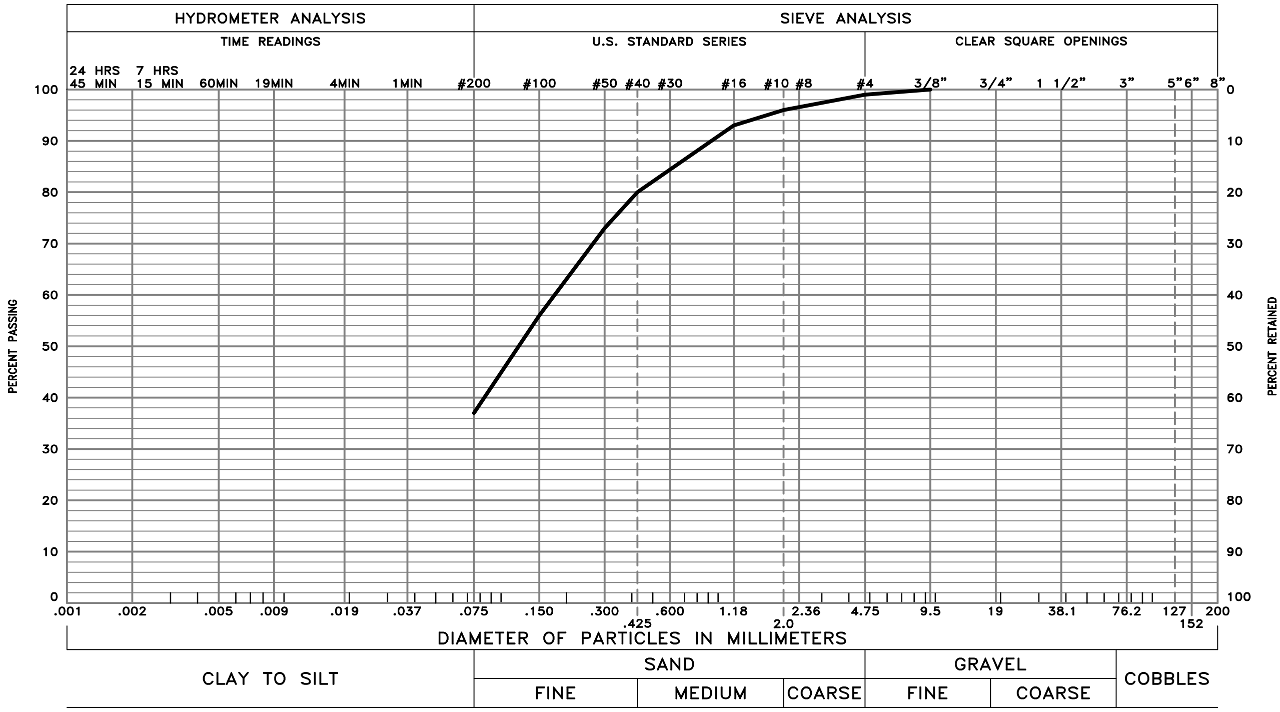

GRAVEL 1 % SAND 62 % SILT AND CLAY 37 %

LIQUID LIMIT 21 PLASTICITY INDEX 4

SAMPLE OF: Silty Clayey Sand (SC–SM) FROM: Boring 11 @ 4"–5'

These test results apply only to the samples which were tested. The testing report shall not be reproduced, except in full, without the written approval of Kumar & Associates, Inc. Sieve analysis testing is performed in accordance with ASTM D422, ASTM C136 and/or ASTM D1140.

19–2–112	Kumar & Associates	GRADATION TEST RESULTS	Fig. 8

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Kumar and Associates, Inc.

TABLE I

SUMMARY OF LABORATORY TEST RESULTS

Project No.: 19-2-112
Project Name : Monument Academy Charter School
Date Sampled: 2/14/2019
Date Received: 2/15/2019

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				GRAVEL (%)	SAND (%)		LIQUID LIMIT	PLASTICITY INDEX			
1	4'	1/20/19	7.0	123.6	8	77	15	33	14		A-2-6 (0)	Clayey Sand (SC)
2	2'	1/20/19	3.7	117.7	2	60	38	21	3	0.02	A-4 (0)	Silty Sand (SM)
3	9'	1/20/19	7.0	126.3	3	83	14	29	8		A-2-4 (0)	Sandstone
5	4'	1/20/19	7.5	118.4			39	26	10	0.02	A-4 (1)	Clayey Sand (SC)
6	9'	1/20/19	12.4	117.4			40	27	12		A-6 (1)	Clayey Sand (SC)
7	2'	1/20/19	2.5	108.6	0	77	23		NP		A-2-4 (0)	Silty Sand (SM)
9	4" - 5'	1/20/19			4	66	30	19	3		A-2-4 (0)	Silty Sand (SM)
9	2'	1/20/19	5.8	112.1						0.01		Silty Sand (SM)
10	4" - 5'	1/20/19			1	48	51	22	5		A-4 (0)	Sandy Silty Clay (CL-ML)
10	2'	1/20/19	3.0	110.4								Sandy Silty Clay (CL-ML)
11	4" - 5'	1/20/19			1	62	37	21	4		A-4 (0)	Silty Clayey Sand (SC-SM)
11	4'	1/20/19	8.4	118.5								Silty Clayey Sand (SC-SM)