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GEOTECHNICAL ENGINEERING STUDY
FOR PROPOSED BUILDINGS
COLORADO MOUNTAIN COLLEGE
SPRING VALLEY CAMPUS
COUNTY ROAD 114
GARFIELD COUNTY, COLORADO

PROJECT NO. 18-7-184

MARCH 30, 2018

PREPARED FOR:

COLORADO MOUNTAIN COLLEGE
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TABLE OF CONTENTS

PURPOSE AND SCOPE OF STUDY

This report presents the results of a geotechnical engineering study for the proposed buildings to be located at Colorado Mountain College Spring Valley Campus, County Road 114, Garfield County, Colorado. The project site is shown on Figure 1. The purpose of the study was to develop recommendations for the foundation design. The study was conducted in accordance with our proposal for geotechnical engineering services to Colorado Mountain College dated January 4, 2018.

A field exploration program consisting of exploratory borings was conducted to obtain information on the subsurface conditions. Samples of the subsoils obtained during the field exploration were tested in the laboratory to determine their classification, compressibility or swell and other engineering characteristics. The results of the field exploration and laboratory testing were analyzed to develop recommendations for foundation types, depths and allowable pressures for the proposed building foundation. This report summarizes the data obtained during this study and presents our conclusions, design recommendations and other geotechnical engineering considerations based on the proposed construction and the subsurface conditions encountered.

PROPOSED CONSTRUCTION

The proposed development consists of a new field house, new welcome center building and an addition to the student center located as shown on Figure 1. The field house will be a 2-story structure cut into the hillside with a walkout lower level to the south. The welcome center building will be single-story. The student center addition will be attached to the south side of the existing building with the lower level opening to the south. Ground floors will be slab-on-grade. Grading for the structures will be relatively significant at the field house and student center for the basement levels and relatively minor at the welcome center building. We assume relatively light to moderate foundation loadings for the welcome center and student addition to possibly relatively heavy at the field house and carried mainly be continuous foundation walls.

If building loadings, location or grading plans change significantly from those described above, we should be notified to re-evaluate the recommendations contained in this report.

SITE CONDITIONS

The site conditions are varied in terrain and by prior site development. The field house site is mostly natural hillside covered with pinon pine and juniper trees with understory of sparse grass and brush. Two small buildings in the eastern part will be removed and underground utilities will be relocated for the new construction. The welcome center building area is a gently sloping, open grass field with about 4 feet of elevation drop from north to south across the proposed building footprint. The student center addition along the south side is graded in two relatively flat lawn areas stepped up to the east with about 8 feet difference in elevation. Various underground utilities cross this area.

GEOLOGIC CONDITIONS

Bedrock of the Pennsylvanian age Eagle Valley Evaporite underlies the CMC Spring Valley Campus. These rocks are a sequence of gypsiferous shale, fine-grained sandstone and siltstone with some massive beds of gypsum and limestone. There is a possibility that massive gypsum deposits associated with the Eagle Valley Evaporite underlie portions of the campus. Dissolution of the gypsum under certain conditions can cause sinkholes to develop and can produce areas of localized subsidence. Sinkholes have been observed scattered throughout the general area including one located to the east of the proposed field house on the perimeter of the soccer fields and appear similar to other sinkholes associated with the Eagle Valley Evaporite.

Sinkholes were not observed in the immediate area of the subject building sites. No evidence of cavities was encountered in the subsurface materials; however, the exploratory borings were relatively shallow, for foundation design only. Based on our present knowledge of the subsurface conditions at the proposed building sites, it cannot be said for certain that sinkholes will not develop. The risk of future ground subsidence throughout the service life of the proposed buildings, in our opinion, is low and similar to other sites not known to be impacted by subsurface voids; however, the owner should be made aware of the potential for sinkhole development. If further investigation of possible cavities in the bedrock below the site is desired, we should be contacted.

FIELD EXPLORATION

The field exploration for the project was conducted on March 12 and 16, 2018. Eight exploratory borings were drilled at the locations shown on Figure 1 to evaluate the subsurface conditions. The borings were advanced with 4-inch diameter continuous flight augers powered by a truck-mounted CME-45B drill rig. The borings were logged by a representative of H-P/ Kumar.

Samples of the subsoils were taken with 1⅜ inch and 2-inch I.D. spoon samplers. The samplers were driven into the subsoils at various depths with blows from a 140 pound hammer falling 30 inches. This test is similar to the standard penetration test described by ASTM Method D-1586. The penetration resistance values are an indication of the relative density or consistency of the subsoils. Depths at which the samples were taken and the penetration resistance values are shown on the Logs of Exploratory Borings, Figure 2. The samples were returned to our laboratory for review by the project engineer and testing.

SUBSURFACE CONDITIONS

Graphic logs of the subsurface conditions encountered at the site are shown on Figure 2. The subsoils, below a thin root zone, typically consist of stiff to very stiff, sandy silt and clay with scattered gravel to silty clayey sand with basalt gravel and cobbles to depths of 4½ to 22 feet overlying relatively dense, basalt gravel, cobbles and boulders in a sandy silt and clay matrix. The soils are low to medium plasticity and typically calcareous cemented. Drilling in the coarse granular soils with auger equipment was difficult due to the cobbles and boulders and drilling refusal was encountered in the deposit at Borings 1 and 6.

Laboratory testing performed on samples obtained from the borings included natural moisture content and density, gradation analyses, unconfined compressive strength and liquid and plastic limits. Results of swell-consolidation testing performed on relatively undisturbed drive samples, presented on Figures 4 through 8, typically indicate low to moderate compressibility under conditions of loading and wetting. A clay sample from Boring 1 at 5 feet showed a high expansion when wetted under light loading. Results of gradation analyses performed on small diameter drive samples (minus 1½ inch fraction) of the coarse granular subsoils are shown on Figure 9. An unconfined compressive strength test performed on a medium plastic clay sample showed very stiff consistency. The laboratory testing is summarized in Table 1.

No free water was encountered in the borings at the time of drilling and the subsoils were slightly moist to moist.

FOUNDATION BEARING CONDITIONS

The subsoils encountered in the exploratory borings drilled at the project sites indicate stiff to very stiff, sandy silt and clay will be the predominant soils expected at cut depths for the proposed buildings. Basalt gravel, cobble and boulder soils with a silt and clay matrix will probably also be encountered. The natural soils should be suitable for support of lightly loaded spread footings with relatively low settlement potential. The clay soils at subgrade level should be evaluated for expansion potential and sub-excavated where needed. The bearing soils have an IBC Seismic Site Class D based on an average stiff soil profile. Concrete exposed to the onsite soils should contain Type I-II cement and be air entrained. If a higher capacity foundation or lower settlement risk foundation is needed, the bearing level could be extended down to the basalt rock soils such as with drilled piers or driven piles.

DESIGN RECOMMENDATIONS

FOUNDATIONS

Considering the subsurface conditions encountered in the exploratory borings and the nature of the proposed construction, we recommend the buildings be founded with spread footings bearing on the natural soils. If a deep foundation is needed due to heavy foundation loadings or settlement sensitive building, we should be contacted for additional analysis and recommendations.

The design and construction criteria presented below should be observed for a spread footing foundation system.

1) Footings placed on the undisturbed natural soils should be designed for an allowable bearing pressure of 2,500 psf. Based on experience, we expect settlement of footings designed and constructed as discussed in this section will be between about ½ to 1½ inches. When building loadings and footing sizes have been determined, we should reevaluate the settlement potential.
2) The footings should have a minimum width of 18 inches for continuous walls and 2 feet for isolated pads.
3) 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 36 inches below exterior grade is typically used in this area.
4) Continuous foundation walls should be reinforced top and bottom to span local anomalies such as by assuming an unsupported length of at least 12 feet. Foundation walls acting as retaining structures should also be designed to resist lateral earth pressures as discussed in the "Foundation and Retaining Walls" section of this report.
5) Existing fill, debris, topsoil and loose or disturbed soils should be removed and the footing bearing level extended down to the firm natural soils. The exposed soils in footing area should then be moisture adjusted to near optimum and compacted. Structural fill placed to reestablish footing bearing level, such as where boulders or unsuitable soils are removed should be limited to about 4 feet deep and consist of granular material such as CDOT Class 6 base course.
6) A representative of the geotechnical engineer should observe all footing excavations prior to concrete placement to evaluate bearing conditions.

FOUNDATION AND RETAINING WALLS

Foundation walls and retaining structures which are laterally supported and can be expected to undergo only a slight amount of deflection should be designed for a lateral earth pressure computed on the basis of an equivalent fluid unit weight of at least 55 pcf for backfill consisting of the on-site soils. Cantilevered retaining structures which are separate from the buildings and 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 at least 45 pcf for backfill consisting of the on-site soils. Backfill should not contain organics, debris or rock larger than about 6 inches.

All foundation and retaining structures should be designed for appropriate hydrostatic and surcharge pressures such as adjacent footings, 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 a foundation wall or retaining structure. An underdrain should be provided to prevent hydrostatic pressure buildup behind walls.

Backfill should be placed in uniform lifts and compacted to at least 90% of the maximum standard Proctor density at near optimum moisture content. Backfill placed in pavement and walkway areas should be compacted to at least 95% of the maximum standard Proctor density. Care should be taken not to overcompact the backfill or use large equipment near the wall, since this could cause excessive lateral pressure on the wall. Some settlement of deep foundation wall backfill should be expected, even if the material is placed correctly, and could result in distress to facilities constructed on the backfill. A relatively well graded granular material such as CDOT Class 5 or 6 base course and compaction to at least 98% of standard Proctor density could be used to help limit the settlement potential.

The lateral resistance of foundation or retaining wall footings will be a combination of the sliding resistance of the footing on the foundation materials and passive earth pressure against the side of the footing. Resistance to sliding at the bottoms of the footings can be calculated based on a coefficient of friction of 0.35. Passive pressure of compacted backfill against the sides of the footings can be calculated using an equivalent fluid unit weight of 350 pcf. The coefficient of friction and passive pressure values recommended above assume ultimate soil strength. Suitable factors of safety should be included in the design to limit the strain which will occur at the ultimate strength, particularly in the case of passive resistance. Fill placed against the sides of the footings to resist lateral loads should be compacted to at least 95% of the maximum standard Proctor density at a moisture content near optimum.

FLOOR SLABS

The natural on-site soils, exclusive of topsoil, are suitable to support lightly loaded slab-on-grade construction with low risk of settlement/heave. We should evaluate the slab subgrade conditions at the time of excavation. In slab areas sensitive to movement, such as the field house, we recommend at least 2 feet of imported relatively well graded granular material such as CDOT Class 6 base course be used for the slab support. To reduce the effects of some differential movement, non-structural 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 requirements for joint spacing and slab reinforcement should be established by the designer based on experience and the intended slab use. A minimum 4-inch layer of free-draining gravel should be placed beneath basement level slabs to facilitate drainage. This material should consist of minus 2-inch aggregate with at least 50% retained on the No. 4 sieve and less than 2% passing the No. 200 sieve.

All fill materials for support of floor slabs should be compacted to at least 95% of maximum standard Proctor density at a moisture content near optimum. Required fill can typically consist of the on-site soils devoid of vegetation, topsoil and oversized rock.

We recommend vapor retarders conform to at least the minimum requirements of ASTM E1745 Class C material. Certain floor types are more sensitive to water vapor transmission than others. For floor slabs bearing on angular gravel or where a flooring system sensitive to water vapor transmission are utilized, we recommend a vapor barrier be utilized conforming to the minimum requirements of ASTM E1745 Class A material. The vapor retarder should be installed in accordance with the manufacturers' recommendations and ASTM E1643.

UNDERDRAIN SYSTEM

Although free water was not encountered during our exploration, it has been our experience in mountainous areas and where there are clay soils that local perched groundwater can develop during times of heavy precipitation or seasonal runoff. Frozen ground during spring runoff can create a perched condition. We recommend below-grade construction, such as retaining walls, crawlspace and basement areas, be protected from wetting and hydrostatic pressure buildup by an underdrain system.

The drains should consist of drainpipe placed in the bottom of the wall backfill surrounded above the invert level with free-draining granular material. The drain should be placed at each level of excavation and at least 1 foot below lowest adjacent finish grade and sloped at a minimum 1% to a suitable gravity outlet. Free-draining granular material used in the underdrain system should contain less than 2% passing the No. 200 sieve, less than 50% passing the No. 4 sieve and have a maximum size of 2 inches. The drain gravel backfill should be at least 1½ feet deep. An impervious membrane such as 30 mil PVC should be placed beneath the drain gravel in a trough shape and attached to the foundation wall with mastic to prevent wetting of the bearing soils.

SITE GRADING

The risk of construction-induced slope instability at the site appears low provided the buildings are located in the less steep sloping areas as planned and cut and fill depths are limited. We assume the cut depths for the basement levels will not exceed about 12 feet. Fills should be limited to about 8 to 10 feet deep. Embankment fills should be compacted to at least 95% of the maximum standard Proctor density near optimum moisture content. Prior to fill placement, the subgrade should be carefully prepared by removing all vegetation and topsoil and compacting to at least 95% of the maximum standard Proctor density. The fill should be benched into slopes that exceed 20% grade. Permanent unretained cut and fill slopes should be graded at 2 horizontal to 1 vertical or flatter and protected against erosion by revegetation or other means. This office should review site grading plans for the project prior to construction.

SURFACE DRAINAGE

The following drainage precautions should be observed during construction and maintained at all times after the buildings have been completed:

1) Inundation of the foundation excavations and underslab areas should be avoided during construction.

2) Exterior backfill should be adjusted to near optimum moisture and compacted to at least 95% of the maximum standard Proctor density in pavement and slab areas and to at least 90% of the maximum standard Proctor density in landscape areas.

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 12 inches in the first 10 feet in unpaved areas and a minimum slope of 2½ inches in the first 10 feet in paved areas. Free-draining wall backfill should be covered with filter fabric and capped with at least 2 feet of the on-site soils to reduce surface water infiltration.

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

5) Landscaping which requires regular heavy irrigation should be located at least 5 feet from foundation walls.

LIMITATIONS

This study has been conducted in accordance with generally accepted geotechnical engineering principles and practices in this area at this time. We make no warranty either express or implied. The conclusions and recommendations submitted in this report are based upon the data obtained from the exploratory borings drilled at the locations indicated on Figure 1, the proposed type of construction and our experience in the area. Our services do not include determining the presence, prevention or possibility of mold or other biological contaminants (MOBC) developing in the future. If the client is concerned about MOBC, then a professional in this special field of practice should be consulted. Our findings include interpolation and extrapolation of the subsurface conditions identified at the exploratory borings and variations in the subsurface conditions may not become evident until excavation is performed. If conditions encountered during construction appear different from those described in this report, we should be notified so that re-evaluation of the recommendations may be made.

This report has been prepared for the exclusive use by our client for design purposes. We are not responsible for technical interpretations by others of our information. As the project evolves, we should provide continued consultation and field services during construction to review and monitor the implementation of our recommendations, and to verify that the recommendations have been appropriately interpreted. Significant design changes may require additional analysis or modifications to the recommendations presented herein. We recommend on-site observation of excavations and foundation bearing strata and testing of structural fill by a representative of the geotechnical engineer.

Respectfully Submitted,

H-P≋KUMAR

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PROFESSIONAL ENGINEER
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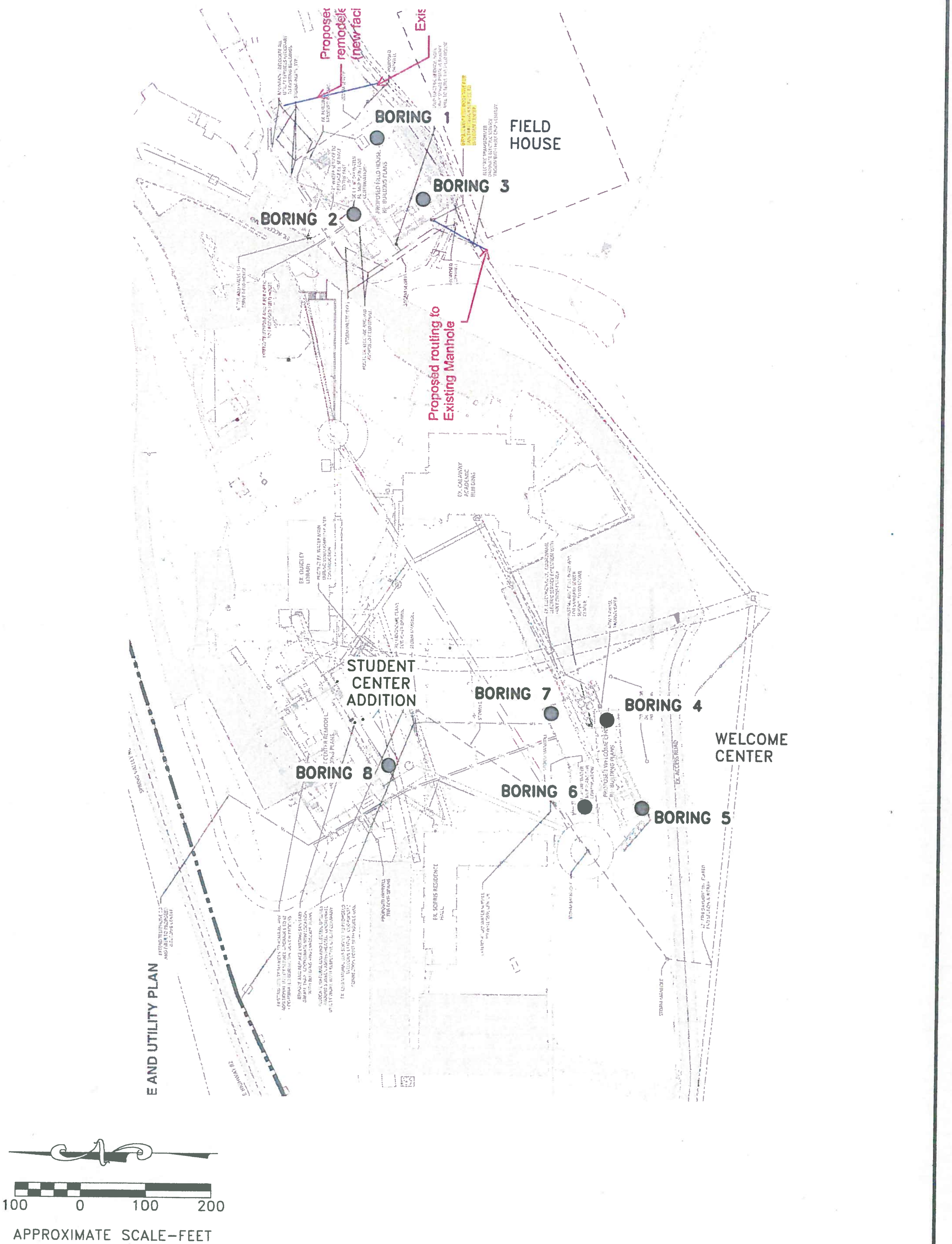

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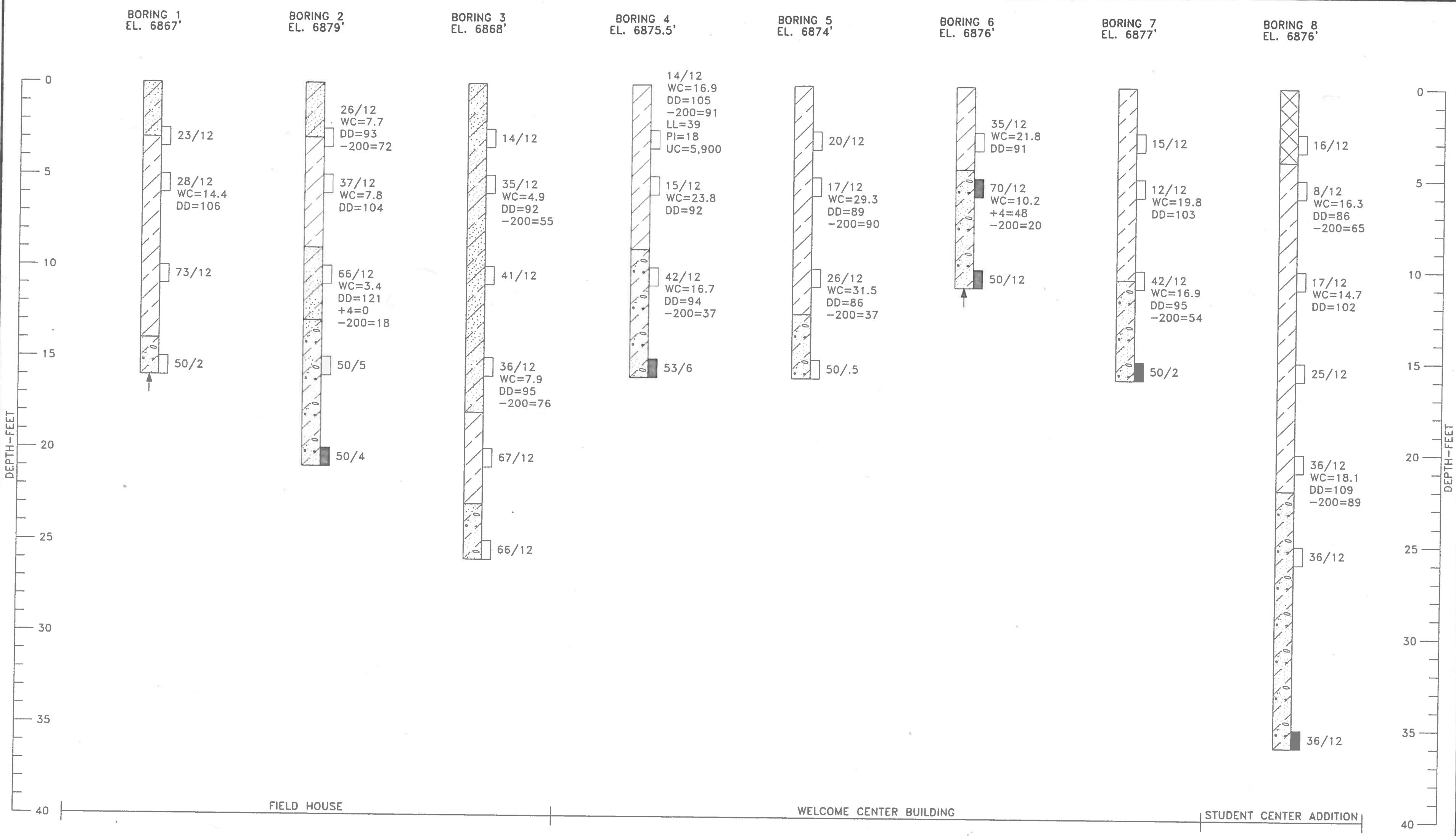
18-7-184	H-P≈KUMAR	LOCATION OF EXPLORATORY BORINGS	Fig. 1



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18-7-184	H-P≋KUMAR	CMC SPRING VALLEY CAMPUS	LOGS OF EXPLORATORY BORINGS	Fig. 2

LEGEND

FILL: ORGANIC SANDY SILT AND CLAY, STIFF TO VERY STIFF, MOIST, DARK BROWN.

CLAY (CL); SILTY, SANDY, SCATTERED GRAVEL, STIFF TO VERY STIFF, MOIST, BROWN, LOW PLASTICITY, SLIGHTLY CALCAREOUS.

SILT AND CLAY (ML–CL); SANDY, SCATTERED GRAVEL, STIFF TO VERY STIFF, SLIGHTLY MOIST TO MOIST, WHITE TO BROWN, SLIGHTLY TO MODERATELY CALCAREOUS, ROOT ZONE AT SURFACE.

SAND AND CLAY (SC–CL); SILTY, BASALT GRAVEL, MEDIUM DENSE/VERY STIFF, SLIGHTLY MOIST, LIGHT BROWN, SLIGHTLY TO MODERATELY CALCAREOUS, ROOT ZONE AT SURFACE.

SAND AND GRAVEL (SC–GC); CLAYEY, BASALT COBBLES AND BOULDERS, MEDIUM DENSE TO DENSE, SLIGHTLY MOIST, MIXED BROWN AND GRAY, CALCAREOUS.

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

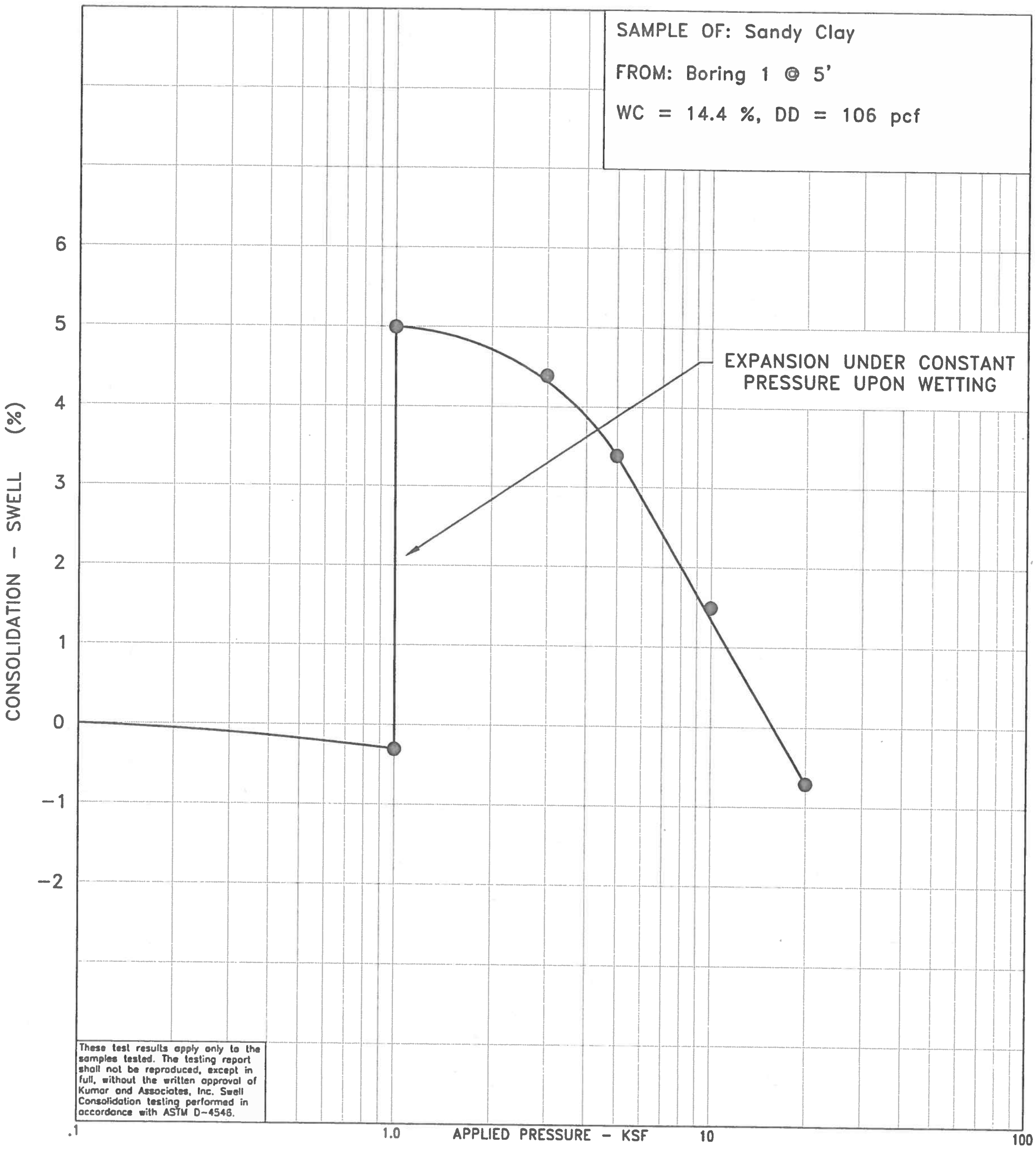
DRIVE SAMPLE, 1 3/8–INCH I.D. SPLIT SPOON STANDARD PENETRATION TEST.

23/12 DRIVE SAMPLE BLOW COUNT. INDICATES THAT 23 BLOWS OF A 140–POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 12 INCHES.

↑ PRACTICAL AUGER REFUSAL.

NOTES

1. THE EXPLORATORY BORINGS WERE DRILLED ON MARCH 12 AND 16, 2018 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.
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);
   UC = UNCONFINED COMPRESSIVE STRENGTH (psf) (ASTM D 2166).



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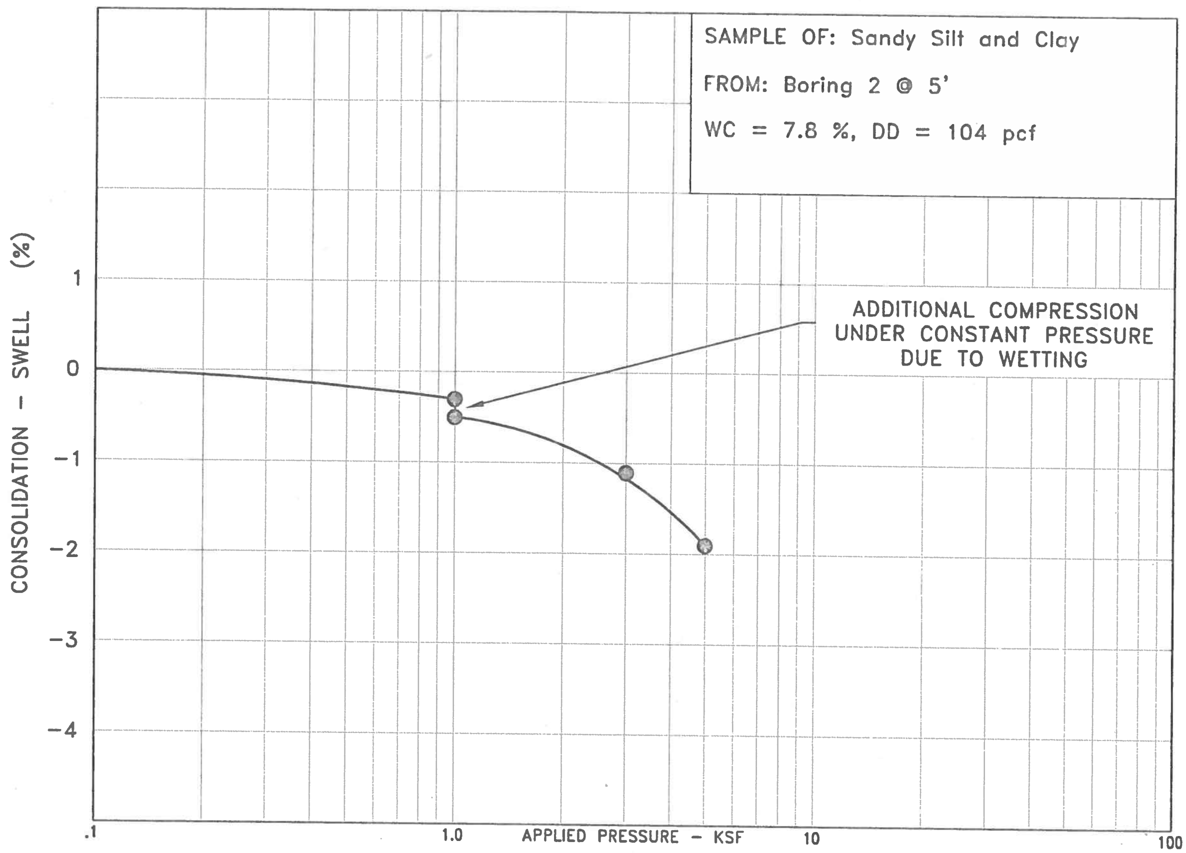
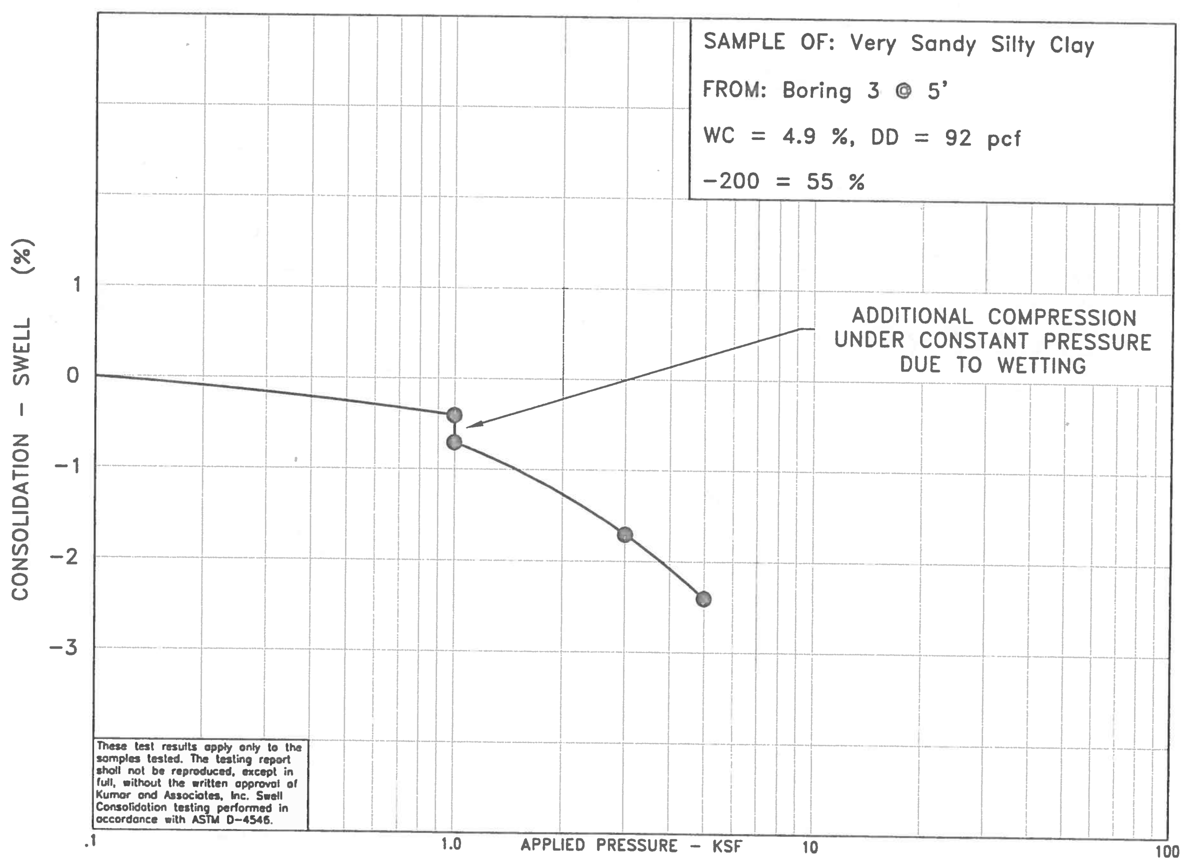
18-7-184	H-P≋KUMAR	SWELL-CONSOLIDATION TEST RESULTS	Fig. 4





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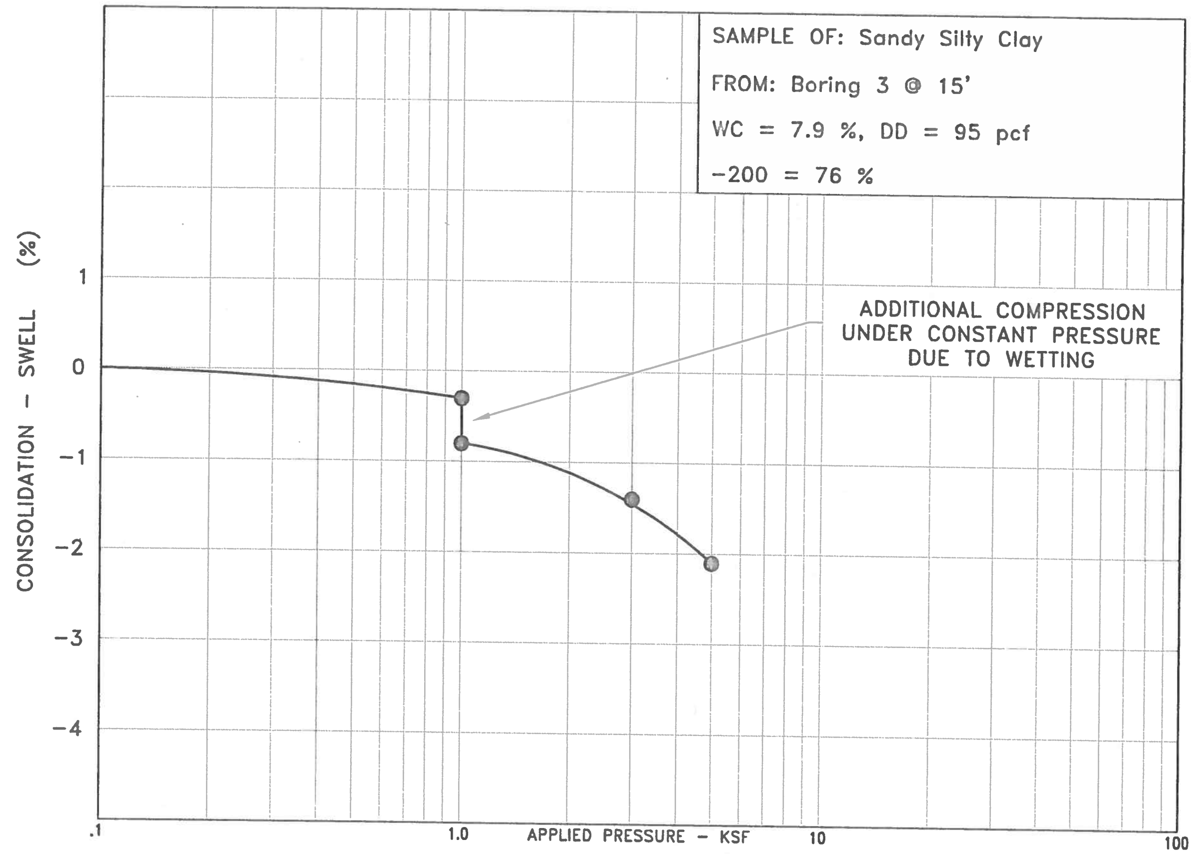
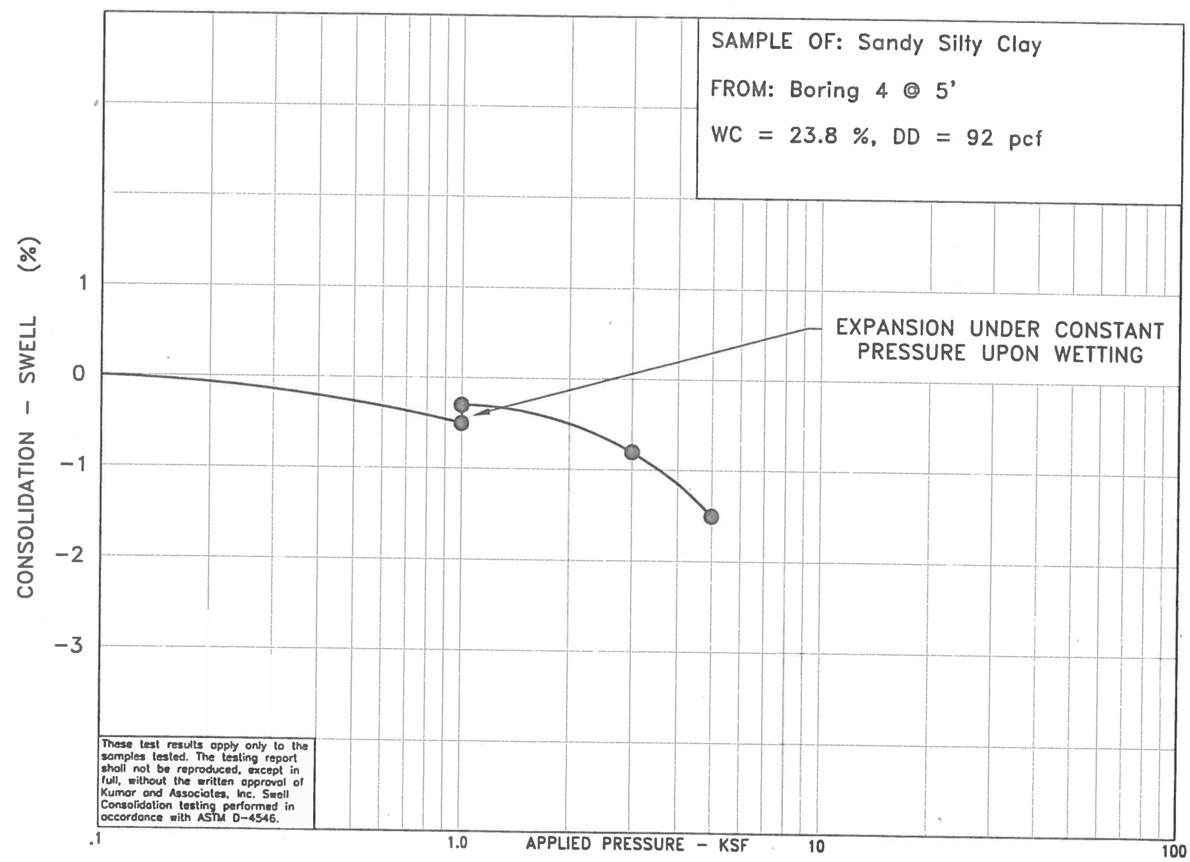
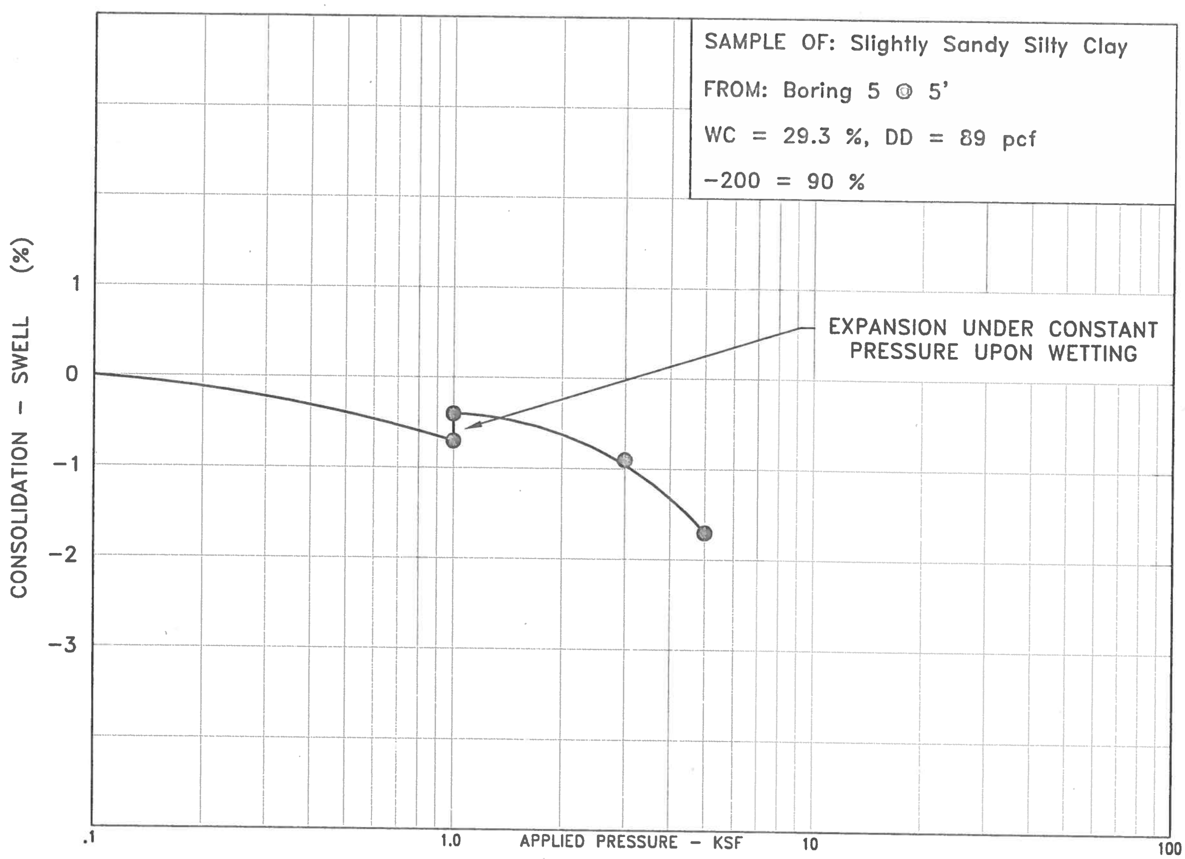
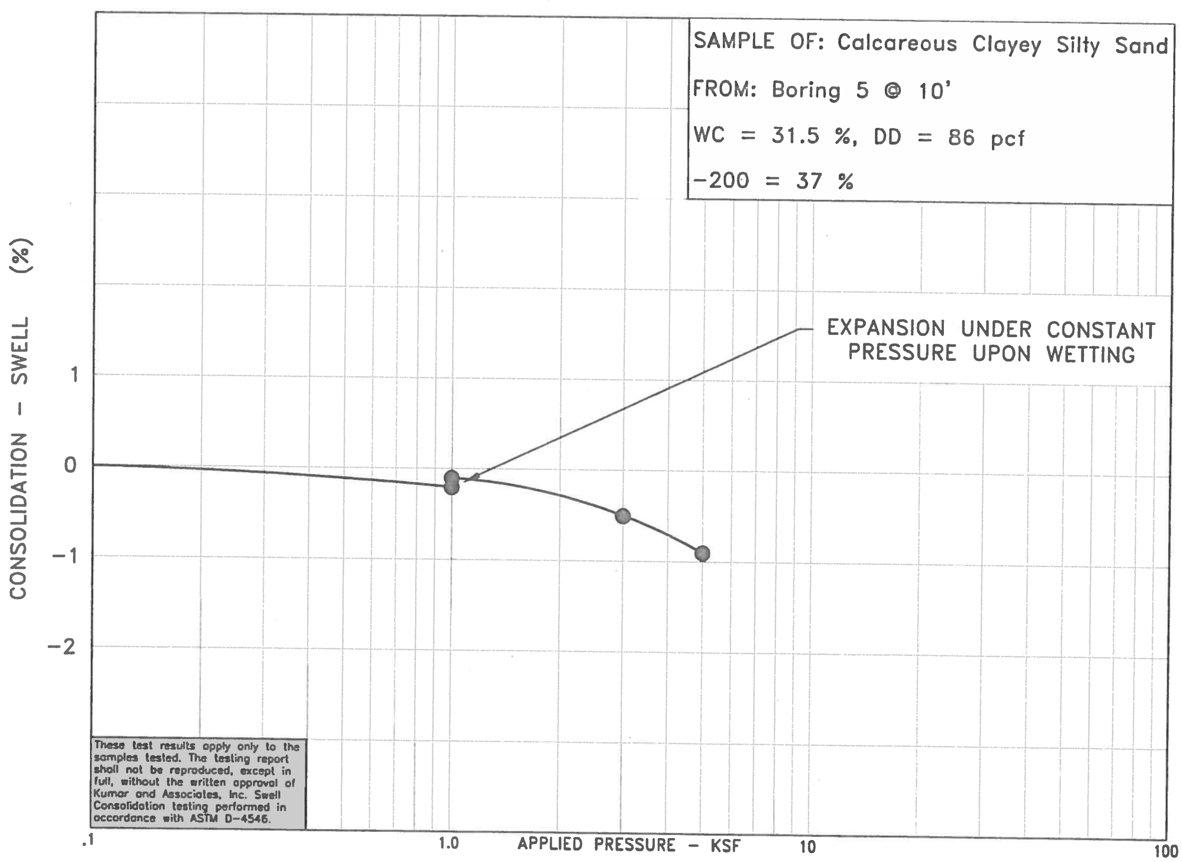
18-7-184	H-P KUMAR	SWELL-CONSOLIDATION TEST RESULTS	Fig. 5



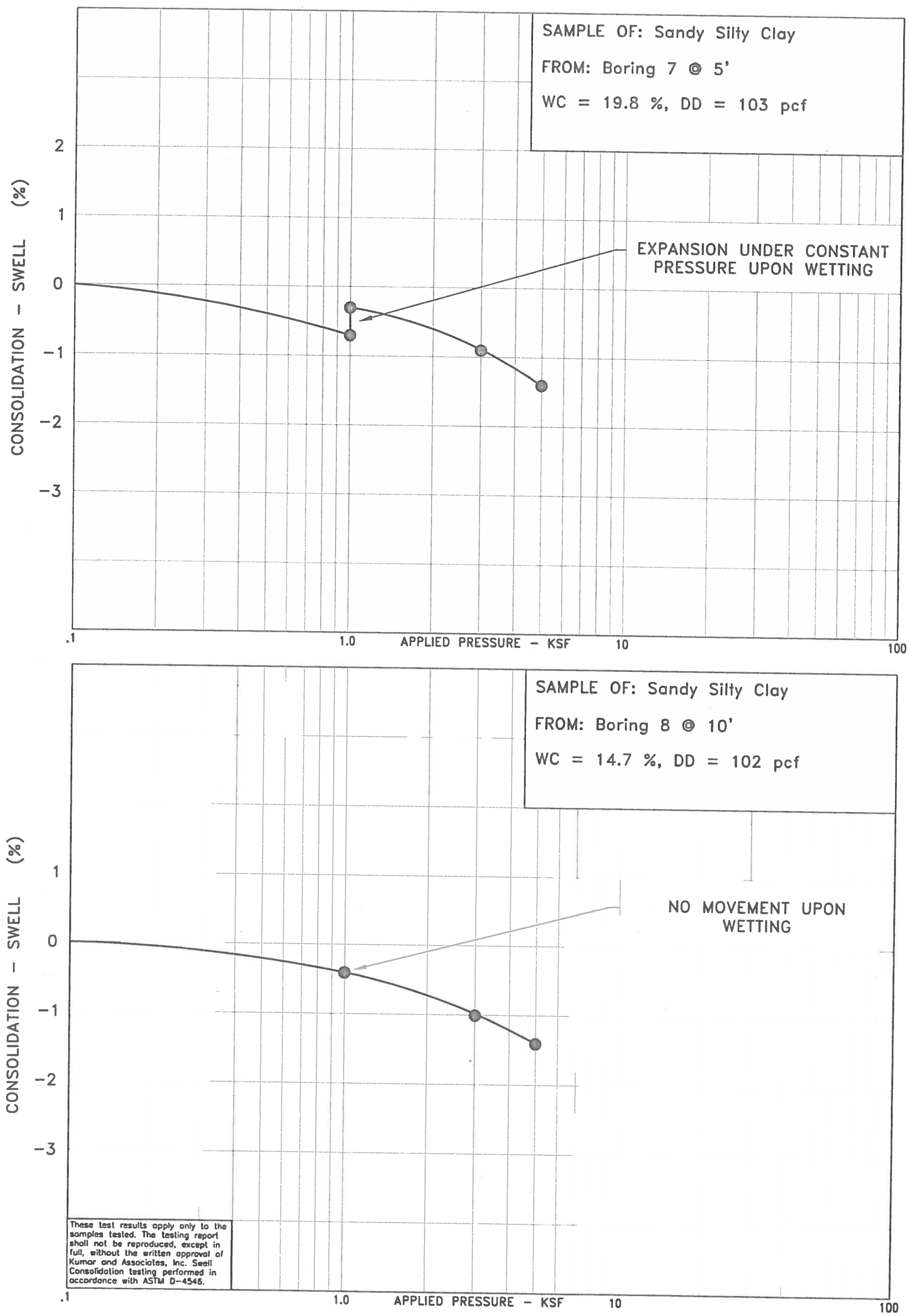


18-7-184	H-P≋KUMAR	SWELL-CONSOLIDATION TEST RESULTS	Fig. 6





18-7-184	H-P≋KUMAR	SWELL-CONSOLIDATION TEST RESULTS	Fig. 7



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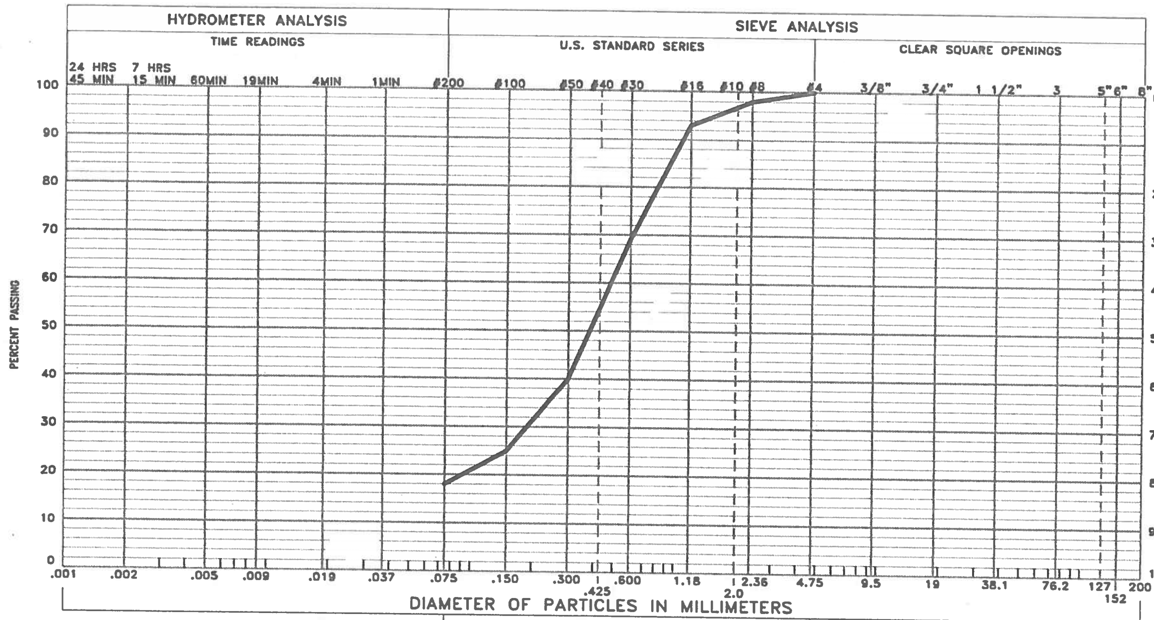
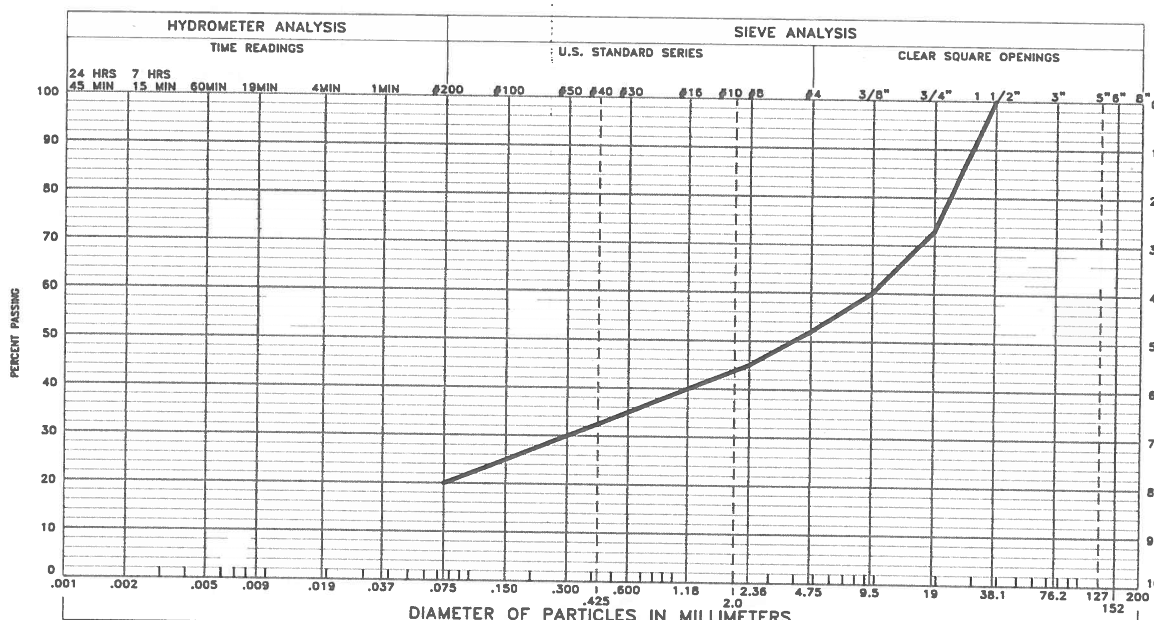
18-7-184	H-P≋KUMAR	SWELL-CONSOLIDATION TEST RESULTS	Fig. 8



GRAVEL 0 % SAND 82 % SILT AND CLAY 18 %

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Silty Sand FROM: Boring 2 @ 10'



GRAVEL 48 % SAND 32 % SILT AND CLAY 20 %

LIQUID LIMIT PLASTICITY INDEX

SAMPLE OF: Silty Clayey Sandy Gravel FROM: Boring 6 @ 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.

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18-7-184	H-P≈KUMAR	GRADATION TEST RESULTS	Fig. 9

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TABLE 1
SUMMARY OF LABORATORY TEST RESULTS

SAMPLE LOCATION		NATURAL MOISTURE CONTENT	NATURAL DRY DENSITY	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH		SOIL TYPE
BORING	DEPTH (ft)	(%)	(pcf)	GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTIC INDEX (%)	(psf)		
1	5	14.4	106								Sandy Clay
2	2½	7.7	93			72					Calcareous Sandy Clay and Silt
	5	7.8	104								Sandy Silt and Clay
	10	3.4	121	0	82	18					Silty Sand
3	5	4.9	92			55					Very Sandy Silty Clay
	15	7.9	95			76					Sandy Silty Clay
4	2½	16.9	105			91	39	18	5,900		Slightly Sandy Silty Clay
	5	23.8	92								Sandy Silty Clay
	10	16.7	94			37					Silty Clayey Sand with Gravel
5	5	29.3	89			90					Slightly Sandy Silty Clay
	10	31.5	86			37					Calcareous Clayey Silty Sand

H-P KUMAR

TABLE 1
SUMMARY OF LABORATORY TEST RESULTS

SAMPLE LOCATION		NATURAL MOISTURE CONTENT	NATURAL DRY DENSITY	GRADATION		PERCENT PASSING NO. 200 SIEVE	ATTERBERG LIMITS		UNCONFINED COMPRESSIVE STRENGTH		SOIL TYPE
BORING	DEPTH (ft)	(%)	(pcf)	GRAVEL (%)	SAND (%)		LIQUID LIMIT (%)	PLASTIC INDEX (%)	(psf)		
6	2½	21.8	91								Sandy Silty Clay
	5	10.2		48	32	20					Silty Clayey Sandy Gravel
7	5	19.8	103								Sandy Silty Clay
	10	16.9	95			54					Very Sandy Silty Clay with Gravel
8	5	16.3	86			65					Sandy Silt and Clay
	10	14.7	102								Sandy Silty Clay
	20	18.1	109			89					Sandy Silty Clay