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

SUBSOIL STUDY
FOR FOUNDATION DESIGN
PROPOSED HOUSING PROJECT
EAST 3rd STREET
EAGLE, COLORADO

PROJECT NO. 22-7-248

JUNE 20, 2022

PREPARED FOR:

HABITAT FOR HUMANITY VAIL VALLEY
ATT: EMILY PEYTON
P.O. BOX 4049
AVON, COLORADO 81620
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PURPOSE AND SCOPE OF STUDY

This report presents the results of a subsoil study for a proposed housing project to be located at East 3rd Street, Eagle, 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 agreement for geotechnical engineering services to Habitat for Humanity Vail Valley dated March 25, 2022.

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 housing project will consist of 8 buildings, 4 single family residences and 4 duplex residences. They will be one and two story structures with attached garage. The single family buildings will be above a basement level and the duplex buildings above a crawlspace. Basement and garage floors will be slab-on-grade. Grading for the structures is assumed to be relatively minor with cut depths between about 3 to 10 feet. We assume relatively light foundation loadings, typical of the proposed type of construction.

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 property is approximately 2.3 acres and located on the north side of East 3rd Street and between the middle school to the east and the fire station to the west as shown on Figure 1. The property is vacant and vegetated with grass and weeds. There was about six inches of snow cover at the time of our field exploration. Trees are located along the west and south property lines. The ground surface is relatively flat in the rear (northern) part of the site with a grade of about 4 percent down to the west. The grade steepens in the southern portion of the site and ranges from about 10 to 15 percent down to the south and southwest. The site is bordered by the gently sloping football field to the east and relatively steep terrain to the north.

SUBSIDENCE POTENTIAL

Bedrock of the Pennsylvanian age Eagle Valley Evaporite underlies the Eagle area. 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 lot. Dissolution of the gypsum under certain conditions can cause sinkholes to develop and can produce areas of localized subsidence. During previous work in the area, several sinkholes were observed scattered throughout the Eagle area. These sinkholes appear similar to others associated with the Eagle Valley Evaporite in other areas of the Eagle River valley.

Sinkholes were not observed in the immediate area of the subject site. 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 site, it cannot be said for certain that sinkholes will not develop. The risk of future ground subsidence at the site throughout the service life of the proposed buildings, in our opinion, is low and similar to other nearby properties; 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 April 13, 2022. Five 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 Kumar & Associates, Inc.

Samples of the subsoils were taken with a 2 inch I.D. spoon sampler. The sampler was 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 about 1 to 1½ feet of topsoil consist of slightly clayey silty sand and sandy silt with scattered gravel. A sandy silty clay layer was encountered at Borings 4 and 5 below around 15 feet.

Laboratory testing performed on samples obtained from the borings included natural moisture content and density, percent finer than No. 200 sieve gradation analyses and Atterberg limits. Results of swell-consolidation testing performed on relatively undisturbed drive samples of the subsoils, presented on Figures 3 through 8, generally indicate low to moderate compressibility under loading and minor to low collapse when wetted. Samples from Borings 4 and 5 showed a minor expansion potential when wetted. 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 sandy silt and silty sand soils encountered at typical shallow foundation depth mainly tend to settle when they become wetted under load. A shallow foundation placed on these soils will have a risk of settlement if the soils become wetted and care should be taken in the surface and drainage around the buildings to prevent the bearing soils from becoming wet. It will be critical to the long-term performance of the structures that the recommendations for surface grading and drainage contained in this report be followed. The amount of settlement, if the bearing soils become wet, will mainly be related to the depth and extent of subsurface wetting. We expect that initial settlements will be less than 1 inch. If wetting of the shallow soils occurs, additional settlements of around 1 to 2 inches could occur and cause building distress. Mitigation methods such as deep foundations (piles or piers) or removing and replacing the bearing soils with 3 feet of compacted structural fill could be used to support the proposed buildings with a lower risk of settlement. If a deep foundation is desired, we should be contacted to provide further design recommendations.

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 or compacted structural fill.

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 1,200 psf. Based on experience, we expect initial settlement of footings designed and constructed as discussed in this section will

be about 1 inch or less. Additional differential settlements of about 1 to 2 inches could occur if the bearing soils are wetted. Footings placed on compacted structural fill should be designed for an allowable bearing pressure of 1,500 psf. The sub-excavated areas should extend at least 3 feet below bearing level and 1½ feet beyond the footing edges. Based on experience, we expect initial settlement of footings designed and constructed as discussed in this section will be about 1 inch or less with additional differential settlement of around 1 inch if the bearing soils were to become wetted.

2) The footings should have a minimum width of 20 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 42 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 14 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) All topsoil and any loose or disturbed soils should be removed and the footing bearing level extended down to the relatively undisturbed soils. The exposed soils in footing area should then be moistened and compacted.

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 50 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.

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 a moisture content near optimum. 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. Backfill should not contain organics, debris or rock larger than about 6 inches.

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 some risk of settlement if the bearing soils are wetted. 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 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 consist of the on-site soils devoid of vegetation, topsoil and oversized rock.

UNDERDRAIN SYSTEM

Although free water was not encountered during our exploration, it has been our experience in the area 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, deep crawlspace and basement areas, be protected from wetting and hydrostatic pressure buildup by an underdrain system. Shallow crawlspace around 3½ feet does not need an underdrain with proper wall backfill and surface grading.

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 20 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.

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 3 inches in the first 10 feet in paved areas. Free-draining wall backfill should be covered with filter fabric and capped with about 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 and sprinkler heads should be located at least 10 feet from foundation walls. Consideration should be given to use of xeriscape to reduce the potential for wetting of soils below the building caused by irrigation.

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,

Kumar & Associates, Inc.

Louis Eller

Reviewed by:

Steven L. Pawlak, P.E.

LEE/kac

cc: Justin Yarnell (justin@theyarnells.com)

22-7-248	Kumar & Associates	HABITAT FOR HUMANITY VAIL VALLEY	LOCATION OF EXPLORATORY BORINGS	Fig. 1

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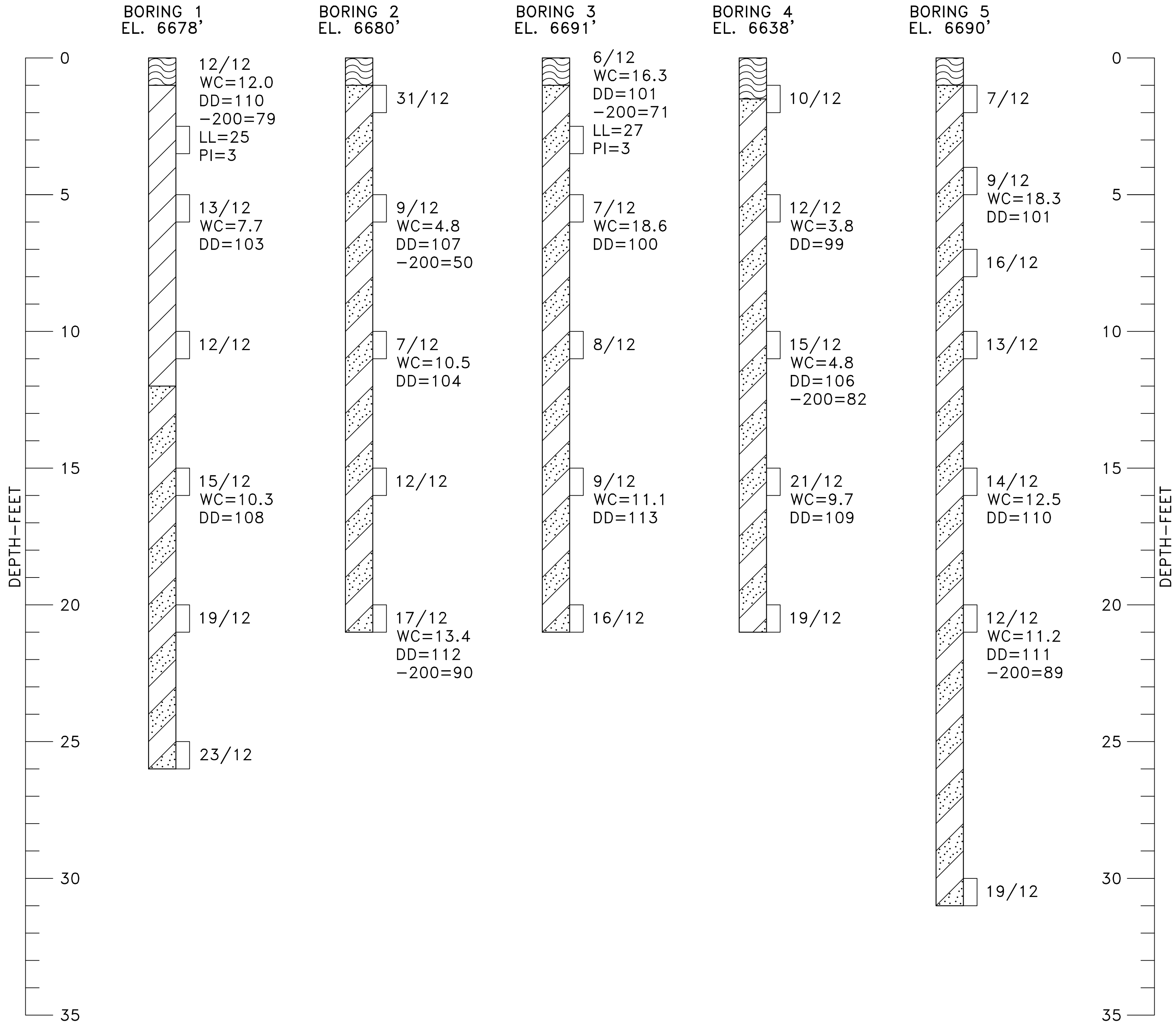


LEGEND

TOPSOIL, ORGANIC SANDY CLAY AND SILT, FIRM, MOIST, BROWN.

SAND AND SILT (SM−ML); SLIGHTLY CLAYEY, SANDY CLAY ZONES AT BORING 5, SLIGHTLY GRAVELLY, MEDIUM DENSE/LOOSE TO STIFF, SLIGHTLY MOIST TO MOIST, LIGHT BROWN.

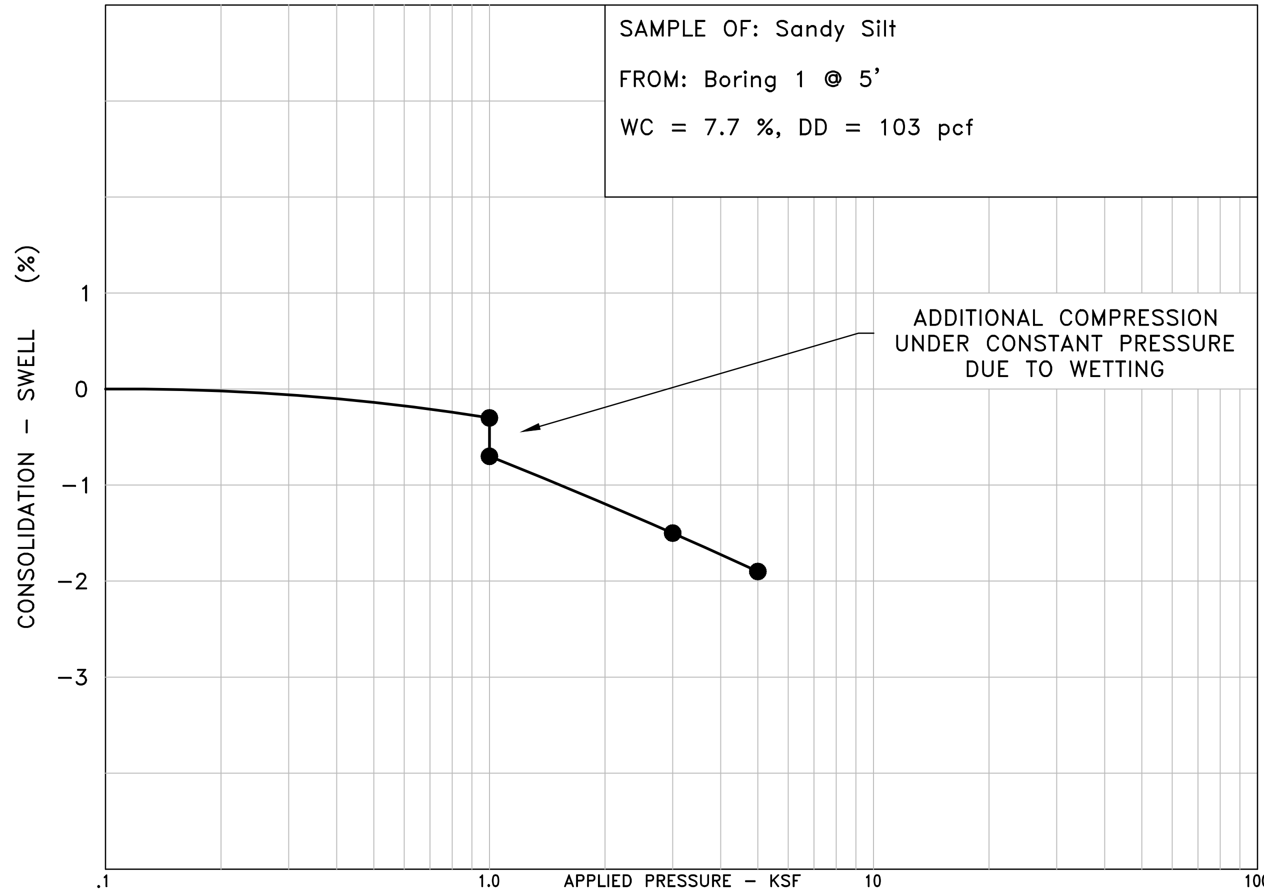
DRIVE SAMPLE, 2−INCH I.D. CALIFORNIA LINER SAMPLE.

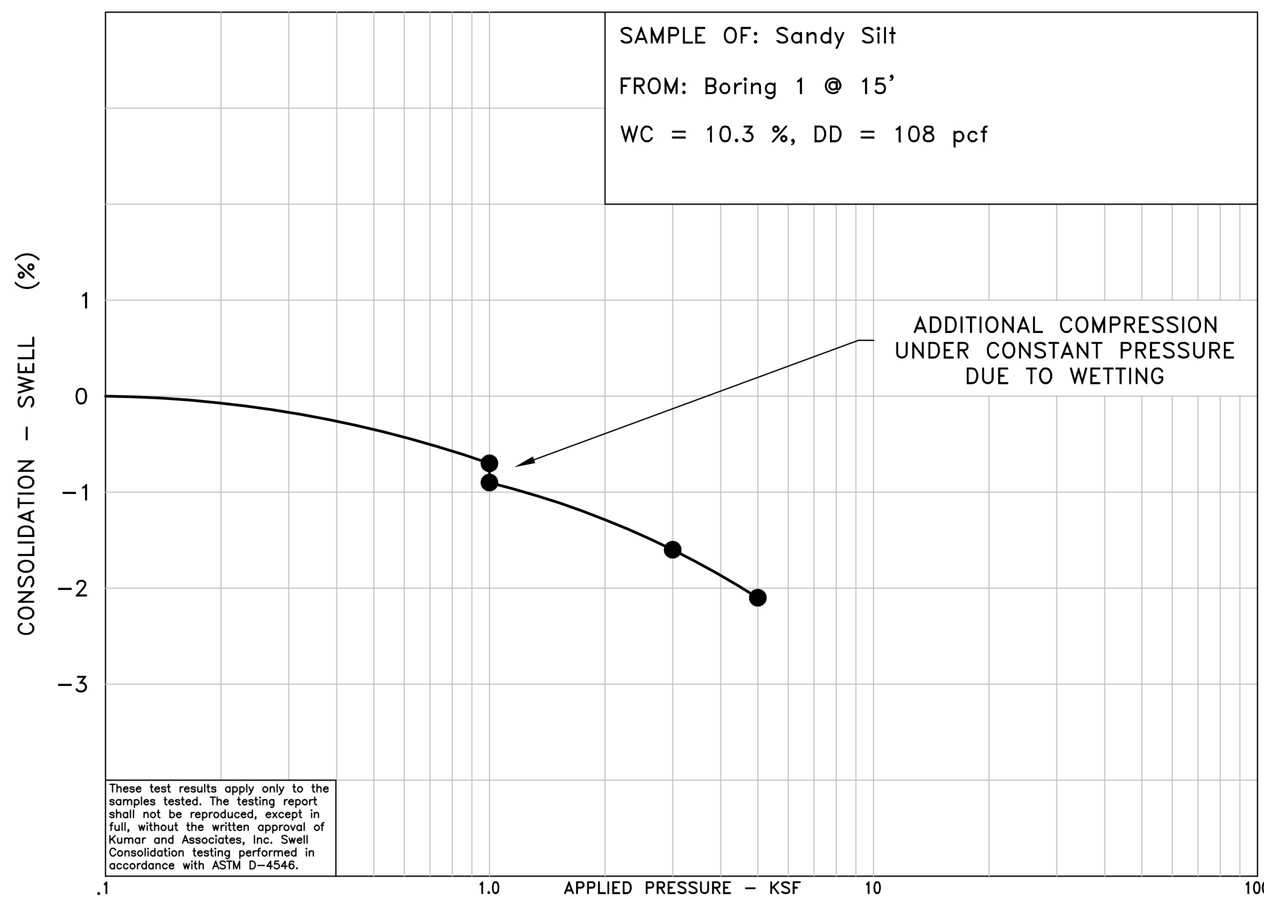
15/12 DRIVE SAMPLE BLOW COUNT. INDICATES THAT 15 BLOWS OF A 140−POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE THE SAMPLER 12 INCHES.

NOTES

1. THE EXPLORATORY BORINGS WERE DRILLED ON APRIL 13, 2022 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 D2216);
   DD = DRY DENSITY (pcf) (ASTM D2216);
   −200 = PERCENTAGE PASSING NO. 200 SIEVE (ASTM D1140);
   LL = LIQUID LIMIT (ASTM D4318);
   PI = PLASTICITY INDEX (ASTM D4318).

22−7−248	Kumar & Associates	HABITAT FOR HUMANITY VAIL VALLEY	LOGS OF EXPLORATORY BORINGS	Fig. 2





22-7-248	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 3

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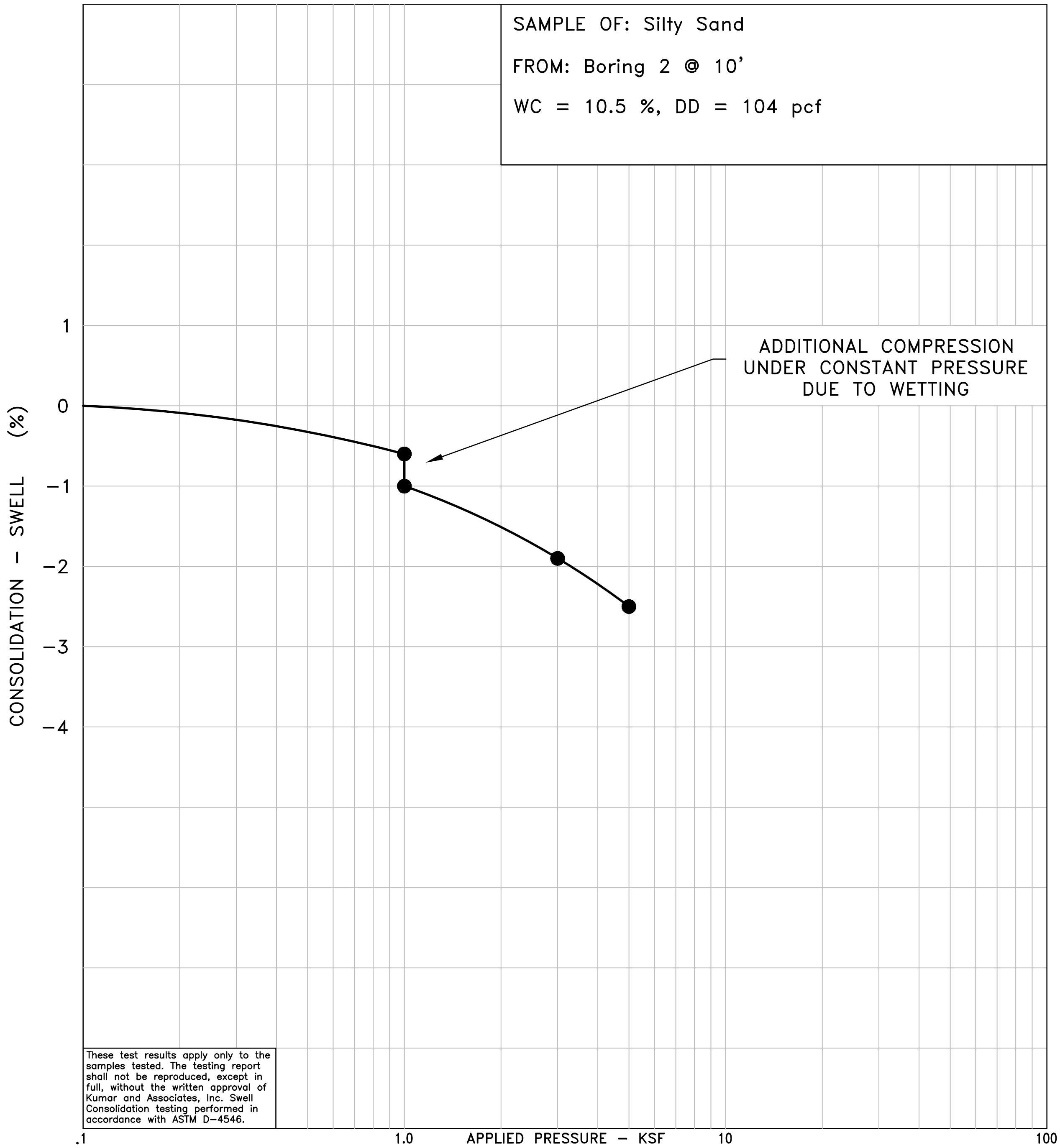

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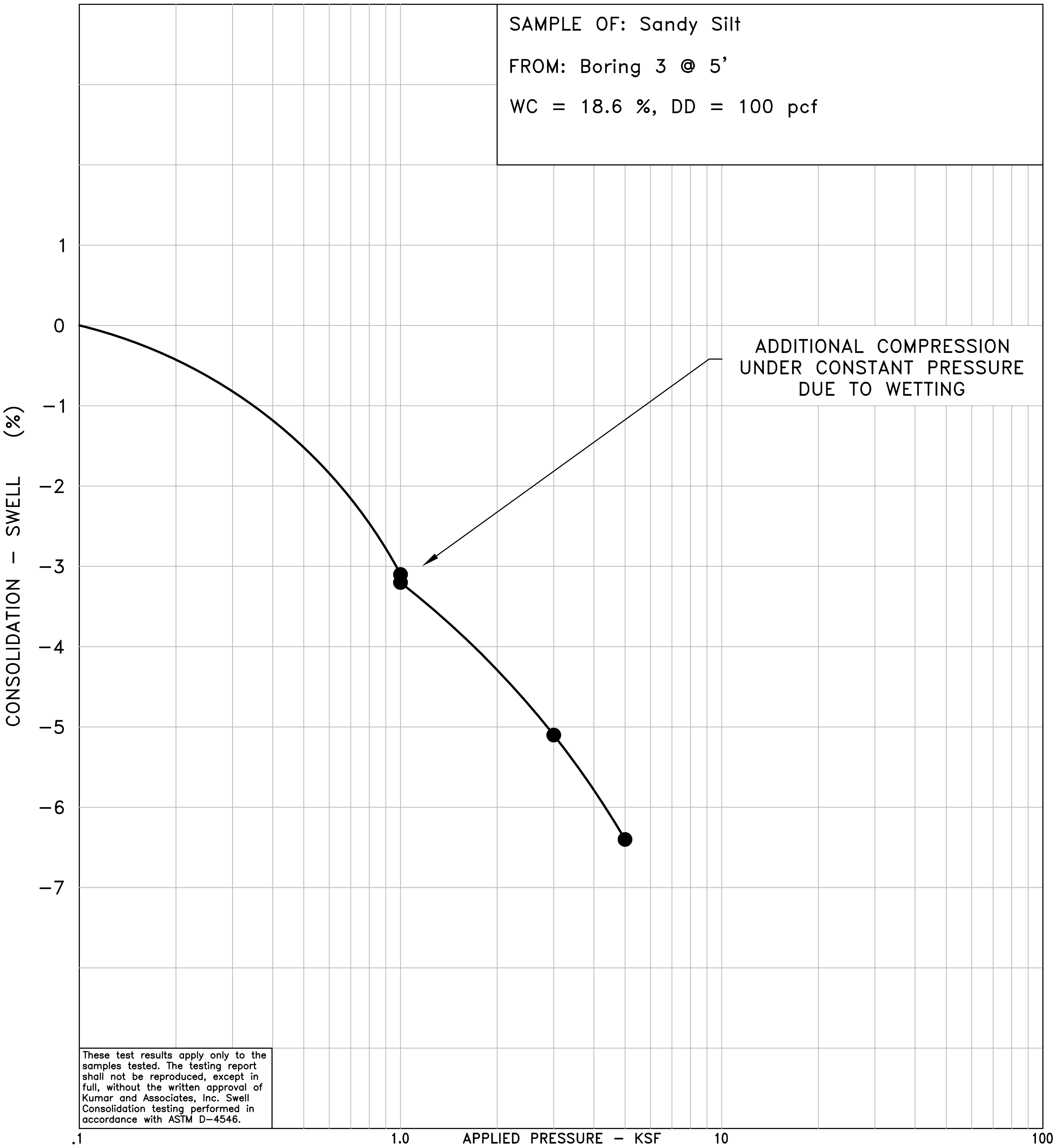
22-7-248	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 4



22-7-248	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 5

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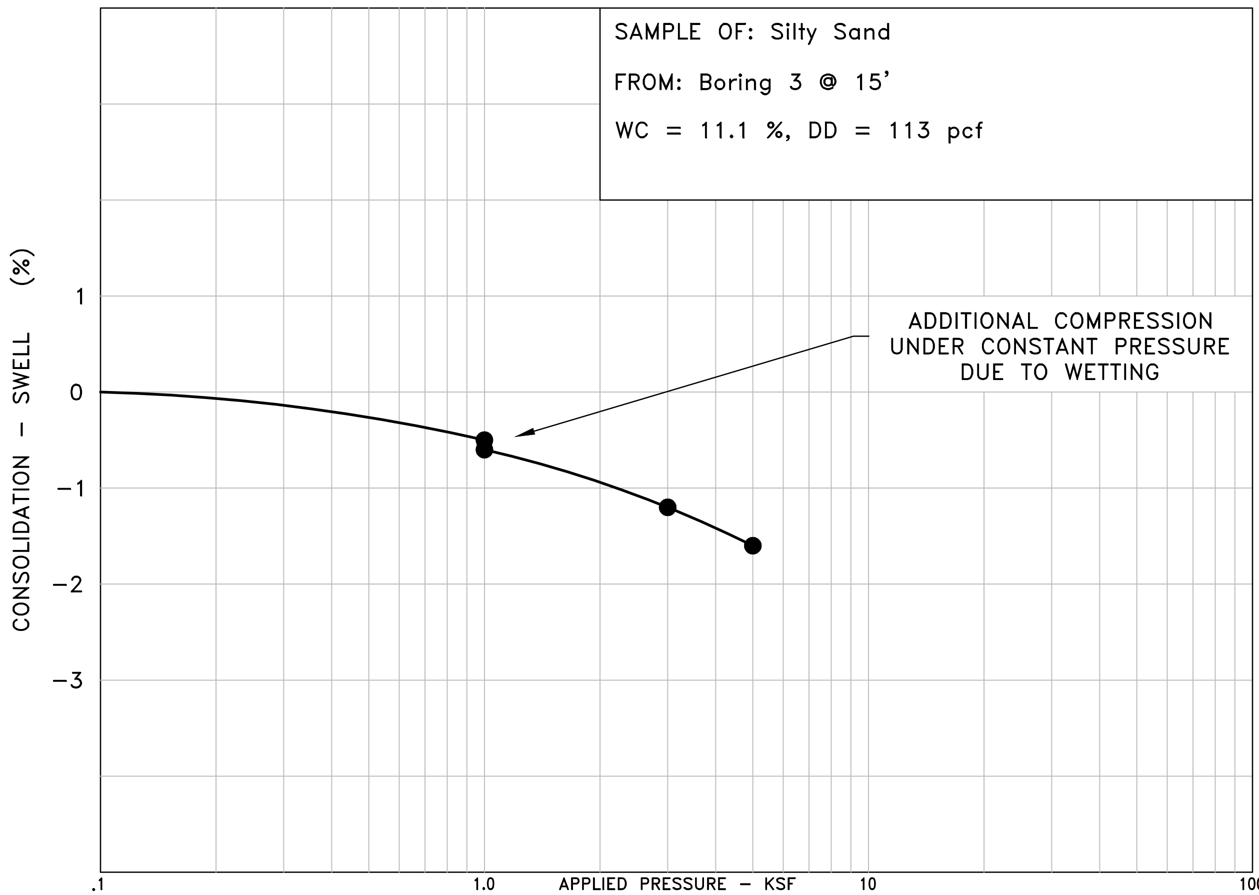

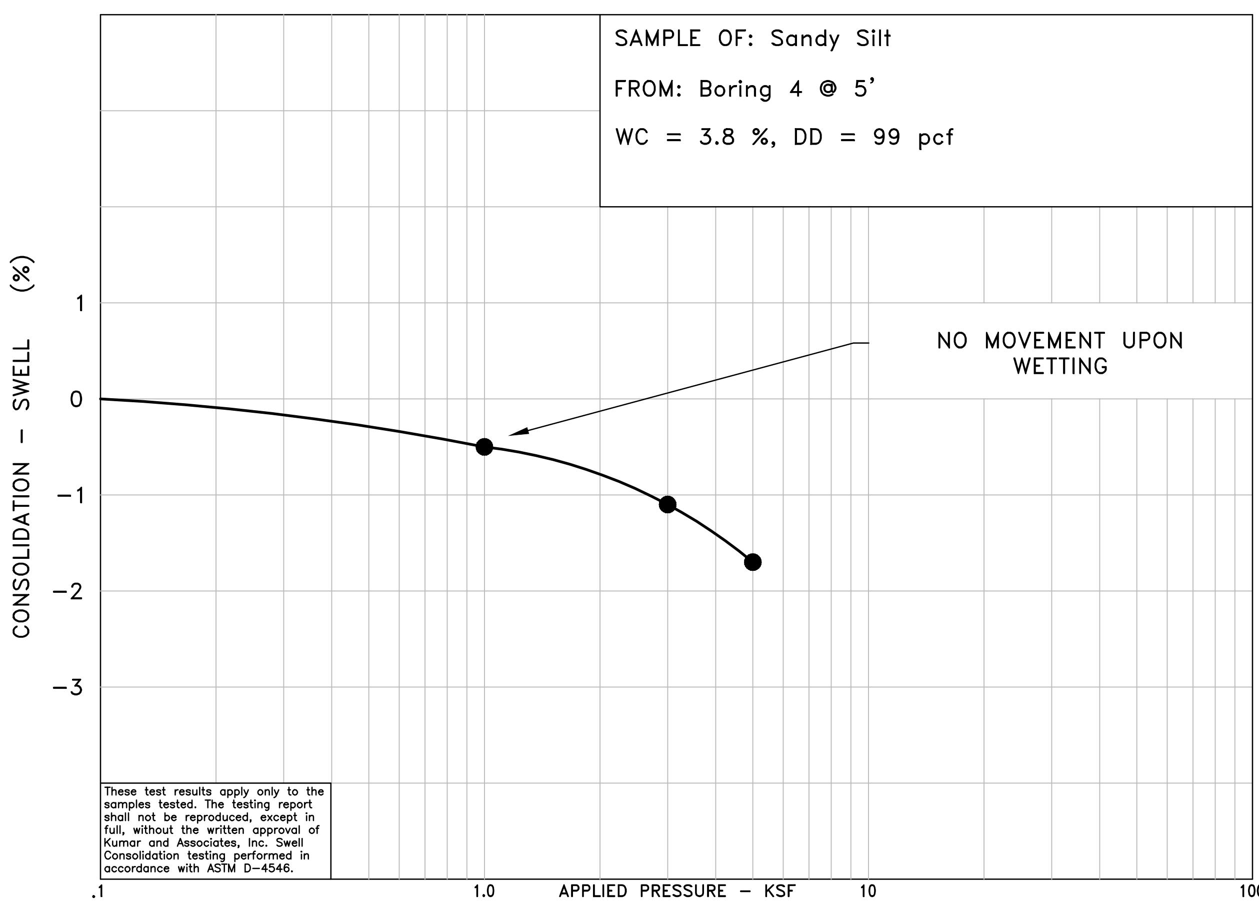

22-7-248	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 6

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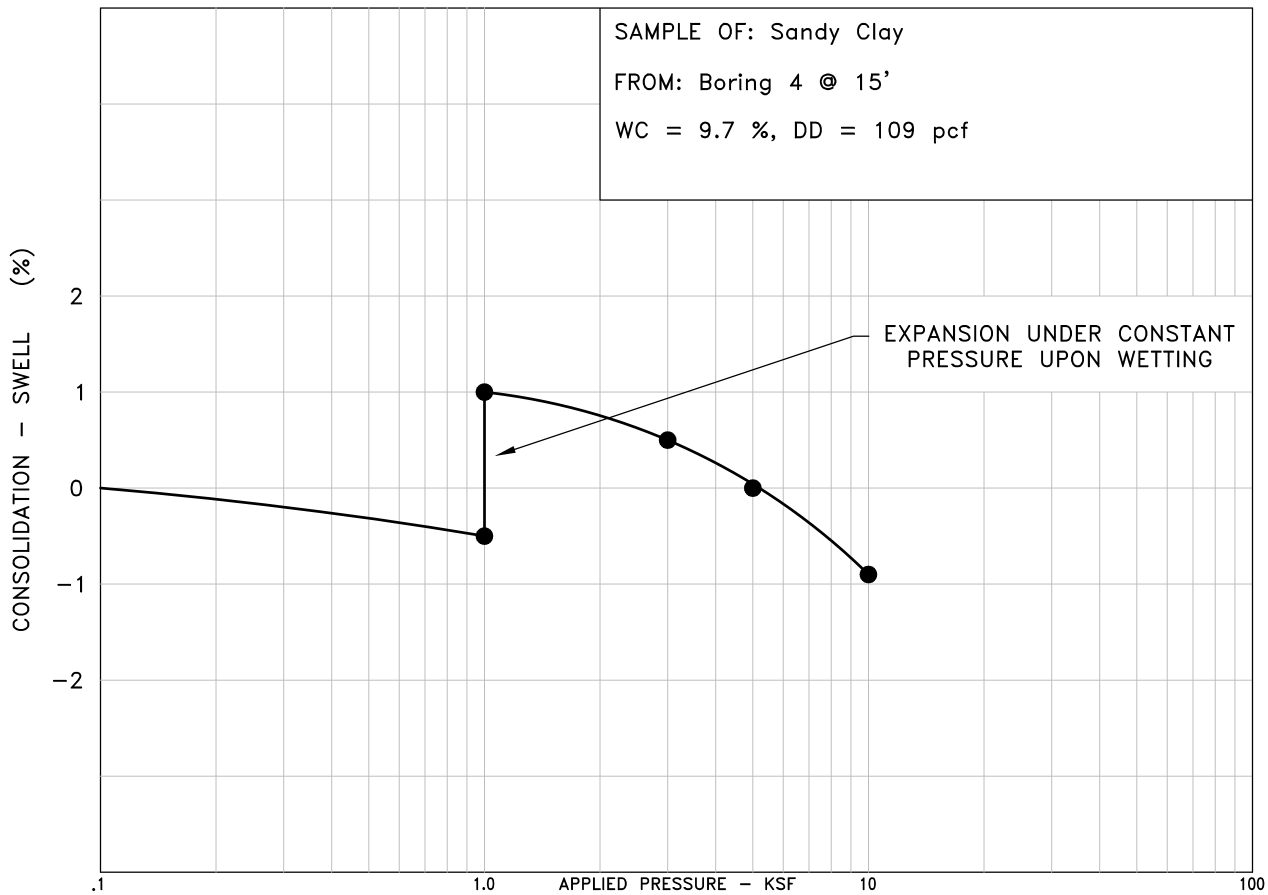
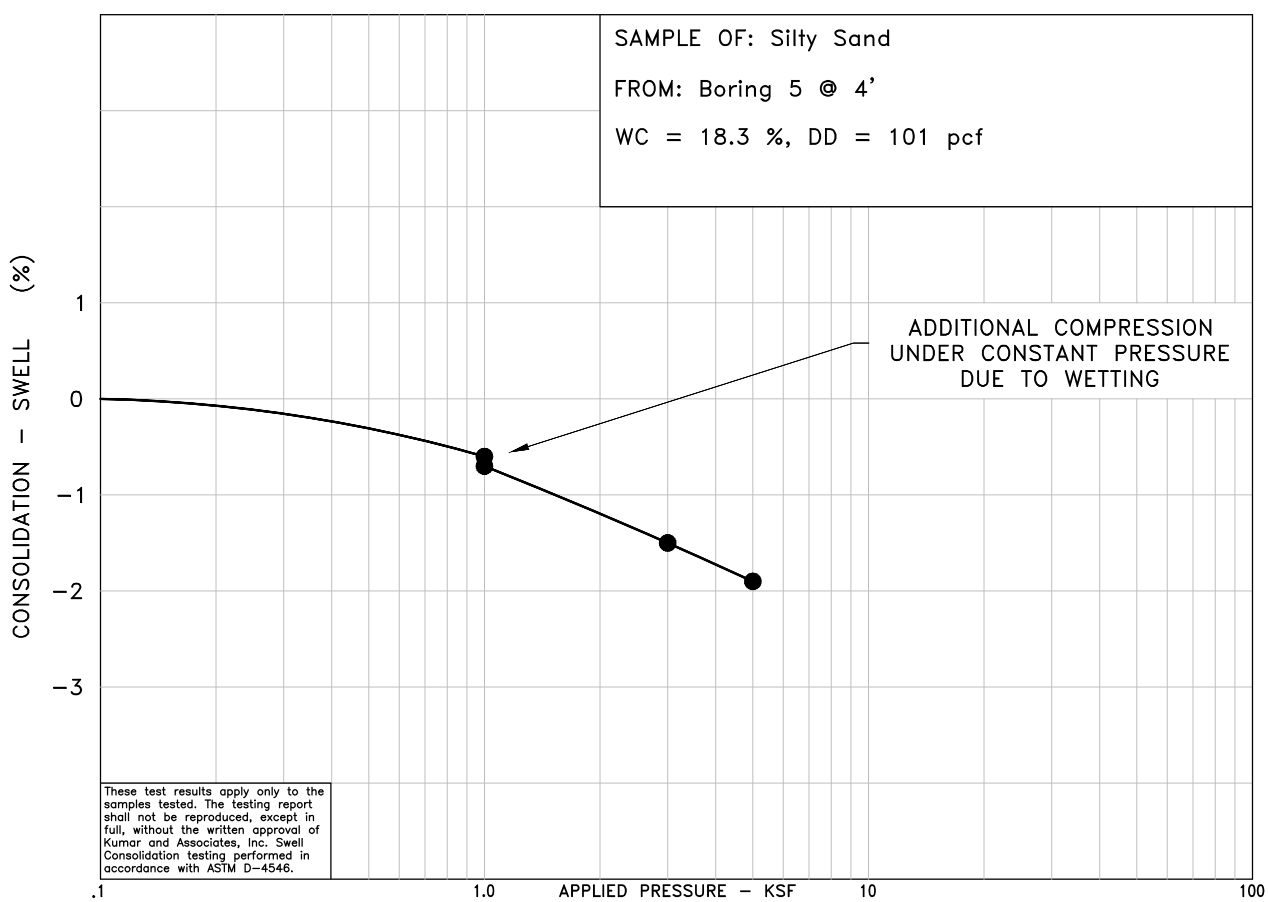
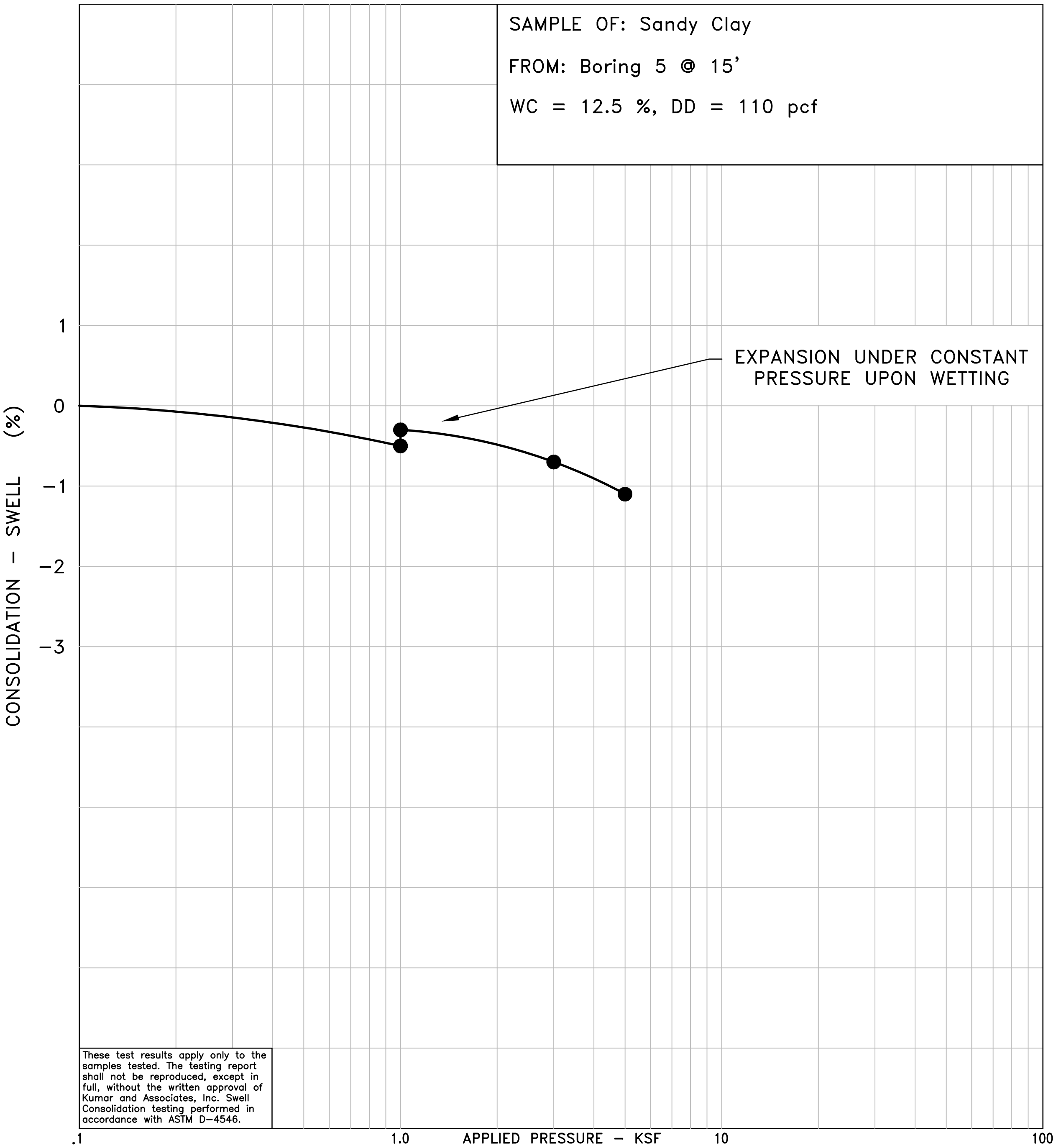




22-7-248	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 7



22-7-248	Kumar & Associates	SWELL-CONSOLIDATION TEST RESULTS	Fig. 8

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TABLE 1
SUMMARY OF LABORATORY TEST RESULTS

Project No. 22-7-248

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	2½	12.0	110			79	25	3			Sandy Clayey Silt
	5	7.7	103								Sandy Silt
	15	10.3	108								Sandy Silt
2	5	4.8	107			50					Very Silty Sand with Gravel
	10	10.5	104								Silty Sand
	20	13.4	112			90					Sandy Silt
3	2½	16.3	101			71	27	3			Sandy Clayey Silt
	5	18.6	100								Sandy Silt
	15	11.1	113								Silty Sand
4	5	3.8	99								Sandy Silt
	10	4.8	106			82					Sandy Silt

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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)		
4	15	9.7	109								Sandy Clay
5	4	18.3	101								Silty Sand
	15	12.5	110								Sandy Clay
	20	11.2	111			89					Sandy Silt