STS General Notes

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DRILLING & SAMPLING SYMBOLS:

SS : Split Spoon - 1-3/8" I.D. 2" O.D.
Unless otherwise noted
ST : Shelby Tube-2" O.D.
Unless otherwise noted
PA : Power Auger
DB : Diamond Bit-NX, BX, AX
AS : Auger Sample
JS : Jar Sample
VS : Vane Shear

OS : Osterberg Sampler
HS : Hollow Stem Auger
WS : Wash Sample
FT : Fish Tail
RB : Rock Bit
BS : Bulk Sample
PM : Pressuremeter Test
GS : Giddings Sampler

Standard "N" Penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2 inch O.D. split spoon sampler, except where otherwise noted.

WATER LEVEL MEASUREMENT SYMBOLS:

WL : Water Level
WS : While Sampling
WD : While Drilling
AB : After Boring

WCI : Wet Cave In
DCI : Dry Cave In
BCR : Before Casing Removal
ACR : After Casing Removal

Water levels indicated on the boring logs are the levels measured in the boring at the time indicated. In pervious soils, the indicated elevations are considered reliable groundwater levels. In impervious soils, the accurate determination of groundwater elevations may not be possible, even after several days of observations; additional evidence of groundwater elevations must be sought.

GRADATION DESCRIPTION AND TERMINOLOGY:

Coarse grained or granular soils have more than 50% of their dry weight retained on a #200 sieve; they are described as boulders, cobbles, gravel or sand. Fine grained soils have less than 50% of their dry weight retained on a #200 sieve; they are described as clay or clayey silt if they are cohesive and silt if they are non-cohesive. In addition to gradation, granular soils are defined on the basis of their relative in-place density and fine grained soils on the basis of their strength or consistency and their plasticity.

Major Component of Sample	Size Range
Boulders	Over 8 in. (200 mm)
Cobbles	8 inches to 3 inches (200 mm to 75 mm)
Gravel	3 inches to #4 sieve (75 mm to 4.76 mm)
Sand	#4 to #200 sieve (4.76 mm to 0.074 mm)
Silt	Passing #200 sieve (0.074 mm to 0.005 mm)
Clay	Smaller than 0.005 mm

Description of Other Components Present in Sample	Percent Dry Weight
Trace	1-9
Little	10-19
Some	20-34
And	35-50

CONSISTENCY OF COHESIVE SOILS:

Unconfined Compressive Strength, Qu, tsf	Consistency
<0.25	Very Soft
0.25 - 0.49	Soft
0.50 - 0.99	Medium (firm)
1.00 - 1.99	Stiff
2.00 - 3.99	Very Stiff
4.00 - 8.00	Hard
>8.00	Very Hard

RELATIVE DENSITY OF GRANULAR SOILS:

N-Blows per foot	Relative Density
0 - 3	Very Loose
4 - 9	Loose
10 - 29	Medium Dense
30 - 49	Dense
50 - 80	Very Dense
>80	Extremely Dense

STS Soil Classification System (1)

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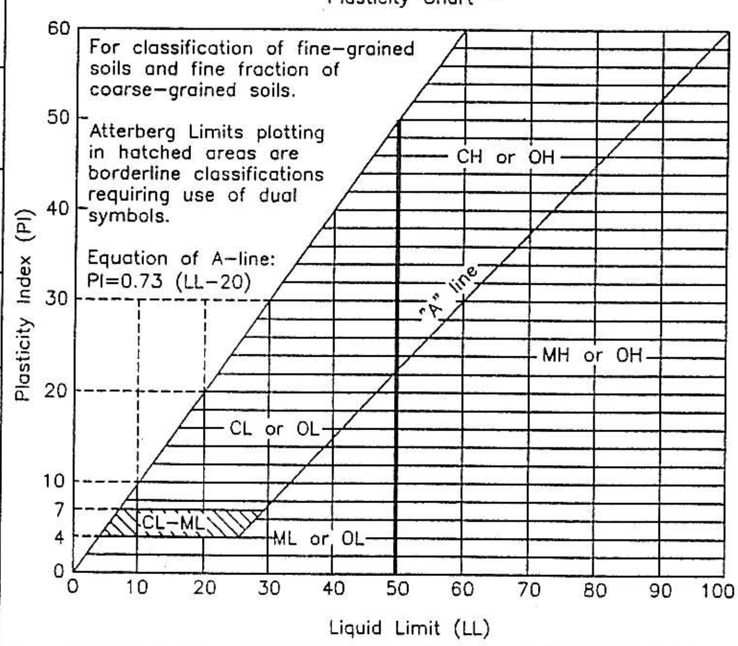
Major Divisions			Group Symbols	Typical Names	Laboratory Classification Criteria		
Coarse-grained soils (More than half of material is *larger* than No. 200 sieve size)	Gravel (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravel (Little or no fines)	GW	Well-graded, gravel, gravel-sand mixtures, little or no fines	Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows: Less than 5 percent ..... GW, GP, SW, SP; More than 12 percent .... GM, GC, SM, SC; 5 to 12 percent ...... Borderline cases *requiring* dual symbols (3)	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 & 3	
			GP	Poorly graded gravel, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravel with fines (Appreciable amount of fines)	GM	Silty gravel, gravel-sand-silt mixtures		Atterberg limits below "A" line or PI less than 4	Above "A" line with PI between 4 and 7 are ***borderline*** cases requiring use of dual symbols
			GC	Clayey gravel, gravel-sand-clay mixtures		Atterberg limits above "A" line or PI greater than 7	
	Sand (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sand (Little or no fines)	SW	Well-graded sand, gravelly sand, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ greater than 6; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 & 3	
			SP	Poorly graded sand, gravelly sand, little or no fines		Not meeting all gradation requirements for SW	
		Sand with fines (Appreciable amount of fines)	SM	Silty sand, sand-silt mixtures		Atterberg limits below "A" line or PI less than 4	Limits plotting in hatched zone with PI between 4 and 7 are ***borderline*** cases requiring use of dual symbols
			SC	Clayey sand, sand-clay mixtures		Atterberg limits above "A" line or PI greater than 7	
Fine-grained soils (More than half of material is *smaller* than No. 200 sieve size)	Silt and clay (Liquid limit less than 50)		ML	Inorganic silt and very fine sand, rock flour, silty or clayey fine sand or clayey silt with slight plasticity	Plasticity Chart (2)		
			CL	Inorganic clay of low to medium plasticity, gravelly clay, sandy clay, silty clay, lean clay			
			OL	Organic silt and organic silty clay of low plasticity			
	Silt and clay (Liquid limit greater than 50)		MH	Inorganic silt, micaceous or diatomaceous fine sandy or silty soils, elastic silt			
			CH	Inorganic clay of high plasticity, fat clay			
			OH	Organic clay of medium to high plasticity, organic silt			
	Highly organic soils		PT	Peat and other highly organic soil			

Plasticity Chart (2)



1) See STS General Notes for component gradation terminology, consistency of cohesive soils and relative density of granular soils.

2) Reference: Unified Soil Classification System

3) Borderline classifications, used for soils possessing characteristics of two groups, are designated by combinations of group symbols. For example: GW-GC, well-graded gravel-sand mixture with clay binder.

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SUBSURFACE EXPLORATION FIELD PROCEDURES

Hand-Auger Drilling (HA)

In this procedure, a sampling device is driven into the soil by repeated blows of a sledge hammer or a drop hammer. When the sampler is driven to the desired sample depth, the soil sample is retrieved. The hole is then advanced by manually turning the hand auger until the next sampling depth increment is reached. The hand auger drilling between sampling intervals also helps to clean and enlarge the borehole in preparation for obtaining the next sample.

Power Auger Drilling (PA)

In this type of drilling procedure, continuous flight augers are used to advance the boreholes. They are turned and hydraulically advanced by a truck, trailer or track-mounted unit as site accessibility dictates. In auger drilling, casing and drilling mud are not required to maintain open boreholes.

Hollow Stem Auger Drilling (HS)

In this drilling procedure, continuous flight augers having open stems are used to advance the boreholes. The open stem allows the sampling tool to be used without removing the augers from the borehole. Hollow stem augers thus provide support to the sides of the borehole during the sampling operations.

Rotary Drilling (RB)

In employing rotary drilling methods, various cutting bits are used to advance the boreholes. In this process, surface casing and/or drilling fluids are used to maintain open boreholes.

Diamond Core Drilling (DB)

Diamond core drilling is used to sample cemented formations. In this procedure, a double tube (or triple tube) core barrel with a diamond bit cuts an annular space around a cylindrical prism of the material sampled. The sample is retrieved by a catcher just above the bit. Samples recovered by this procedure are placed in sturdy containers in sequential order.

FIELD SAMPLING PROCEDURES

Auger Sampling (AS)

In this procedure, soil samples are collected from cuttings off of the auger flights as they are removed from the ground. Such samples provide a general indication of subsurface conditions; however, they do not provide undisturbed samples, nor do they provide samples from discrete depths.

Split-Barrel Sampling (SS) - (ASTM Standard D-1586-99)

In the split-barrel sampling procedure, a 2-inch O.D. split barrel sampler is driven into the soil a distance of 18 inches by means of a 140-pound hammer falling 30 inches. The value of the Standard Penetration Resistance is obtained by counting the number of blows of the hammer over the final 12 inches of driving. This value provides a qualitative indication of the in-place relative density of cohesionless soils. The indication is qualitative only, however, since many factors can significantly affect the Standard Penetration Resistance Value, and direct correlation of results obtained by drill crews using different rigs, drilling procedures, and hammer-rod-spoon assemblies should not be made. A portion of the recovered sample is placed in a sample jar and returned to the laboratory for further analysis and testing.

Shelby Tube Sampling Procedure (ST) - ASTM Standard D-1587-94

In the Shelby tube sampling procedure, a thin-walled steel seamless tube with a sharp cutting edge is pushed hydraulically into the soil and a relatively undisturbed sample is obtained. This procedure is generally employed in cohesive soils. The tubes are identified, sealed and carefully handled in the field to avoid excessive disturbance and are returned to the laboratory for extrusion and further analysis and testing.

Giddings Sampler (GS)

This type of sampling device consists of 5-foot sections of thin-wall tubing which are capable of retrieving continuous columns of soil in 5-foot maximum increments. Because of a continuous slot in the sampling tubes, the sampler allows field determination of stratification boundaries and containerization of soil samples from any sampling depth within the 5-foot interval.

LABORATORY PROCEDURES

Water Content (Wc)

The water content of a soil is the ratio of the weight of water in a given soil mass to the weight of the dry soil. Water content is generally expressed as a percentage.

Hand Penetrometer (Qp)

In the hand penetrometer test, the unconfined compressive strength of a soil is determined, to a maximum value of 4.5 tons per square foot (tsf) or 7.0 tsf depending on the testing device utilized, by measuring the resistance of the soil sample to penetration by a small, spring-calibrated cylinder. The hand penetrometer test has been carefully correlated with unconfined compressive strength tests, and thereby provides a useful and a relatively simple testing procedure in which soil strength can be quickly and easily estimated.

Unconfined Compression Tests (Qu)

In the unconfined compression strength test, an undisturbed prism of soil is loaded axially until failure or until 20% strain has been reached, whichever occurs first.

Dry Density (γd)

The dry density is a measure of the amount of solids in a unit volume of soil. Use of this value is often made when measuring the degree of compaction of a soil.

Classification of Samples

In conjunction with the sample testing program, all soil samples are examined in our laboratory and visually classified on the basis of their texture and plasticity in accordance with the STS Soil Classification System which is described on a separate sheet. The soil descriptions on the boring logs are derived from this system as well as the component gradation terminology, consistency of cohesive soils and relative density of granular soils as described on a separate sheet entitled "STS General Notes". The estimated group symbols included in parentheses following the soil descriptions on the boring logs are in general conformance with the Unified Soil Classification System (USCS) which serves as the basis of the STS Soil Classification System.

STS STANDARD BORING LOG PROCEDURES

In the process of obtaining and testing samples and preparing this report, standard procedures are followed regarding field logs, laboratory data sheets and samples.

Field logs are prepared during performance of the drilling and sampling operations and are intended to essentially portray field occurrences, sampling locations and procedures.

Samples obtained in the field are frequently subjected to additional testing and reclassification in the laboratory by experienced geotechnical engineers, and as such, differences between the field logs and the final logs may exist. The engineer preparing the report reviews the field logs, laboratory test data and classifications, and using judgment and experience in interpreting this data, may make further changes. It is common practice in the geotechnical engineering profession not to include field logs and laboratory data sheets in engineering reports, because they do not represent the engineer's final opinions as to appropriate descriptions for conditions encountered in the exploration and testing work. Results of laboratory tests are generally shown on the boring logs or are described in the text of the report, as appropriate.

Samples taken in the field, some of which are later subjected to laboratory tests, are retained in our laboratory for sixty days and are then discarded unless special disposition is requested by our client. Samples retained over a long period of time, even in sealed jars, are subject to moisture loss which changes the apparent strength of cohesive soil, generally increasing the strength from what was originally encountered in the field. Since they are then no longer representative of the moisture conditions initially encountered, observers of these samples should recognize this factor.

Care should be exercised to minimize disturbance and degradation of subgrade soils for foundations, slabs-on-grade, pavements and areas to be filled. Water should not be allowed to pond on the surface of exposed subgrade soils, as this could cause a softening of the subgrade, particularly when subjected to construction traffic. Disturbed or softened subgrade soils should be removed to a suitable undisturbed subgrade prior to fill or concrete placement.

Wet subgrade conditions may result from precipitation, runoff and groundwater seepage through excavation walls and bottom. Precipitation risk can be minimized by scheduling construction for drier seasons. The subgrade should be sloped to drainage ditches and sumps to minimize water accumulations. Runoff from adjacent areas should be eliminated by use of berms and ditches to channel water away. Groundwater seepage may be minimized by use of dewatering systems such as wells and/or groundwater isolation systems such as cutoff walls or trenches. Dewatering wells and/or groundwater isolation systems are recommended where upward seepage is likely to cause the subgrade to loosen and become "quick" or where lateral seepage may erode the face soil or cause "piping" of fines from the soil matrix as exhibited by muddy or silt laden water.

If moisture or disturbance sensitive subgrade soils and wet conditions are expected and construction of facilities bearing on the subgrade will not promptly protect the subgrade soils, then consideration should be given to protecting the subgrade by promptly placing appropriate combinations of a geotextile, a gravel base course and a lean concrete mud mat over the prepared and approved subgrade. Geotextiles should be considered for use to separate the subgrade and gravel where subgrade soils are at risk of migrating into the gravel base course. A suitably designed gravel base course should help surcharge the subgrade and act as a drainage layer for removing water accumulations. A lean concrete or flowable fill mud mat with a thickness of several inches or more may be placed directly on the subgrade if upward seepage does not exist. If base drainage is needed, a lean concrete or flowable fill mud mat may be placed over a gravel base course. A mud mat will help to isolate water, provide surcharge against loosening and will provide a stable surface which is resistant to disturbance from construction traffic. Sump and pump systems or dewatering wells should be used to remove any accumulating water or water pressure in the gravel base course.

In any areas where unsuitable conditions develop despite protection measures, subgrade stabilization should be performed as described in a separate sheet entitled "STS Subgrade Stabilization Guideline".

Subgrade stabilization may be required if zones of unsuitable soil are encountered upon excavating to the subgrade level or if subgrade degradation occurs from construction traffic, moisture accumulations, freeze-thaw cycles or other causes. Care should always be used to minimize disturbance and degradation of subgrade soils below foundations, slabs-on-grade, pavements and fill areas. Water should not be allowed to pond on the surface of exposed subgrade soils, as this could cause a softening of the subgrade, particularly when subjected to construction traffic. Detrimental groundwater seepage should not be allowed to soften or loosen the subgrade.

Unsuitable subgrade soils that are encountered or subgrade soils that become disturbed or softened after exposure should be improved prior to concrete or new material placement. The unsuitable soils should either be properly compacted in place (if feasible based on material type, moisture content and thickness), or over-excavations should extend through the unsuitable soils to remove them to an underlying competent soil stratum.

If improvement by over-excavating is performed, footing walls can be extended deeper and supported at the level where suitable soil is encountered. Alternatively, the over-excavations can be backfilled to the design level using either a suitable compacted structural fill material or a flowable cementitious fill.

If the over-excavations are backfilled using structural soil fill, the over-excavations should extend a minimum of 1 foot horizontally from each edge of the footing for each foot of fill required below the footing base. The structural soil fill should be placed, compacted and tested in accordance with a separate document entitled STS Earthwork Guideline. Generally, a well-graded granular material is more suitable for stabilization work than cohesive soils. If an open-graded granular material is planned as the backfill and the new subgrade or surrounding soils contain zones of cohesionless fine sands or silts which may migrate into the open-graded backfill, then an appropriately designed geotextile should be utilized to separate the stabilization material from the subgrade and surrounding trench soils. Failure to provide such separation may cause lost ground from surrounding soils and detrimental settlements.

Horizontal over-excavation is unnecessary if footing walls are extended to the lower suitable subgrade level or if flowable fill is used to backfill the over-excavated area. Flowable fill should have a sufficient Portland cement and/or fly ash content to achieve 28 day unconfined compressive strengths in the range of 50 to 200 pounds per square inch (psi).

Fill or backfill required on the project should consist of a non-frozen, non-organic granular material, aggregate or natural soil that is free of debris and particles larger than 25 percent of the loose lift thickness. The natural water content of cohesive fill soil at the time of compaction should generally be within -2 to +3 percent of the optimum water content as determined by the Standard Proctor test (ASTM D-698). Difficulty in obtaining the desired degree of compaction is expected for soil that is too dry or too wet. The water content should be adjusted by sprinkling if too dry or by scarifying and aerating if too wet. Blending with an additive such as fly ash or drier soil may also help produce an acceptable water content.

Fill or backfill which is relatively uniform should be used on the project. Non-uniform materials or mixing two or more materials will reduce the degree of certainty in the test results and will tend to cause variable compressibility of the fill.

Fill or backfill should be placed on a firm, checked subgrade in horizontal lifts with a loose thickness not greater than 12 inches for granular material and 9 inches for cohesive soil. It should then be compacted with equipment that is suited to the soil type and compaction requirements. Normally, vibratory roller or plate compactors are better suited for granular soils, while a sheepsfoot or other "kneading" type of compactors are more effective in cohesive soils. Lighter, hand-propelled compactors should generally be utilized to compact backfill within 5 feet of structures unless the structure is designed to resist expected lateral pressures from use of heavier compactors. When using lighter, hand-propelled compactors, a maximum loose lift thickness of 8 inches should be used for granular material and 6 inches for cohesive soil.

Unless stated otherwise in the report text, fill or backfill that supports foundations, floor slabs that are loaded in excess of 400 psf, and roadway pavement that is subjected to concentrated automobile or truck traffic should be compacted to a dry density of 95% or more of the maximum dry density determined by Standard Proctor tests (ASTM D-698) on representative samples of the fill material. Fill or backfill that supports lightly loaded floor slabs, sidewalks or pavement that is subjected to dispersed automobile traffic should be compacted to a dry density of 90% or more of the maximum dry density determined by Standard Proctor tests on representative samples of the fill material. Compaction tests may be considered satisfactory if the average of five consecutive tests on similarly compacted material exceeds the required compaction and no individual test is more than 2% below the required percentage of compaction.

Proper compaction is generally difficult to achieve near the edge of a slope or embankment fill due to lack of confinement. For this reason, we recommend that the compacted fill or backfill zone extend horizontally beyond the edge of foundations a minimum of 1 foot at the subgrade level and then with depth at a minimum slope of 1 horizontal to 1 vertical.

Fill material acceptability, subgrade preparation and testing for suitability, fill placement and fill compaction should be monitored continuously or at least regularly by a qualified soils technician whom reports to the geotechnical engineer for the project. Compaction density for structural fill should be tested at a minimum frequency of once per 5000 ft^2 of fill area or once per 200 yd^3 of compacted material placed unless stated otherwise in our report. In non-structural fill areas, testing frequencies may be reduced in half.