Important Points in soil classification in Foundation Design

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Abstract: It is necessary for the foundation engineer to classify the site soils for use as a foundation for several reasons: l. To be able to use the data base of others in predicting foundation performance. 2. To build the geotechnical engineer's data base in the "art" application of design. 3. To maintain a permanent record which can be understood by others should problems later develop and outside parties be required to investigate the original design. Normally the Unified Soil Classification system (Table 2-1) with slight modifications is used in foundation design work. For example, in much foundation work it is academic whether a sand is well or poorly graded, but its density and the presence of gravel are of considerable interest. Whether a fine-grained cohesive soil is actually a clayey silt rather than a silty clay is not as important as identifying its strength and settlement characteristics

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1- Introduction

In foundation work the following terms are commonly used for cohesionless soil deposits:
Loose
Medium
Dense

Table 3-2 gives additional subdivisions with quantifications based on using field exploration data. Noting that these terms are both subjective and comparative[1], one should avoid using an excessive number of subdivisions. Similar subjective terms used for cohesive soils are:
Very soft
Soft
Medium
Stiff
Hard

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2- Soil Classification Terms

Identifying names, some of which are local in nature, are assigned to certain sizes or types of rock or soil formations, of which some of the principal ones are as follows:

1. Bedrock. Rock in its native location, usually extending greatly both horizontally and vertically. This material is generally overlain by soil of varying depths. If exposed, the outer portions may become weathered. Bedrock varies from igneous rocks, generally the hardest and formed from molten magma, to metamorphic rocks formed from metamorphosing sedimentary rocks under great heat and pressure, to sedimentary rocks formed as a combination of chemical action and pressure from overlying soil deposits. Rocks may be solid, but the interface with the overlying soil

may be much fractured and eroded and may contain voids from several weathering processes. Depending on the geologic history of the area, the rocks may be much fractured, folded, and faulted. Various textbooks on geology should be consulted for further information, especially concerning particular areas [e.g., Legget (1962), Thornbury (1965), both with extensive references].

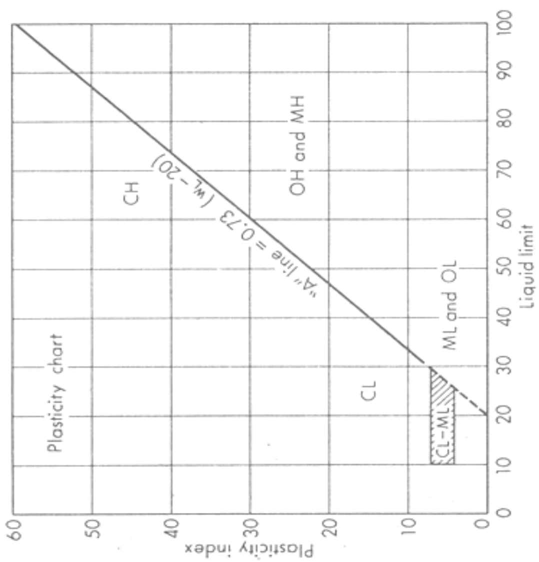
2. Boulders. Smaller pieces of material which have broken away from the bedrock, usually 250 to 300 mm or more in dimension (Table 2-2). Pieces smaller than boulders may be called cobbles (50 to 75 mm minimum size) or pebbles (3 to 5 mm minimum size).

3. Gravel. Common term used to describe pieces of rock from about 150 mm maximum to less than 5 mm dimensions. May be crushed stone when manufactured, hank-run gravel when excavated from a naturally occurring deposit and containing finer material, or pea yrauef if it has been screened to sizes 5 to 3 mm (pea size). Gravel is a cohesionless material; that is, it does not possess particle adhesion or attraction.

Major divisions			Group symbols	Typical names		Laboratory classification criteria	
Coarse-grained soils (More than half of material is larger than No. 200 sieve size)	Gravels (More than half of coarse fraction is larger than No. 4 sieve size)	Clean gravels (Little or no fines)	GW	Well-graded gravels, 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†	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ between 1 and 3	
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines		Not meeting all gradation requirements for GW	
		Gravels with fines (Appreciable amount of fines)	GM* d / u	Silty gravels, gravel-sand-silt mixtures		Atterberg limits below "A" line or I_p less than 4	Above "A" line with I_p between 4 and 7 are *borderline* cases requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures		Atterberg limits above "A" line with I_p greater than 7	
	Sands (More than half of coarse fraction is smaller than No. 4 sieve size)	Clean sands (Little or no fines)	SW	Well-graded sands, gravelly sands, 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 and 3	
			SP	Poorly graded sands, gravelly sands, little or no fines		Not meeting all gradation requirements for SW	
		Sands with fines (Appreciable amount of fines)	SM* d / u	Silty sands, sand-silt mixtures		Atterberg limits below "A" line or I_p less than 4	Limits plotting in hatched zone with I_p between 4 and 7 are *borderline* cases requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures		Atterberg limits above "A" line with I_p greater than 7	

Table 1

Fine-grained soils (More than half of material is smaller than No. 200 sieve)	Silts and clays (Liquid limit less than 50)	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, or clayey silts with slight plasticity	
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
		OL	Organic silts and organic silty clays of low plasticity	
	Silts and clays (Liquid limit greater than 50)	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts	
		CH	Inorganic clays of high plasticity, fat clays	
		OH	Organic clays of medium to high plasticity, organic silts	
	Highly organic soils	Pt	Peat and other highly organic soils	



Material	Upper, mm	Lower, mm	Comments
Boulders (or cobbles)	300 +	75	
Gravel	75	2–5	No. 4 or No. 10 sieve
Sand	2–5	0.074–0.05	No. 200 sieve or less
Silt	0.074–0.05	0.006	
Rock flour	0.006		Inert
Clay	0.002	0.001	Particie attraction
Colloids	0.001		

Table 2

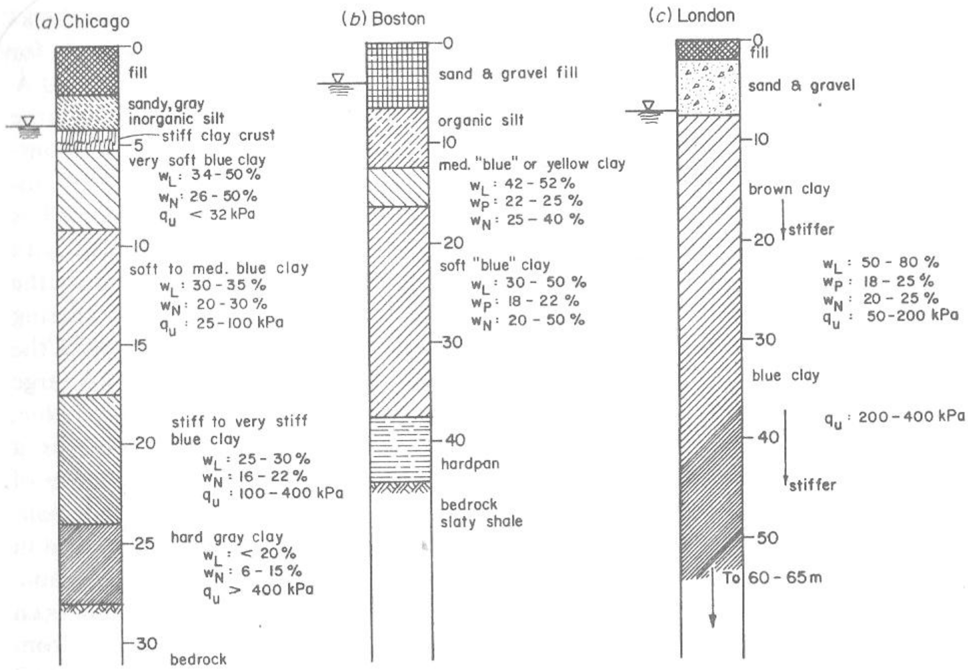
4. Sand. Mineral particles smaller than gravel but larger than about 0.05 to 0.074 mm. May be fine, medium, or coarse, depending on the size of the majority of the particles. Sand is a cohesionless material; however, if it is damp or moist, the surface tension of the water may give an apparent cohesion which disappears when the material dries or becomes saturated. Sand is a favorable construction material. It has excellent bearing capacity if confined. Unconfined medium to fine sand will flow from beneath foundations, pavements, etc., and this process can be accelerated by water flowing through and by wave or stream action eroding it. Since water flows easily through sand, any retaining structure for water must contain non sand materials such as silts, clays, or mixtures of both. Excavations in sand will stand on slopes of about 16' to 1.SH or less. Excavations steeper than this are potentially unstable.

5. Silt. Mineral particles ranging in size from 0.05 to 0.074 mm maximum to 0.002 to 0.006 mm. It is called organic silt if it contains appreciable quantities of organic materials, and inorganic silt if no organic materials are present. Silt usually exhibits some cohesion, or particle attraction and adhesion, and may also have apparent cohesion, which is lost upon drying. Generally the cohesion in silt soils is due to the presence of clay particles dispersed through the mass. Often as little as 5 to 8 percent clay particles will give significant clay characteristics to a silt. Silt is generally not a very good foundation material unless dry or highly compressed into a sedimentary rock (siltstone). It is normally loose and quite compressible. As a construction material, it is difficult to compact unless the water content is carefully controlled. Material too wet is likely to weave (sometimes termed bull's liver) ahead of compaction equipment.

6. Clay. Mineral particles smaller than silt size (most authorities currently take clay particles as sizes 0.002 mm or smaller). If the particles are smaller than about 0.001 mm (1 μm), they may be called colloids. The clay particles are complex hydroaluminum silicates (AI_2O_3 – $nSiO_2$ - kH_2O, where n and k are numerical values of molecules attached). Montmorillonite is a term for the most common mineral of the montmorillonite group, and is the most active of the identified clay minerals.

3- Review of expriements

The particle consists of a gibbsite (approximately, $A1_2O_3$ - $3H_2O$) mass sandwiched between two silica sheets for a total thickness of approximately 10 $\mathring{A}$ (angstroms). This material has a strong affinity for water, and may take on as much as 200 $\mathring{A}$ of water for a total of 400 $\mathring{A}$ between clay particles. It is this affinity for water which accounts in a large part for the high shrinkage and swelling characteristics (activity) of the montmorillonite clays. The usual thickness of water is probably 10 to 100 $\mathring{A}$. Another clay mineral, illire, the most commonly occurring of the illite group, is less active than montmorillonite, since the adjacent silica layers are bonded with potassium ions, which provide a stronger bond than the water bond of the montmorillonite mineral. A third clay mineral, the most commonly occurring of the kaolin group, is kaolinite ($A1_2O_3$ - 2SiO - $2H_2O$), the least active of the clay minerals. Some other clay minerals are bentonite, which contains large quantities of montmorillonite and is highly active, halloysite, pyrophyllite, chlorite, and vermiculite. Clay is also defined as a cohesive material, that is, a material in which the particles tend to stick together from a combination of interparticle attractions and water effects. Kaolinite, illite, and montmorillonite are the most commonly occurring clay minerals[2]. Clays tend to be named in certain locales. For example, London clay is a clay found in London, England, with certain characteristics, Boston blue clay from Boston, Mass., has been reported by Casagrande and Fadum (1944) and others. Chicago blue clay from Chicago, Ill., has been extensively studied by Peck [see Peck and Reed (1954)] and others. Leda clay found in large areas of Ottawa Province in Canada has been extensively studied and reported [Crawford (1961), Soderman and Quigley (1965)].



Typical rofiles of the Boston, Chicago, and London, clay are illustrated in Fig. 2-4

Conclusion

1- Never use the soil that you do not know what activity it will have under structure pressure
2- Using of Rock in foundation of heavy structure can make the foundation site smart.

References

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