Construction Site Work, Site Utilities, and Substructures DATABOOK

- Excavation and Soils
- Piping Specifications
- Concrete/Masonry
- Piles, Caissons, Rock and Soil Anchors
- Equipment Selection

Sidney M. Levy

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Introduction

The *Construction Site Work, Site Utilities, and Substructures Databook* provides the builder, the project manager, the construction superintendent, design consultants, and facility managers with a one-source reference guide to soils, excavation and site work, substructures, underground piping systems, landscaping and site improvement components, installation techniques, and product specifications. No need to consult numerous volumes when all of the most frequently required data is readily at hand in one book.

Valuable information such as typical working ranges for excavating and hoisting equipment can be extracted in order to select the right equipment for the job. A section on metrification will prove useful as the U.S. construction market slowly adjusts to this soon-to-be-universal system.

Complete specifications and recommended installation instructions for concrete and corrugated metal pipe, ductile iron, cast pipe and fittings along with non-metallic piping will ensure that a proper installation can be effected. Need to convert the Latin name for those trees or shrubs on the landscaping plan to common names? Just look in Section 7.

Much of the material in the *Databook* has been gleaned from manufacturers' sources and trade association–furnished information; some of this information is proprietary in nature, but much is generic.

How many times during project meetings, field visits, or conversations with specialty contractors is it convenient to have a concise source of site-work-related information handy? The *Construction Site Work, Site Utilities, and Substructures Databook* will go a long way in satisfying those needs.

I selected those products and equipment that, in my 40 years in the industry, appear to be those for which reference material is so often required, always needed "yesterday," and so elusive to find in a hurry.

For those experienced construction professionals, the *Construction Site Work, Site Utilities, and Substructures Databook* may serve as a "refresher" course, and for those new to the industry, it offers a simpler way to become familiar with the complex and often bewildering array of products on the market.

I hope you find the *Databook* a worthwhile addition to your construction library.

Sidney M. Levy

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Sitework

Contents

1.0.0 Investigation

Site work involves working with various types of soils and dealing with the unexpected—even in the presence of extensive soil test borings.

Even prior to commencing construction, a thorough investigation of the site, both visually and after a review of available geotechnical reports, the contractor will be more prepared for what lies ahead.

1. Does a visual inspection of the site reveal any clues to the composition and consistency of the soil?
2. Are there rock outcroppings? If so, what is the nature of the rock?
3. Is there any indication of the presence of ground water close to the surface of the site?
4. Do any remains of abandoned subsurface structures appear in areas where excavation will be required?
5. Do any structures require demolition in areas where new structures are to be built or where underground utilities are to be installed?
6. Are any utilities absent that might be required during construction (i.e., water, electric power, telephone lines, sanitary and storm sewers, or gas mains)? Are any of these utilities in areas where new construction will be required and are to be relocated?
7. What do the soil test borings reveal?

Analyzing a typical soil test boring should start with a look at the consistency of the soil (as reported on the report), the presence or absence of rock or any other underground obstructions, the level at which water was observed, and the blow count (an indication of soil-bearing capacity). The blows per foot also reveal the plasticity of the soil.

1.1.0 Glossary of Terms

AASHTO American Association of State Highway and Transportation Officials.

AASHTO T-180 American Association of State Highway and Transportation Officials standard for the modified Proctor test.

AASHTO T-99 American Association of State Highway and Transportation Officials standard for the standard Proctor test.

Aeolian deposits Wind-deposited materials such as sand dunes or other silty-type materials.

Aggregate (coarse or fine) Crushed rock, sand, or gravel that has been graded and may be used as backfill material.

Air gap reading The nuclear density meter test procedure that allows for cancellation of error in reading due to the chemical composition of the soil tested.

Alluvium Material that has been deposited by streams that may no longer exist or that form existing floodplains.

Amplitude The distance an oscillating body moves in one direction from its neutral axis to the outer limit of travel.

Aquifer A geologic formation that provides water in sufficient quantities to create a spring or well.

ASTM American Society for Testing and Materials.

ASTM D 1557 American Society for Testing and Materials standard for the modified Proctor test.

ASTM D 698 American Society for Testing and Materials standard for the standard Proctor test.

Backfill Materials used to refill a cut or other excavation, or the act of such refilling.

Backscatter A method of nuclear density meter soil testing in which the radiation source is placed in contact with the soil surface and density readings taken from the reflected radiation, the principle being that dense materials absorb more radiation than materials that are not as dense.

Bank A mass of soil that rises above the normal earth level. Generally any soil that is to be dug from its natural position.

Bank-run gravel (run of bank gravel) Gravel as it is excavated from a bank in its natural state.

Bank-yards The measurement of soil or rock taken before digging or disturbing from its original position.

Base The course or layer of materials in a road section on which the actual pavement is placed. This layer may be composed of many different types of materials, ranging from selected soils to crushed stone or gravel.

Base course A layer of material selected to provide a subgrade for some load-bearing structure (such as paving) or to provide some for drainage under a structure above.

Berm An artificial ridge of earth. This term is generally applied to the slide-slopes of a road bed.

Binder A material that passes through a No. 40 U.S. standard sieve that is used to fill voids or hold gravel together.

Borrow pit An excavation from which fill material is taken.

Boulder A rock fragment with a diameter larger than 12 inches (304.8 mm).

Capillary action The cohesive, adhesive, or tensive force that causes water that is contained within soil channels to rise or depress on the normal horizontal plane or level.

Cemented soil Soil in which particles are held together by a chemical agent, such as calcium carbonate.

Centrifugal force The pulling force of an eccentric weight when put in rotary motion that may be changed by varying the rotational speed and/or mass of the eccentric and/or center of gravity (shape) of the eccentric weight.

Clay A cohesive mineral soil consisting of particles less than 0.002 mm in equivalent diameter, a soil textural class, or a fine-grained soil with more than 50 percent passing through a No. 200 sieve that has a high plasticity index in relation to its liquid limit.

Clean Free of foreign material. When used in reference to sand or gravel, it means the lack of a binder.

Cobble A rock fragment, generally oblong or rounded, with an average dimension ranging from 3 inches (75 mm) to 12 inches (305 mm).

Cohesion Shear resistance of soil at zero normal stress; also, the quality of some soil particles to attract and stick to like particles; sticking together.

Cohesionless soil A soil that when air-dried in an unconfined space has little cohesion when submerged.

Cohesive material A soil having properties of cohesion.

Cohesive soil A soil that when in an unconfined state has considerable strength when air-dried and submerged.

Compacted yards The cubic measurement of backfill after it has been placed and compacted in fill.

Compaction A process to decrease voids between soil particles when subjected to the forces applied by special equipment.

Compressibility The property of a soil to remain in a compressed state after compaction.

Contact reading A reading by a nuclear density meter when the bottom of the meter is in full contact with the compacted material to be tested.

Core A cylindrical sample of an underground formation, cut and raised by a rotary hollow bit drill.

Crown The center elevation of a road surface used to encourage drainage.

Datum Any level surface used as a plane of reference to measure elevations.

Density The mass of solid particles in a sample of soil or rock.

Double amplitude The distance an oscillating body moves from its neutral axis to the outer limit of its travel in opposite directions.

Dry soil Soil that does not exhibit visible signs of moisture content.

Dynamic linear force The force pounds per inch (lb/in.) seen by the soil as produced by a vibratory roller. Calculated by dividing the centrifugal force by the width of the compacting surface(s).

Eccentric A mass of weight off-balanced to produce centrifugal force (lb) and being part of the exciter unit that produces vibration.

Elasticity Properties that cause soil to rebound after compaction.

Embankment A fill whose top is higher than the adjoining natural compaction.

End result specifications Compaction specifications that allow results instead of method specifications to be the determining factor in the selection of equipment.

Exciter The component of a vibratory compactor that creates centrifugal force by means of a power-driven eccentric weight.

Fines The smallest soil particles (less than 0.002 mm) in a graded soil mixture.

Fissured soil Soil material that has a tendency to break along definite planes of fracture with little resistance.

Foot or shoe The bottom part of a vibratory impact rammer contacting the soil.

Frequency The rate at which a vibrating compactor operates, usually expressed in vibrations per minute (VPM).

Glacial till Unstratified glacial materials deposited by the movement of ice and composed of sand, clay, gravel, and boulders in any proportion.

Grade Usually defined as the surface elevation of the ground at points where it meets a structure; also, surface slope.

Grain distribution curve A soil analysis graph showing the percentage of particle size variations by weight.

Granular material A type of soil whose particles are coarser than cohesive material and do not stick to each other.

Granular soil Gravel, sand, or silt with little or no clay content. It has no cohesive strength, cannot be molded when moist, and crumbles easily when dry.

Gravel Round or semi-round particle of rock that pass through a 3-inch (76.2 mm) sieve and be retained by a No. 4 U.S. standard sieve [approximately $^1/_4$ inch (6.35 mm)]. It is also defined as an aggregate, consisting of particles that range in size from $^1/_4$ inch (6.35 mm) to 3 inches (76.2 mm).

Gumbo Clays that are distinguished in the plastic state by a soapy or waxy appearance and great toughness.

Hardpan Soil that has become rocklike because of the accumulation of cementing minerals, such as calcium carbonate, in the soil.

Impervious Resistance to movement of water.

In-situ The natural, undisturbed soil in place.

Internal friction The soil particle's resistance to movement within the soil mass. For sand, the internal friction is dependent on the gradation, density, and shape of the grain and is relatively independent of the moisture content. For a clay, internal friction varies with the moisture content.

Layered system Two or more distinctly different soil or rock types arranged in layers.

Lift A layer of fill as spread or compacted. A measurement of material depth. The amplitude of a rammer's shoe. The rated effective soil depth a compactor can achieve.

Liquid limit The water content at which the soil changes from a plastic to a liquid state.

Loam A soft, easily worked soil that contains sand, silt, clay, and decayed vegetation.

Loess A uniform aeolian deposit of silty material having an open structure and relatively high cohesion because of the cementation of clay or marl.

Marl Calcareous clay that contains from 35 to 65 percent calcium carbonate.

Muck Mud rich in humus or decayed vegetation.

Mud Generally, any soil containing enough water to make it soft and plastic.

Optimum moisture content Water content at which a soil can be compacted to a maximum-unit dry-unit weight.

Organic clay/soil/silt Clay/soil/silt with high organic content.

Pass A working trip or passage of an excavating, grading, or compaction machine.

Peat A soft, light swamp soil consisting mostly of decayed vegetation.

Perched water table A water table of generally limited area that appears above the normal free-water elevation.

Plastic A property of soil that allows the soil to be deformed or molded without cracking or causing an appreciable volume change.

Plasticity index The numeric difference between a soil's liquid limit and its plastic limit.

Plastic limit The lowest water content of a soil, at which the soil just begins to crumble when rolled into a cylinder approximately $\frac{1}{8}$ inch (3.17 mm) in diameter.

Proctor modified A moisture–density test of more rigid specifications than the standard Proctor test. The basic difference is use of a heavier weight dropped from a greater distance in laboratory determinations.

Proctor standard A test method developed by R. R. Proctor for determining the density–moisture relationship in soils. It is almost universally used to determine the maximum density of any soil so that specifications may be properly prepared for field construction requirements.

Quicksand Fine sand or silt that is prevented from stabilizing by a continuous upward movement of underground water.

Relative compaction The dry unit of weight of soil compared to the maximum unit weight obtained in a laboratory compaction test and expressed as a ratio.

Silt A soil composed of particles between 0.00024 inches (0.006 mm) and 0.003 inches (0.076 mm) in diameter.

Soil The loose surface material of the earth's crust.

Specific gravity The ratio of weight in air of a given volume of solids at a stated temperature to the weight in air of an equal volume of distilled water at the stated temperature.

Stabilize To make soil firm and prevent it from moving.

Static linear force The force in pounds per inch (lb/in.) seen by the soil as produced by a nonvibratory roller. Calculated by dividing the dead weight of the compactor by the width of the compacting surface(s).

Subbase The layer of selected material placed to furnish strength to the base of a road. In areas where construction goes through marshy, swampy, unstable land, it is often necessary to excavate the natural material in the roadway and replace it with more stable materials. The material used to replace the unstable natural soils is generally called subbase material, and when compacted is known as the subbase.

Subgrade The surface produced grading native earth, or inexpensive materials that serve as a base for a more expensive paving.

VPM Vibrations per minute, derived by the rate of revolutions the exciter makes each minute.

1.1.1 Soil Classification Systems

Soils can be classified in several different methods and categories. The Tyler System uses opening per lineal inch of wire screen to determine particle size. For example, according to this system, a No. 20 mesh has 20 openings per lineal inch of screen, which equates to a sieve size of 0.0328 inches (0.833 mm).

The Unified Soil Classification System, the most widely used classification system, uses letters to designate soil types within three major groups: coarse-grained, fine-grained, and highly organic soils.

- *Coarse-grained soil* Includes gravel, sands, and mixtures of the two. The letter *G* denotes gravel and the letter *S* denotes sand. In mixtures, the first letter indicates the primary constituent, e.g., GS. Both gravel and sand are further divided into four groups:
  - *Well graded* Designated by the letter *W*.
  - *Poorly graded* Designated by the letter *P*.
  - *Dirty with plastic fines* Designated *P*.
  - *Dirty with nonplastic silty fines* If it will pass through a No. 200 sieve, it is designated by the letter *M*.

  The coefficient of uniformity (Cu) is computed from data taken from a grain size distribution curve.

- *Fine-grained soils* These soils are further divided into inorganic silts (M), inorganic clays (c), and organic silts or clays (O). Each group is further divided into soils having liquid limits lower than 50 percent (L) and those with liquid limits higher than 50 percent (H). For example, an inorganic silt with liquid limit lower than 50 percent would be designated *ML*.
- *Highly organic soils* This group is identified by the letters *Pt*, for peat, which is characteristic of materials in this grouping.

1.1.2 Unified Soil Classification

TABLE 2. UNIFIED SOIL CLASSIFICATION

MAJOR DIVISIONS		SYMBOL	TYPICAL NAMES
GRAVELS (More than half of coarse fraction larger than #4 sieve size)	Clean gravel	GW	Well-graded gravel, gravel-sand mixtures
		GP	Poorly graded gravel, gravel-sand mixtures
	Gravel with fines	GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand clay mixtures
SANDS (More than half of coarse fraction smaller than #4 sieve size)	Clean Sands	SW	Well-graded sands, gravelly sands
		SP	Poorly graded sands, gravelly sands
	Sands with fines	SM	Silty sands, sand-silt mixture
		SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (More than half of material is smaller than #200 sieve)	Silts & Clays (LL < 50)	ML	Inorganic silt & very fine sands, clayey fine sands/silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, sandy/gravelly clays
		OL	Organic silts and organic silty clays of low plasticity
	Silts & Clays (LL > 50)	MH	Inorganic silts, fine sandy/silty soils, elastic silts
		CH	Inorganic clays, medium to high plasticity, fat clays
	Highly organic soils	PT	Peat and highly organic soils

1.1.3 OSHA Soil Classification

OSHA uses a soil-classification system as a means of categorizing soil and rock deposits in a hierarchy of stable rock, Type A soil, Type B soil, and Type c soil, in decreasing order of stability. Maximum allowable slopes are set forth, according to the soil or rock type.

Soil or rock type	Maximum allowable slope for excavation less than 20 feet
Stable rock	Vertical (90 degrees)
Type A soil	3/4:1 (53 degrees)
Type B soil	1:1 (45 degrees)
Type C soil	1½:1 (34 degrees)

A short-term maximum allowable slope of 1½ H:1V (63°) is allowed in excavations in Type A soil that are 12 ft (3.67 m) or less in depth. Short-term maximum allowable slopes for excavations greater than 12 ft (3.67 m) in depth shall be ¾ H:1V (53°)

Note: Consult OSHA for definition of *short-term.*

Type A: A cohesive soil with an unconfined compressive strength of 1.5 tons per square foot (144 kPa) or greater. Cohesive soils can be categorized as silty, clay, sandy clay, clay loam, and cemented soils. No soil is classified Type A if:

1. The soil is fissured.
2. The soil is subject to vibration from heavy traffic or pile driving.
3. The soil has previously been disturbed.
4. The soil is part of a sloped, layered system, where the layers dip into the excavation on a slope of 4 horizontal to 1 vertical.
5. The material is subject to other factors that tend to make it less stable.

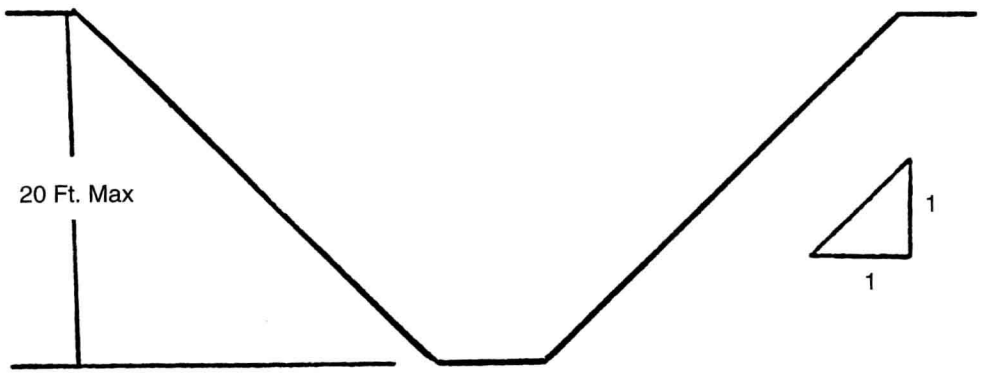
Type B: A cohesive soil with an unconfined compressive strength of greater than 0.5 tons per square foot (48 kPa), but not less than 1.5 tons per square foot (144 kPa). This classification applies to cohesionless soils, including angular gravel (similar to crushed rock), silt, silt loam, sandy loam, and in some cases, silty clay loam and sandy clay loam. This classification also applies to previously disturbed soils, except those that would be classified as Type C or soil that meets the unconfined compressive strength or cementation requirements for type A, but is fissured or subject to vibration; dry rock that is not stable; or material that is part of a sloped, layered system, where the layers dip into the excavation on a slope less steep than 4 horizontal to 1 vertical, but only if the material would otherwise be classified Type B.

Type C: A cohesive soil with an unconfined compressive strength of 0.5 tons per square foot (48 kPa) or less, generally consisting of granular soils (including gravel, sand and loamy sand, submerged soil, soil from which water freely seeps, submerged rock that is not stable, or material in a sloped, layered system, where the layers dip into the excavation on a slope of 4 horizontal to 1 vertical (or steeper).

OSHA, in 1926.652 Appendix B, lists standards, interpretations, and illustrations of simple, single, multiple benches, and the use of trench support and shield systems for 20-foot (maximum) excavation depths. OSHA pages 186.8 and 186.9 of Appendix B contain diagrams that depict benched excavations for various types of excavations. For a complete explanation of excavations and trench-protection requirements, refer to the entire text of OSHA CFR 1926.652 in Appendix B.

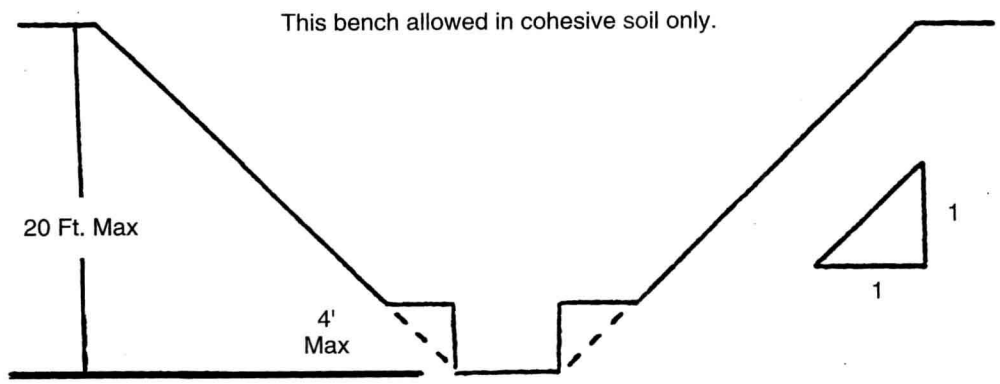
1.1.4 OSHA Simple Slope and Single- and Multiple-Bench Diagrams

1.

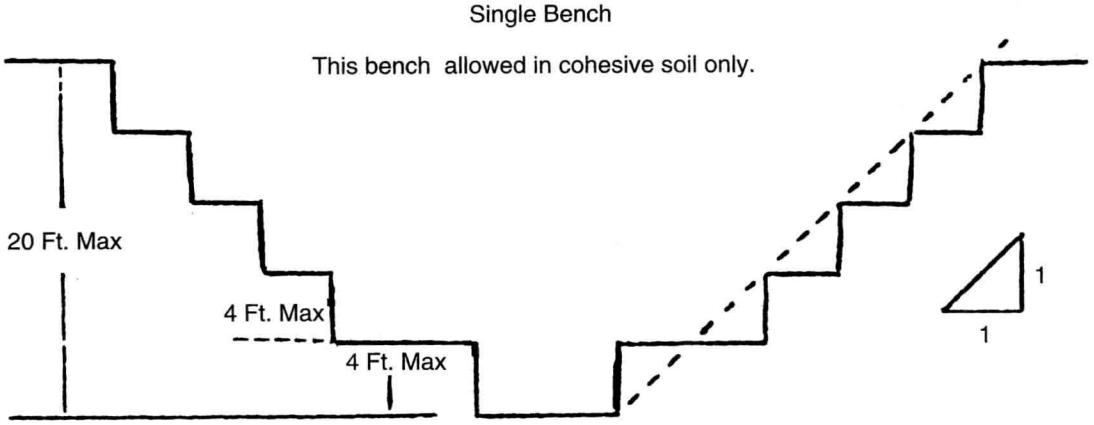


Simple slope

2. All benched excavations 20 feet or less in depth shall have a maximum allowable slope of 1 : 1 and maximum bench dimensions as follows:



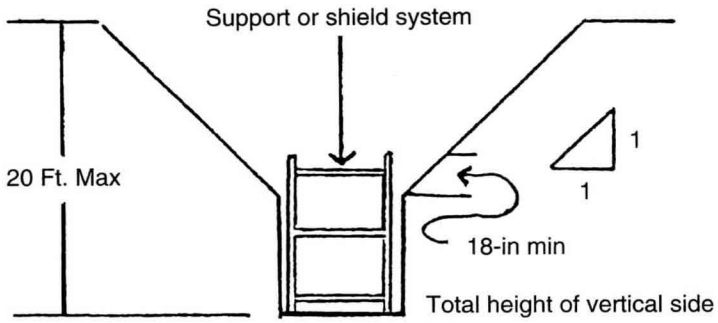
Single Bench



Multiple Bench

3. All excavations 20 feet or less in depth that have vertically sided lower portions shall be shielded or supported to a height at least 18 inches above the top of the vertical slide. All such excavations shall have a maximum allowable slope of 1 : 1.

1.1.5 OSHA Simple Slope and Vertical-Sided Trench-Excavation Diagrams

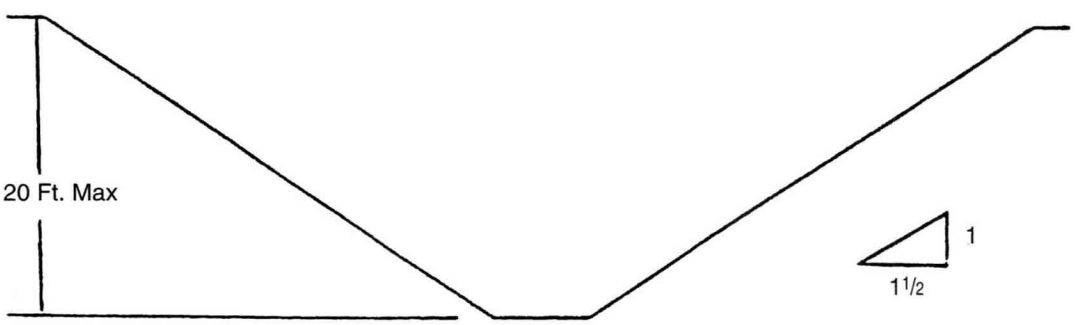


Vertical-Sided Lower Portion

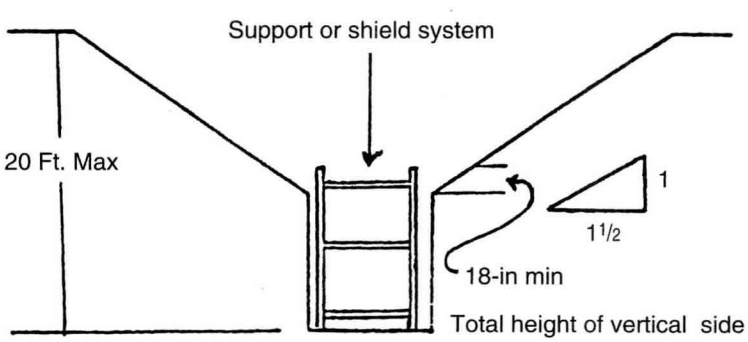
4. All other sloped excavations shall be in accordance with the other options permitted in §1926.652(b).

1.1.6 Excavations Made in Type C Soil

1. All simple slope excavations 20 feet or less in depth shall have a maximum allowable slope of $1^1/_2 : 1$.



Simple Slope



Vertical-Sided Lower Portion

1.2.0 Definition of Soil by Grain Size

Sieve size	Corresponding soil classification
12" (304.8 mm) or more	Boulders
3" (76.2 mm) to 12" (304.8 mm)	Cobbles
¾" (19.05 mm) to 3" (76.2 mm)	Coarse gravel
No. 4 to ¾" (19.05 mm)	Fine gravel
No. 4 to No. 10	Coarse sand
No. 10 to No. 40	Medium sand
No. 40 to No. 200	Fine sand
Passing through No. 200	Silt and clay fines

1.2.1 Uniform Building Code Standard 18-1: Soils Classification

Based on Standard Method D 2487-69 of the American Society for Testing and Materials. Extracted, with permission, from the *Annual Book of ASTM Standards,* copyright American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428

See Sections 1801.2 and 1803.1, *Uniform Building Code*

SECTION 18.101 — SCOPE

This standard describes a system for classifying mineral and organomineral soils for engineering purposes based on laboratory determination of particle-size characteristics, liquid limit and plasticity index.

SECTION 18.102 — APPARATUS

Apparatus of an approved type shall be used to perform the following tests and procedures: Preparation of soil samples, liquid limit test, plastic limit test and particle-size analysis.

SECTION 18.103 — SAMPLING

Sampling shall be conducted in accordance with approved methods for soil investigation and sampling by auger borings, for Penetration Test and Split-barrel Sampling of Soils, and for Thin-walled Tube Sampling of Soils.

The sample shall be carefully identified as to origin by a boring number and sample number in conjunction with a job number, a geologic stratum, a pedologic horizon or a location description with respect to a permanent monument, a grid system or a station number and offset with respect to a stated center line.

The sample should also be described in accordance with an approved visual-manual procedure. (A soil which is composed primarily of undecayed or partially decayed organic matter and has a fibrous texture, dark brown to black color, and organic odor should be designated as a highly organic soil, PT, and not subjected to the classification procedures described hereafter.)

SECTION 18.104 — TEST SAMPLE

Test samples shall represent that portion of the field sample finer than the 3-inch (76 mm) sieve and shall be obtained as follows:

Air dry the field sample; weigh the field sample; and separate the field sample into two fractions on a 3-inch (76 mm) sieve. Weigh the fraction retained on the 3-inch (76 mm) sieve. Compute the percentage of plus 3-inch (76 mm) material in the field sample and note this percentage as auxiliary information. Thoroughly mix the fraction passing the 3-inch (76 mm) sieve and select test samples.

SECTION 18.105 — PRELIMINARY CLASSIFICATION PROCEDURE

Procedure for the determination of percentage finer than the No. 200 (75 μm) sieve is as follows:

1. From the material passing the 3-inch (76 mm) sieve, select a test sample and determine the percentage of the test sample finer than the No. 200 (75 μm) sieve. (This step may be omitted if the soil can obviously be classified as fine-grained by visual inspection.)

2. Classify the soil as coarse-grained if more than 50 percent of the test sample is retained on the No. 200 (75 μm) sieve.

3. Classify the soil as fine-grained if 50 percent or more of the test sample passes the No. 200 (75 μm) sieve.

SECTION 18.106 — PROCEDURE FOR CLASSIFICATION OF COARSE-GRAINED SOILS (MORE THAN 50 PERCENT RETAINED)

Select test samples from the material passing the 3-inch (76 mm) sieve for the determination of particle-size characteristics, liquid limit and plasticity index. Determine the cumulative particle-size distribution of the fraction coarser than the No. 200 (75 μm) sieve.

Classify the sample as *gravel,* G, if 50 percent or more of the coarse fraction [plus No. 200 (75 μm) sieve] is retained on the No. 4 (4.75 mm) sieve. Classify the sample as *sand,* S, if more than 50 percent of the coarse fraction [plus No. 200 (75 μm) sieve] passes the No. 4 (75 mm) sieve.

If less than 5 percent of the test sample passed the No. 200 (75 μm) sieve, compute the coefficient of uniformity, C_u, and coefficient of curvature, C_z, as given in Formulas 18-1-1 and 18-1-2:

$$C_u = \frac{D_{60}}{D_{10}} \qquad (18\text{-}1\text{-}1)$$

$$C_z = \frac{(D_{30})^2}{D_{10} \times D_{60}} \qquad (18\text{-}1\text{-}2)$$

in which D_{10}, D_{30} and D_{60} are the particle size diameters corresponding respectively to 10, 30 and 60 percent passing on the cumulative particle size distribution curve.

Classify the sample as well-graded gravel, GW, or well-graded sand, SW, if C_u is greater than 4 for gravel and 6 for sand, and C_z is between 1 and 3. Classify the sample as poorly graded gravel, GP, or poorly graded sand, SP, if either the C_u or the C_z criteria for well-graded soils are not satisfied.

If more than 12 percent of the test sample passed the No. 200 (75 μm) sieve, determine the liquid limit and the plasticity index of a portion of the test sample passing the No. 40 (425 μm) sieve in accordance with approved methods.

Classify the sample as silty gravel, GM, or silty sand, SM, if the results of the limits tests show that the fines are silty, that is, the plot of the liquid limit versus plasticity index falls below the "A" line (see Plasticity Table 18-1-A) or the plasticity index is less than 4.

Classify the sample as clayey gravel, GC, or clayey sand, SC, if the fines are clayey, that is, the plot of liquid limit versus plasticity index falls above the "A" line and the plasticity index is greater than 7.

If the fines are intermediate between silt and clay, that is, the plot of liquid limit versus plasticity index falls on or practically on the "A" line or falls above the "A" line but the plasticity index is in the range of 4 to 7, the soil should be given a borderline classification, such as GM-GC or SM-SC.

If 5 to 12 percent of the test sample passed the No. 200 (75 μm) sieve, the soil should be given a borderline classification based on both its gradation and limit test characteristics, such as GW-GC or SP-SM. (In doubtful cases the rule is to favor the less plastic classification. Example: A gravel with 10 percent fines, a C_u of 20, a C_z of 2.0, and a plasticity index of 6 would be classified as GW-GM rather than GW-GC.)

1.3.0 Section 18.107—Procedure for Classification of Fine-Grained Soils (50 Percent or More Passing)

From the material passing the 3-inch (76 mm) sieve, select a test sample for the determination of the liquid limit and plasticity index. The method for wet preparation shall be used for soils containing organic matter or irreversible mineral colloids.

Determine the liquid limit and the plasticity index of a portion of the test sample passing the No. 40 (425 μm) sieve.

Classify the soil as inorganic clay, C, if the plot of liquid limit versus plasticity index falls above the "A" line and the plasticity index is greater than 7.

Classify the soil as inorganic clay of low to medium plasticity, CL, if the liquid limit is less than 50 and the plot of liquid limit versus plasticity index falls above the "A" line and the plasticity index is greater than 7. See area identified as CL on the Plasticity Chart of Table 18-1-A.

Classify the soil as inorganic clay of high plasticity, CH, if the liquid limit is greater than 50 and the plot of liquid limit versus plasticity index falls above the "A" line. In cases where the liquid limit exceeds 100 or the plasticity index exceeds 60, the plasticity chart may be expanded by maintaining the same scales on both axes and extending the "A" line at the indicated slope. See areas identified as CH on the Plasticity Chart, Table 18-1-A.

Classify the soil as inorganic silt, M, if the plot of liquid limit versus plasticity index falls below the "A" line or if the plasticity index is less than 4, unless it is suspected that organic matter is present in sufficient amounts to influence the soil properties, then tentatively classify the soil as organic silt or clay, O.

If the soil has a dark color and an organic odor when moist and warm, a second liquid limit test should be performed on a test sample which has been oven dried at 110°C ± 5°C for 24 hours.

Classify the soil as organic silt or clay, O, if the liquid limit after oven drying is less than three fourths of the liquid limit of the original sample determined before drying.

Classify the soil as inorganic silt of low plasticity, ML, or as organic silt of low plasticity, ML, or as organic silt or silt-clay of low plasticity, OL, if the liquid limit is less than 50 and the plot of liquid limit versus plasticity index falls below the "A" line or the plasticity index is less than 4. See area identified as ML and OL on the Plasticity Chart, Table 18-1-A.

Classify the soil as inorganic silt of medium to high plasticity, MH, or as organic clay or silt-clay of medium to high plasticity, OH, if the liquid limit is more than 50 and the plot of liquid limit versus plasticity index falls below the "A" line. See area identified as MH and OH on the Plasticity Chart of Table 18-1-A.

In order to indicate their borderline characteristics, some fine-grained soils should be classified by dual symbols.

If the plot of liquid limit versus plasticity index falls on or practically on the "A" line or above the "A" line where the plasticity index is in the range of 4 to 7, the soil should be given an appropriate borderline classification such as CL-ML or CH-OH.

If the plot of liquid limit versus plasticity index falls on or practically on the line liquid limit = 50, the soil should be given an appropriate borderline classification such as CL-CH or ML-MH. (In doubtful cases the rule for classification is to favor the more plastic classification. Example: a fine-grained soil with a liquid limit of 50 and a plasticity index of 22 would be classified as CH-MH rather than CL-ML.)

TABLE 18-1-A—SOIL CLASSIFICATION CHART

	MAJOR DIVISIONS		GROUP SYMBOLS	TYPICAL NAMES
COARSE-GRAINED SOILS More than 50% retained on No. 200 (75 μm) sieve*	GRAVELS 50% or more of coarse fraction retained on No. 4 (4.75 mm) sieve	CLEAN GRAVELS	GW	Well-graded gravels and gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines
		GRAVELS WITH FINES	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand-clay mixtures
	SANDS More than 50% of coarse fraction passes No. 4 (4.75 mm) sieve	CLEAN SANDS	SW	Well-graded sands and gravelly sands, little or no fines
			SP	Poorly graded sands and gravelly and sands, little or no fines
		SANDS WITH FINES	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS 50% or more passes No. 200 (75 μm) sieve[1]	SILTS AND CLAYS Liquid limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands
			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 sands or silts, elastic silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity
	Highly Organic Soils		PT	Peat, muck and other highly organic soils

[1]Based on the material passing the 3-inch (76 mm) sieve.