CLASSIFICATION OF SOILS FOR EXCAVATIONS

Method no.:	ID-194
Version:	2.0
Sample:	Soil (excavated earth material).
OSHA Regulations:	Earth material that is excavated must be properly sloped or supported for construction and safety purposes. The factors and specifications that relate to this protection are outlined in 29 CFR 1926 Subpart P Appendix A (3.1). They include instructions for the proper sloping and shoring and bracing of the soil as determined by an analysis and classification of the material.
Sample Size:	A sample of approximately 1.4 kg (3 lb) or 1 L (1 qt) is preferred. All samples are analyzed regardless of size.
Procedure:	Obtain a sample by any safe means and seal it in an airtight plastic bag. Affix an official sample identification seal on the bag. Enclose and secure the bag in a second bag for protection. Place this prepared material and required identification papers in a box for shipping by certified mail. The sample will be analyzed by visual and manual tests and a classification determined.

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Revised March 2014 — Senior Soil Scientist: Don Halterman

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1. History

When a trench or other excavation is made in soil, the residual forces in the ground work to restore the soil to a more stable configuration. If those residual forces (gravity) are greater than those holding the trench or excavation walls where they are, a cave-in occurs. There are a number of factors which determine the stability of a given excavation wall. It is beyond the scope of this document to fully describe soil mechanics in this way. However, it has been found empirically that soil, when sloped appropriately, will resist the residual forces and remain safely stable.

Because the evaluation of soil conditions and structure is crucial to safe operation in and around excavations, an excavation standard was among the first promulgated by OSHA in 1971. In that standard, soils were classified into three types called running, unstable, and hard compact (Ref. 3.2). These terms were generally misunderstood. Later, the terms were revised and renamed granular, cohesive, granular cohesionless, and cemented (Ref. 3.1).

In 1989, it was estimated that there were 70 fatalities and more than 800 lost workday injuries annually in the United States due to excavation accidents. Responding to this high incidence rate, OSHA promulgated the current excavation standards (Ref 3.1) and it has the following requirements:

1) Classification of soil and rock deposits. Each soil and rock deposit shall be classified by a competent person as Stable Rock, Type A, Type B, or Type C in accordance with the definitions set forth in 29 CFR 1926 Subpart P Appendix A.
2) Basis of classification. The classification of the deposits shall be made based on the results of at least one visual and at least one manual analysis. Such analyses shall be conducted by a competent person using tests described in 29 CFR 1926 Subpart P Appendix A, or in other recognized methods of soil classification and testing such as those adopted by the American Society for Testing Materials, or the U.S. Department of Agriculture textural classification system.
3) Visual and manual analyses. The visual and manual analyses, such as those noted as being acceptable in 29 CFR 1926 Subpart P Appendix A, shall be designed and conducted to provide sufficient quantitative and qualitative information as may be necessary to identify properly the properties, factors, and conditions affecting the classification of the deposits.
4) Layered systems. In a layered system, the system shall be classified in accordance with its weakest layer. However, each layer may be classified individually where a more stable layer lies under a less stable layer.
5) Reclassification. If, after classifying a deposit, the properties, factors, or conditions affecting its classification change in any way, the changes shall be evaluated by a competent person. The deposit shall be reclassified as necessary to reflect the changed circumstances.

As a result of the new regulations, the Bureau of Labor Statistics reported, in 1999, 44 deaths due to excavation and trenching accidents. (Ref. 3.10).

The angle of the slope depends upon the properties of the soil in which the excavation has been made. The mineral particles that constitute soil and other earth materials can bond by chemical and physical forces that oppose the force of gravity. Chemical bonding, or cohesion, refers to the chemical forces that bond mineral particles. Physical bonding refers to the bonding of the more coarse grains such as sand and gravel by frictional forces that include the interlocking of particles.

29 CFR 1926 Subpart P Appendix A is based on site and environmental conditions, and on the structure and composition of the soil deposits. The soil classification system means a method of categorizing soil and rock deposits in a hierarchy of Stable Rock, Type A, Type B, and Type C, in decreasing order of stability.

1) Stable rock means natural solid mineral matter that can be excavated with vertical sides and remain intact while exposed.

2) Type A means cohesive soils with an unconfined, compressive strength of 1.5 ton per square foot (tsf) (144 kPa) or greater. Examples of cohesive soils are: clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. Cemented soils such as caliche and hardpan are also considered Type A. However, no soil is Type A if:
   a) The soil is fissured; or
   b) The soil is subject to vibration from heavy traffic, pile driving, or similar effects; or
   c) The soil has been previously disturbed; or
   d) The soil is part of a sloped, layered system where the layers dip into the excavation on a slope of four horizontal to one vertical (4H:1V) or greater; or
   e) The material is subject to other factors that would require it to be classified as a less stable material.
3) Type B means:
   a) Cohesive soil with an unconfined compressive strength greater than 0.5 tsf (48 kPa) but less than 1.5 tsf (144 kPa); or
   b) Granular 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.
   c) Previously disturbed soils except those which would otherwise be classed as Type C soil.
   d) Soil that meets the unconfined compressive strength or cementation requirements for Type A, but is fissured or subject to vibration; or
   e) Dry rock that is not stable; or
   f) Material that is part of a sloped, layered system where the layers dip into the excavation on a slope less steep than four horizontal to one vertical (4H:1V), but only if the material would otherwise be classified as Type B.
4) Type C means:
   a) Cohesive soil with an unconfined compressive strength of 0.5 tsf (48 kPa) or less; or
   b) Granular soils including gravel, sand, and loamy sand; or
   c) Submerged soil or soil from which water is freely seeping; or
   d) Submerged rock that is not stable, or
   e) Material in a sloped, layered system where the layers dip into the excavation or a slope of four horizontal to one vertical (4H:1V) or steeper.

In its 1989 rule making, OSHA relied heavily on a classification system developed in 1982 by the National Bureau of Standards (now the National Institute of Standards and Technology – NIST). In addition, OSHA used several other sources of information including ASTM standards. (Ref. 3.10)

In addition to these fundamental references, SLTC used *The Unified Soil Classification System* (Refs. 3.3 and 3.4), the *Engineering Geology Field Manual of the U.S. Bureau of Reclamation* (Ref. 3.5), and other documents (Refs. 3.6-3.9) in the development of this method.

OSHA Method ID-194 was developed to emphasize the performance and engineering properties of soil and is consistent with the objectives and requirements of the 1989 Federal excavation regulations. Many other methods used to classify soil provide a textural name for soil such as clay, silty clay, sandy clay, clay loam and, in some cases, silty clay loam and sandy clay loam. Because each of these methods specify slightly different tests, the names are similar to each other but can have a different meaning. An attempt is made to provide a textural name of the soil with this OSHA method (so that a comparison can be made with other methods) but a complete separation of all of the soil components is not performed by the tests described in this method. This could result in a textural name that is slightly different from other soil classifying methods.

In March 2014, the United States Department of Agriculture Animal and Plant Health Inspection Service (USDA APHIS) imposed new requirements for soil sterilization. In order to prevent the introduction and spread of harmful or invasive organisms into the local environment, the SLTC was thereafter required to sterilize all excavable materials at a minimum temperature of 110 °C for a minimum of 16 hours in order to maintain a USDA permit to receive and handle soils from multiple states and U.S. territories. All previous references to the initial drying of the sample were changed from 60 °C to 110 °C in order to meet the new requirements and adhere to the USDA APHIS permit agreement.

2. Analytical

The analytical procedures of this method are grouped under the headings: visual, manual, and classification. Soil samples may represent a proposed excavation site or selected areas of an existing excavation. All samples are analyzed and classified by the methods outlined and described here.

Safety and health precautions include care to prevent airborne dust and the use of gloves and safety glasses when handling wet soil.

2.1 Visual (Ref. 3.1)

Copy all sample identification numbers from the sample submission report form to sample work data sheets (An example is included at the back of this method.). For analytical convenience, accountability, and continuity, record the number of each container used in analysis.

Open the soil bag and record the general characteristics of the sample, such as sand, gravel, or clay. Note and set aside any rock fragments (pieces of rock >3 in.) that may be present. Estimate the percent of the sample that is in the form of clumps between ¼ and 1 in., and identify possible structural discontinuities such as layers, lenses (discontinuous layers) and cracks or fissures. Note the presence of water or other features that are peculiar to the sample.

2.2 Manual

The manual tests include the equipment required for analysis and the procedures used to determine the specific properties and classification of the soil.

2.2.1 Equipment

a) Bread pans of regular size for drying samples.

b) Stainless steel bowls of at least 2- L capacity.

c) A forced air oven that will hold and dry samples at 110 °C.

d) U.S.A. Standard 8-in. dry sieving pans #4 (4.75-mm opening), #40 (0.425-mm opening), a #200 (0.075-mm opening) and a catch pan and cover.

e) A #200 U.S.A. Standard 8-in. wet sieving pan.

f) A laboratory balance that will read up to 3 kg with a precision of ±1.0 g.

g) A standard soil pocket penetrometer (Ref. 3.2) for the measurement of the unconfined compressive strength.

h) A fine hair bristle brush and a wire bristle brush for cleaning the test sieves.

2.2.2 Procedures

a) Unconfined Compressive Strength (Ref. 3.1)

Within five minutes after a sample of broken soil is exposed to the open air, remove one or more of the largest clumps and analyze it with a pocket penetrometer. Slice each clump with a spatula to provide a smooth surface for analysis.

Press the penetrometer cylinder against the sample and compress the soil and the calibrated spring of the instrument to the marked ring on the cylinder. Read the position of the ring on the calibrated scale of the cylinder. Record the unconfined compressive strength reading in tons per square foot (tsf) or kilograms per square centimeter (kg/cm^2). Report the average of at least three readings if possible. Note all samples that break apart and do not provide a positive analysis.

b) Plasticity (Refs. 3.3 and 3.4)

Plasticity is defined as an inherent property of certain soils to mold and roll between the palms of the hands into a stable thread 0.3 cm (1/8 in.) in diameter and the tensile strength to support a 5-cm section when held at one end. To possess plasticity for classification purposes, the soil must satisfy these conditions and contain at least 15% silt and clay as determined by gradation analysis.

Determine and record the state of plasticity of the soil at the as-received water content. If plasticity is not observed, analyze the sample after it is dried using only that part of the sample that passes the #40 sieve. Add water in different amounts to obtain a wide range of water content for analysis. If the clay content is low, plasticity is not an inherent property of the soil, and it will not be identified at any water content.

c) Gradation Analysis (Ref. 3.3)

This test is used to determine the amount of gravel, sand, and total silt and clay in a soil sample. These constituents are identified using the particle size scale of the Unified Soil classification system. Silt and clay are not distinguished from each other in this test. The gradation procedures are described as follows:

Dry the soil at 110 °C for a minimum of 16 hours to prepare the soil for analysis. Vent the air from the oven to the outside to avoid exposure to possible toxic fumes.

Tare a bowl on a laboratory balance. Add at least 100 g of a dry fine-grained sample or 200 g of a coarse-grained sample (sand and gravel) to the bowl. If that amount is not available, use as much as possible. Record the weight and cover the sample with water. Let it stand in this state for at least 2 hours and up to 24 hours.

Transfer this material to a #200 wet sieving pan and wash the fine grains of silt and clay through the sieve with running water until it is visibly clear. Wash the material that is retained on this sieve back into the bowl and decant the water and any supernatant. Dry this residue at 60 °C or at any other preferred temperature.

Place the dried soil onto a nest of pans containing a #4 sieve at the top, a #200 sieve in the middle, and a pan at the bottom to catch any residual silt and clay. Tap the pans manually on a table top at least 20 times to separate the grains by size.

Report the total gravel as the weight of material retained on the top or #4 sieve and the total sand as the weight of material retained on the next or #200 sieve. The total silt and clay content is equal to the difference between the combined weight of the sand and gravel and the weight of the sample used. Silt and clay comprise the fine-grained material that is washed through the #200 sieve during analysis. Convert the weight of the material retained on the #4 sieve and the #200 sieve as the dry weight percent of the gravel and sand, respectively.

2.3 Classification

The analytical data is used to classify the soil according to the dominate texture, structure, and Type (strength), the ultimate objective of analysis. These classifications are identified according to specific conformance and performance standards and definitions outlined in 29 CFR 1926 Subpart P Appendix A and the following definitions and instructions:

2.3.1 Structural Classification

The common soils include those that correspond to a granular, cohesive, or granular cohesionless structures outlined in the Federal excavation regulations. They are identified as follows:

- Granular soil contains <15% silt and clay (>85% sand and gravel) (Ref. 3.4)
- Cohesive soil possess the property of plasticity
- Granular cohesionless soil contains >15% silt and clay and does not possess plasticity, or otherwise, is neither granular nor cohesive. (Ref. 3.4)
- Fissures are identified visually or indirectly by the tendency of clay with a Q_u >1.5 to break into small pieces between ¼ and 1 in. due to microfissures when disturbed.

2.3.2 Type Classification:

- Granular soil is Type C
- Granular Cohesionless soil is Type B
- Cohesive soil is Type C if the unconfined compressive strength, $Q_{u,}$ is <0.5
- Cohesive soil is Type B if Q_u is 0.5 to 1.5
- Cohesive soil is Type A if Q_u is >1.5 and not fissured
- Cohesive soil that is fissured is Type B unless the Q_u dictates that it is Type C.
- Fissures may be identified visually or indirectly by the tendency of clay with a Q_u >1.5 break into small pieces between ¼ and 1 in. due to microfissures when disturbed.

A more convenient guide to classification is given in the chart after Section 2.3.5. The three soil structures appear at the top of the chart, and the appropriate definitions and properties that apply are listed below with Soil Type at the bottom. Soil Structure and Soil Type systematically unfold accordingly.

2.3.3 Textural Classification

Soil texture is based on the following definitions and instructions:

- Designate clay as the last word in the textural name of all soils that are cohesive, and designate sand or gravel as the last word for all soils that are granular.
- Modify that name with the less predominant constituents as a first name.
- Do not use either sand or gravel in the textural name if the soil contains <10% and <30% of the dry weight of the soil, respectively.

An example and the most typical of all soils classified at OSHA-SLTC is sandy clay.

2.3.4 Report

The following information will be entered onto the sample report in the section titled 'Comments for Specific Analyte':

Classification:

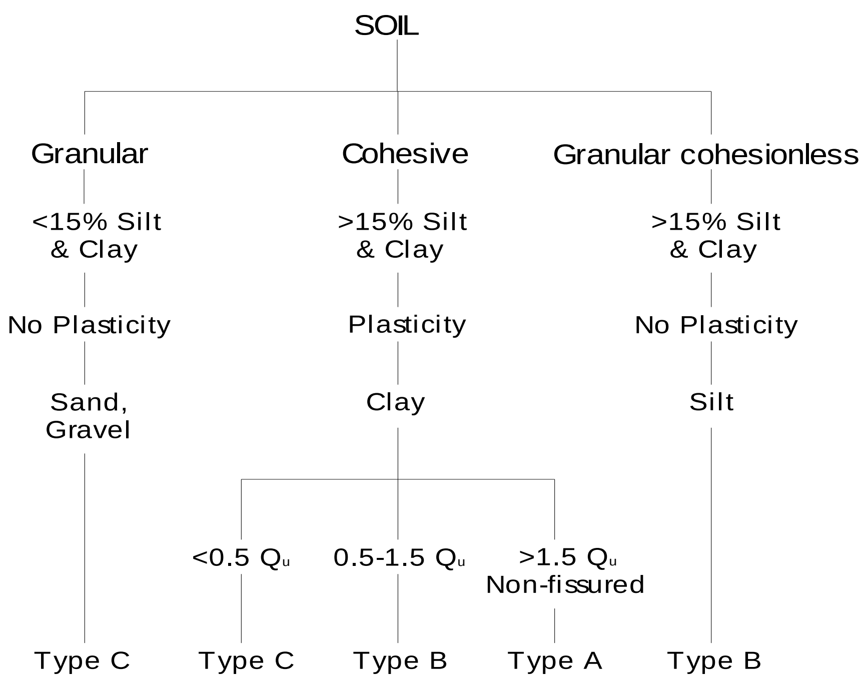
Textural: xxxx (e.g., Sandy Clay)
Structural: xxxx (e.g., Cohesive)
Type: x (e.g., B)

The above classification is based on visual/manual procedures described in OSHA Method ID-194.

2.3.5 Soil Reclassification

Classification of soils by this method is based upon measurement of physical properties appropriate to the OSHA excavation standard, and the condition of the sample as it is received at the Salt Lake Technical Center. Certain field conditions, such as the presence of standing water, may override this laboratory classification as mentioned in 29 CFR 1926 Subpart P Appendix A. Supplemental testing by other methods of analysis may provide a more appropriate description and classification of unusual or atypical soils.

SOIL CLASSIFICATION CHART



Note:

1) Intact cemented soils such as hardpan and caliche (a layered carbonate accretion) are classified Type A.
2) All fissured soils are classified cohesive and Type B.
3) Angular gravel and rock fragments are classified granular cohesionless and Type B.
4) The value of 15% in the above chart corresponds to the maximum amount of silt and clay that is permitted in a soil that is granular in structure. (Ref. 3.4)

3. References

3.1 Code of Federal Regulations, Title 29, Part 1926, Subpart P, 1999, pp. 372-409. U.S. Government Printing Office, Washington, D.C. 20402-9328.

3.2 Ibid. 1987, p. 207.

3.3 *Earth Manual,* U.S. Dept of the Interior, Water and Power Resources Service, Denver, CO, 1980, pp.1-22.

3.4 U.S. Bureau of Reclamation, Engineering Geology Field Manual, Volume 1. p.38. U.S. Government Printing Office, Washington, D.C. 20402-9328.

3.5 *Fundamentals of Geotechnical Analysis*, Dunn, I.S., 1980, p.33, John Wiley and Sons, Inc.

3.6 *Materials Testing Catalogue,* Soiltest Inc., Corporate Headquarters, 86 Albrecht Drive, Lake Bluff, Illinois, 60044-8004.

3.7 *National Academy of Sciences, Compendium 13. Slopes: Analysis and Stabilization*, 1980, p.141. Washington, D.C. 20402-9328.

3.8 *Mechanics in Foundation Engineering*, Wilun, Z. and Starzewski, K., p.77, 1972, Surrey Press, 450 Edgeware Rd. London.

3.9 *Engineering Classification and Index Properties of Intact Rock*, Deere, D.U., and Miller, R.P.,Clearance House for Federal Scientific and Technical information, Dept. of Commerce, Washington D.C.

3.10 *Federal Register*, Vol. 54, No. 209 p45894 et seq., U.S. Government Printing Office, Washington, D.C. 20402-9328

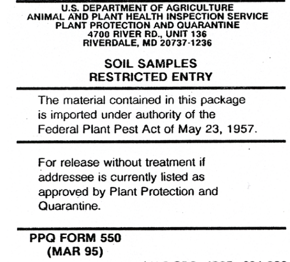
Addendum A

The method for packaging the soil samples for shipment to the SLTC will be in a sturdy, leak-proof container, which include the following:

a) Samples will be placed in a heavy-duty plastic bag that will not tear and secured and sealed airtight with tape. The plastic bag will be placed in a heavy-duty cotton bag for additional protection.

b) Each soil sample will be sealed for identification with an official Form 21 seal containing a field number, sampling date and the sampler's name.

c) If the soil sample being shipped from all foreign sources, including Guam, Hawaii, Puerto Rico, and the U.S. Virgin Islands through any U.S. port of entry, a PPQ Form 550 will be attached to the outside of the shipping box. Copies of this form may be obtained by telephoning 801-524-7900 and asking for the Soils Laboratory. Requests for the form can also be made by e-mail to alan.peck@osha.gov or dan.crane@osha.gov.



U.S. DEPARTMENT OF AGRICULTURE
ANIMAL AND PLANT HEALTH INSPECTION SERVICE
PLANT PROTECTION AND QUARANTINE
4700 RIVER RD., UNIT 136
RIVERDALE, MD 20737-1236

SOIL SAMPLES
RESTRICTED ENTRY

The material contained in this package is imported under authority of the Federal Plant Pest Act of May 23, 1957.

For release without treatment if addressee is currently listed as approved by Plant Protection and Quarantine.

PPQ FORM 550
(MAR 95)

☆U.S.GPO: 1995—621-030

Below is an example of the Soil Permit that is necessary to import soil samples into the United States. A copy of the actual permit is to be attached to the OSHA Form 91A. The permit can be obtained by contacting the persons mentioned above.

Soil Permit

Permit Number: S-40368

UNITED STATES DEPARTMENT OF AGRICULTURE

Animal and Plant Health Inspection Service

Plant Protection and Quarantine

Issued To: Occupational Safety and Health Administration
(Rick Cee)
1781 South 300 West, Salt Lake Technical Center
Salt Lake City, Utah 84115

TELEPHONE: (801) 487-0073

Under the authority of the Federal Plant Pest Act of May 23, 1957, permission is hereby granted to the facility/individual named above subject to the following conditions:

1. Valid for shipments of soil not heat treated at the port of entry, only if a compliance agreement (PPQ Form 519) has been completed and signed.
2. To be shipped in sturdy, leakproof, containers.
3. To be released without treatment at the port of entry.
4. To be used only for analysis and only in the facility of the permittee at Occupational Safety and Health Administration, located in Salt Lake City, Utah.
5. No use of soil for growing purposes is authorized, including the isolation or culture of organisms imported in soil.
6. All unconsumed soil, containers, and effluent is to be autoclaved, incinerated, or heat treated by the permittee at the conclusion of the project as approved and prescribed by Plant Protection and Quarantine.
7. This permit authorizes shipments from all foreign sources, including Guam, Hawaii, Puerto Rico, and the U.S. Virgin Islands through any U.S. port of entry.

EXAMPLE

MARCH 31, 2004
Expiration Date

Deborah M. Knott
Approving Official DEBORAH M. KNOTT

PPQ FORM 525B (6/94)

DEBMITTEE

Classification of Soils for Excavations
Sample Work Data Sheet

Analyst:			Sampling Number:		
CSHO ID:		Reporting ID:		Inspection Number:	
Laboratory Number:			Submission Number:		
Sample Description:					
Compressive Strength (tsf) (average):					
Clumps (estimated):			Fissures:	Yes	No
>1 in. (%):			Layers or Lenses:	Yes	No
>¼ in.<1 in. (%):			Water Present:	Yes	No
Drying Pan Number:					
Plasticity:	Yes No				
Graduation Bowl Number:			Sample Weight (g):		
>#4 Sieve (g):		>#200 Sieve (g):		<#200 Sieve (g):	
Gravel (%):		Sand (%):		Silt & Clay (%):	

Classification

Textural:			
Structural:	Granular	Cohesive	Granular Cohesionless
Type:	A	B	C

Notes: