PDHonline Course C289 (3 PDH)

Sampling from Test Pits, Trenches and Stockpiles

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Soil is usually obtained from a borrow area explored in detail to ensure quantity and uniformity desired. A uniform deposit is most desirable. Stratified deposits may be used, provided selective excavation and processing is practical and economical compared to using other potential sources. Selective excavation and mixing during stockpiling may be necessary to provide a soil as uniform in grading and moisture content as practicable. Screening equipment may be necessary to (1) remove undesirable organic material and oversize particles; (2) remove or reduce the size of sand, silt, and clay aggregations, called "clay balls," which tend to form in the borrow areas containing lenses of clay.

Laboratory testing is required to determine the quantity and type of cement, the moisture limits, and the compaction requirements to be specified for construction. Representative samples of the finest, average, and coarsest material should be submitted for laboratory testing. The water proposed for mixing should be reasonably clean and free from organic matter, acids, alkali, salts, oils, and other impurities. Clear water that does not have a saline or brackish taste and is suitable for drinking may be used; however, doubtful sources should be sampled and tested.

c. Soil-Cement Slurry.—Soil-cement slurry is a cement stabilized soil consisting of a mixture of soil and cement with sufficient water to form a material with the consistency of a thick liquid that will flow easily and can be pumped without segregation. Sands with up to 30-percent nonplastic or slightly plastic fines are best.

Reclamation has used soil-cement slurry for pipe bedding [26, 27]. Even though materials from the trench excavation may be used, locating the borrow areas along the pipeline alignment is generally more economical and usually results in a better controlled and more uniform product. Soil-cement slurry has often been supplied by commercial ready-mix firms when haul distances are economical.

d. Modified Soil.—A modified soil is a mixture of soil, water, and a small amount of an additive. The various components are well mixed before compaction or added to the soil in place to modify certain properties—temporarily or permanently—to within specified limits. Because of the small amount of additive, a modified soil usually retains most of the characteristics of the original soil because it is an aggregation of uncemented or weakly cemented particles rather than a strongly cemented mass. Limited experience has been acquired on even the most commonly used additives including asphalt, portland cement, fly ash, lime, slag, resins, elastomers, and organic chemicals.

As a soil additive, use of lime is the oldest known method of chemical stabilization: it was used by the Romans to construct the Appian Way. Soil-lime is a mixture of soil (usually clay), lime, and water which is compacted to form a dense mass. Experience has shown that mixtures of most clay soils with either quick or hydrated lime and water will form cementitious products in a short period of time. Reclamation applications for water resources works have been limited to use of lime for stabilizing expansive clay soils and dispersive clay soils.

Reclamation's Friant-Kern Canal in California experienced severe damage to both earth and concrete-lined sections from expansive clay soils. Lime, 4 percent by dry mass of soil, was used during rehabilitation of Friant-Kern Canal; and the soil-lime lining has proved durable after more than 20 years of service [28].

Dispersive clay soils will erode in slow-moving or even still water by individual colloidal clay particles going into suspension and then carried away by flowing water. Dispersive clay soils may be made nondispersive by addition of 1 to 4 percent lime by dry mass of soil. Generally, the design lime content is defined as the minimum lime content required to make the soil nondispersive. If lime-treated soil is to be used in surface layers, adding additional lime may be desirable to increase the shrinkage limit to near optimum water content to prevent cracking from drying. In construction specifications, the lime content is often increased 0.5 to 1.0 percent above the design value to account for losses, uneven distribution, incomplete mixing, etc. Dispersive clay soils were found throughout the borrow areas for Reclamation's McGee Creek Dam in Oklahoma. Lime was used to stabilize those soils for certain critical parts of the dam, and specifications required between 1.5 and 3.0 percent lime to be added to the soil [29].

B. Exploratory Methods

2-8. General.—Exploration methods may be grouped in different ways: (1) those that produce usable samples and those that do not, and (2) those that are accessible and those that are not. In investigations of foundations or materials, one purpose of an exploration is to secure samples of soil and rock, either for visual examination or for laboratory testing. Procedures which will not produce samples should be used only where the general characteristics of the materials to be penetrated are already known, where sufficient samples have been secured for testing, or where penetration test or other in-place test data can be used to define or refine an investigation plan or program. Sampling methods will vary according to the type of material to be sampled and according to the acceptable degree of sample disturbance; and test holes or other investigations may be advanced by manual labor or by mechanical power. Exploratory holes may be of various sizes depending upon:

- the need to access,
- the penetration depth,
- the size of sample to acquire, and
- the type of material to penetrate.

Stability of small-size holes entirely above the water table is dependent on the type of material encountered. Holes in soil below the water table usually require support by steel casing, augers, or by drilling fluid. Sometimes, exploratory holes require protection with steel casing because of potential damage to the hole by drilling operations and to prevent contamination of samples with materials from higher elevations. As part of a foundation investigation, many exploratory holes require water testing. When casing is used, specific portions of the foundation may be water tested to simplify evaluation, to concentrate on certain foundation conditions, and to determine required treatment. If water testing or piezometer installation is a part of the requirement, bentonite drilling mud should not be used.

In soft or loose soil foundations, the strength of the materials in the wall of the hole may be insufficient to keep soil from flowing into the bottom of the hole. In many instances, just keeping the hole filled with water will suffice to hold materials in place. In severe cases, a wall stabilizer, a heavy fluid, or both must be used. Information on the various stabilizers may be obtained from drilling fluid manufacturers. If water testing is not required, drilling fluid consisting of a mixture of commercially available bentonite or other materials and water may be used. Drilling fluid may be specially prepared to have a required mass per unit volume due to addition of finely divided solid material or to addition of other additives. (See USBR 7105 and USBR 5890 through 5895.)

Samples may be secured from holes supported by drilling fluid or casing with either double-tube or triple-tube soil samplers, core samplers, drive tube, or with push-tube samplers. To minimize sample disturbance, fixed-piston-type samplers are preferable for very soft soils. The double-tube hollow-stem auger sampler is best for water sensitive, very loose, or unsaturated low density soils. If undisturbed sampling is not successful, a number of in-place tests can be performed that yield valuable information concerning foundation soil conditions. Radiographs (X-ray) may be taken of undisturbed samples after they are received in the laboratory. The radiographs are studied to determine degree of disturbance to each sample. Radiographs are also useful to identify:

- slip planes,
- fault gouge zones,
- slickensides,
- contamination by drilling fluid,
- amount of slough on top of a sample,
- location of gravel particles within a sample,
- various other conditions.

Figure 2-18 shows some of the samplers available for obtaining undisturbed samples.

In drilling exploratory holes through hard materials, where support might normally be unnecessary, crushed zones or faults may be encountered from which rock fragments fall into the hole and either plug the hole, bind the drilling equipment, or both. In such situations, cement grout may be placed in that area; after the grout has set, the hole can be drilled through the grout. Because these crushed zones or faults represent some of the critical conditions being investigated from an engineering standpoint, all pertinent tests (such as water tests) must be performed before grouting the unstable section of hole; a record of the conditions should be fully reported and recorded.

All exploratory holes should be protected with suitable covers and fences to prevent foreign matter from entering the holes and to keep people and animals from disturbing them or falling into them. All holes should be filled or plugged after fulfilling their purpose.

2-9. Accessible Exploratory Methods.—

a. General.—Open test pits, large diameter borings, trenches, and tunnels are accessible and yield the most complete information of the ground penetrated. They also permit examination of the foundation bedrock. When depth of overburden and ground-water conditions permit their economical use, these methods are recommended for foundation exploration in lieu of relying solely on borings. In prospecting for concrete aggregate, embankment, filter, or drain materials containing cobbles and boulders, open pits and trenches may be the only feasible means for obtaining the required information.

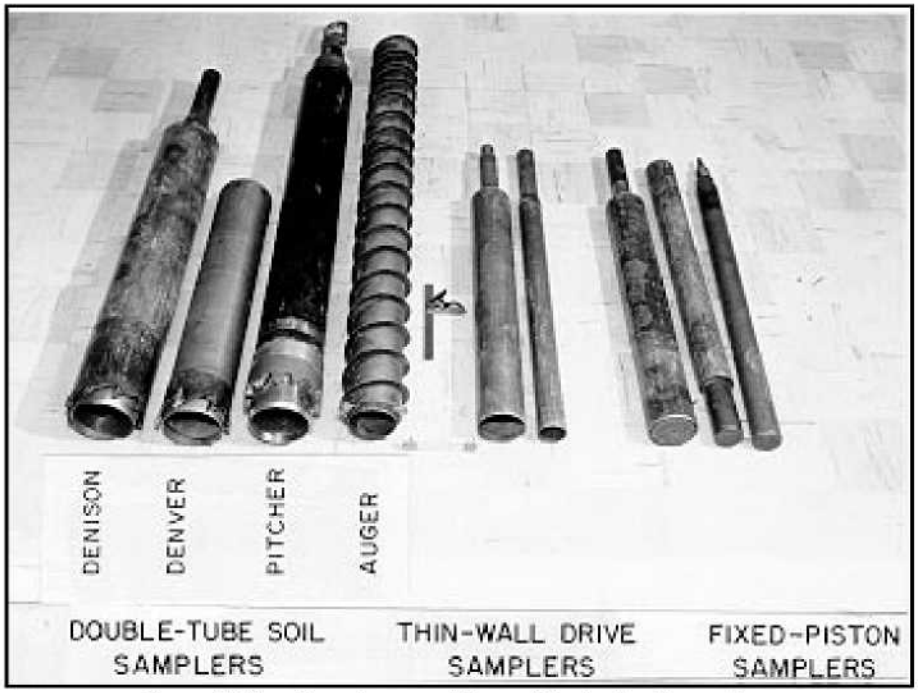

Figure 2-18.—Samplers used for undisturbed soil sampling.

b. Test Pits.—Test pits are an effective means to explore and sample earth foundations and construction materials and to facilitate inspection, sampling, and testing. The depth of a test pit is determined by investigation requirements but is usually limited to the depth of the water table. Dragline, backhoe, clamshell, caisson drilling or auger equipment, and bulldozer pits are usually more economical than digging pits by hand for comparatively shallow materials explorations. Explosives may be required to break up large boulders. At the surface, the excavated material should be placed in an orderly manner around the pit to indicate depth of pit from which the material came to facilitate accurate logging and sampling. The moisture condition should be determined and recorded before drying occurs by exposure to air.

Investigations in open, accessible explorations such as test pits, large diameter borings, trenches, and tunnels are inherently hazardous. Federal, State, and local regulations must be followed when planning and executing accessible investigations. Occupational Safety and Health Act (OSHA) regulations for excavation safety (29 CFR 1926.650-652) should be consulted prior to planning accessible explorations. Regulations require that competent personnel plan, design, and monitor excavations. Excavations greater than 5 ft in depth normally require sloping or shoring systems designed by professional engineers. Large diameter borings and deep trenches may be considered to be confined space and may require special ventilation, monitoring, and rescue safety equipment.

Deep test pits should be ventilated to prevent accumulation of dead air. Ventilating pipe, which begins slightly above the floor extending about 1 m (3 ft) above the mouth of the pit, is usually satisfactory. Canvas and plastic sheeting have been used to deflect wind into the hole. Oxygen meters should be used to determine satisfactory air quality. Test pits left open for inspection must be provided with covers and barricades for safety. All applicable safety and shoring requirements must be met.

When water is encountered in the pit, a pumping system is required for further progress. Small, portable, gasoline-powered, self-priming, centrifugal pumps can be used; however, air or electric powered equipment is preferred whenever possible because of the change of carbon monoxide poisoning. The suction hose should be 15 mm (½ in) larger in diameter than the pump discharge and not more than 5 mm (15 ft) long. This requires resetting the pump in the pit (on a frame attached to the cribbing) at about 4-m (12-ft) intervals. When an air or electric powered pump is not available, and a gasoline engine is used, pipe the exhaust gases well away from the pit when the engine is in or near the pit. When a gasoline engine is operating within a pit, personnel shall not be allowed in the pit for any extended period of time regardless of how well the system is vented. Dewatering test pits is usually expensive and is often unwarranted.

c. Large-Diameter Borings.—Caisson auger rigs using large-diameter discs, gushers, or buckets are often used when accessible explorations are required to be deeper than about 6 m (20 ft). Depths of over 30 m (100 ft) have been achieved using this method. Wall support must be provided for the total depth. Typical wall support for large-diameter borings may consist of welded steel casing installed after the boring is complete or preformed steel liner plate segments bolted together and placed as the boring progresses. Personnel access within a drilled caisson hole may be provided by an elevator platform rigging using power from a crane hoist or by notched safety rail ladder using an approved grab-ring safety belt. Work may be performed at any depth in the drilled caisson boring using steel platform decking attached to the steel wall support, from a steel scaffolding, or from an elevator platform.

Access for material logging or sample collection outside a steel-encased caisson hole may be accomplished by cutting openings in the casing at desired locations or by removing bolted liner plate segments to expose the sides of the boring. Sufficient ventilation must be maintained at all times for personnel working within the excavation. Radio communication to surface personnel should be maintained. Water within a drilled excavation may be removed by an electric or air-powered pump with discharge conduit to the surface. Dewatering may require stage pumping by using several holding reservoirs, at appropriate elevations, and additional pumps as required to lift the water from the borehole to the ground surface.

Large-diameter borings left open for inspection should always be provided with locking protective covers and should be enclosed by a fence or barricade.

d. Trenches.—Test trenches are used to provide a continuous exposure of the ground along a given line or section. In general, they serve the same purpose as open test pits but have the added advantage of disclosing the lateral continuity or character of particular strata. They are best suited for shallow exploration (10-15 ft [3-4.5 m]). Trenching can be used to drain wet borrow areas and at the same time fulfill investigation requirements.

On a slope, field work consists of excavating an open trench from the top to the bottom to reach representative undisturbed material. Either a single slot trench is excavated down the face of a slope, or a series of short trenches can be spaced at appropriate intervals along the slope.

Depending on the extent of investigation required, bulldozers, backhoes, or draglines can be used. Figure 2-19 shows a trench excavated by bulldozer. *All* safety procedures and guidelines *must* be followed when excavating deep trenches to prevent accidents caused by caving ground.

The material exposed by trenches may represent the entire depth of significant strata in an abutment of a dam; however, their shallow depth may limit investigation to only a portion of the foundation, and other types of exploration may be required to explore to greater depths. Test trenches, however, are often extensively used to delineate stratigraphy in borrow areas. As with test pits, trenching permits visual inspection of soil strata which facilitates logging of the profile and selection of samples. Large undisturbed samples or large disturbed individual or composite samples are easily retrieved from test trenches. Trenches in sloping ground have the further advantage of being self-draining.

e. Tunnels.—Tunnels, adits, or drifts have been used to explore and test areas beneath steep slopes in or back of clifflike faces. Any exploratory tunnel or drift is usually roughly rectangular in shape and about 1.5 m wide by 2 m high (5 ft by 7 ft). When lagging is required for side and roof supports, it should be placed to follow excavation as closely as practicable. Excavation of exploratory tunnels can be a slow, expensive process; consequently, this type of investigation should be employed only when other methods will not supply the required information.

Logging and sampling of exploratory tunnels should proceed concurrently with excavation operations if possible (see fig. 2-20).

If explosives were used to excavate the tunnel, selecting locations for undisturbed samples must be carefully made. This includes removal of all material disturbed by the explosives, thereby exposing undisturbed material.

2-10. Nonaccessible Exploratory Methods.—

a. General.—The usual nonaccessible exploratory methods are cone penetrometer, standard penetration, auger drilling, rotary drilling, core drilling, and in-place field testing. Of the methods, auger drilling, rotary drilling, and core drilling are the most commonly used to obtain samples

Figure 2-19.—Shallow test trench excavated by bulldozer.