Chapter 8
Procedures for Disturbed Soil Sampling In Borings

8-1. Advancing the Borehole

Boreholes for disturbed soil samples may be advanced in the same manner as those procedures used for boreholes for undisturbed soil samples. After a vertical pilot hole has been established, if necessary, attach the drill bit or auger to the drill rod and lower the string into the borehole. Attach more drilling rods as necessary. At the bottom of the borehole, perform drilling operations to advance the hole to the desired depth. After the hole has been advanced, remove the excess cuttings before the drill string is withdrawn from the borehole. As the drill string is withdrawn from the hole, disconnect the sections of rod and lay aside. Repeat until the cutting head is retrieved.

When lowering the equipment into the borehole, count the number of rods to determine the depth of the borehole. Carefully monitor and record the depth of the hole for use during the sampling operations as the vertical location of the sample is needed. All trips in and out of the borehole should be made without rotation of the drill string.

The methods and procedures for cleaning boreholes for disturbed sampling operations are similar to the procedures for cleaning boreholes for undisturbed sampling operations. Boreholes may be cleaned by rotary drilling and augering methods as previously reported in Chapter 6. Bailers or sand pumps may also be used to clean cased holes provided that bailing is controlled to prevent the disruption of the soil that is to be sampled. A clean, open hole is essential for obtaining satisfactory samples; disturbance of the soil at the sampling depth is not critical unless it results in a nonrepresentative sample.

a. Diameter of the borehole. The diameter of the borehole should be at least 6 mm (1/4 in.) greater than the OD of the sampler or casing, if casing is used.

b. Methods of advance. Boreholes for disturbed samples may be advanced by augering, rotary drilling, displacement, or churn drilling. Hammer drilling is gaining acceptance for drilling in certain soils, such as gravelly soils. However, samples are generally not recovered as a part of the hammer drilling operations. Therefore, hammer drilling is not discussed in this chapter; equipment and procedures for hammer drilling are discussed in paragraph 3-3*d*. The use of the Becker hammer drill as a penetration test is discussed in Appendix C.

(1) *Augering*. Augers may be used to obtain disturbed samples of the in-place soil. However, the samples may not be representative of the in situ formation due to the mixing action of the auger. The structure of the soil may be completely destroyed and the moisture content of individual soil strata layers encountered may be changed.

A large number of augers are available. In addition to handheld augers, such as the Iwan or posthole type, helical and tubular augers which are described in Chapter 7, machine-driven augers including single- or continuous-flight (spirals) solid-stem or hollow-stem augers, disk augers, and bucket or barrel augers may be used to advance boreholes for disturbed samples in the same manner as described for advancing boreholes for undisturbed samples in paragraph 6-1*b*.

Auger borings are generally used in soils where the borehole will remain open, usually above the groundwater table. Below the groundwater table, drilling fluid or casing may be required to stabilize the borehole. Because auger borings typically do not use drilling fluid, the augering method may be preferred for drilling holes in embankment dams; the absence of drilling fluid eliminates the potential for hydraulic fracturing.

Augers operate best in somewhat loose, moderately cohesive, moist soils. In general, the holes are bored without the addition of water, although the introduction of a small amount of water may aid in drilling, especially in hard, dry soils or cohesionless soils. If water is added to the borehole, it should be noted on the boring logs.

(2) *Rotary drilling*. The method of advancing the borehole by rotary drilling consists of rotation and application of downward pressure on the drill bit or cutting shoe which is attached to the bottom end of the drill string. Drilling fluid, such as compressed air or drilling mud, must be used to remove the cuttings from the face of the drill bit and out of the borehole. Bottom discharge rotary bits are not acceptable for advancing the borehole. Side discharge bits may be used with caution. Jetting through an open-tube sampler to clean out the borehole to sampling depth is not permitted. Prior to sampling, the loose material from the hole must be removed as carefully as possible to avoid disturbing the material to be sampled. As a rule of thumb, boreholes may be advanced in the same manner as for undisturbed samples which is

described in paragraph 6-1; cleaning of the borehole prior to sampling is discussed in paragraph 6-3.

Boreholes in soft or loose soils or when the boring is extended below the groundwater level may be stabilized with casing or drilling mud. Procedures and requirements for casing are similar to those described in paragraphs 3-4*d* and 6-2*b*. However, only disturbed samples shall be taken when the casing is driven in the boreholes.

If the casing is driven, the driving hammer is usually 113 to 181 kg (250 to 400 lb). Other equipment which is needed includes a driving shoe, a driving guide, and an assembly to pull the casing. Before the casing is driven, a small flat area should be shoveled on the surface of the ground and a short piece of casing should be selected. While the casing is held steady, the cathead or wire drum can be used to lift and drop the hammer to drive the casing. After several sections of casing have been added, rotate the casing clockwise. This operation tends to free the casing and make it easier to drive. The casing should not be driven to a depth greater than the top of the next sample interval.

After the casing has been placed, the inside of the casing must be cleaned. Wash boring and rotary drilling with fluid circulation methods are suitable for removing the material in the casing. If rotary drilling techniques are used, follow the procedures that are suggested in paragraph 6-2*b*. If the wash boring method is used, a water swivel and water hose should be attached to the top of the drill rods and connected to the water pump, and a chopping bit should be attached to the bottom of drill rods. After the drill rods have been lowered into the casing, circulation of drilling fluid should be started. The drill string should be raised and dropped by the cathead and rope method or by the wire drum hoist. The drill string should be rotated frequently. The jetting action of the drilling fluid will wash the material out of the casing.

After the soil in the casing has been removed, the casing should be raised slightly to allow the casing header or adapter to be removed to permit the sampler to be operated through the casing. To permit sampling through the casing, the ID of the casing must be slightly larger than the OD of the sampler. When a larger diameter casing is used, the jetting action of the drilling fluid is reduced. Thus, segregation and alteration of the intended soil sample is minimized.

(3) *Displacement methods*. Displacement samplers may be used to advance boreholes for disturbed samples. After a plug has been installed in the bottom of the sampling apparatus, the sampler is driven or pushed to the depth to which the sample is to be taken. To sample, the plug is retracted and the sampling drive is executed. For most soils, the disturbance created below the plug or sampler is not believed to be sufficient to prevent obtaining a satisfactory disturbed sample.

(4) *Percussion drilling*. The churn-drilling method, which is also called cable-tool drilling, is accomplished by raising and dropping a chisel-shaped bit attached to a heavy weight or drill bar suspended from a steel cable. A small amount of water is added to the bottom of the borehole to form a slurry with the loose material which has been chopped or dislodged by the bit. When the carrying capacity of the slurry is reached, the bit is withdrawn and the slurry is removed by bailing. More water is then added to the borehole, and the drilling and bailing segments of the operation are repeated. In soft or cohesionless soils, it is sometimes possible to advance the boring by bailing alone, although the material does not constitute an acceptable sample. When borings in fat clays are advanced, small amounts of sand may be added to increase the cutting action of the bit. Similarly, clay may be added to increase the carrying capacity of the slurry when drilling in coarse, cohesionless soils.

Casing is generally required for churn drilling and is normally driven with the churn-drill driving mechanism. The borehole is advanced ahead of the casing. If the casing is advanced ahead of the borehole, heaving at the bottom of the hole may occur. If heaving occurs, water or drilling fluid may help to stabilize the borehole, although the efficiency of the churn drill is dramatically decreased. In soft or cohesionless soils, it is often difficult to impossible to advance the borehole ahead of the casing. Furthermore, the quality of the samples may be suspect as fines will remain in suspension in the slurry. Hence, the slurry should not be considered as representative of the in situ materials.

Continuous sampling may be obtained by the churn-drilling method if the chopping bit is replaced by an open-tube sampler and the short-stroke drilling jar, which is attached between the drill bit and drill rod, is replaced by a long-stroke fishing jar. The longer jar facilitates the driving of the sampler without imparting an upward motion to the sampler. Although the borehole is advanced by the sampling operation itself, the hole must be cleaned by bailing each time the casing is advanced. Additional information is presented in paragraph 3-3*b*.

Another method of advancing the borehole by the percussion technique is hammer drilling, i.e., the Becker hammer drill and the eccentric reamer system. Since the use of these systems does not directly yield soil samples, a discussion of sampling procedures is not presented herein. However, discussions of the Becker hammer drill and the eccentric reamer system are presented in paragraph 3-3*d*; the use of the Becker hammer drill as an in situ test is discussed in Appendix C.

8-2. Sampling Procedures

a. Augers. When augers (paragraph 7-2) are used as samplers for disturbed sampling operations, the auger should be carefully lowered to the bottom of the borehole to prevent dislodging material from the sidewalls of the hole. After the auger reaches the bottom of the hole, it may be advanced by rotation and a slight downward force. The speeds of advance and rotation should be adjusted to obtain maximum-size cuttings in an attempt to preserve the in situ composition of the soil to the greatest extent possible. The depth of penetration of the auger should be carefully monitored to allow for an accurate determination of the depth from which the sample is obtained.

The method of sampling with flight augers depends upon the type of auger. For single-flight augers, the auger must be carefully removed from the borehole prior to sampling. Disturbed samples can be obtained from the cuttings on the leading edge of the auger, provided that the cuttings are not contaminated with materials from other depths or segregation has not occurred because of the loss of material as the auger is removed from the borehole. Disturbed or undisturbed samples can be obtained by removing the auger from the spindle and replacing the equipment with a sampling device such as a split-spoon or thin-walled sampler. If this method is used, the depth should be carefully checked to ensure that material has not ravelled from the walls of the borehole or fallen from the auger as it was withdrawn from the hole.

For continuous-flight augers, soil can be sampled at the top of the flights of the auger, although sampling by this method is not a good practice because soil from different depths may be mixed. If a solid-stem auger is used, the auger must be removed from the borehole before a sampling device can be used to obtain disturbed or undisturbed samples. Procedures are similar to those required for sampling with the single-flight auger. If the hollow-stem auger is used, the borehole can be advanced to the desired depth, the center plug can be removed, and sampling can be conducted by lowering a wireline sampler or some other suitable sampler through the hollow stem of the auger to the bottom of the borehole. When sampling through the hollow-stem auger, the hollow stem of the auger acts as a casing. A discussion of equipment and procedures for the hollow stem auger sampler is presented in paragraphs 5-1*c* and 6-4*c*, respectively.

b. Drive samplers. Push or drive samplers (paragraph 7-3) may be advanced by pushing, jacking, or driving with a hammer. If an open-tube sampler is used, the sampler must be lowered carefully to prevent dislodging material from the sidewalls of the borehole and filling of the sampling tube before it reaches the bottom of the hole. When a piston sampler is used, procedures which are similar to those described in paragraph 6-4*a* for obtaining undisturbed samples should be followed. Unless a sample retainer is used with the drive-sampler assembly, it may be necessary to allow several minutes to elapse following the completion of the drive before the sampling tube is withdrawn from the formation. This delay will permit adhesion and friction between the sample and the sampling tube to develop which will help to prevent loss of the sample upon withdrawal.

c. Displacement samplers. Displacement samplers (paragraph 7-4), i.e., Memphis, Porter, or similar samplers, are assembled with a pointed plug piston fixed at the bottom of the sampler and are driven to a depth corresponding to the top of the intended sample. To sample, the pointed plug is retracted to a sampling position and the sample drive is made. A slight rotation of the piston rod following the sampling operations closes the vents; this action helps to prevent sample loss during the withdrawal of the sampler from the borehole.

d. Vibratory samplers. To obtain a sample with a vibratory sampler (paragraph 7-5), a sharpened, thin-walled tube as long as 10 m (33 ft) or more is vibrated at a frequency of approximately 2 cycles/second (120 Hz). A slight downward pressure which can be applied by hand is usually sufficient to cause a fairly rapid penetration of the sampling tube. At the completion of the drive, an expandable packer may be placed in the top of the tube to aid in sample recovery. A block and tackle attached to a guide frame can be used to extract the sample and tube from the borehole.

Before the sampling drive is initiated, the sampling tube should be oriented vertically. Verticality should be maintained during the drive to facilitate the sample withdrawal from the borehole. If extracting the sample tube is difficult, a few cycles of vibration may be applied to reduce the friction and adhesion between the walls of the borehole and sampling tube. However, excessive vibrations should not be applied as the sample may fall from the tube.

The sample may be extruded, examined, and logged in the field or may be sealed and shipped to the laboratory for testing. If a field examination is conducted, the sample may be extruded by vibrating the slightly inclined sampling tube while simultaneously sliding a half section tray under the sharpened edge of the tube. Provided that the core trough is moved at the appropriate rate, a continuous core may be observed. If the core is to be preserved in the sampling tube, the tube should be cut into segments about 1 m (3 ft) long to facilitate handling. The ends of each segment should be sealed to preserve the in situ moisture content and stratification of the soil sample, as required by the project. Segments should be identified and boring logs updated.

e. Percussion samplers. Percussion samplers (paragraph 7-6) include wireline samplers which are driven by a sliding-weight hammer or long, weighted drilling or fishing jars. The wireline sampler and driving mechanism are lowered to the bottom of the hole, and the wireline is marked for length of intended drive. The driving mechanism is then raised and lowered by cable action in strokes slightly less than the total stroke of the hammer. When the drive is completed, the total assembly is removed from the borehole by the wireline. If the sampler becomes stuck in the soil, it can be driven upward using the hammer-drive mechanism to extract it from the formation.

8-3. Boring and Sampling Records

All pertinent borehole and sample data must be recorded in a boring log. Clear and accurate data are required to describe the soil profile and sample locations. Information and observations which may aid in estimating the condition of the samples and the physical properties of the in situ soil should be recorded. The log of a disturbed sample boring should contain all applicable information as discussed in Chapter 13 and in paragraph 6-6 for undisturbed samples.

8-4. Preservation and Shipment of Samples

Disturbed samples should be handled and preserved to prevent contamination by foreign material and to ensure that the in situ water content is preserved, if necessary. Each specimen should be representative of the in situ soil at the depth from which the sample was taken. Stratification should be preserved, if possible. For specific cases, soil samples should be protected from temperature extremes during shipment and storage. Additional guidance for preservation and shipment of samples is provided in Chapter 13 and ASTM D 4220-83 (ASTM 1993).

a. Containers. If the water content of the sample is to be preserved, the sample should be sealed in a glass jar or other suitable container. Large-volume representative samples may be placed in tightly woven cloth bags and tied securely to prevent contamination and loss of sample. If samples are to be stored for an extended time, the soil should be placed in plastic-lined cloth bags as soil moisture will cause the cloth bags to deteriorate. In general, metal containers should not be used if samples are to be stored, as the container will tend to rust or corrode and may contaminate the sample.

b. Sealing. Samples for water content determination must be sealed to prevent changes of soil moisture. If glass jars are used, the gasket and the sealing edge of the container must be clean to ensure a good seal.

c. Identification. All soil samples must be properly marked to accurately identify the origin of the sample. A completed ENG Form 1742 and/or 1743 (see Figure 13-1) should be securely fastened to each sample. A second tag should be placed in a waterproof envelope inside the sample bag; this tag will aid in sample identification in case the outer tag is lost. All markings should be made with waterproof, nonfading ink.

d. Packing for shipment. In general, disturbed samples do not require special shipping precautions. However, the sample containers should be protected from breakage and exposure to excessive moisture which may cause deterioration of the labels and/or cloth bags. Glass jars usually can be packed in the cartons furnished by the manufacturer. If the transportation requires considerable handling, the cartons should be placed in wooden boxes. Double bags should be used if the bag samples are expected to receive considerable handling.

e. Methods of shipment. The most satisfactory method of sample shipment is in a vehicle that can be loaded at the exploration site and driven directly to the testing laboratory. This method helps to minimize sample handling and allows the responsibility of transporting the samples to be delegated to one person. Samples shipped by commercial transportation companies require special packing or crating, special markings, and instructions to ensure careful handling and minimum exposure to excessive heat, cold, or moisture.