Chapter F-12
Sampling from Stockpiles and Bins, Transportation Units, or Conveyor Belts

12-1. Introduction

Sampling from stockpiles, storage bins, loaded freight cars or trucks, and conveyor belts is unique. Because segregation of the material may occur within the unit, especially for well-graded aggregates, samples should be obtained only if proper sampling techniques and intervals or locations are considered and employed. The principal objectives which must be considered include obtaining samples that are representative of the mass of material, or obtaining samples to document the variability within the mass, or both. The volume or mass of a representative sample should be large enough not to be affected by the variability of small units of the bulk material; by contrast, the volume of a random sample should be small enough such that significant variability within the unit is not masked. With other factors constant, larger samples will tend to be more representative of the total. In most cases, sample disturbance is unimportant.

If significant variability of one or more specific parameters for the respective sampled units is found to exist, regardless of whether samples were obtained for assessment of variability or uniformity of bulk material, a statistical study should be considered as a means for interpreting the test results. A suggested method is described in ASTM E 122-89: "Standard Recommended Practice for Choice of Sample Size to Estimate a Measure of Quality for a Lot or Process" (ASTM 1992c). According to ASTM E 122-89, two approaches can be used: (a) determine the number of samples required to meet a prescribed precision, or (b) determine the precision which can be estimated based upon the number of available samples. Based upon this ASTM specification, an estimate of an average characteristic or parameter of the bulk material may be made.

Because of the difficulty of devising a comprehensive sampling plan to obtain a few representative samples to assess the characteristics of bulk material, a general sampling plan does not exist. Each sampling plan must be devised to satisfy the requirements of the specific study. The suggestions which are presented in paragraph 12-2 regarding a sampling plan are intended for guidance only. It is hoped that these suggestions will stimulate ideas for developing better and more comprehensive plans for sampling specific units of material. Geotechnical personnel are encouraged to use imagination, common sense, technical knowledge, and experience to develop a plan for sampling the material which will permit the acquisition of data of a quality necessary to satisfy the specific engineering requirements.

Additional reading materials which are suggested as guidance for developing a plan for obtaining representative samples of materials from stockpiles, bins, transportation units, or conveyor belts include ASTM C 50-86 (ASTM 1992b), C 702-87 (ASTM 1992a), D 75-87 (ASTM 1992a, 1992b, 1993), D 3665-82 (ASTM 1992b), E 105-58 (ASTM, 1992c), E 122-89 (ASTM 1992a), and Roberts et al. (1991).

12-2. Sampling Plan

When the contents of stockpiles, storage bins, loaded freight cars or trucks, or conveyor belts are sampled, the laws of chance dictate that a few particles may be unequally distributed among samples which are smaller than the whole unit. However, a properly designed sampling plan will tend to minimize the effects caused by sampling errors. Samples should be taken at random with respect to location, time, or both, to minimize any bias on behalf of the person obtaining the samples. Samples may be examined individually to assess the variability of the material or combined to form a representative sample. If power equipment is available, the bulk material should be sampled from its top to its bottom. If power equipment is unavailable, samples should be obtained at several locations or increments of time. Because certain materials tend to segregate as a result of handling, care is necessary to ensure that samples do not contain a disproportionate share of material from the top or bottom layers of the unit. ASTM D 3665-82: "Standard Practice for Random Sampling of Construction Materials" (ASTM 1992b) provides additional guidance.

To satisfy the requirements for obtaining samples at random which, by definition, is the product of a definite and willful effort to produce disorder, several criteria should be considered. All units, i.e., a stockpile, storage bin, freight car or truck, or material on a conveyor belt, should be defined by some rule or number to ensure that randomness is satisfied. Every portion of a unit must have a nonzero chance of selection with respect to location, time, or both. The probability of selection of a given unit, area, or zone of material must be known. Each sample of material must be weighted in inverse proportion to its probability of selection.

Before a good sampling plan can be developed, the problem and objectives of the sampling operation should be identified. Information about relevant properties, i.e., gradation of the material, percent passing the U.S. Standard Sieve No. 200 (0.074 mm) sieve, water content of the coarser as compared to the finer fraction of the material, etc., should be collected. A number of potential plans for sampling the material should be evaluated. Costs, difficulties of obtaining samples, types and availability of sampling equipment, and the required number of samples or the desired precision of data, and the representativeness or randomness of samples should be considered. The potential plans should be evaluated, and the most desirable plan should be selected. Upon the commencement of the sampling operations and again as the preliminary data are evaluated, the preceding steps should again be reconsidered. Suggested sampling plans for obtaining representative samples based upon location and/or time increments for specific engineering purposes follow.

a. Loaded freight cars or trucks. For loaded freight cars or trucks, determine the number of samples required and estimate the number of freight cars or trucks which will be used to transport the material. Establish suitable criteria for sampling the material at all locations within the respective transportation units. Use random numbers to determine which transportation units will be sampled and the location within the respective units in which samples will be obtained. For example, a truck which is loaded with bulk material may be arbitrarily divided into four equal quadrants, as determined by a plan view of the truck box. Based upon the proposed sampling plan, use random numbers to determine which truck(s) will be sampled; repeat the process to determine which quadrant of material in a specific truck will be sampled. If power equipment is available, a cross section of material should be obtained for the full depth of the material. If power equipment is not available, obtain samples from a horizontal cross section of material at a reasonable depth below the surface of the material. Within practical limitations, sampling of bulk materials should be done in a manner which will prevent disproportionate shares of the top or bottom layers of material from being obtained. When packaged materials are to be sampled, assume that a stack of bags or containers is analogous to a quadrant of the truck box and that depth corresponds to a particular container within a specified stack of containers.

b. Conveyor belts. For conveyor belts, determine the number of samples required and estimate the length of time needed to transport the material on the conveyor belt. By the use of random numbers, determine the elapsed time when samples are to be obtained. All materials within the cross section of the conveyor belt, including fines, should be carefully sampled. A similar procedure can be used for sampling a windrow of material; the principal difference is that the time variable for the conveyor belt should be replaced by the length of the windrow.

c. Storage bins. Two options are available for sampling the contents of storage bins. The material may be sampled as it is removed from storage bins through chutes, hoppers, or conveyor belts. The other option consists of sampling within the confines of the storage bin; samples should be obtained at various locations and depths within the material. To obtain samples from a conveyor belt or chute, follow the procedures for random sampling with respect to time that are given in paragraph 12-2*b*. If samples are obtained from within the storage bin, follow the guidance for sampling loaded freight cars and trucks. If power equipment is available, samples should be obtained from random depths and locations; the sampling plan should ensure that a disproportionate volume (mass) of the top or bottom layers of material is not obtained. If power equipment is unavailable, obtain samples from a horizontal cross section of material at a reasonable depth below the surface of the material.

d. Stockpiles. To obtain samples of the material in a stockpile, the use of power drilling and sampling equipment is more desirable than obtaining samples by hand. Establish a plan for sampling the contents of the stockpile at various locations and depths similar to the procedures which were given in the example for sampling transportation units. By the use of random numbers, select zones of material to be sampled. If power equipment is unavailable, develop a plan for sampling the material at random locations along the periphery of the pile. For example, zones of material located at elevations of 1/3 and 2/3 or 1/4, 1/2, and 3/4 of the height of the pile as well as the top of the pile should be sampled. As a general rule, do not sample the bottom 1/4 of the stockpile because disproportionate amounts of coarser material may have fallen to the base of the stockpile. Test results should be interpreted cautiously; it is possible that materials in stockpiles may have segregated.

e. Roadways. To obtain record samples for quality control of subbase or base materials for roadways, determine the length of the foundation material and the number of samples required, similar to the procedures which were suggested for obtaining samples of materials in windrows or on conveyor belts. The location with respect to the center line of the roadway can be treated as analogous to the depth of material in a transportation unit or stockpile. Select a random number to determine the station along the center line of the roadway; repeat the process to determine the location perpendicular to the center line of the roadway for obtaining the sample.

12-3. Sampling Procedures

In general, it is more desirable to use power drilling and sampling equipment than small hand tools to obtain samples of bulk material because a fairly large volume (mass), i.e., 0.01 to 0.1 m^3 (1/3 to 4 ft^3) or more, of material for each sample is often required. Furthermore, the use of power equipment permits samples to be obtained at relatively great depths. Equipment, such as hollow- or solid-stem augers, drive samplers fitted with basket retainers, or various types of vibrator samplers affixed to a crane or cherry picker, has been used to sample bulk materials. These types of drilling and sampling equipment have been described in Chapters 3, 5, 6, 7, and 8 and therefore will not be discussed here.

However, if drilling and sampling equipment is not available or cannot be used because of specific constraints, such as cost-ineffectiveness or inability to access storage bins or stockpiles with the power equipment, samples can be obtained by hand excavation. The remainder of this chapter presents guidance for obtaining representative samples of bulk material by hand-sampling techniques.

Methods and techniques for obtaining samples of geotechnical materials which are stored in stockpiles or storage bins or loaded on freight cars or trucks are suggested in the following paragraphs. Samples may be taken from loaded freight cars or trucks; from conveyor belts delivering materials to or from stockpiles, bins, or transportation units; from storage bins at the point of discharge or from an exposed surface; from exposed surfaces of stockpiles; or from packaged materials.

a. Loaded freight cars or trucks. To obtain samples of material from a transportation unit, select the zone of material to be sampled, as determined from the sampling plan which was discussed in the preceding paragraphs. Excavate two trapezoidal-shaped trenches across the segment of the transportation unit to be sampled; the trenches should intersect to form a "cross" at the center of the quadrant, as determined by a plan view of the transportation unit. The bottom of the trenches should be level and at least 0.3 m (1 ft) deep and 0.3 m (1 ft) wide. At five locations along the bottom of these two trenches, obtain a sample by pushing a shovel downward into the material. As an alternative sampling plan, excavate three or more trenches across the unit that will give a reasonable estimate of the characteristics of the load. At least two shovelfuls of material should be obtained at random locations from the bottom of each trench. Each shovelful of material may be placed in a separate container or combined, depending upon the requirements of the investigation. The number of increments or the size of each sample can be adjusted accordingly to meet the requirements of the investigation. When bulk materials are sampled, sound judgment is required to ensure that disproportionate shares of segregated materials are not obtained.

b. Conveyor belts. Three locations can be used to sample the contents of a conveyor belt: the point of discharge of material onto the conveyor belt, an intermediate location on the conveyor belt, or the point of discharge of material from the conveyor belt. To sample at the point of loading or discharge, a stream of material can be captured. Care is required to ensure that the sampling device intercepts the entire width of the discharge stream and that material does not overflow the sampling device; these precautions are necessary to reduce the potential for segregation of material which could result in misinterpretation of the test data. If an intermediate point along the conveyor belt is sampled, the full width of flow must be sampled. Insert two templates, shaped as the cross section of the conveyor belt, into the material to define a volume (mass) of material to be sampled. Scoop all material, including fines, into a suitable container. Samples should not be obtained from the initial or final discharge from a storage facility or transportation unit; this material may be segregated.

c. Storage bins. Two methods are available for sampling the contents of storage bins: samples may be obtained at the point of discharge from the storage facility or from an accessible location, such as the top of the material stored in the facility. If samples of material are obtained at the point of discharge, follow the procedures which are described in the paragraph for sampling the contents of a conveyor belt. If samples are obtained from an exposed surface of material, such as the top of material in a storage bin, follow the procedures which are described in the paragraph on sampling the contents of transportation units. The number of increments which are sampled should be adjusted to the size of the storage bin and/or to satisfy the requirements of the investigation. Individual samples can be examined to determine the variation of material within the bin or combined for a representative sample. Use judgment to ensure that disproportionate shares of segregated materials are not obtained.

d. Stockpiles. To sample the contents of a stockpile, select a zone along the periphery of the stockpile at some point away from the bottom of the pile. Climb to a location about 1 m (3 ft) above the zone to be sampled. Shove a form or several boards vertically into the stockpile just above the zone to help prevent material from raveling down the side of the stockpile onto the material to be sampled. After the form has been placed, remove material from the surface of the stockpile to a depth of about 0.3 to

0.6 m (1 to 2 ft) perpendicular to the original surface of the stockpile. Obtain a sample by pushing a shovel into the material in a direction which is perpendicular to the original surface of the stockpile. Repeat this process to obtain the required number of samples or the desired volume (mass) of material. For fine aggregates, it may be possible to push or drive small-diameter sampling tubes into the material to obtain samples. If sampling tubes are used, remove the outer layer of material as previously described; then push the sampling tube into the material in a direction perpendicular to the original surface of the stockpile. Samples should be taken at various levels and locations on the stockpile; individual samples may be combined for a representative sample or placed in separate containers to evaluate the variability of material in the stockpile. As a general rule, do not sample the bottom or exposed surfaces of the stockpile because the coarser and finer particles may have segregated to a greater degree at these locations.

A power-driven front-end loader may be used to obtain sample(s) provided that care is taken to ensure that the sample(s) is representative of the contents of the stockpile. If a front-end loader is used, a sampling plan should be devised which satisfies all of the requirements which have been identified for hand-sampling methods; the principal difference is merely the volume (mass) of soil obtained by the front-end loader as compared to hand- sampling methods. According to the data presented in Table 12-1, a volume of material as large as 0.1 m^3 (4 ft^3) could be required, depending upon the gradation of material; this volume of material is negligible when compared to the volume of material which can be moved in the bucket of a power front-end loader. Hence, the use of the front-end loader for obtaining representative samples of materials from a stockpile may not be as feasible as hand-sampling techniques.

e. Roadways. For quality control of subbase or base materials for roadways, use hand-sampling techniques which are described in this chapter or in Chapter 11. If power drilling equipment is used, follow the methods and procedures which are described in Chapters 5 through 8.

f. Quarries and borrow pits. To obtain samples of aggregates from quarries or bank-run sands or gravels, follow the procedures which are discussed in the Chapters 5 through 8 if power-drilling and sampling equipment is used or Chapter 11 if samples are obtained by hand-excavation methods, depending upon the requirements of the investigation. Drill test holes or excavate to determine the lateral and vertical extent of the deposit and its quality. The required depth of the samples will depend on the quantity and character of the material that is needed, the nature and topography of the deposit, and the value of the material. If a visual examination of the material reveals that a significant variation of materials within the formation exists, a specific plan for sampling the materials, i.e., random locations to define the uniformity or variability of material or specific locations to define an anomaly, should be considered.

12-4. Required Volume of Samples

The volume (mass) of each sample of material must be tailored to satisfy the requirements for the investigation. The data in Table 12-1 can be used by geotechnical personnel to estimate the weight of material which is required to conduct a routine sieve analysis. If other tests are planned, the weight of material should be adjusted accordingly.

12-5. Preservation of Samples and Test Records

a. Preservation of samples. Samples should be placed in a noncorrosive container or bag and preserved as a representative sample for the particular zone or stratum of material. If the natural water content of the sample is to be preserved, the container must be waterproofed. For shipment, each sample of material should be packaged to prevent damage, such as loss or mixing of materials, freezing of aggregates, or change of water content, which could affect test results. Details for preserving and transporting soil samples are presented in Chapter 13; additional guidance is offered in ASTM D 4220-83 (ASTM 1993).

b. Test records. All pertinent data, including the project name, job or contract number, and the location of the respective samples, must be recorded on data sheets. The location of a sample should be referenced to a permanent control, whenever possible. A detailed description of the method(s) used to obtain each sample should be recorded. Each soil sample should be numbered and identified by visual techniques which are described in Appendix E; the sample number and a visualdescription of the material should be written on the data sheet as well as on a tag attached to the sample container. The type of sample container should also be noted. If field tests are performed, a data sheet for the various tests must be prepared giving all pertinent data which were determined. All data sheets should be dated and signed by the crew chief or technician performing the operation. Other details pertaining to test records are presented in Chapter 13.

12-6. Precautions

Caution should be exercised by personnel involved in sampling of material in stockpiles, storage bins, transportation units, or on conveyor belts. In addition to the normal precautions required for working in the proximity of power equipment, the use of dust-control masks may be needed when sampling bulk materials. Personnel are also advised to use caution when sampling the contents of storage bins or stockpiles; these materials may slough without warning. Supervisory and/or safety personnel should inspect and approve all techniques and procedures which are used to gain access to a particular zone of material within a stockpile or storage bin.

Table 12-1
Minimum Field Sampling Masses (after ASTM D 75-87)

Nominal Size of Aggregate	Minimum Mass of Sample, kg
Fine Aggregate	
No. 8 (2.36 mm)	10 (25 lb)
No. 4 (4.75 mm)	10 (25 lb)
Coarse Aggregate	
9.5 mm (3/8 in.)	10 (25 lb)
12.5 mm (1/2 in.)	15 (35 lb)
19.0 mm (3/4 in.)	25 (55 lb)
25.0 mm (1 in.)	50 (110 lb)
37.5 mm (1-1/2 in.)	75 (165 lb)
50 mm (2 in.)	100 (220 lb)
63 mm (2-1/2 in.)	125 (275 lb)
75 mm (3 in.)	150 (330 lb)
90 mm (3-1/2 in.)	175 (385 lb)