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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Practices for Handling, Storing, and Preparing Soft Undisturbed Marine Soil[1]

This standard is issued under the fixed designation D 3213; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 These practices cover methods for project/cruise reporting, and handling, transporting and storing soft cohesive undisturbed marine soil. Procedures for preparing soil specimens for triaxial strength, and consolidation testing are also presented.

1.2 These practices may include the handling and transporting of sediment specimens contaminated with hazardous materials and samples subject to quarantine regulations.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in Sections 1, 2 and 7.

1.4 The values in acceptable SI units are to be regarded as the standard. The values given in parentheses are for information only.

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2435 Test Method for One-Dimensional Consolidation Properties of Soils[2]

D 2488 Practice for Description and Identification of Soils (Visual Manual Procedure)[2]

D 2850 Test Method for Unconsolidated, Undrained Compressive Strength of Cohesive Soils in Triaxial Compression[2]

D 4186 Test Method for One-Dimensional Consolidation Properties of Soils Using Controlled-Strain Loading[2]

D 4220 Practices for Preserving and Transporting Soil Samples[2]

D 4452 Methods for X-Ray Radiography of Soil Samples[2]

3. Terminology

3.1 *Definitions*—The definitions of terms used in these practices shall be in accordance with Terminology D 653.

4. Summary of Practice

4.1 Procedures are presented for handling, transporting, storing, and preparing very soft and soft, fine-grained marine sediment specimens that minimize disturbance to the test specimen from the time it is initially sampled at sea to the time it is placed in a testing device in the laboratory.

5. Significance and Use

5.1 Disturbance imparted to sediments after sampling can significantly affect some geotechnical properties. Careful practices need to be followed to minimize soil fabric changes caused from handling, storing, and preparing sediment specimens for testing.

5.2 The practices presented in this document should be used with soil that has a very soft or soft shear strength (undrained shear strength less than 25 kPa (3.6 psi)) consistency.

NOTE 1—Some soils that are obtained at or just below the seafloor quickly deform under their own weight if left unsupported. This type of behavior presents special problems for some types of testing. Special handling and preparation procedures are required under those circumstances. Test are sometimes performed at sea to minimize the effect of storage time and handling on soil properties. An undrained shear strength of less than 25 kPa was selected based on Terzaghi and Peck.[3] They defined a very soft saturated clay as having undrained shear strength less than 25 kPa.

5.3 These practices shall apply to specimens of naturally formed marine soil (that may or may not be fragile or highly sensitive) that will be used for density determination, consolidation, permeability testing or shear strength testing with or without stress-strain properties and volume change measurements (see Note 2). In addition, dynamic and cyclic testing can also be performed on the sample.

NOTE 2—To help evaluate disturbance, X-Ray Radiography has proven helpful, refer to Methods D 4452.

5.4 These practices apply to fine-grained soils that do not allow the rapid drainage of pore water. Although many of the procedures can apply to coarser-grained soils, drainage may occur rapidly enough to warrant special handling procedures not covered in these practices.

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[1] These practices are under the jurisdiction of ASTM Committee D-18 on Soil and Rock and are the direct responsibility of Subcommittee D18.13 on Marine Geotechnics.

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] Terzaghi, K. and Peck, R. B., *Soil Mechanics in Engineering Practice*, 2nd ed., Wiley, 1967, p. 729.

5.5 These practices apply primarily to soil specimens that are obtained in thin-walled or similar coring devices that produce high-quality cores or that are obtained by pushing a thin-walled tube into cores taken with another sampling device.

5.6 These practices can be used in conjunction with soils containing gas, however, more specialized procedures and equipment that are not covered in these practices have been developed for use with such materials.

NOTE 3—For information on handling gas charged sediments, the reader is referred to papers by Johns, et al.,[4] and Lee.[5]

6. Apparatus

6.1 *Coring Device*, capable of obtaining high-quality soil specimens, including related shipboard equipment such as cable and winch. Typical coring devices used in industry are the wireline push or piston samplers.

NOTE 4—Some sampling devices, for example, box corers, obtain samples of a size or shape that are difficult to preserve. Such cores can be subsampled aboard ship by pushing a thin-walled sampler into the larger size core. This method can produce samples from soils obtained near the seafloor. The subsamples can then be handled and stored according to these practices.

6.1.1 *Metal or Plastic Liners or Barrels (Pipe or Thin-Walled Tubes*—), the soil will be obtained or stored within, or both. Short sections of the liner, sharpened on one end, may also be used to subsample larger sized cores (see Note 4). It is important to note that liners constructed of cellulose acetate butyrate (CAB) plastic are pervious to water. Polycarbonate is nearly impervious and polyvinyl chloride (PVC) is impervious to water migration.

6.2 *Equipment Required on Board Ship to Seal and Store Soil Samples*:

6.2.1 *Identification Material*—This includes the necessary writing pens, tags, and labels to properly identify the sample(s).

6.2.2 *Caps*, either plastic, rubber, or metal, to be placed over the end of thin-walled tubes, liners and rings, and sealed with tape or wax, or both.

6.2.3 *Packers*, or add wax to top and bottom of core to seal the ends of samples within thin-walled tubes.

NOTE 5—Plastic expandable packers are preferred. Metal expandable packers seal equally well; however, long-term storage using metal expandable packers may cause corrosion problems.

6.2.4 *Filler Material*, used to occupy the voids at the top and bottom of the sediment container. The material must be slightly smaller than the inside dimensions of the container and must be a light-weight, nonabsorbing, nearly incompressible substance. For example, wooden disks of various thicknesses that have been coated with a waterproofing material can be used.

6.2.5 *Tape*, either waterproof electrical or duct tape.

6.2.6 *Cheesecloth or Aluminum Foil*, to be used in conjunction with wax for block sample.

6.2.7 *Sealing Wax*, non-shrinking, non-cracking wax, includes microcrystalline wax, beeswax, ceresine, carnaubawax, or combination thereof.

NOTE 6—The wax must be able to adhere to the container and be ductile enough not to chip or flake off during handling at cold temperatures. Microcrystalline wax alone or in combination with other waxes has been shown to be satisfactory in sealing the ends of cores stored at low temperatures.

6.2.8 *Plastic Wrap*, used to prevent the wax from adhering to other objects and providing additional protection against soil moisture loss.

6.2.9 *Core Storage Boxes*.

6.2.10 *Rope, Cord, or Chains*, used to immobilize containers, boxes, or other core storage fixtures aboard ship.

6.2.11 *Shipboard Refrigeration Equipment*, when geochemical, or gas charged sediments are present or other special use. Refrigeration may not be needed under some circumstances, such as coring in shallow water in the tropics.

6.3 *Equipment for Transporting Cores*, used from the ship to a shore-based laboratory facility.

6.3.1 *Packing*—Material to protect against vibration and shock, includes foam rubber.

6.3.2 *Insulation*, if refrigeration is not used, either granule (bead) sheet, or foam type, to resist temperature change of soil or to prevent freezing.

6.3.3 *Shipping Containers*, either box or cylindrical type and of proper construction to protect against vibration, shock, and the elements. Refer to Practices D 4220.

NOTE 7—The length, girth, and weight restrictions for commercial transportation must be considered.

6.4 *Equipment for Storing Cores*, used at the shore-based laboratory facility.

6.4.1 *Refrigeration Unit*, capable of maintaining a temperature close to the in situ condition, see 6.2.11.

6.4.2 *Core Storage Boxes or Racks*, capable of supporting all cores in the vertical orientation in which they were obtained.

NOTE 8—An environment that is close to 100 % relative humidity may be required to minimize sediment water loss during storage of samples obtained within cellulose acetate butyrate (CAB) liners unless they are totally coated with impervious wax and plastic wrap. Other liner materials, such as polycarbonate or polyvinyl chloride (PVC) may be more suitable for sample storage because of their low water transmissibility.

6.5 *Equipment for Preparing Specimens*, used for laboratory testing.

6.5.1 *Thin-Walled Rings*, made of stainless steel or other noncorrosive metal or material, used to obtain samples for consolidation or permeability testing.

NOTE 9—The sampling ring may also be used as the test confining ring. For size and deformation requirements of consolidation test rings refer to Test Methods D 2435 and D 4186. Because of the small height to diameter ratio of consolidation samples and due to the nature of consolidation testing, the inside clearance ratio as specified by Practice D 1587 can be reduced from 1 % to zero. The ring area ratio, A_r, equal to $[(Do^2 - Di^2)/Di^2] \times 100$ (terms are defined in Practice D 1587) should be less than

[4] Johns, M. W., Taylor, E., and Bryant, W. R., "Geotechnical Sampling and Testing of Gas-Charged Marine Sediments at In Situ Pressures," *Geo-Marine Letters*, Vol 2, 1982, pp. 231–236.

[5] Lee, H. J., "State of the Art: Laboratory Determination of the Strength of Marine Soils," *Strength Testing of Marine Sediments, ASTM STP 883*, ASTM, 1985, pp. 181–250.

13 % to minimize subsampling disturbance.[6]

6.5.2 *Thin-Walled Piston Subsampler*, used to obtain triaxial test specimens from soil that quickly deforms under its own weight if left unsupported (see Fig. 1).

NOTE 10—To minimize soil disturbance, the sampler wall thickness should be the thinnest possible that will adequately obtain a test specimen. The area ratio (see Note 9) should be less than 10 % and the inside clearance ratio (refer to Practice D 1587) should be zero.

7. Hazards

7.1 Preserving and transporting soil samples may involve personnel contact with hazardous materials, operations, and equipment. It is the responsibility of whoever uses these practices to consult and establish appropriate safety and health practices and to determine the applicability of regulatory limitations and requirements prior to use.

7.2 Special instructions, descriptions, and marking of containers must accompany and be affixed to any sample container that may include radioactive material, toxic chemicals, or other hazardous materials.

7.3 Interstate transportation, containment, storage, and disposal of soil samples obtained from certain areas within the United States and the transportation of foreign soils into or through the United States are subject to regulations established by the U.S. Department of Agriculture, Animal and Plant Health Service, Plant Protection, and Quarantine Programs, and possibly to regulations of other federal, state, or local agencies.

[6] International Society for Soil Mechanics and Foundation Engineering, *International Manual for the Sampling of Soft Cohesive Soils*, Tokai University Press, Tokyo, 1981, p. 129.

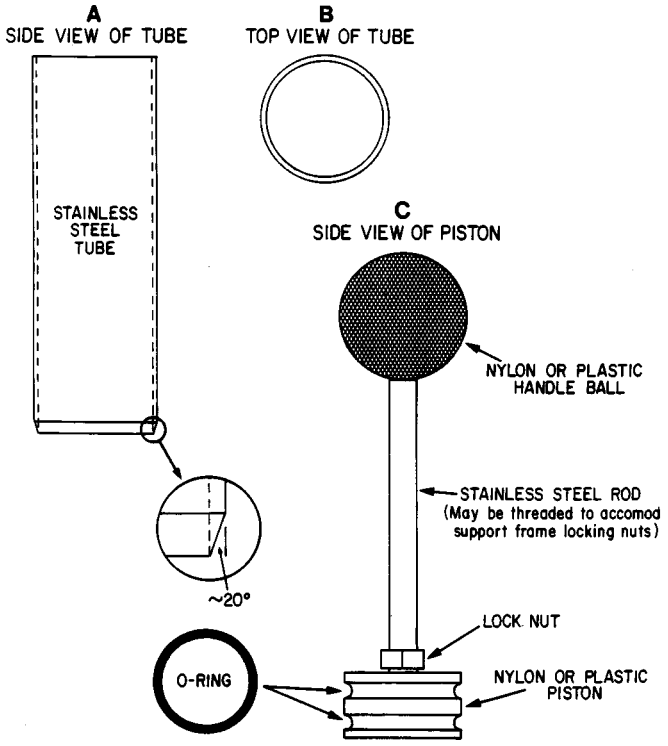

FIG. 1 Thin-Walled Piston Sampler

8. Procedure

8.1 *Shipboard Handling of Soil Cores not Requiring Subsampling*:

8.1.1 Carefully bring soil sampling or coring device aboard ship, avoid contact with either the side of the ship or moon pole, or dropping the device onto the deck during this process. For drop corers, have an end cap available to prevent material from dropping out.

NOTE 11—Proper coring and sampling operations may not be possible during adverse weather conditions or sea states.

8.1.2 Remove liner or core tube from soil sampling or coring device.

8.1.3 *Sealing the Bottom of the Sample Liner*:

8.1.3.1 Either insert expandable packer and tighten (some sediment may have to be removed) or add wax at top and bottom of core in its tube.

8.1.3.2 Apply an end cap and securely tape in place with waterproof electrical tape or duct tape. If the sample is to be stored for over 2 weeks prior to testing, insure that the tape is completely covered with wax by dipping the liner and end cap into a container of melted wax. Cover with plastic wrap prior to storage. Leakage or evaporation of pore water during storage is not acceptable.

NOTE 12—If an air void is present between the end of the liner and the soil surface, cut the liner level with the soil surface prior to applying the end cap or fill the void with a nearly incompressible, nonabsorbing inert material, or add wax (see Note 5). Free water accumulating above the sample when held vertically can be drained by either a small cut in the liner, drilled hole, or decanting. The liner is then cut off level with the soil surface. When cutting the liner, be sure that the method used does not impart significant vibrations to the soil or distort the liner.

NOTE 13—A rotary pipe cutter, fine-toothed crosscut hand or power saw, or custom-made device may be used to cut liner with a circular cross section. Snug-fitting metal sleeves applied around the liner perimeter on each side of the cut can be used to minimize liner distortion during the cutting process.

NOTE 14—Cheesecloth or aluminum foil taped to the end cap and liner allows better adhesion of the wax and reduces the potential of wax to chip or crack during handling. Cheesecloth or aluminum foil and wax may be applied to entire core sections to reduce leakage and evaporation.

8.1.4 *Recording Information on Core Liner*:

8.1.4.1 Mark a series of arrows or other appropriate symbols or text on the liner indicating the top of the core.

8.1.4.2 Mark the core liner in accordance with the project requirements with information such as cruise, station, and boring number/core identifiers and subbottom depth intervals on the liner at several locations. Adhesive labels can be used if they are securely fastened in place with tape or a coating of wax.

8.1.5 *Sealing the Top of the Sample Liner*:

8.1.5.1 Refer to 8.1.3.1 or 8.1.3.2 and Note 12 and Note 14.

8.1.5.2 Cores that are stored vertically for less than two weeks do not need the top cap waxed.

8.1.5.3 Cores that are stored horizontally for longer than 2 weeks require either waxing of both ends if packers are not used. Either brush wax on or dip ends into wax.

8.1.6 If the recovered core is larger than 1.5 m (4.9 ft), cut the liner into lengths of 1 m (3.3 ft) or less. Seal the ends in accordance with 8.1.3.1 or 8.1.3.2. It is desirable for ease of

storage and handling that cores are cut to the same length as far as practical.

8.1.7 Securely store the core in the same orientation in which it was obtained away from sources of vibration in an area typically along the vessel centerline and amidships, where the ship motion will be minimized.

NOTE 15—Cores are typically obtained and stored vertically. Some circumstances may require horizontal storage; for example, if significant gravitational compaction is anticipated, then the cores can be stored horizontally. However, horizontal storage can cause problems. For example, a smear zone can develop along one side of the core by gravitational compaction while oriented horizontally. If the cores are stored horizontally, make a note to that effect on the core sample information report. Better sample quality will be obtained by storing short cores sections vertically than by storing long cores horizontally.

NOTE 16—If refrigeration equipment is available aboard ship the soil samples should ideally be stored at the in situ, seafloor temperature. Deep sea soil is often stored at 5 ± 2°C. Under no circumstances should cores or subsamples be frozen because of possible water migration and volume change if index property, compressibility, and strength testing are to be performed, unless they contain permafrost or were naturally frozen.

NOTE 17—Where applicable, follow procedures for soil Groups C and D in Practices D 4220.

8.2 *Shipboard Handling of Soil Requiring Subsampling*:

8.2.1 Carefully bring coring device aboard ship; avoid contact with the side of the vessel or dropping the device onto the deck during this process.

8.2.2 Expose sediment surface to be subsampled.

8.2.3 Insert subsampling device into core.

NOTE 18—The subsampling device may be a piece of liner sharpened on one end, a thin-walled stainless steel ring, or a thin-walled stainless steel piston sampler (Fig. 1). The inside diameter of the thin-walled subsampler may be the same as the outside diameter of the laboratory test specimen.

8.2.4 Remove the subsampler from the large-size core and clean the excess soil from the exterior of the subsampler with a spatula and wipe with either a cloth or paper towel.

8.2.5 Seal the ends of the subsampling device to prevent drainage. Refer to 8.1.3.1 or 8.1.3.2.

8.2.6 Refer to 8.1.4 and 8.1.7.

NOTE 19—Sealed subsampled sections for long term storage can be stored in tanks of seawater to reduce the potential for moisture loss. The salinity of the seawater should be similar to the salinity of the sediment's pore water.

8.3 *Transportation of Samples from the Ship to the Shore-Based Laboratory*:

8.3.1 Transport cores or subsamples in accordance with Practice D 4220 for soil Groups C and D where applicable.

NOTE 20—If cores are stored at in situ temperature aboard ship, then provision for maintaining that temperature during transportation to the shore-based laboratory would be optimal. However, if transit time is short and containers are adequately insulated, special provisions are generally unnecessary.

NOTE 21—Tilt indicators can be applied to the interior and exterior of shipping containers to record mishandling. Any mishandling must be noted and considered when analyzing data from the resulting test program.

8.4 *Storage of Samples at the Shore-Based Laboratory*:

8.4.1 Securely store cores and subsamples in the orientation in which they were obtained in situ. Refer to Note 15.

8.4.2 Check the cores as appropriate for signs of leakage. Report and correct any leakage.

8.4.3 Store cores in the dark at their in situ temperature at high humidity.

8.4.4 Test cores as soon as possible after sampling.

NOTE 22—Storage time should be minimal. Some properties may change for some types of soil within hours or days of sampling. Storage should not be allowed to adversely affect the soil properties to be measured.

8.5 *Specimen Preparation*:

8.5.1 Follow specimen handling procedures for each respective test.

8.5.2 If any test, for example, a consolidation test, requires that a top cap be placed on the soil make the top cap out of a light-weight inert material so that applied consolidation or shear stresses are minimized.

8.5.3 For the triaxial compression test, refer to Test Method D 2850, and the following special provisions.

8.5.3.1 Specimens that cannot be trimmed with a common soil lathe because the soil quickly deforms if left unsupported can be prepared by using a thin-walled piston sampler (Fig. 1).

8.5.3.2 Obtain test specimen. The piston sampler is operated by keeping the piston fixed at the level of the soil surface while pushing the tube down into the soil. Use the piston sampler in conjunction with a support device that keeps the piston stationary, during both subsampling and subsequent extrusion.

8.5.3.3 Quickly place a membrane around the specimen after extrusion, assemble and fill the test chamber with fluid.

NOTE 23—Whenever water must be added it is preferable to add water having the same electrolyte as the natural water.

NOTE 24—The above procedure should provide an acceptable triaxial specimen for all but the weakest marine soil.

9. Report

9.1 The following data obtained onboard ship and in the laboratory for each core or boring should be reported. Individual items are marked as follows: E − essential, D − desirable, U − useful.

9.1.1 Cruise or Project identification (E),

9.1.2 Station/boring number and core identification (E),

9.1.3 Date and time of sampling (D),

9.1.4 Location, including latitude and longitude (E),

9.1.5 Water depth (D),

9.1.6 Sea state, weather conditions (U),

9.1.7 Corer or sampler type (E),

9.1.8 Core barrel or sampler length, and cross section dimension(s) (D),

9.1.9 Free-fall height or rate of penetration (U),

9.1.10 Amount of weight added and total weight of coring device (U),

9.1.11 Bottom elevation (D),

9.1.12 Subbottom penetration depth, depth of sampling interval (E),

9.1.13 Total recovered length and length of individual subsections (D),

9.1.14 Soil description (see Practice D 2488) (D),

9.1.15 Storage orientation (U),

9.1.16 Storage temperature (U), and

9.1.17 Names of party members (U),

9.2 Note if any of the following conditions were present or occurred:

9.2.1 Visible degassing (D),

9.2.2 Pore water leakage, when it occurred, how it was corrected (D),

9.2.3 Soil disturbance, at what subbottom depths in the core (D),

9.2.4 Mishandling or problems during recovery, transportation and storage (E), and

9.2.5 Potential hazardous substances (E).

10. Keywords

10.1 laboratory fine-grained soils; marine; soft; storage; undisturbed samples