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Guidelines for handling, storing, and preparing soft marine sediment for geotechnical testing

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ABSTRACT

These guidelines present: (1) a list of the equipment needed to properly store and sample marine sediment cores at sea and on land; (2) a set of procedures for handling the cores that minimize disturbance during shipping, storage, and sample preparation; and (3) a list of information that should be included in a sediment core/sample report form.

INTRODUCTION

Some sediment that is obtained at or just below the seafloor quickly deforms under its own weight if left unsupported. Special handling and preparation procedures are required under those circumstances. That type of behavior also presents special problems for some types of testing. In fact, tests are sometimes performed at sea in order to minimize the effect of handling and storage time on sediment properties.

Physical disturbance imparted to sediment after sampling can significantly affect some geotechnical properties. The primary purpose of these guidelines, many of which are currently used at the U.S. Geological Survey (USGS) geotechnical testing laboratory in Woods Hole, Mass., is to set forth methods for handling, transporting, and storing soft fine-grained marine sediment samples that minimize disturbance to the final test specimen from the time it is initially sampled at sea to the time it is placed in a testing device in the shore-based laboratory. A device used to obtain compressive strength test specimens in very soft sediment is also described.

These guidelines apply to naturally formed marine sediment samples some of which may be fragile or highly sensitive, that are to be tested for density, consolidation, permeability, and shear strength. These procedures apply to fine-grained sediment that does not allow the rapid drainage of pore water. Although many of the practices can apply to coarser-grained sediment, drainage may occur rapidly enough to warrant special handling procedures not covered here.

These practices primarily apply to sediment samples that are obtained in thin-walled or similar coring devices or that are obtained aboard ship by pushing a thin-walled tube into another coring device.

APPARATUS

Some sampling devices disturb the sediment less than other equipment. Thin-walled samplers that penetrate the seafloor under the influence of gravity or those that are pushed into the sediment are preferred to samplers that are thick-walled and/or are hammered or vibrated into the seafloor.

Box corers and other sampling devices can 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 sized core. The subsamples can then be treated for handling and storage according to these guidelines. This method can obtain excellent sediment samples.

In addition to a coring device and recovery equipment such as the cable and winch, a shipboard sampling operation should also be outfitted with metal or plastic liners and/or barrels (pipe) that the sediment will be obtained and/or stored within. Short sections of the liner, sharpened on one end, may also be used to subsample larger sized cores.

Equipment required on board ship to seal and store sediment samples:

- o Identification material - this includes writing pens, tags, and labels to properly identify the samples;
- o Caps, either plastic, rubber, or metal, to be placed over the ends of thin-walled tubes, liners, and rings, in union with vinyl plastic electrical tape and/or wax;
- o Packers, devices which expand when tightened to create a tight seal around the inside-perimeter of liners or barrels, used to seal the ends of samples within thin-walled tubes; - Plastic expandable packers are preferred to metal packers which may cause corrosion problems during long-term storage.
- o 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-diameter of the container (if round) and must be a light-weight, nonabsorbing, nearly incompressible substance. Wooden disks of various thicknesses, which have been coated with a water proofing material, can be used.
- o Tape, either waterproof vinyl plastic electrical or duct tape;
- o Cheesecloth, to be used in union with wax;
- o Sealing wax, such as microcrystalline wax, parafin, beeswax, ceresine, carnaubawax, or combinations thereof; - The wax must be able to adhere to the container and be ductile enough to resist chipping and flaking during handling at cold temperatures. Microcrystalline wax alone or in combination with other waxes has been satisfactory in sealing the ends of cores stored at low temperatures.
- o Plastic wrap, used to prevent the wax from adhering to other objects and providing additional protection against sediment moisture loss;
- o Core storage boxes; - Refer to Standard practices for preserving and transporting soil samples D4220 (ASTM, 1986).
- o Rope or cord, used to immobilize cores aboard ship; and
- o Shipboard refrigeration equipment (if needed).

Equipment required to transport cores from the ship to the shore-based laboratory facility includes:

- o Packing material (e.g., foam rubber) to protect against vibration and shock;
- o Insulation, either granule (bead), sheet, or foam type, to resist temperature change of soil or to prevent freezing; and
- o Shipping containers, either box or cylindrical type and of proper construction to protect against vibration, shock, and the elements;

- The core storage boxes used aboard ship can be used for transporting the samples, however, the length, girth, and weight restrictions for commercial transportation must be considered. Refer to Standard practices for preserving and transporting soil samples D4220 (ASTM, 1986).

Equipment required to store cores at the shore-based laboratory facility includes:

- o Refrigeration unit, capable of maintaining a temperature close to the in situ condition (if needed); and
- o Core storage boxes or racks, capable of supporting all cores in the orientation in which they were obtained.

Equipment required to prepare specimens for laboratory testing includes:

- o Thin-walled rings, made of stainless steel or other noncorrosive metal or material, used to obtain samples for consolidation or permeability testing; and
- o Thin-walled piston subsampler, used to obtain triaxial test specimens from sediment that quickly deforms under its own weight if left unsupported (Fig. 1).

PRECAUTIONS

Preserving and transporting soil samples may involve employee contact with hazardous materials, operations, and equipment. Samples may be subject to quarantine and statutory regulations, and these need to be determined in advance. It is also most important that appropriate safety and health practices are known and established before these procedures are used.

Containers that may include radioactive material, toxic chemicals, or other hazardous materials must be clearly marked and described, and must be handled in accordance with specific instructions.

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. Dept. of Agriculture, Animal and Plant Health Service, Plant Protection, and Quarantine Programs, and possibly to regulations of other Federal, State, or local agencies.

These guidelines do not purport to address all of the safety problems associated with handling and transporting hazardous material. It is the responsibility of the user to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use (ASTM Standard D4220, 1986).

PROCEDURE

Shipboard handling of sediment cores not requiring subsampling:

1. Carefully bring coring device aboard ship; avoid contact with the side of the ship or dropping the device onto the deck during this process. Proper coring and sampling operations may not be possible during adverse weather conditions or sea states.
2. Remove liner or sampling pipe from coring device.
3. Seal the bottom of the sample tube by one of these methods: (a) insert expandable packer and tighten; or (b) apply an end cap and securely tape in place with waterproof electrical tape or duct tape. The end cap and tape should be completely brushed with or dipped in wax and covered with a plastic wrap prior to storage. Leakage or evaporation of pore water during storage is not acceptable.

   If an air void is present between the end of the liner and the sediment surface, fill the void with a nearly incompressible, nonabsorbing, inert material or cut the liner level with the sediment surface prior to applying the end cap. When cutting the liner be sure that the method used does not impart significant vibration to the sediment or distort the liner.

   A rotary pipe cutter or custom made device may be used to cut liner with a circular cross section. Snug fitting aluminum sleeves applied around the liner perimeter on each side of the cut can be used to minimize liner distortion during the cutting process.

   Cheesecloth taped to the end cap and liner allows better adhesion of the wax and reduces the potential of the wax to chip or crack during handling. Sometimes cheesecloth and wax is applied to entire core sections to reduce leakage and evaporation.

Record information on liner or pipe:

4. Clean and dry liner.
5. Mark a series of arrows or other appropriate symbols or text on the liner indicating the top of the core. Mark the cruise, station, and 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.
6. Seal the top of the sample tube with the same procedure that was used on the bottom of the sample (step 3).

   Cores that are stored vertically for a short period of time do not need the top cap waxed. Cores that are stored horizontally, require waxing of both ends. Do not tip the core end over end to dip the top in wax; the wax should be brushed on.
7. If the recovered core is greater than 1.5 m long, cut the liner into less than 1 m lengths to reduce the hydrostatic head and potential for leakage at the base of the liner, reduce the potential for sediment compaction, and to facilitate transportation. Be sure to label all parts of a core after cutting. Seal the ends according to steps 3 and 6.
8. Securely store the core in the same orientation in which it was obtained away from sources of vibration. If possible, storage should be along the centerline and amidships, where ship motion will minimally affect the sediment.

Cores typically are obtained and stored vertically. Some circumstances may require horizontal storage; 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 if gravitational compaction is followed by tilting the sediment back into a vertical position. If the cores are stored horizontally, a note to that effect must be made on the core sample information report.

If refrigeration equipment is available aboard ship, the sediment samples should be stored at the in situ temperature. Deep sea sediment is often stored at approximately 4°C. Under no circumstances should cores or subsamples be frozen, unless they contain permafrost or were naturally frozen. Sediment samples obtained from shallow waters in tropical zones probably do not require refrigeration.

Where applicable, procedures for soil groups C and D in Preserving and transporting soil samples D4220 (ASTM, 1986) should be followed.

Shipboard handling of sediment that requires subsampling aboard ship should be handled in the following manner:

9. Carefully bring coring device aboard ship; avoid contact with the side of the ship or dropping the device onto the deck during this process.
10. Expose sediment surface to be subsampled.
11. Insert subsampling device into the core. 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 sub-samplers may be the same as the outside diameter of the laboratory test specimen.
12. Remove the subsampler from the large-size core and clean the sediment from the exterior of the subsampler. Dry the subsampler.
13. Seal the ends of the subsampling device to prevent drainage (steps 3 and 6).
14. Record information on the subsampler liner (step 5).

Sealed subsampled sections can be stored in tanks of sea water to reduce the potential for moisture loss. The salinity of the sea water should be similar to the salinity of the sediment's pore water.

Transportation of samples from the ship to the shore-based laboratory:

15. Transport cores or subsamples according to methods in Preserving and transporting soil samples D4220 (ASTM, 1986) for soil groups C and D where applicable.

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 samples are in adequately insulated containers, special provisions are generally unnecessary.

Tilt indicators can be applied to the interior and exterior of shipping containers to record mishandling. Any mishandling must be noted.

Storage of samples at the shore-based laboratory:

16. Securely store cores and subsamples in the dark at their in situ temperature under high humidity conditions in the orientation in which they were obtained in situ (if possible). Cores should be checked daily during the first week for signs of leakage, then weekly. Any leakage should be reported and corrected.

    Cores should be tested as soon as possible after sampling. Storage time should be minimal. Some properties may change for some types of sediment within days or weeks of sampling, and samples should be checked at regular intervals to assure that storage is not adversely affecting the sediment properties to be measured. All sediment should be tested within six months of sampling.

Sample Preparation:

17. Handle specimens according to ASTM procedures (if applicable) for each respective test, for example, Standard test method for unconsolidated, undrained compressive strength of cohesive soils in triaxial compression D2850 (ASTM, 1986).

    If any test requires that a top cap be placed on the sediment, the top cap should be made out of a light weight inert material with low compressiblity so that applied consolidation or shear stresses are minimized.

    Some unsupported sediment quickly deforms and therefore cannot be trimmed with a standard soil lathe. Specimens can be prepared in such circumstances using a thin-walled piston sampler (Fig. 1). The following procedure, utilizing a piston sampler, should provide an acceptable triaxial specimen for all but the weakest marine sediment.

18. Assemble the piston sampler as shown in Figure 2b. Keep the piston fixed at the level of the sediment surface while pushing the tube down into the sediment (Fig. 2c). The piston sampler should be used in conjunction with a device that keeps the piston stationary during subsampling and subsequent extrusion.
19. Quickly place a membrane around the specimen after extrusion.
20. Quickly assemble and fill the test chamber with fluid. Some investigators use sea water for the chamber fluid, but it not mandatory.

REPORT

The following information should be obtained and recorded onboard ship and in the laboratory:

- Cruise identification;
- Station and core identification;
- Date and time of sampling;
- Location, including latitude and longitude, (or equivalent);
- Water depth;
- Sea state, weather conditions;
- Corer or sampler type;

- Core barrel or sampler length and cross-sectional dimensions;
- Free-fall height or rate of lowering;
- Amount of weight added to corer;
- Subbottom penetration depth;
- Total recovered length and length of individual subsections;
- Sediment description;
- Storage orientation;
- Storage temperature; and
- Names of party members.

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

a. Visible degassing;
b. Pore water leakage; When did it occur? How was it corrected?
c. Sediment disturbance; What type? At what subbottom depth(s) in the core?
d. Mishandling or problems during recovery, transporation, or storage.

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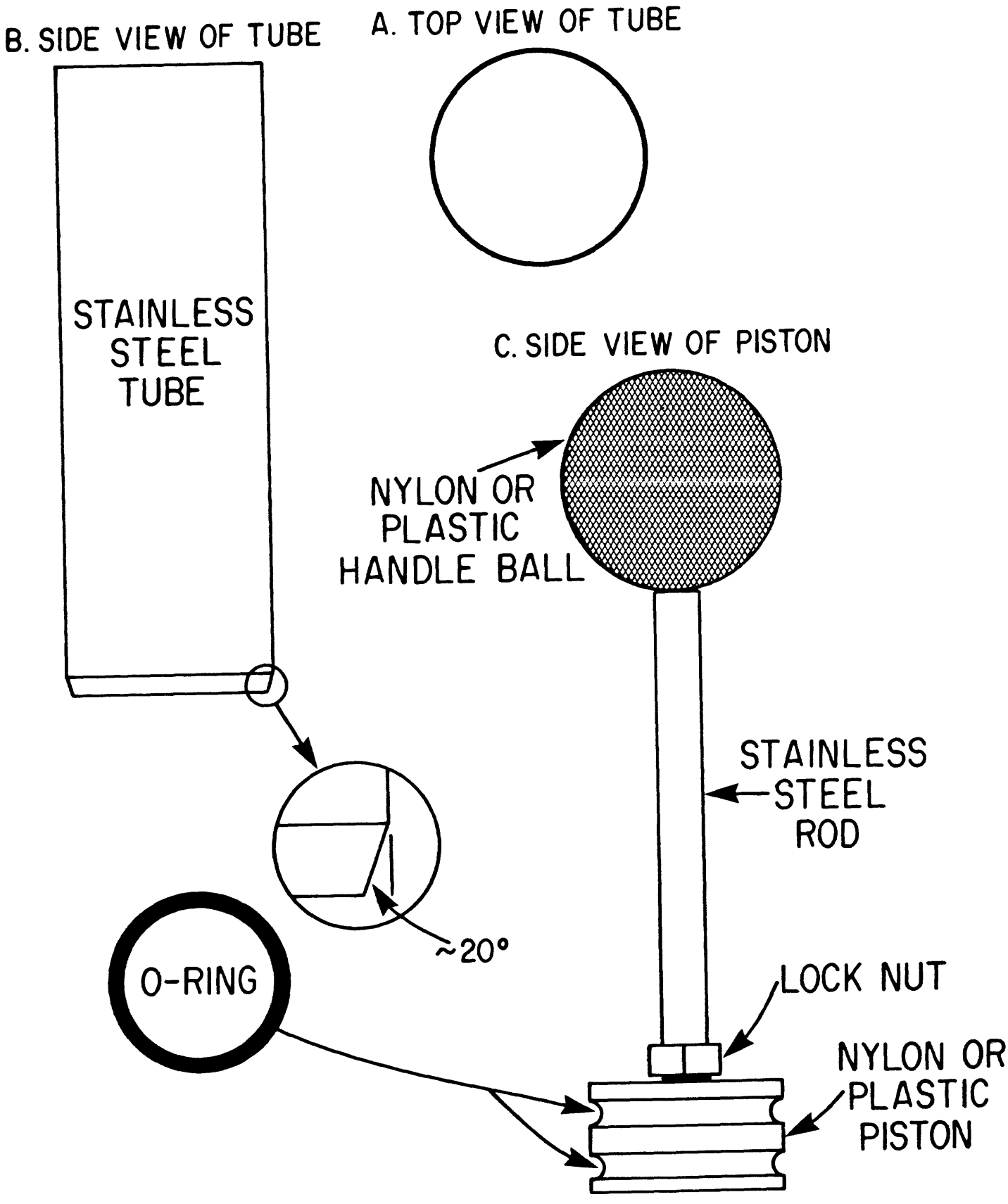

Figure 1. Thin-Walled Piston Sampler.

(a) Piston sampler components and sediment sample.

(b) Piston and tube in contact with sediment surface.

(c) Piston still at sediment surface level, tube pushed into sediment.

Figure 2. Operation of Thin-Walled Piston Sampler.