Chapter 23

HANDLING AND TRANSPORTING ROCK AND SOIL SAMPLES

Introduction

Subsurface sampling is expensive and time consuming, so it makes sense to obtain all information possible from the investigative process and the retrieved samples. After expending the money and effort to obtain subsurface information, the samples should not be subjected to unacceptable temperature, rough handling, shoddy packaging, or harsh transportation methods. Any type of mishandling of a sample may make the sample useless for testing or logging, and the investigation may have to be repeated.

There are certain procedures in the handling and transporting of samples that should be a part of every investigation. However, some programs might require more demanding techniques in the handling of samples than others, depending on the types and ultimate uses of the samples. Proper handling results in lower overall costs when the cost of repeating an investigation is considered.

The care and handling required for samples collected for hazardous or toxic material investigations can vary considerably, and details for this type of sampling are not provided in this chapter. Information on required volumes of material, types of storage containers, methods of collection and preservation, and maximum holding periods should be obtained from the appropriate regulatory agency.

Poor samples are sometimes the result of poor drilling practices rather than mishandling. Compression fracturing of core, "spun" core, or uneven or wavy core surfaces may indicate that drilling techniques are inappropriate for the conditions. Problems should be noted in the logs and corrections or improvements should be made immediately, if practicable, to the drilling procedures.

When samples requiring extreme care are obtained, personnel involved in the investigation must be totally familiar with the following procedures, and they must have a clear understanding of which geologic features are to be sampled and why they are to be sampled.

The geologic characteristics and the intended use of the rock and soil samples determine the extent and type of care required. If engineering properties are to be determined, the sample must be handled and preserved so that the properties are not significantly influenced by mechanical damage, changes in chemistry, and environmental conditions such as moisture and temperature.

Design requirements for samples range from geologic logging to complex and critical testing in the laboratory. Priorities for multiple uses or different types of tests must sometimes be established when available samples are limited and when a use or test precludes another test. When the required level of protection is unknown, overprotection is better than underprotection. If the sample is intended for geologic logging only, the care and preservation may be entirely different from that which would be needed if testing in the laboratory is required. Even though the sample has been geologically logged, other studies might be necessary, and continuous care in handling and proper storage may be required.

Samples can range from highly disturbed to relatively undisturbed. The methods of obtaining soil samples vary and may range from "grab" samples to samples obtained by highly refined drilling and sampling techniques. Soil can be difficult to sample whether by drilling or test pits, and obtaining an "undisturbed" sample of soil can be an ordeal. To obtain good "undisturbed" (minimally-disturbed) soil samples, extensive knowledge and experience with numerous types of soil sampling equipment, drilling methods, and drilling fluid additives is necessary.

Specific procedures for the disposal of rock core and samples depend on several factors; see chapter 24 for guidelines.

Sample Protection

The following describes recommended procedures for handling rock and soil samples (samples). The sample groupings are based on the type of testing to be performed, rather than any physical condition of the samples, and generally conform with ASTM Standards. Groups 1 through 4 deal with rock core, but note that the change to soil-like characteristics is transitional rather than abrupt. Table 23-1 summarizes the procedures.

Drilled core not requiring special preservation should be removed from the core barrel and placed directly into the core box. Core requiring special preservation should be placed in the core box as soon as possible after completion of preservation. Any required special moisture preservation procedures should be done immediately. Fragile core must be immediately protected by wrapping and sealing. Preliminary logging should take place in the field, but protective measures take precedence over time-consuming detailed logging. Any core that is to be wrapped or otherwise protected should be photographed first. With extremely sensitive core, protective measures take precedence over photography.

Table 23-1.—Rock- and soil-sample categories for handling and transportation

			Group							
			Rock				Soil			
			1	2	3	4	A	B	C	D
Characteristics	Rock	Non-sensitive, non-fragile	●							
		Moisture sensitive		●						
		Fragile, moisture or temperature sensitive			●					
		Soil-like rock				●				
	Soil	Visual identification, gradation					●			
		Percent moisture, Proctor, density						●		
		Intact, special testing [2]							●	
		Intact; fragile or highly sensitive for special testing								●
Testing Requirements	Logging		●	●	●	●	●	●	●	●
	Percent Moisture			●	●			●	●	●
	Special Testing [2]			●	●			●	●	●
Handling and Transporting	Rock	Core boxes	●	●	●					
		Film, foil, and wax		●	●			●	●	●
		Shock or vibration protection			●	[1]			●	●
		Heat or cold protection			●				●	●
	Soil	Avoid contamination					●			
		Any type container					●			
		Sealed, moisture-proof container			●			●	●	●
		Keep in natural position							●	●

[1] See Groups A through D requirements.
[2] Special testing can include density and swell determinations, consolidation, permeability, shear and compressive strength, and other tests as required.

The core should be photographed to provide images as shown in figure 23-1. The boxes should be oriented relative to the camera to minimize distortion and lighting should be appropriate to maximize resolution. A photography frame, as shown in figure 23-2, provides consistent orientation and image quality.

Group 1: Nonsensitive, nonfragile samples for which only geologic logging is necessary belongs to this group.

For rock cored in 5- to 10-foot (1.5- to 3-m) runs, samples are sufficiently protected if placed in strong wood or plastic core boxes. Cardboard boxes are unacceptable because the boxes deform when wet, rot, and are readily destroyed by insects. If very long solid cores have been recovered and need to be preserved intact, place each core in a stiff tube or two half-rounds of tubing of equal or slightly greater length than the core and secure both ends. The inside diameter of the tube should be slightly larger than the core diameter and the tube walls must be rigid enough to prevent core breakage because of bending.

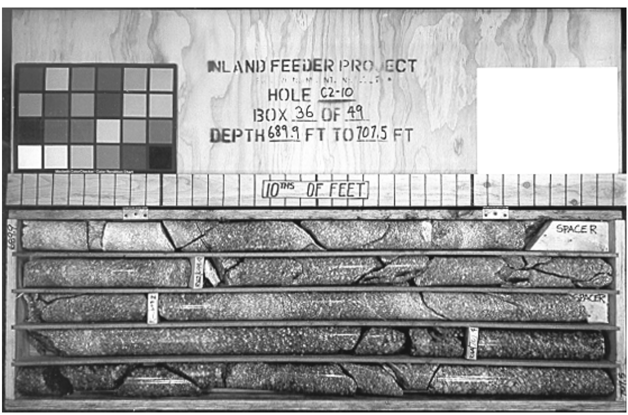


Figure 23-1.—Properly boxed and labeled core.

Figure 23-2.—Core storage area with boxes neatly arranged and separated by spacers for ventilation. Note core photography frame in center of photograph.

The tubing should be impermeable, such as Lucite or PVC, to prevent loss of stiffness of the tubing in moist conditions.

Group 2: Rock core that is subject to moisture loss or gain and must be tested later belongs in this group. Requirements for this level of protection include requirements for Group 1.

The moisture condition of some rocks and even the moisture history of rocks such as shales affect the rock properties. If tests are to be performed on the core and if a change in moisture conditions may influence the test results, the core must be sealed to prevent moisture loss. This same procedure applies to any samples when it is important to maintain fluids other than water, such as hydrocarbons.

The term, "wax," refers to a "plastic" microcrystalline mixture composed of one part microcrystalline wax for strength and adhesion and one part paraffin or beeswax for plasticity. This mixture optimizes adherence and minimizes brittleness and cooling cracks in the wax. This material should be applied at no more than 18 degrees Fahrenheit (° F) (10 degrees Centigrade (° C) above its melting point, especially if the wax is applied in direct contact with the sample material. Wax that is too hot can penetrate sample pores and cracks. If the wax bonds to the sample, the wax is too hot.

Sealing samples to preserve moisture should consist of a tightly fitting wrapping of a plastic film, such as vinylidene chloride (Saran wrap), covered by a tight wrapping of aluminum foil. Each of these wrappings should be applied so that as little air as possible is trapped beneath the wrappings. Lap the ends of the wrappings over the ends of the sample and fold over to seal the ends. Finally, apply a minimum of ⅛ inch (3 mm) of wax over the entire surface of the sample. A layer of cheese cloth applied on the foil before waxing is a good idea. This thickness of wax should consist of at least two coatings and preferably more. For long periods of storage, apply a minimum of ¼ inch (6 mm) of wax. Wax may be applied by brushing it on or by dipping the wrapped sample in a container of melted wax. After waxing, the sample may be placed and transported in a core box.

In some cases, aluminum foil wrapping might react chemically with either the sample or the sample's fluids. If a reaction is possible, aluminum foil should be replaced with some other metal foil that is nonreactive. A less preferable method is to omit the metal foil and increase the thickness of the sealing wax. If the metal foil is not used, the thickness of the sealing wax should be increased to ¼ inch (6 mm) when the required storage time is short (up to 1 month). For a longer period, a thickness of ⅜ inch (9 mm) is adequate. A layer of cheese cloth should be incorporated into the wax.

Group 3: These are samples that are fragile or moisture or temperature sensitive. This protection level includes the requirements for Groups 1 and 2.

If shock, vibration, or variation in temperature may subject samples to unacceptable conditions during transport, the samples should be placed in core boxes that provide cushioning or thermal insulation. Fragile samples may require packing in a cushioning material, such as sawdust, rubber, Styrofoam, (poly)urethane foam, bubble wrap, or similar material. The cushioning between the samples and walls of the core boxes should have a minimum thickness of 1 inch (25 mm) and should have a minimum thickness of 2 inches (50 mm) on the core box bottom and lid. The samples must fit snugly into the boxes.

Samples that are temperature sensitive should be insulated by placing the core container (box or tube) inside another container that is designed specifically to provide thermal insulation. These containers are generally constructed of double or triple layers of insulating material and are usually relatively airtight.

Group 4: These materials are so poorly indurated that soil sampling procedures must be used to obtain intact pieces of core. Certain shale or highly weathered rock that contains these materials as interbeds belong to this group. Group 4 samples are more soil-like than rock-like and should be treated according to the appropriate instructions for Groups A through D below.

Group A: Consists of soil samples for which only visual identifications or gradations are necessary. The main concern in dealing with this group is to avoid contamination with other soils. Group A samples may be transported in any type of container by any transportation method. If transported commercially, the container need only meet the requirements of the transporting agency and any other requirements necessary to prevent sample loss.

Group B: These are samples for which only water content and classification tests are required or Proctor compaction, relative density, or profile logging are required. Bulk samples that will be remolded or compacted into specimens for tests such as swell pressure, percent swell, consolidation, permeability, and shear testing are also included.

In all cases for Groups B, C, and D soils, a sample should be obtained for determination of in place moisture content; and the determination should be performed as soon as possible.

Group B samples should be preserved and transported in sealed, moisture-proof containers. Containers should be thick enough and strong enough to protect against breakage and moisture loss. The container types include: waterproof plastic bags or pails, glass or plastic jars, thin-walled tubes, and liners. Cylindrical and cube samples should be wrapped in suitable plastic film or cheese cloth, or both, and should be coated with several layers of wax according to the instructions for Group 2 samples.

If plastic bags or wrapping are used, the bags should be placed as tightly as possible around the sample, squeezing or sucking out as much air as possible. The plastic should be three mil or thicker to prevent leakage. If glass or plastic jars are used that do not close tightly, the lids should be sealed with wax. If plastic pails are used and the lids are not air tight, the lids should be sealed with tape and wax.

Thin-wall push tubes can be sealed with expandable packers, waxed wood disks, or cheesecloth and wax. The preferred (although expensive) method for sealing thin-wall tubes is with plastic or metal expandable packers, seated on the soil surface. These devices, tightly abutting the soil, will keep the soil firmly fixed in position in the tube. If waxed wood disks are used, a disk slightly smaller than the inside diameter of the tube should be inserted in each end of the tube, be in snug contact with the soil and then be sealed with wax. Several thin layers of wax are preferred over one thick layer. The final thickness should be at least 0.4 inch (10 mm).

Other spacers or packing materials extending from the waxed-wood disk or waxed-soil surface to the tube end are not recommended because these can allow the samples to move in the tubes. Any packing material must be nonabsorbent and must support the samples throughout shipment and storage.

Metal, rubber, or plastic end caps should be sealed with tape. For long-term storage (longer than 1 month), the taped end caps should be dipped in wax, applying two or more layers. End closures solely of cheesecloth and wax should consist of alternating layers of (a minimum of two each) cheesecloth and wax.

Cylindrical, cubical, or other samples wrapped in plastic or foil should be protected with a minimum of three coats of wax and cheesecloth. Cylindrical and cube samples wrapped in cheesecloth and wax should be sealed with a minimum of three alternating layers. Cylindrical samples and small cube samples placed in cartons must be positioned so that wax can be poured completely around the sample. The wax should fill the void between the sample and container wall. To facilitate handling when placed in cartons, large cube samples, such as waxed "block" samples, should be encapsulated in damp sawdust rather than wax. Generally, waxed samples should be wrapped in plastic or foil before being surrounded by wax in a carton.

These samples may be transported by any available transportation. The samples should be shipped as prepared or placed in larger containers such as bags, cardboard or wood boxes, or barrels. Appropriate packing should be provided to prevent breakage or puncturing of the individual sample wrapping or container.

Group C: These are intact, natural or field compacted samples for density determinations or for swell pressure, percent swell, consolidation, permeability testing, and shear testing with or without stress-strain and volume-change measurements.

These samples are preserved and transported in sealed, moisture-proof containers. Containers should be thick enough and strong enough to prevent breakage and moisture loss. The container types include: plastic bags or pails, glass or waterproof plastic jars for disturbed samples, and thin-walled tubes and liners. Cylindrical and cube samples should be wrapped in suitable plastic film or aluminum foil and coated with several layers of wax and cheesecloth according to the instructions for Group 2 samples. Some soils may corrode aluminum foil; and direct contact with aluminum foil should be avoided where sample composition might cause adverse effects. Temperature sensitive Group C samples should be insulated similar to Group 3.

Samples transported on seats of vehicles can be placed in cardboard boxes or similar containers, and samples need to be packed to prevent bumping, rolling, and dropping.

If the samples are not transported on vehicle seats, the individual samples should be placed in wood, metal, or other types of suitable shipping containers that provide cushioning or insulation for each sample. The cushioning material should completely encase each sample. The cushioning between the samples and walls of the shipping containers should have a minimum thickness of 1 inch (25 mm). A minimum thickness of 2 inches (50 mm) should be provided on the container bottom. When required, the samples should be kept in the same position in which they were sampled from the time they leave the ground until testing is completed. Special conditions should be provided, such as freezing, controlled drainage, or sufficient confinement to maintain sample integrity.

Group D: Samples that are fragile or highly sensitive and that require tests in Group C are assigned to Group D. The requirements for Group C must be met in addition to the following requirements: Samples should be handled and stored, including during transportation, in the same orientation in which they were sampled.

Storage Containers

Containers should be designed to include:

For core

- Core boxes must be constructed rigidly enough to prevent flexing of the core when the box is picked up by its ends. Wood is preferred and should be ¾ inch (nominal) (19 mm) thick. Partitions between core rows should be firmly fixed in place to increase the stiffness of the box. The lid should have strong hinges and hasps or fastened with screws. Do not drive nails in the lid. An example of core box construction is shown in figure 23-3.

- The core box should be designed for the anticipated diameter of core, including any packing and cushioning materials. If the core box is too large for the core, spacers or packing material should be placed in the box to support the core and prevent the core from moving in the box. If the core box is too small for the core, the core should not be hammered into the box.

For soils in Groups C and D and for rock in Groups 3 and 4, if required:

- The container should be constructed so that the samples can be maintained in the same position as when sampled or packed.

- The container should include sufficient packing material to cushion or isolate the samples from vibration and shock.

- The container should include sufficient insulating material to prevent freezing.

Shipping Containers

The following features should be included in the design of shipping containers:

- Plywood (preferably marine plywood) ½ or ¾ inch (13 to 19 mm) thick may be used for shipping containers. The top (cover) should be hinged and latched or fastened with screws. The entire shipping container should be lined with insulation a minimum of 2 inches (50 mm) thick for protection against freezing or temperature fluctuation.

- Metal shipping containers should have cushioning and insulating material similar to wood shipping containers, although slightly greater thicknesses are appropriate. Cushioning with a spring suspension system or any other means that provide similar protection is acceptable.

- Bulk Styrofoam with slots or pockets in the shape of the sample tube or liner should be enclosed in a protective outer box of plywood or cardboard.

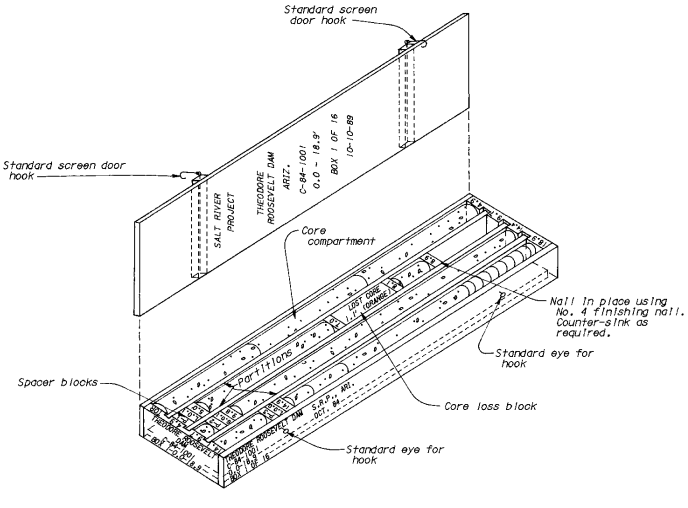
- Properly lined containers constructed of laminated fiberboard, plastic, or reinforced cardboard outer walls are acceptable.

Core Handling

The following procedures are necessary to ensure that rock core is firmly fixed in the core box and is appropriately labeled for inspection and logging:

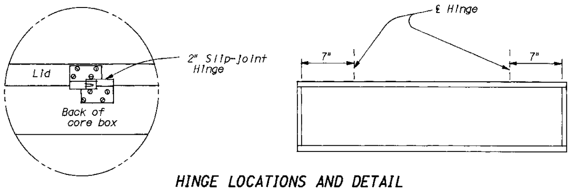
- Orient the core box with the slots horizontal. Place the core in the core box starting with the shallowest depth at the upper left hand corner and progressing across and then downward, as in reading a book, with the deepest depth at the lower right hand corner.

- Place core blocks at the ends of each run with the depth clearly written on them.



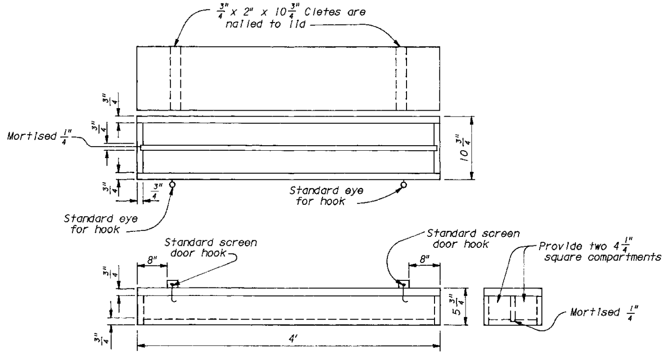
GENERAL LABELING AND TERMINOLOGY DETAILS

NO SCALE



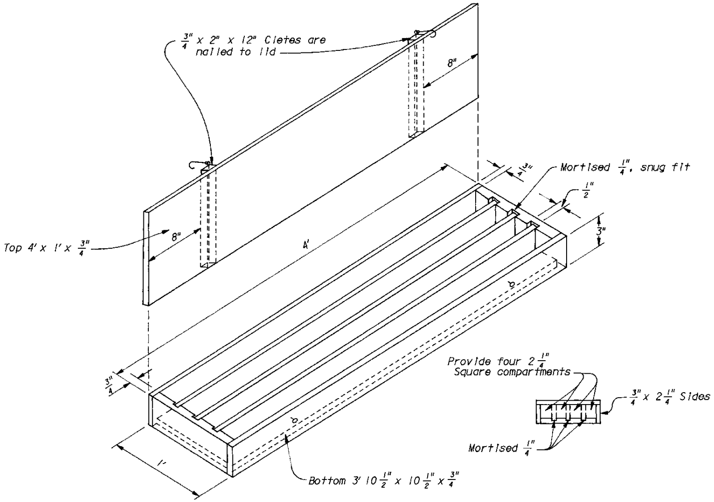
HINGE LOCATIONS AND DETAIL

NO SCALE



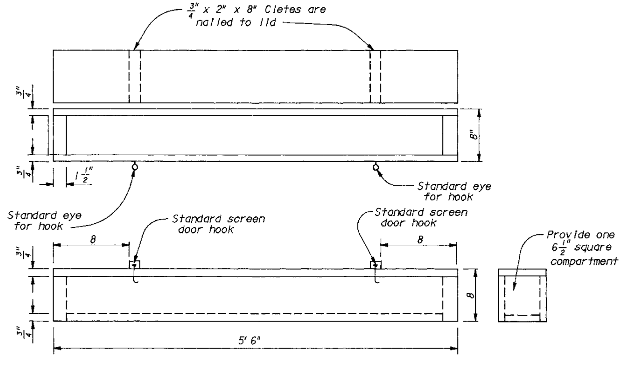
4-INCH CORE BOX CONSTRUCTION AND DIMENSIONS

NO SCALE



N-SIZE CORE BOX CONSTRUCTION AND DIMENSIONS

NO SCALE



6-INCH CORE BOX CONSTRUCTION AND DIMENSIONS

NO SCALE

NOTES

1. **Box construction** - Ends, sides, partitions, lid, and bottom shall be constructed of grade No. 2 pine or better, and surfaced on all sides except that end pieces on 6 in. core boxes shall be 1 1/2 in. thick. The grain shall be parallel to the long axis. All pieces shall be seasoned to prevent objectional warping. All joints shall be securely fastened with 8d ring shank nails, spaced on not over 6-inch centers and with at least two nails at each corner. The ends and bottom shall be mortised 1/4 inch deep to accept partitions. The bottom shall fit snugly within the framework of the box. The lid shall be hinged as shown on this drawing.
2. Partitions for N-size core shall be nominally 4 feet long, 2-1/2 inches high, and 1/2 inch - thick. Partitions for 4 inch core shall be nominally 4 feet long, 4-1/2 inches high and 1 - inch thick.
3. **Spacer blocks.** - Twelve spacer blocks for each N-size box, six spacer blocks for each 4-inch box, and three spacer blocks for each 6-inch box shall be required. Spacer blocks shall be constructed of 3/4-inch nominal clear lumber, sized equivalent to clear opening of the core compartment and are to be nailed in place at the bottom of each core run with number 4 finishing nails. Spacer blocks shall be painted white. Should some core be left in the hole, the driller shall limit his run so as not to overfill the core barrel. The gain shall be recorded when recovered.
4. **Core loss blocks.** - Core loss blocks shall be constructed from wood or styrofoam stock, sized equivalent to the clear opening of the core compartment. The length of these blocks shall be equivalent to the core loss interval and shall be inserted in the run wherever core loss occurs, with the exception that for accumulated (interval indeterminable) core loss, the block shall be placed at the end of the run and before the spacer block. Core loss blocks shall be painted fluoresent orange or tangerine.
5. **Workmanship.** - Boxes shall be constructed substantially to withstand rough usage and shall be nailed to secure members without splitting.
6. **Core box labeling.** - Labeling shall be stencilled on each box with black waterproof paint or equivalent. The following items shall be marked on the interior and exterior center of the lid:
   A. Feature
   B. Project
   C. State
   D. Drill hole number
   E. Drill interval
   F. Box__of__boxes
   G. Date
   Items A., D., E., and F. shall be stencilled in like manner on both exterior ends and the exterior front of each box.
7. Depths in feet and tenths of a foot (meters) shall be marked clearly with a black-waterproof felt-tip pen, or equivalent, on the top of both box ends for each core compartment. Spacer blocks shall be labeled to show Run or Run pull number, starting depth of that Run, and the amount of lost core (or gain) that occurred during that run. Core loss blocks shall be marked in like manner with the top and bottom of the loss interval.
8. **Handling of core and boxes.** - The top of the core shall be placed at the back left corner of the box, and the remaining core shall be placed proceeding left to right, back to front, throughout the remaining core compartments.
9. Unused portions of the partitions shall be filled with wood or styrofoam stock, sized equivalent to the clear opening of the core compartment, cut to fit.
10. Nail the lid into place only if required.

ALWAYS THINK SAFETY

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

SALT RIVER PROJECT - ARIZONA
SAFTY OF DAMS - MODIFICATIONS

THEODORE ROOSEVELT DAM
CORE BOX DETAILS

DESIGNED GEOLOGY STAFF — TECHNICAL APPROVAL [signature]
DRAWN D.D. Drouillard, C.S.B. — SUBMITTED [signature]
CHECKED [signature] — APPROVED [signature] CHIEF, GEOLOGY BRANCH

DENVER, COLORADO
COMPUTER DRAFTING — 25-D-3708

Figure 23-3.—Example core box construction.

- Runs of less than 100-percent core recovery should be shown by spacer blocks placed in the core box at the suspected missing interval and clearly identified.

- After photographing and after samples are prepared, samples removed from the core should be replaced by a spacer block equal in length to the core removed. The block should be labeled "sample," and depths should be noted and placed in the core run.

- Breaking the core should be avoided because it may reduce the number of available test specimens. If it is necessary to make core fit in the core box, note on both the daily drill report and the geologic log and mark on the core to indicate mechanical breakage.

- If needed, add sufficient spacer blocks to prevent the core from shifting during subsequent box handling.

Figure 23-1 is an example of properly boxed and labeled core.

Identification of Samples

All samples, whether rock or soil, must be properly identified, and the following information should be written on the sample or container:

- Project name
- Feature name
- Hole, pit, or trench number
- Top and bottom depths of sample interval
- Sampling date
- Sample number

In addition to the above:

- Clearly and prominently mark samples containing suspected or known hazardous materials.

- Attach sample tracking or "chain-of-custody" form, if required.

- Clearly mark samples that must be handled and stored in the same orientation as sampled, stating that requirement and the required orientation.

Transportation Requirements and Procedures

For all modes of transportation, the loading, transporting, and unloading of shipment containers should be supervised as much as possible. The following requirements and procedures should be considered when transporting core:

- Remove the sample from the drill site before it has a chance to freeze, heat up, or be damaged by activities at the drill site.

- Handle samples gently during loading and unloading. Never drop boxes or tubes; slide them gently into position. If a box or tube is dropped, record this fact.

- Transport by an appropriate vehicle to prevent damage by mechanical vibration, shock, freezing, and high temperatures along the entire transport route. In some cases, it may be necessary to remove the core from the vehicle and place it in a motel room or suitable storage area at night unless the vehicle can be left idling to keep the samples at an appropriate temperature.

- If rough terrain must be crossed, protect samples in the Group 3 and Group D categories by padding around the sides, bottom, and top of the core containers.

- Transportation by passenger car or air freight, rather than van or truck, may be more appropriate for fragile core. However, if air freight is used, ensure that the samples are transported in a heated, pressurized compartment. If the core is to be transported in the bed of a truck, there should be no heavy objects that could slide or roll into the sample containers.

- The driver of the vehicle carrying the samples should be thoroughly instructed in the required care of the samples.

- The vehicle carrying the samples should be in good mechanical condition. A breakdown on the transport route could leave the samples exposed to extreme weather conditions.

- Commercial carriers should be used only when samples are not sensitive to shipping damage and in-house forces and equipment are unavailable. Commercial carriers should be used only if the carrier is capable of delivering the samples in the desired condition. The sample custodian should ensure that all sample care requirements are clearly indicated on the lading documents.

Upright Handling and Shipping of Samples

For some types of studies or testing, such as those performed on liquefiable sands and sensitive clays, the samples must never leave the vertical or upright position. If samples should never leave the vertical or upright position, the following should be considered:

- Samples that must remain in the vertical position should be obtained with a thin-wall push-tube sampler. These samples are the easiest to handle once they are out of the ground. The ends can be easily sealed with expandable packers.

- If thin-wall push tube samples are not taken, sample lengths and diameters should be kept to a minimum. Six-inch- (15-cm-) diameter core that is 2 feet (0.6 m) long is about the maximum size that should be obtained. Samples larger than this are very difficult to handle in any position.

- Samples should never be removed from the liner or sampling tube.

- Sample tubes should be marked so that top and bottom are easily discernable.

- Racks that will hold the samples in an upright position must be designed and built for the size of sample being taken.

- Samples that must be transported commercially should be packed in a wood box. They should be insulated against temperature changes and protected against movement within the box. The packing box should be clearly marked to indicate which side is to remain up, that the contents are fragile, and that the contents require protection from freezing.

Storage Environment

All samples should be grouped according to storage requirements and stored so that air can circulate around the sample or sample container (figure 23-2). Samples that are sensitive to moisture loss should be stored at room temperature (73 °F, 22 °C) and at approximately 60-percent relative humidity. Higher levels of relative humidity can cause fungal growth. Samples in metal tubes should be processed as soon as practical to minimize sample changes that might occur because of interaction between the sample and the metal of the tube.

Wood boxes containing samples should be protected from repeated wetting and drying. This could cause warping and delaminating of the wood. The boxes should be protected against damage by insects and rodents.

Recommended Equipment

Following is a list of equipment necessary to process, handle, and transport either rock or soil samples:

- Vinylidene chloride (Saran wrap) film, aluminum foil, wax, down spout, PVC, or similar tubing
- Stove to melt wax
- Lucite or PVC tubing
- Sawdust, rubber, Styrofoam, or material of similar resiliency to cushion the core
- Miscellaneous equipment, such as adhesive tape and waterproof felt-tip markers

- Wood disks, prewaxed, 1 inch (25 mm) thick, with a diameter slightly less than the inside diameter of the thin wall tube
- Tape, either waterproof plastic or duct tape
- Cheesecloth
- Caps, either plastic, rubber, or metal, to be placed over the end of thin wall tubes
- Plastic or metal expandable end caps to seal the ends of samples within thin wall tubes by mechanically expanding an "O" ring against the tube wall
- Plastic or glass jars, wide-mouthed, with rubber-ringed lids or lids lined with a coated paper seal, commonly ½ pint (250 milliliter [mL]) and quart (1,000 mL)
- Bags, either plastic or burlap, with waterproof liner
- Plastic pails with air-tight lids
- Packing material to protect against vibration and shock
- Insulation to resist temperature change of samples to prevent freezing
- Sample cube boxes for transporting cube (block) samples, constructed with ½- to ¾-inch (13- to 19-mm) plywood (marine type)
- Cylindrical sample containers somewhat larger than the thin-wall tubes or liner samples

- Shipping containers, either box or cylindrical type, of proper construction to protect against vibration, shock, and weather; the length, girth, and weight of the containers must be considered when using commercial transportation

- Spacer-block material to replace samples taken