General TSC Recommendations for Curatorial Care of Concrete and Rock Drill Core Samples

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Rock and Concrete Core Samples obtained in the field should be handled in a manner that meets the needs and purpose of the exploration program, site conditions and the available mode(s) of transportation. For example, freezing conditions in the winter or direct sunlight and heat in the summer may have detrimental effects on the samples for use in specific tests. Therefore, a plan that is carefully thought out (including technical and common sense issues) and implemented is needed to handle the samples from the time they are retrieved to when they are delivered to the various users of the samples.

There is no set way to handle concrete and rock samples at every job site, or for every project. Therefore, a sampling plan will need to be developed for each specific investigation which will best fits the site conditions, equipment, weather, material types, intended purpose(s) of samples, and type of transportation from the drill site to both the local storage area and any final destination.

General guidelines that can be helpful for developing a sampling plan can be found in the following references.

1. USBR Concrete Manual 9th edition 1992
2. USBR Geology Manual, 2nd Edition, Volumes 1 and 2, 1998 and 2001
3. Geology Office Manual, April 1988
4. Electric Power Research Institute – Guidelines for Drilling and Testing Core Samples at Concrete Gravity Dams
5. ASTM Standard D-420 Standard Guide to Site Characterization for Engineering, Design, and Construction Purposes
6. ASTM Standard D-2113 Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation
7. ASTM Standard D-5079 Standard Practices for Preserving and Transporting Rock Core Samples
8. Corps of Engineer's Rock Mechanics Handbook
9. Corps of Engineer's Geotechnical Investigations EM 1110-1-1801
10. American Concrete Institute Guidelines

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http://intra.usbr.gov/library/

Other good resources are persons involved with previous similar projects and local drilling companies or government agencies that may have local experiences. Also, any documentation, especially drilling records in the same the same materials, can have information that is relevant to any special needs and concerns that might be required at the dill site.

With regards to the rock cores, other handling techniques may be needed if there are thick lithologic layers, or discontinuity infilling that are fragile or more soil like. Especially if any of those geologic zones might be tested. It should be remembered that field investigations can sometimes be dynamic, rather than static. Therefore, the sampling requirements may change as the drilling program progresses or as new ideas or demands come from new members of a FER (Field Exploration Program) or inclusion of consultant review members. With the availability of cordless drills, screw drivers, and saws any use of wooden core boxes should be easier to implement, and even construct at the drill site.

It should always be remembered that the cost per foot to drill a hole, if all of the core samples are not being used or tested, is not necessarily the value of all the samples obtained. An extreme example to illustrate this point is where a 125 foot hole is drilled to only obtain the basal shear plane of a landslide for testing. Therefore, the value of that one sample is the cost to drill the entire drill hole. Therefore, the curatorial care of that one sample should reflect the value of that sample. This is not to say that good curatorial practice is not always the goal. The example was to illustrate that depending on the investigations purpose how valuable all the samples are in general and particularly how some samples are extremely more value compared to other samples from the same drill hole. Figures 2 through 6 shows some of the potential consequences for not applying or developing good curatorial practices and hopefully instill proactive, forward thinking planning whether is one sample or many samples.

Any of the documents listed above can be supplied upon request. Please contact the Materials Engineering and Research Laboratory should you need further information or clarification on these documents.

<u>Concrete Cores</u>

Concrete cores are typically collected for uniaxial compression, and elastic modulus tests of the concrete mass and direct shear tests of lift lines. Any change from the in situ moisture content can, and does, affect the static compression test results (references available upon request). Sample quality of lift lines are primarily effect by drilling and handling issues. The following guidelines are with the assumption that preserving the moisture is most important requirement.

The preferred container for storage and shipping consists of wooden core boxes assembled with screws, with an interior plastic liner (IE plastic sheeting). The plastic liner provides a short term hermetic barrier around the wetted saw dust surrounding the concrete sample, which is also wrapped in clear plastic wrap. The wetted saw dust provides an additional barrier that cushions and preserves the moisture and integrity of the sample until it reaches the laboratory.

Plastic half rounds can be used too, if agreed to by the FER team. The ends will need to be capped and the sides seal with some sort of impervious tape if a hermetic seal is required. Plastic wrap of the sample before encapsulating with a plastic half round should still be done. However, it should be realized that while plastic half rounds can be cheap and adequately protect the sample moisture, that depending on the plastic half round wall thickness relative to the core size and length, they may not provide much protection to bending stresses. This is not a serious issue unless you are going to test particular sample intervals or want to preserve intact lift lines for testing. It is also important to plan ahead for the right diameter of plastic half rounds and to adjust either the drill bit size or the half rounds to fit properly.

The length of the core box or plastic half round depends on the diameter of the cores. This is important from the stand point of the lifting weight and sometimes from the space in which the boxes will be handled, like inside a dam gallery. This is especially true for our concrete coring which involves core diameters of 6-inch and larger.

Core boxes, and especially plastic half rounds not in core boxes, need to be handled and stored in both the field and any interim storage in a manner agree able with the site conditions and materials being collected. For example, ASR concrete must not be allowed to dry out, nor wet concrete allowed to freeze, or any other effect that changes the sample properties. This includes any exposure during transport from the drill site. It is easy to forget about this while driving down the road and not to factor in the cooling or drying effect of the ambient air moving over the boxes. The Materials Engineering and Research Laboratory group (D-8180) has empty concrete core boxes and half rounds they can send to the site, plus a core holder which will make it easier at the drill site to both log, photograph, and wrap the concrete cores with plastic wrap. However, the core holder may not suitable for concrete cores that are broken up badly since the rollers on their device are spaced far apart.

You can contact Veronica Madera at 303-445-2424 for assistance and more details on concrete curatorial requirements. This includes any requirements for core photographs in the field.

<u>Rock Cores</u>

The primary testing for this FER consists of direct shear tests of geologic discontinuities. Since this includes faults and other types of discontinuities the Field Exploration Program includes a list of critical features to be sampled. The anticipated condition of the recovered bedding planes and faults (I.E. clay filled, weak, etc) will help determine which storage method is best. The thickness, durability, degree of weathering, and mineralogy of any shear zone, or infilling (both primary and secondary) of discontinuities will require professional judgment at the drill site if the preservation of the test samples is to be selective. Furthermore, potentially weak zones identified for testing should not be allowed to separate in the direction of the core axis and disrupt or lose the material in the test zone. This is very important because any lost of weak samples leads to testing only the stronger materials and results in a bias set of test results. The following discussion and information is to be used to help select the curatorial best fit for this project and to head off any problems before they occur. The goal is to deliver the samples to the laboratory in a manner that the quality and, quantity of samples are not unduly reduce to testing program being reduced to only the best samples and an insignificant number of tests.

If the degree of curatorial care for concrete samples is such that it is important to protect a 5% change in the test results, then the curatorial care of rock cores is just as important, if not even more. This is because, depending on the type of rock and how fragile they are, the test values of the samples can be changed by the way the samples are cared for from 0 to 100%. For an extreme example, if an argillaceous sample dries out and falls apart it is 100% un-testable (see figures 3 and 4). Or an intact weak shear zone or clay filled discontinuity breaks up and/or dries out in the core box during shipping it is 100% un-testable. While rocks like granite may be less sensitive to curatorial care, it is still not unusual to hit zones that have been weathered or fractured and/or sheared to the point of being very fragile.

If the overburden material or any other cored intervals are not needed for the investigation it can be stored differently from the rest of the samples if the FER team is in agreement. However, it may not be cost effective to do so.

The preferred storage container for rock samples is also wooden core boxes (See the Geology Manual for more information) and the discussions that follow are mainly with regard to those types of containers**.** However, there are steel core boxes that are currently cost effective, until the differences between steel and wood prices change again, (www.coresaver.com/Products.htm) and that might be preferred if termites or other environmental issues could be detrimental to the wood core boxes. **Corrugated or plastic coated cardboard boxes, while much cheaper, are not acceptable if they do not meet the needs of the exploration and testing program. Any cost savings from using these boxes will more often than not be exponentially offset by any loss of critical samples needed for the investigation.**

Plastic half rounds, plastic tubing split longitudinally, to put on the outside of the sample to protect it in lieu of any core box are not usually a good idea for all rock cores. However, they are used in conjunction with providing extra protection and for shipping or storing small quantities of samples. Further discussion on half-rounds is discussed later in this document.

The dimensions of the core boxes will depend on many factors. The length of the core boxes will depend on such things as core barrel length and any need to minimize core breaks needed to fit the sample in the boxes, maybe the pallet size for shipping, and maybe the spaces where the boxes need to be handled or even stored. The number of sample channels is primarily determined by the total weight to be handled. Hinges and hooks for the core box lids are shown in the geology manual. While the hinges and hooks provide easy access and security to the samples, they are a hindrance in other ways and are therefore not required. Screws are preferred for both assembling the boxes and securing any lids. The lid should be screwed down on the box when filled and logging is completed. This will minimize any sample loss due to any accidental dropping, even during handling at the drill site.

The box design may need to be such that the samples do not support any weight that bears from stacking the sample boxes, for example the dividers contact the lid and not the sample. This is especially important if the samples, and in particular the samples that will be tested, are weak. **This is another draw back in the corrugated box design because the samples are required to with stand the weight and any gyrations of boxes stacked on top, rather than the core**

box. This can, and does damage samples by splitting and crushing forces. ***Furthermore, any savings in using the corrugated boxes is diminished by the increase in storage costs at the Denver Laboratories since the storage costs are per box. This is because of the added handling costs, smaller size of the boxes and not being able to stack them up as high to reduce storage costs too.***

The width and height of the sample channels also has to be planned so there is no excessive side motion to damage the sample during shipping, or not so tight that the sample is damage removing them from the box. Sample channels should be rigid, firmly attached along the entire length, and higher than the samples to help support the lid if necessary (see figure). Also, box dimensions will need to include provisions for any additional sample protection such as wax coatings or plastic half rounds are used which change the diameter.

While the core boxes discussed above are very protective of the samples, any transport of the boxes from the drill site may also require that the boxes be tied down in the vehicle. This is especially true if, for example, the transport of the boxes from the drill site involves a rough 4x4 road or any rise of an accident (see figure 6).

Major preservation effort of only selected geologic features and/or materials, and not the rest of the samples, may be done if agreed upon by the FER team. These can be left in the main core boxes or removed and place in separate core boxes to simplify boxing of the samples. As mentioned in the references, any removal of select samples should be clearly marked in the boxes with a spacer the same length of the sample and all necessary information on what, when, why and where on the core sample alternate location.

Clear plastic half rounds, sealed with clear plastic tape on the sides and some sort of cap on each end, are preferred for storing sensitive materials (Figure 1). Use of plastic half rounds are the least disturbing method of removing the core from the core barrel, in particular split tube barrel and logging the cores (See basic method in Geology Manual). Also, clear half rounds minimizes the need to open every sample to see what is inside, even though having pictures from the drill site help to minimize the need to open the core boxes or tubes. Ideally, when photos are taken a photo should be taken of the sample in the split tube when first half is taken off and then a second photo graph taken of the other side of the sample when the sample is transferred to the first half of the plastic split tubing. Similarly for non-split tube samplers the sample should be taken when it first removed from the barrel an in a half round and if possible a picture of the other side taken too.

Opaque plastic half rounds are acceptable too, but extensive photographs from the drill site will be even more important to have available. The plastic half rounds are made by splitting longitudinally plastic tubing. The half round can then be cut the exact length of the sample. Any excess space at the end of the tube can be filled to prevent axial spreading of the sample during handling, especially when there are weak discontinuities. The plastic tubing comes in various materials diameters, and wall thicknesses. Therefore, tubing can be obtained that when split will fit the core with in acceptable tolerances. The width of the cut should not be overlooked when determining the type of tubing to order. Also, unless the cuts are perfect the matching half rounds should be kept paired to assure proper fit. Clear plastic half rounds and end caps for HQ cores are available from the TSC laboratory. A list of alternative sources can be provided, if needed.

While the plastic half rounds are very good for protecting the specimens, a layer of clear, thin, plastic sheeting may still needed to be placed around the core samples. This is especially important for clayey materials that may adhere to the inside of the plastic half round and lead to serious damage to the specimen when the half round is removed later for inspection or specimen selection. Please note that the method shown in the geology manual of only protecting a soft zone in plastic does not prevent losing moisture out the ends of the sample and should not be used. The entire sample interval shall be protected. Furthermore, it is very important that only a single layer of plastic be used with a slight over lap and any seam sealed with tape that is resistant to moisture. This is easily accomplished when using a split tube sample barrel, as shown in the geology manual and having the plastic sheeting precut to do the job. If needed the length of a roll of plastic wrap can be easily cut with a band saw and then placed in like a toilet paper or paper towel roll holder to conveniently provide a roll of plastic wrap. The objective of this is to come up with an adequate width to handle the circumference of the sample and minimize the amount of excess plastic wrap against the sample to block viewing the sample and preventing the half round from fitting onto the sample.   Use of the plastic layer also keeps fragments from falling off to the side during removal of the sample from the split tube core barrel. If other sample barrels are used the sample can still be protected if planned correctly. For example, for a single tube barrel the core can be slid out of the barrel onto a plastic half round that already has a sheet of plastic laying in it. In either case, it is important to keep the entire sample in axial compression as much as possible while doing this to keep any weak zones from falling apart. The objective of either method is to take common sense steps that will minimize the disturbance of the core, especially any geologic material or interval to be tested. Wrapping multiple layers of plastic and/or tape around the sample is not desired as it will probably require spinning the sample around like a baton to do so and can actually lead to damaging the sample if it is weak or accidentally dropping it.   Also, damage can occur at the laboratory when attempting to remove all of the multiple layers, especially durable tape such as duct tape, and makes resealing of the sample, if needed, more difficult. Furthermore, core boxes where plastic half rounds are used will need to have allowances for the thickness of the plastic half rounds and/or end caps.

Core box spacers for the end of core runs, core loss zones, filling unused space, and where samples were removed in the core boxes can be made of wood.   However, some sort of durable, foam material that can be written on with an indelible marker works a lot better. Long lengths of square or round durable foam, the width and height of the sample channel in the core boxes, can be stored at the drill site and easily cut to length with a pocket knife, or saw, to fill in the entire space required. The ease of this method actually encourages workers at the site to do a better job of putting spacers in the boxes.

The content of the core boxes, and any other pertinent information, must be marked on the end and top of the core boxes as shown in the geology manual. This facilitates locating and handling of the core boxes when they are stacked and on pallets. Use “hole number” in lieu of “drill hole” on any sample box labels to prevent any confusion between the various types of drill holes and needed label according to the suffix and prefix symbols discussed in the Reclamation Geology Manual and Earth Manual.

Core boxes need to be handled, transported, and stored in the field and any interim storage in a manner consistent with the weather, materials being collected, and any intended tests. For example, argillaceous materials that will be tested must not be allowed to dry out and wet materials must not be allowed to freeze if future compressive tests or core logging results would be affected.

Shipping

Core samples for the Denver Office should be shipped or transported to:

US Bureau of Reclamation
Denver Federal Center

1) Building 56, Door S-6 for personal delivery or large freight loads (phone mounted outside wall). If needed, warehouse personnel are located near this door for assistance.
2) Building 67, room 162 for small UPS type boxes.

Denver Colorado
80225-0007

Attn: 86-68180 for Rock and/or Soil (Tom Strauss 303-445-2343)
86-68180 for Concrete (Veronica Madera 303-445-2424)

Core samples that are in sturdy boxes and properly strapped on pallets can be shipped by motorized, or air freight. Properly strapped means banding or tie downs of proper number, strength, and locations. An example of inappropriate banding is in the attached figure 6.

If needed, there are simple (inexpensive) and hi-tech motion monitors available to meet the requirements of the exploration program to monitor the forces during the transportation of the boxes. These can be obtained for personal use during transportation and if needed, many commerical shippers can provide the services to monitor shipment motions too. An additional or less high tech method of monitoring the shipment quality of the core boxes is to just use the photographs taken at the time the samples were obtained in the field and to compare with the condition of the samples when they are received in at the laboratory.

Both the TSC and the Warehouse Reclamation staff can help with the best (both ease and safe handling) and cheapest method of transportation and any other shipping issues. If possible, a list of boxes shipped and a copy of any draft drill logs was attached to the samples would be helpful and very much appreciated too.

Figure 1 Small scale example of a sample covered with plastic wrap and then enclosed by two clear plastic half rounds and plastic caps and all open joints between the caps and half rounds sealed with clear, non-porous tape that is not affected by moisture. Any open space between the ends of the sample space inside the half rounds may need to be filled to prevent moisture and/or mechanical damage to the sample too.

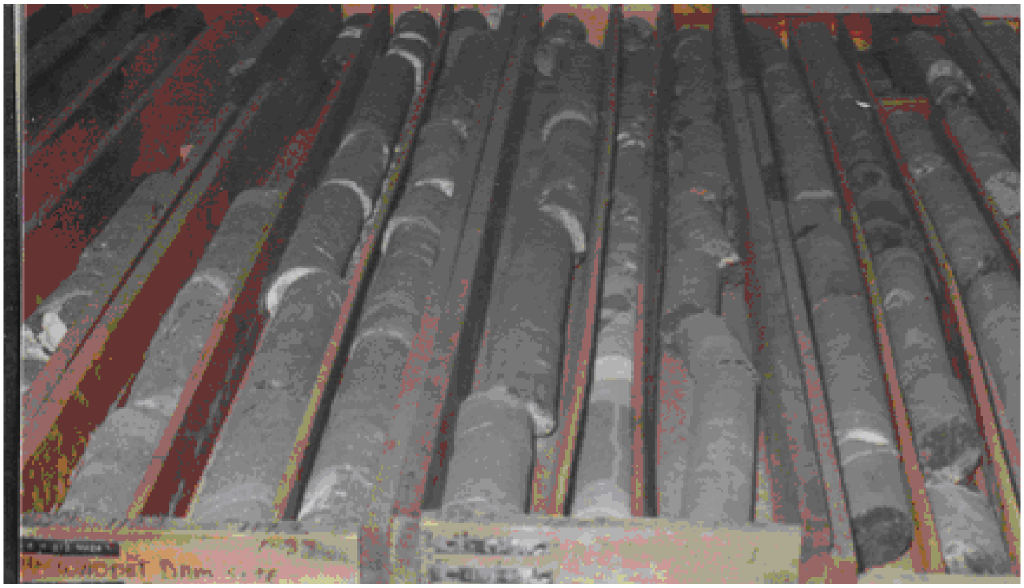

Figure 2 Example above shows sample channels wider than the core diameters, and the dividers not being rigidly attached to the bottom of the box. This resulted in movement during shipping and handling that resulted in the cores being broken up more than what they probably were when obtained at the drill site.

(a) (b)

Figure 3 Example on left (a) shows the weak material has dried out and fell apart from not hermetically sealing the sample. As a result samples are no longer testable. Example on the right (b) shows the disturbance of the samples which occurred during shipping and handling due to no dividers, not filling up the empty space, and trying to use a single half round to act as a core box divider.

Figure 4 Example on left shows what happens to samples that were testable, caliche in this example, when recovered and were shipped without protecting the natural moisture. Example on right shows what happens when using sample dividers that are not rigid and firmly attached in the box and not filling up the unused space. Note all the fragments that came from the sample in the plastic half round because the sides and ends were not sealed.

Figure 5 Extreme example of why it is prudent to screw down the lids on the core boxes and to tie down the boxes to the truck bed both when at the drill site and during transport. The parking brake was not set and approximately 150 feet of core, costing $150,000 to obtain, was lost.

Figure 6 Example of improper way to band core boxes to pallet using duct tape. Note how boxes shifted during shipping and could have come apart during transportation.