SPREE **VAULT DESIGN AND CONSTRUCTION**

INTRODUCTION

While at the PASSCAL Instrument center a number of various stations design were discussed. This is a summary of the possibilities. One important factor is that we are provided with a specific set of equipment and materials. We can (of course) build these stations any way we like, BUT we will have to purchase (and pay for) any non-standard materials we use. PASSCAL will not purchase custom materials for us.

1) SITE SELECTION

Site selection should be carried out with the following characteristics in mind:

security from vandalism
security from flooding either because of the topography or because of the station design
stability rock site vs sand vs clay (clay can swell and shrink with yearly moisture cycles
access to site recall that servicing may be done during times of the year with vastly different conditions that during the installation phase
size a space approximately 3m X 3m (10' X 10') is needed to contain all the components - vault, data-logger enclosure and solar panels

2) DESIGN AND CONSTRUCTION

The important design characteristics are:

- protecting the equipment in case of flood - especially during spring snow melt which tends to be very wet in this region
- physical isolation of the sensor from the vault (de-coupled from the vault)
- thermal isolation
- ease of access during servicing should also be a consideration - there are times, especially in clay soils when the sensor may need to be re-leveled not just re-centering the masses.

There are a multiple possible designs for these sites. Some possibilities are (1) the type of station used in the FLED and MOMA deployments, (2) the type used in previous FlexArray deployments, (3) modifications of the basic FlexArray design and (4) a modification of the design for stations which cannot be buried (e.g. on the Canadian Shield)

A) FLED design

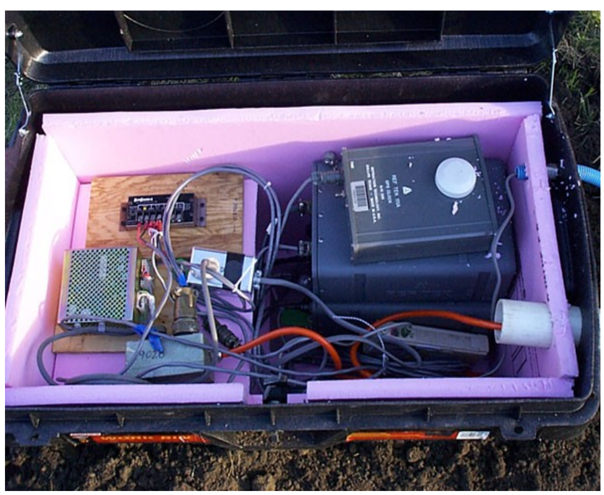


Note that although there is a drain in these pictures, the drain comprises the thermal isolation of the sensor and is not suggested here.

Note also that the seismometer must be on a pier about 4" above the bottom of the vault. In the case of flood, water will rise up inside the inner barrel. This height is to protect sensors such as the STS-2 and T120 which have connectors near the base of the unit. This height is really not necessary for a Guralp 3T.



Note the small inner barrel with concrete blocks. While this protects well from flooding I do not believe that it does a good job of thermal isolation.


During the Tonga Fiji deployment we tried a modification of this design, where the battery and data-logger were placed in the same barrel as the sensor in place of the concrete weights. This would be a good design for a drier climate. I was not happy with this modification in places where an inordinate amount of water over a short time occurs. We had issues with the data logger and battery compartment being flooded and causing some damage although the sensor was protected. This could be remedied by burying the barrel a little less deep that was using in Tonga and Fiji, but this affects thermal stability.

Advantages of this design:

- using a concrete paver the entire station can be constructed by one team in one day
- properly done the sensor and data-logger are protected from flood
- the sensor is (to some degree) decoupled from the vault barrel

Disadvantages of this design:

- while there is some thermal isolation - it is not as good as the FA design
- if not built well (drain, pier raised up off the floor of the vault 4" - 6") there can be flood damage
- cost - we would have to purchase the following: (use the supplied data-logger enclosure)

concrete pavers	$12.00
55 gal drums	$110.00
30 gal drums	$ 75.00

TOTAL ~$200.00 per station in addition to batteries

B) FexArray Design

Note the similarity of this design with what we have done in the past (to be honest the similarity is expected as both designs are doing the same simple job).
Note however
- the barrel is much more narrow than the 55 gal. drum we are use to using , so the use of an inner barrel for flood protection is not possible
- the "action packer" is about the same as the tufbins we used in the past but more flimsy. These have holes in the bottom, but plugs and bolts are provided to make the case water tight.

Here note that the image on the left is the BOTTOM of the vault barrel. There is a membrane on the bottom of the barrel to seal the vault from water.   Wet concrete is poured into the hole and the barrel (with membrane) is pushed down into the wet cement. More concrete is added to the inside of the barrel. The sensor is placed directly on this inner pad (allowing for the cement to cure of course). This means that the sensor is more strongly coupled to the barrel than in the FLED design.

The sensor is leveled and then wrapped in plastic. The vault is filled with clean sand. This leads to excellent thermal isolation, but does have it's own set of issues - see disadvantages)

Notice that the barrel is not completely below the surface - it is buried up to the hose fitting, then covered with a tarp.
Advantages of this design:
- There may be a reduction of noise due to the sand - or there may not be some stations do better covered with sand but some have no improvement
- we will use the materials supplied and not have to purchase barrels etc from our part of the grant.

Disadvantages of this design: (which may be real disadvantages or just something to think about)
- sensor is strongly coupled to the barrel, so the barrel will need to be completely buried.
- SHOULD the vault flood, this will be a terrible mess to clean up.
- during a service trip, should the sensor not be able to correctly center the masses, it will be more difficult to check that the problem is simply a non-level sensor and to adjust the sensor
- care must be taken NOT to get an air bubble under the bottom membrane when placing the barrel down in the wet cement in the bottom of the hole.
-great care must be taken with the pouring and tamping of sand around the sensor. Sand must be tamper well and evenly with every few inches of sand poured

EQUIPMENT PROVIDED BY FLEX ARRAY

Data Logger Enclosure -> Rubbermaid Storage container - with all plugs, hose fittings and clamps. Note that holes have been drilled into the bottoms of these containers, but there are a set of plugs which (I am told) will make the bin water-tight again.

Vault -> cylinder, with all clamps and hose fittings There is a rubber membrane covering the bottom of the vault cylinder.

Solar Panel mount -> They use a 65Watt PV. An easily transported A-frame mount is provided, but the top of the frame is only about 3' high. In my opinion this is not tall enough to keep the solar panel out of any drifting snow. We will have to provide our own. (this is easily done with a few sections of 2" X 4")

In general FlexArray provides everything needed for a site (vault, data logger enclosure, fittings, hose clamps etc. etc.) EXCEPT:

- concrete for the outside of the vault
- grout to form the inside plug of the vault
- sand to cover the sensor
- fencing and fence posts for the site
- batteries

C) MODIFICATION OF (B)

There has been ongoing discussions about a "direct burial" station design. This design does NOT use a vault and pier. A hole is dug about 2' to 3' down. The bottom of the hole is layered with sand. The feet are removed from the sensor and the sensor is placed in a long plastic bag. The sensor is placed directly on the sand , leveled and oriented. The long plastic bag runs out of the hole into the data logger enclosure, encased in conduit. The advantage of this design is ease of installation. However, this has only been used (to my knowledge) in dry climates (Nevada, New Mexico). We can think about a few modifications to the FlexArray design.

1) One problem with the standard FA design is that a station needs to be built in two steps. The first step is to dig the hole, place the cylinder and pour the grout to form the inner plug and concrete the cylinder into the ground. This needs to be left for a few days to allow the concrete and grout to cure. This means that each site will need to be visited twice. This is logistically more difficult - but does have the advantage that the some of the rebound associated with digging the hole is recovered by the time the sensor is installed. In the past we have tried to avoid this. We can prepare the cylinders prior to deploying (during the huddle tests for example) by pouring the internal plug. The bottom of the cylinder and membrane would then need to be protected during transport (a simple foam pad taped to the bottom). Then in one site visit, the vault can be installed, concrete poured around the outside of the cylinder and the rest of the station installed.

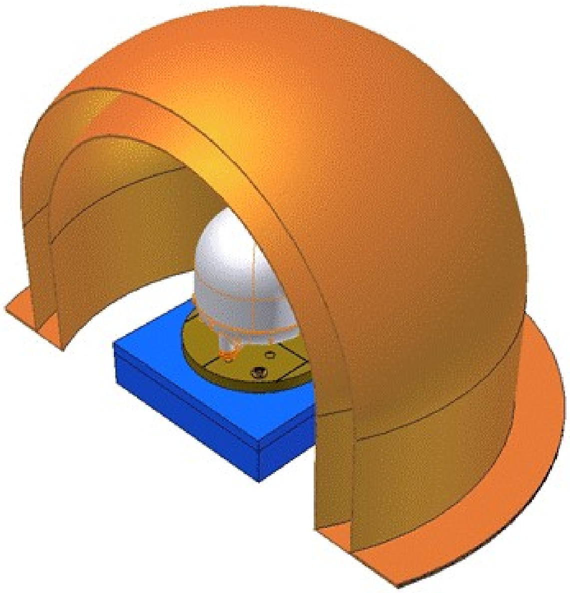
2) Another problem with the standard FA design is the case of movement of the pier shortly after installation and subsequent movement as the ground (clay) changes moisture content. We have found cases where the sensor has tilted enough to require re-leveling. This is going to be difficult (not impossible but difficult) with the standard design. The sensor will need to be dug out of the sand. *ALL* the sand will need to be removed from th hole, and the sensor re-installed. We can however use a hybrid design between direct burial and the FA vault. The idea here is to lay a few inches of sand inside the cylinder plug, remove the feet from the sensor and place the sensor (in a plastic bag) on the sand. Subsequent re-leveling would involve only the removal of enough sand to adjust the tilt of the sensor.

D) MODIFICATION FOR SITES WHERE BURIAL IS NOT POSSIBLE

It is expected that it may be difficult/impossible to bury the sensor vault at some site in the Canadian Shield. There is a vault design which will be useful here. PASSCAL can fabricate some number of the enclosures pictured below.

The inner sensor enclosure has a flange drilled so that the enclosure can be rock-bolted to a HORIZONTAL surface. There may need to be some work involved in making the horizontal surface, but this can be done. This is a standard installation method with the Polar deployment POLENET.

This barrel is enclosed in a dome (also rock-bolted to the surface, shown below) to reduce wind noise.



These have been used successfully at rock sites in the Antarctic.

PASSCAL can fabricate these items for us , but at a cost of :
$300 for the dome
$600 for the inner barrel (with flange and glass pier plate)

There is no specific plan for the data logger enclosure, however it should be possible to use a set of straps or bungee cords across the top of the data logger enclosure to hold the lid and the enclosure itself in place. Another option would be something more robust, as used in an Antarctic deployment. The data logger box is used as a weight to hold the solar panel mount. A set of guy lines (rock bolted in) are used to secure the solar panel mount as well.

SUGGESTION

Based on the added expense to the grant of doing anything extremely different than the standard FA design, I think that we should go ahead and use that design. At the present time, however, I think that we should implement the changes discussed in part C.