Seismic vault construction and challenges: HartRAO and Klerefontein

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1. Overview

The National Academic Co-located Seismology Network is a collaborative project between Hartebeesthoek Radio Astronomy Observatory (HartRAO) and Tshwane University of Technology (TUT) whereby at least twelve seismic stations are to be built across South Africa, Marion and Gough islands. These stations are to continuously monitor real-time seismic events (see instruments in Figure 1) for scientific use and seismic risk determination. Before construction of each station various parameters need to be carefully considered, eg. a geological survey of the site must be conducted and the civil engineering design that will suit this geology must cater for different environmental conditions. It is best for a seismic station to be located on bedrock, so as to ensure good coupling between instrumentation and the local geology. An underground vault was constructed at HartRAO utilizing precast chamber sections; these sections are engineered to withstand the pressure of overburden safely. The construction at Klerefontein is to have a similar design as at HartRAO with the main difference being the excavation process.

2. HartRAO seismic vault: construction and challenges

Seismic site selection is based on the following criteria; internet access, electricity, bedrock, security, remote area with no busy roads, railways or aircraft flight paths. The vault is best placed underground to protect it from non-seismic vibrations. The instruments should be connected to bedrock to ensure optimal transfer of vibrations from Earth's crust and not from the vault structure itself. HartRAO is located in a valley in the Magaliesberg hills, 50 km north-west of Johannesburg, in the province of Gauteng, South Africa. It is a good site for a seismic vault since it meets the required criteria for seismic site selection and in addition is co-located with various space geodetic equipment which adds scientific value to the installation. The geology consists of shale dipping at about 45 degrees, therefore excavation was chosen to access bedrock, which was found at 4 m below the ground surface. A concrete floor slab of 3.5 x 3.5 m was casted at the bottom of the hole. Six square precast concrete sections of 2 x 2 x 0.5 m each, were stacked on top of each other onto the slab, to create a chamber. Every layer was joined by waterproof glue. It was closed off by a roof slab which contained holes for access, ventilation and cabling. Backfilling was done manually, to ensure stability of the area surrounding the vault (Figure 2).

Due to the shallow bedrock, the vault can be constructed at a site where it can be partly buried. The structure is to be placed directly on the surface and boulders of rock will be added around the structure to create a small man-made hill, blending with the local environment and effectively burying the vault. Klerefontein is a challenging site as it is remote and there is no easy access to building material and earth-working machinery.

Figure 1: Seismometer (left), accelerometer (center) and digitizer (right) as used at each station within our seismic network.

Figure 2 (from left to right): Excavation during the initial phase, the stacked sections creating the chamber, final result after backfilling.

The most important challenges we encountered during the construction of the HartRAO seismic vault:

- Ground levelling – due to the shale dipping at an angle, a wet concrete mix was first poured onto the excavated surface and then levelled before construction commenced
- Delays – it is vital that one considers possible delays (e.g. curing of concrete, procurement processes and delivery times) and plan for it
- Water penetration – proper sealing is required throughout the construction and additional sealing can be done afterwards as the need arises

3. Klerefontein seismic vault planning

The Klerefontein site is located about 90 km from the SKA (Square Kilometre Array) core site near Carnarvon, in the Northern Cape Province. The geology is largely Karoo with sediments of shale and siltstones, intruded by dolerite dykes and sills. As a result, blasting or creating a manmade hill from rocks (to cover the vault structure) would be a preferred option rather than excavation. An ideal site has already been selected (Figure 3). After levelling the site, the same construction procedure as for the HartRAO site will be followed.

Figure 3: Klerefontein site

4. Conclusion

This chamber vault model has been proven to be a proper design for hosting seismic instruments. About 10 additional seismic stations are in the planning or in the construction phase. The completed seismic monitoring network will provide dense seismic data, enhancing analysis possibilities. This will positively affect the study of plate tectonics. In future, it might even help to predict some seismic events.

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