International
Progress Report

IPR-02-64

Äspö Hard Rock Laboratory

Temperature Buffer Test

Report for retaining plug and anchoring

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September 2002

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Report no.	No.
IPR-02-64	F12K
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Approved	Date
Christer Svemar, Bertrand Vignal	03-02-12

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Keywords: Temperature Buffer Test, retaining plug, anchoring

Abstract

The deposition hole DD 0086G01, will be retained by a concrete plug shaped in a conical form and a steel lid. The steel lid will be anchored to the rock with anchor cables.

The work to be performed regards drilling for anchor cables, installation of plug and anchors and hardening of plug.

The plug is dimensioned for a pressure of 9.0 MPa. (The estimated load from buffer and water is 9.0 MPa). The purpose with the described design of the plug is to ensure that the plug is able to move upwards during pressure and also possible to dismantle later on.

The moulding of the anchoring is made out of consideration for the transmission of the power and the capacity concerning anchoring, and also to make it possible for a certain vertical deformation.

The steel structure will be covered with mould oil, or similar that will guarantee the possibility of a free vertical movement of the concrete plug.

A test lifting will confirm that the movement described above will be possible to perform.

The work described above will result in a plug design with the aim to prevent an uncontrolled expansion of the bentonite and to be comparable with the conditions in a real repository.

Sammanfattning

Deponeringshål DD 0086G01, kommer att förseglas med hjälp av en konisk betongplugg och ett stållock förankrat i berg med bergstag. Arbetet rör borrning för stag, installation av plugg samt förankring och uppspänning av plugg.

Pluggen är dimensionerad för ett tryck på 9 MPa. Syftet med utformningen är att pluggen skall kunna röra sig uppåt vid bentonittryck och senare kunna demonteras. Förankringsutformningen är vald med tanke på kraftöverföring och förankringsförmåga, samt att möjliggöra viss vertikal deformation. Stålkonformen skall beläggas med formsläppolja eller liknande som garanterar en fri vertikal rörelse av betongkonen. Provlyftning skall bekräfta att en sådan vertikal rörelse är möjlig.

Arbetets genomförande kommer att leda till en plugg vars huvudsakliga syfte är att förhindra en okontrollerad expansion av bentoniten samt att efterlikna förhållandena i ett verkligt förvar.

Contents

Appendixes

1 Introduction

The French organisation ANDRA is carrying out an experiment named “Temperature Buffer Test” (TBT) with international co-operation at Äspö Hard Rock Laboratory in Sweden.

The scientific background to the project is as follows:

The Swedish design of a repository for spent fuel (KBS-3) and the Japanese design for vitrified waste (‘H12’ report) both limit the surface temperature of the packages to 100 °C.

The French repository concept, with temperatures above 100 °C, requires detailed information on temperature distribution in dimensioning of the clay engineered barriers. Two possible approaches have been investigated:

- allowing the temperature of the bentonite to exceed 100 °C temporarily
- use of composite sand / bentonite engineered barriers.

The TBT-test aims at evaluating the benefits of extending our current understanding of the behaviour of engineered barriers to include high temperatures above 100°C and the experimental resources needed to achieve this.

This report describes the retaining system consisting of a concrete plug, a steel lid and anchor cables. The retaining system will provide a controlled boundary for vertical displacement.

2 Installation arrangement

A retaining system will be used to control the vertical displacement due to the swelling bentonite buffer and water pressure in the Temperature Buffer Test. The test will be performed in deposition hole DD 0086G01.

The retaining system is built up with three main components; one concrete plug, one steel lid and nine anchoring cables.

To get the right distance of 8,5 m between the foundation in the deposition hole and the bottom of the concrete plug at the top, it is necessary to cut a recess around the deposition hole for the steel lid.

The recess will be cut 175 mm below the existing tunnel floor and be shaped like an octagon with a largest diameter of 2922 mm. The bottom of the recess must be horizontal.

2.1 Mould for concrete plug

The mould for the concrete plug will be made conical to ensure that the concrete plug can move vertically, The mould will be made of stainless steel sheets.

The steel sheets are screwed into the wall. Joints and bottom of the mould will be sealed. The void between the mould and the rock wall will be grouted in order to restrain the pressure from the concrete during casting.

2.2 Concrete plug

The concrete plug is cast in-situ. The height of the plug is 0.5 m. Concrete of quality K 40 shall be used.

A rubber mat shall be placed on top of the bentonite block to prevent swelling during the casting. The rubber mat must be waterproof and sealed to the mould.
The concrete layer covering the reinforcement shall be at least 50 mm thick.

The plug is estimated to have a weight of 3000 kg. Lifting devices at the top of the plug shall be attached to the wires on the gantry crane and they shall be able to be removed so that the top of the plug becomes flat.

2.3 Lid

The lid is made of steel with a thickness of 150 mm and a diameter of 2400 mm.

The lid is designed to prevent the bentonite buffer from swelling.

The design load from buffer and water is 9.0 MPa. There are nine cut-outs in the lid for the anchor cables. The anchor cables are attached to the lid via wedge seats on a machined surface for good load distribution.

A steel ring is mounted on the outside of the wedge seats to prevent the wedge seats to slide.

The lid is designed to retain a total load of 12 MPa from beneath.
The weight of the lid is 5325 kg, the supporting ring 1325 kg and nine pieces wedge seats 360 kg, make the total installation weight 7010 kg.

2.4 Anchor cables

Ten metre long holes are drilled for the anchor cables with an outward angle of 21,8 ° from the deposition hole. The drill hole diameters will be ca.120 mm.

The total length of each anchor cable is 11 m. The anchorage will be done grouting 7,5 m of the cables. The type of anchor cables that are used is VSL 5-19. The ultimate strength is 3530 kN for each cable. The weight of the cable is 15.2 kg/m.
The ultimate strength for all the nine anchor cables is; F=31770 kN.

2.5 Pre-tensioning of anchor cables

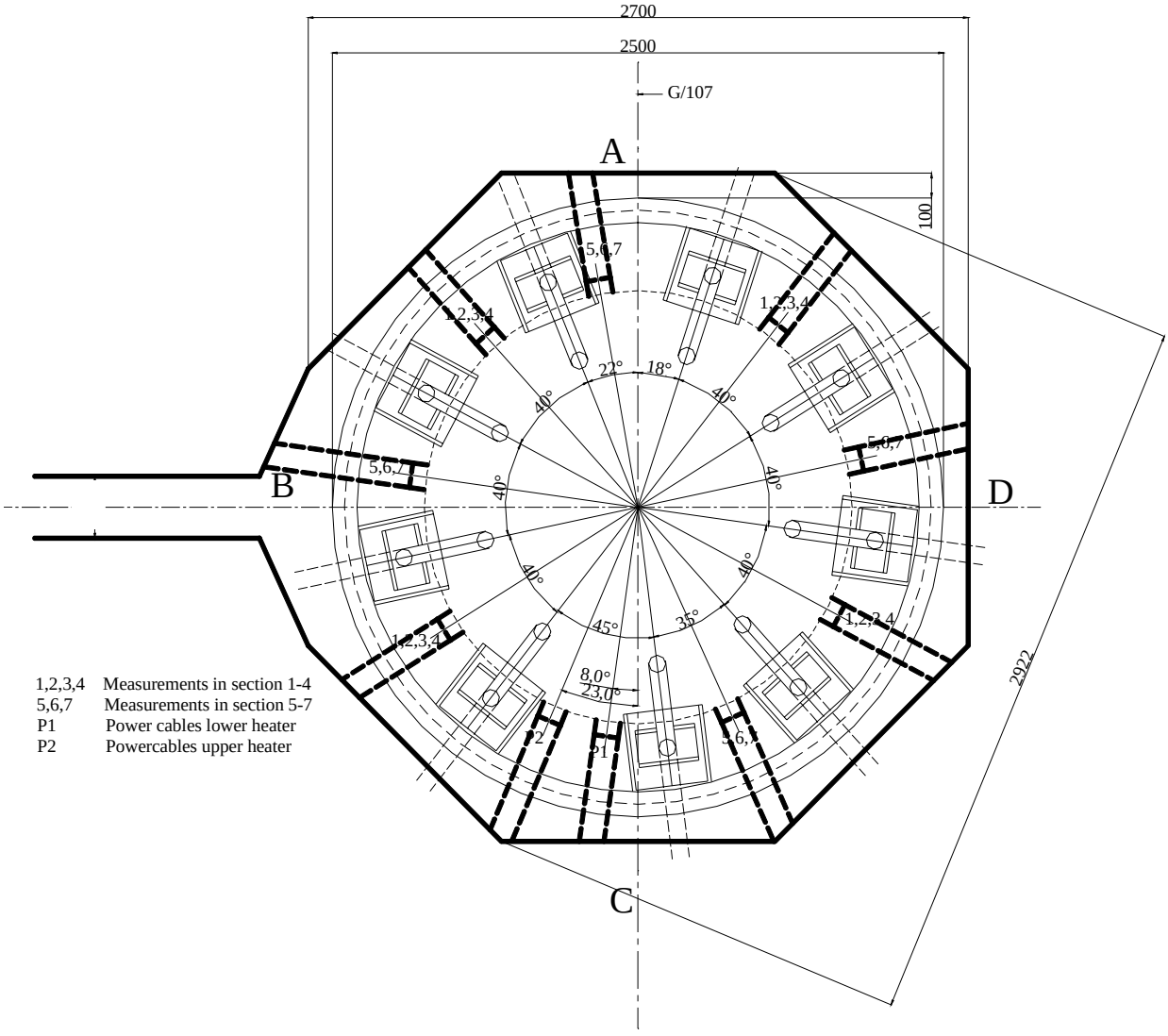
Three hydraulic jacks are used parallel to pre-tension the anchor cables.
Load cells are mounted to three of the anchor cables to make it possible to monitor the load during installation and also the total load from the buffer during operation.

Pre-tensioning of the anchor cables must be done in two steps.
To start with only three of the nine cables are used to retain the plug. The load-cells are connected to those three cables. The pre-tension force for those cables is 40 kN each.

When the load on the three cables has reached 500 kN each, the load shall be distributed equally on all anchor cables in the following way:

1. Three other anchor cables are pre-tensioned to 170 kN each at the same time as the force on three first cables is released to 330 kN each.
2. The three cables left is tensioned to 170 kN each and the other six is adjusted to 170 kN each.

Appendix 1
Layout of the slots



1,2,3,4 Measurements in section 1-4
5,6,7 Measurements in section 5-7
P1 Power cables lower heater
P2 Powercables upper heater

Appendix 2

Explanatory drawing of the deposition hole