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D3.10 FSS drift model construction report

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ABSTRACT:

This report gives an overview of the tunnel (drift) model (also called the “test box” in the text) construction story, as built for the needs of Andra’s FSS experiment.

It includes an overview of the main construction phases (illustrated by photos) c/w practical details and dates.

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Executive Summary

In DOPAS, Work Package 3 (WP3) is related to the construction of large scale demonstrators of seals and plugs.

FSS (Full-scale Seal) is the seal demonstrator built by Andra with the scientific help of NAGRA, while other WMO's (DOPAS partners) are building or have built their own prototype.

This report gives an overview of the tunnel (drift) model (also called the "test box" in the text) construction story, as built for the needs of Andra's FSS experiment.

It includes an overview of the main construction phases (illustrated by photos) c/w practical details and dates.

Links to previous and future Andra's FSS specific (or DOPAS more general) deliverable reports are given.

List of Acronyms

This list of acronyms is generic. It concerns entities, activities, concepts, equipment and materials which are Andra specific in the context of the FSS experiment.

ASN: Autorité de Sûreté Nucléaire (Nuclear Authority).

CIGEO: Centre Industriel de Stockage Géologique (Industrial Repository, AKA Cigéo).

CNE: Commission nationale d'évaluation (National Assessment Board).

DGR: Deep Geological Repository (see also GDF)

DOPAS: Full-scale Demonstration of Plugs and Seals (Name of Project on Seals).

EBS: Engineered Barrier System.

EC: European Commission.

EDZ: Excavation damaged zone.

ESDRED: Engineering Studies and Demonstration of Repository Designs (name of previous EC supported Project).

FSS: Full-scale Seal.

GDF: Geological Disposal Facility.

GME: Groupement momentané d'entreprises (FSS General Contractor).

HLW: High-level Waste.

IAEA: International Atomic Energy Agency.

ILW: Intermediate-level Waste.

IRSN: Institut de Recherche sur la Sûreté Nucléaire (Expert Organization support to ASN).

LLW: Low-level Waste.

R&D: Research and Development.

SCC: Self-compacting concrete.

URL: Underground research laboratory (Bure is the French URL).

WMO: Waste Management Organisation.

WP: Work Package.

List of DOPAS Project Partners

The 14 partners in the EC supported DOPAS Project are listed below. In the remainder of this report each partner (if mentioned) is referred to as indicated:

Andra:	Agence nationale pour la gestion des déchets radioactifs (France).
B+ Tech:	B+ Tech Oy (Finland).
CTU:	Czech Technical University (Czech Republic).
DBE TEC:	DBE TECHNOLOGY GmbH (Germany).
Galson Sciences:	Galson Sciences Limited (United Kingdom).
GRS:	Gesellschaft für Anlagen und Reaktorsicherheit (Germany).
Nagra:	Die Nationale Genossenschaft für die Lagerung Radioaktiver Abfälle (Switzerland).
NDA:	Nuclear Decommissioning Authority (United Kingdom).
NRG:	Nuclear Research and Consultancy Group (The Netherlands).
Posiva:	Posiva Oy (Finland).
RAWRA:	The Radioactive Waste Repository Authority (Czech Republic).
SKB:	Svensk Kärnbränslehantering AB (Sweden).
UJV:	UJV Řež a.s. (Czech Republic).
VTT:	Teknologian Tutkimuskeskeskus VTT (Finland)

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1. National Context for the FSS Experiment

In France, the repository host rock is the 155-million-year-old Callovo-Oxfordian clayish formation, which lies in the east of the Parisian Basin. The repository project is referred to as Cigéo. The disposal reference inventory includes long-lived Intermediate-level waste (ILW) from operation, maintenance and decommissioning of nuclear facilities and HLW from spent fuel reprocessing. The waste will be disposed of in physically separated disposal zones: one for ILW and one for HLW. The repository's primary function is to isolate the waste from human activities at the surface and its second function is to confine radioactive substance and control the transfer pathways which may in the long term bring radionuclides into contact with humans and the environment (ANDRA, 2013). The principal contribution of the seals in Andra's concept is to provide the second function.

The ILW disposal zone includes several tens of large-diameter disposal vaults, each about 500m long. Vault concrete lining and disposal containers provide a cementitious (buffer) environment for the ILW waste. The gaps between waste packages and vault lining could be left empty or backfilled with cementitious material or neutral filler (e.g. sand).

In the French concept, seals are defined as hydraulic components for closure of large diameter (several meters) underground installations and infrastructure components such as shafts, ramps, drifts[1] and ILW disposal vaults. Each seal consists of a swelling clay core (EBS) and concrete containment walls. The conceptual design of drift and ILW disposal vault seals is the same. The location of seals in the planned Cigéo repository is shown in Figure 1.

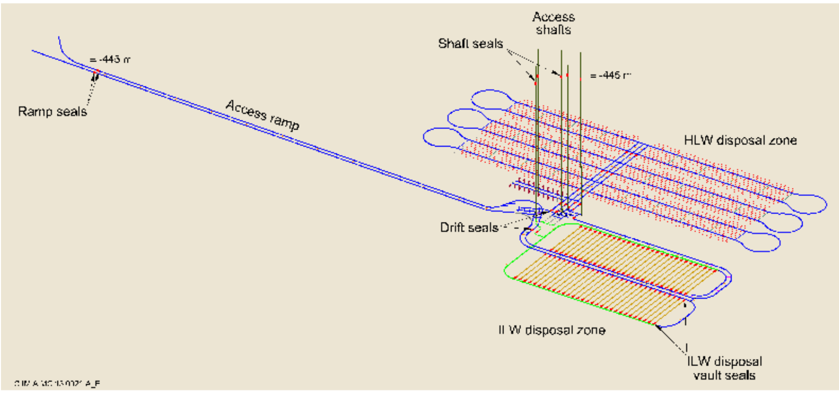

Figure 1: Location of the seals in the French repository concept

[1] Drifts are horizontal tunnels, whereas ramps are inclined tunnels.

2. FSS Design Basis and Link to the Cigéo Reference Design Basis

The FSS experiment is a full-scale technical demonstration of construction feasibility for a drift and ILW disposal vault seal, being carried out in a hangar of a surface facility in Saint-Dizier, which is close to the French URL at Bure.

The FSS test calls for a large excavation, with a significant length and a considerable amount of equipment and materials mobilized and emplaced. The Bure URL is essentially a qualification facility, in which the logistical means are somehow limited (transport means, number of people admitted underground, geometry restrictions for large pieces of equipment,…). Moreover the Bure URL is busy with various other experiments which cannot be conducted concurrently with large experiments such as FSS.

For that reason, and for standalone reasons, like global experimental costs, global schedule and needs for dismantling, it was decided to go for a surface facility, instead of working underground. The Saint-Dizier site was proposed by the Contractor (GME) in charge of the FSS test, and accepted by Andra, since the vicinity of Bure (30km), the height of hangar (more than 10m of free gap under the roof frame), and the possibility of air parameters control were in line with the experiment technical expectations.

2.2 FSS Design basis

The FSS test is part of a wide-ranging programme of R&D and demonstrator experiments that was established in response to the discussions with ASN and the French National Assessment Board (CNE) in 2009, during which it has been noted that seals, and in particular drift and ILW disposal vault seals, require demonstration in order to achieve licensing authorisation.

As a result, R&D studies and demonstration tests have been launched to assess the technical feasibility and to develop the post-closure requirements of seals in the repository. Those tests cover the performance and constructability issues. FSS belongs to this last category.

The main objective of the FSS test is to develop confidence in, and to demonstrate, the technical feasibility of constructing a full-scale drift (or ILW disposal vault) seal. Technical feasibility includes demonstrating the ability of the approach used to emplace the clay to be suitable for filling recesses (breakouts) in the clay host rock, and also the capacity to build large low pH concrete containment walls with satisfactory mechanical properties.

The test is focused on the construction of the seal, and the swelling clay will not be saturated or otherwise pressurised. The conceptual design of the FSS test is illustrated in Figure 2.

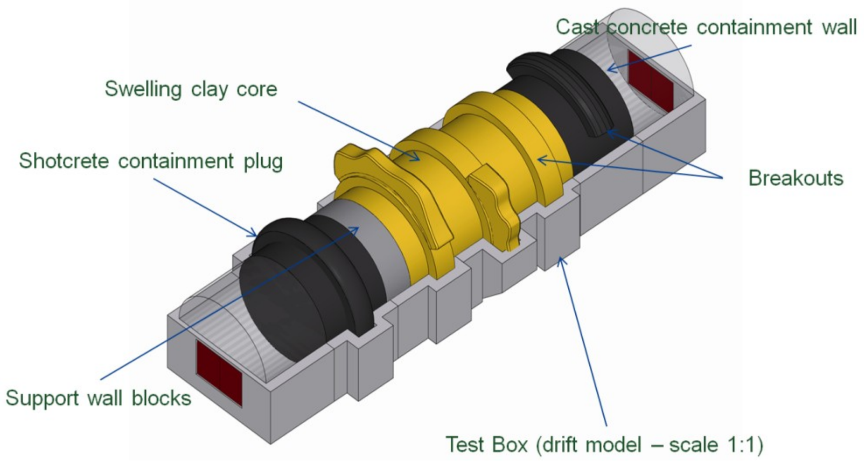

Figure 2: Conceptual design for the ANDRA FSS test.

The main difference between the Cigéo reference and FSS design bases for the Andra drift seal is the length of the seal. The real seal underground will be longer than the seal considered in the FSS experiment. The Cigéo seal design basis and that of the FSS test are justified in DOPAS Deliverable D2.4 “Design Bases and Criteria”.

The FSS test box is some 7.6m ID and 36m long. The drift concrete liner (70cm thick) and the formation break outs (recesses) likely to be generated by the drift lining deposition (up to 1m depth at the liner extrados) are simulated.

Representative underground ambient conditions (temperature around 18-30 °C, hygrometry between 50% and 75%), have to be maintained within the drift model.

Low pH cast-concrete/shotcrete 5m long containment walls will close the volume of the swelling core, on both sides. The bentonite swelling core will be some 14m long.

2.3 FSS Test Box Design

The FSS Test Box design was elaborated between July and October 2012. The workshop drawings were also supplied during that period on the basis of the FSS test box concept (as specified by Andra), and (following modelling and dimensioning) derived from the schematic and general lay-out presented in Figure 3 and Figure 4 respectively.

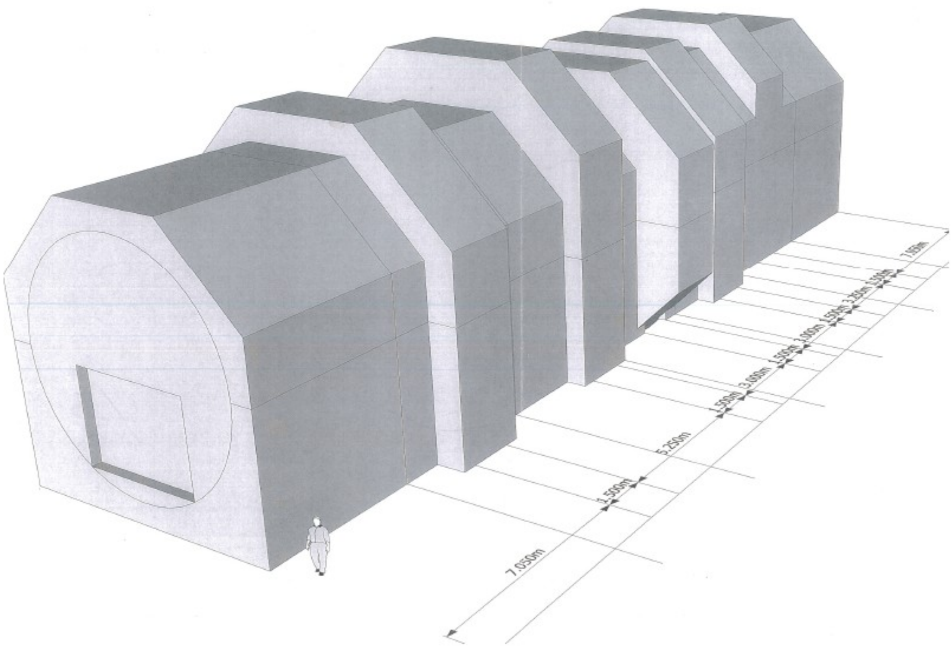

Figure 3: 3D schematic of the FSS test box

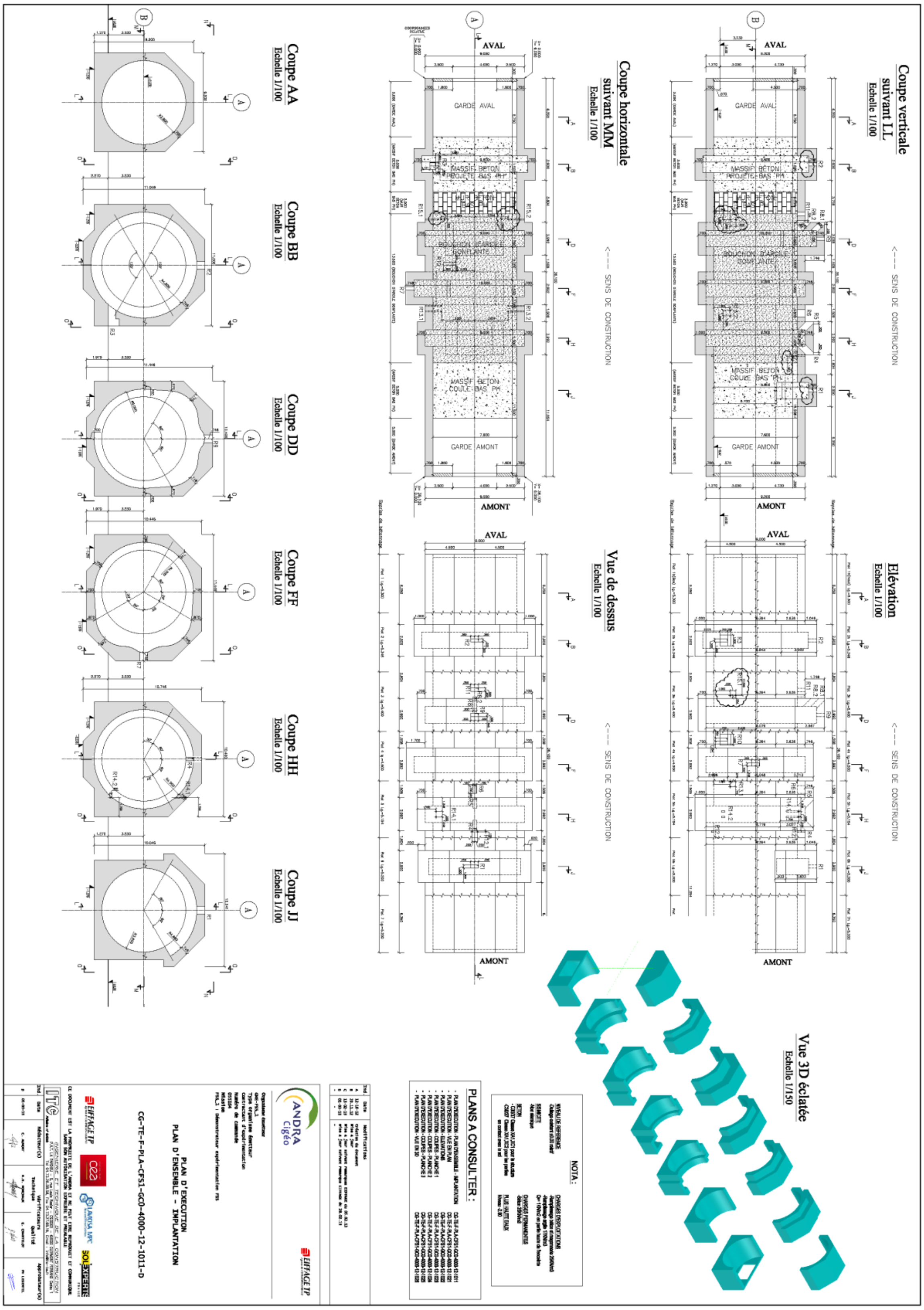

Figure 4: General structural layout of the FSS test box

3. The Construction of the Test Box

3.1 Construction start-up

Turning the first sod for the FSS construction took place on October 29th, 2012, with a partial cutting and dismantling of the hangar concrete slab.

The results of a preliminary geotechnical campaign had concluded there was a need for replacing the alluvium layer with a substrate (a limestone aggregate) between -2 m and -4 m. That soil reinforcement action (Figure 5) derived from the following design requirement: "the test box cannot be deformed or moved by more than 5mm during the filling operations".

Figure 5: Excavating works and soil reinforcement operations

3.2 Erection of the concrete structure

On December 10th, 2012, the lower part of the concrete box framework was started. Before that a concrete foundation raft had been poured on the newly created platform (Figure 6).

Figure 6: View of foundation raft on completion

The box structure was then built with 7 lower blocks and 7 upper blocks (each 5m long). A wood formwork was used to make the circular inner form, while for the outside a classic steel formwork was used (Figure 7).

Figure 7: View of the wood circular inner form and steel form

To simulate the argillite breakouts (Figure 8), recesses were made, thanks to wood rings placed on the principal inner formwork, while a special folio was pasted on the rings to simulate the aspect of the argillite walls.

Figure 8: View of the folio pasted on the wood circular inner form and of the “argillite like” results

Nine weeks were necessary to build the lower part of the box. A layer of sand was then laid on the ground around the box intrados (Figure 9) in order to work on a flat floor and 3 steel sheets were used to slide the scaffolding equipment, from a given block casting position to the next one.

After that, the inner wood framework was turned upside down and deposited on a shoring system made of a support beam and brackets and the construction of the box upper part could be launched.

Between 2 phases of concrete casting, the external framework was totally removed, while the internal framework was slipped on rollers (Figures 10 & 11). For the purpose, the weight of the coffering wood tool and of the fresh concrete was supported by 8 brackets per block.

During the sliding operation, the jacks were moved down from one position to the other.

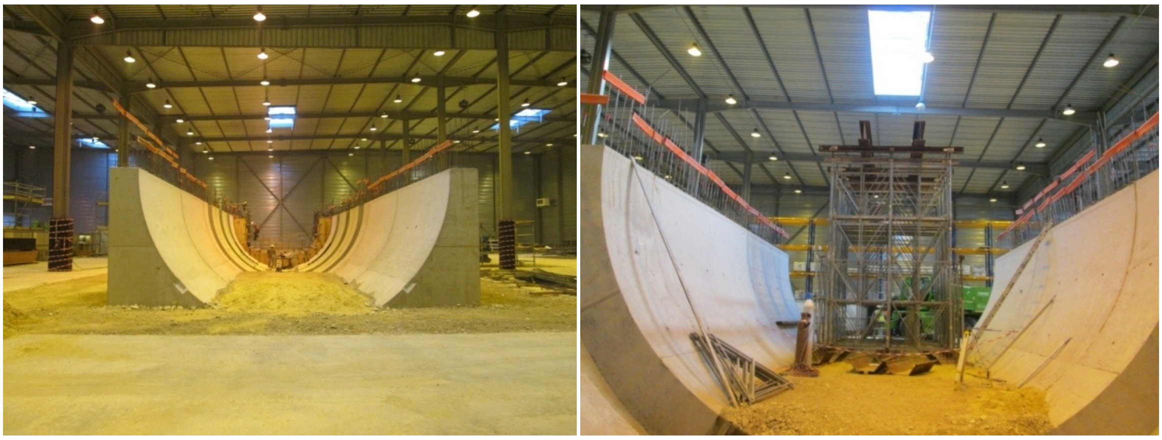

Figure 9: View of the box lower part completed

Figure 10: Removal and translation of the wood formwork between 2 phases of upper block casting

Figure 11: Details of the shoring system c/w jacks, rollers and brackets, used to slide the inner formwork

Only 13 weeks were necessary to build the upper part and the last block concrete casting phase took place on May 2013 (Figure 12).

Figure 12: View of the FSS test box at the end of its construction

The access to the top of the test box was made possible thanks to a set of stairs. In order to see and check the bentonite backfill, 12 observations windows were also created (Figure 13).

A local exhaust ventilation system ("mine like") was installed, with a closing door in the front of the box, in order to control the ambient temperature and the average hydric rate (Figure 14). A temperature and hygrometry monitoring device was also installed.

The box could then be commissioned and get the "ready for experiment" status Figure 15).

Figure 13: View of the FSS test bow access stairs and observation windows

Figure 14: View of the FSS “mine like” ventilation system

Figure 15: The FSS test box ready for seal construction

4. Box stability monitoring

4.1 Objective

The box potential movements (subsidence, tilting, and pitch) must be measured thanks to a topographic system (automatic theodolites), enabling a permanent monitoring of the box stability during each phase of the seal backfilling operations. The measures collected are to make sure that the predetermined maximum movement values (5mm) are not reached or passed. A topographic system was designed and installed for that purpose.

4.2 Positioning of the topographic system

The box deformation is followed by installing targets (prisms) on the box outside. Nine measurement sections are positioned to allow for an easy targeting of the prisms by the theodolites. The 2 automatic theodolites are positioned on the 2 sides of the box (Figure 16).

The prisms (targets) are installed around the main sections of the box structure, providing a total of 48 measurement points (Figure 17).

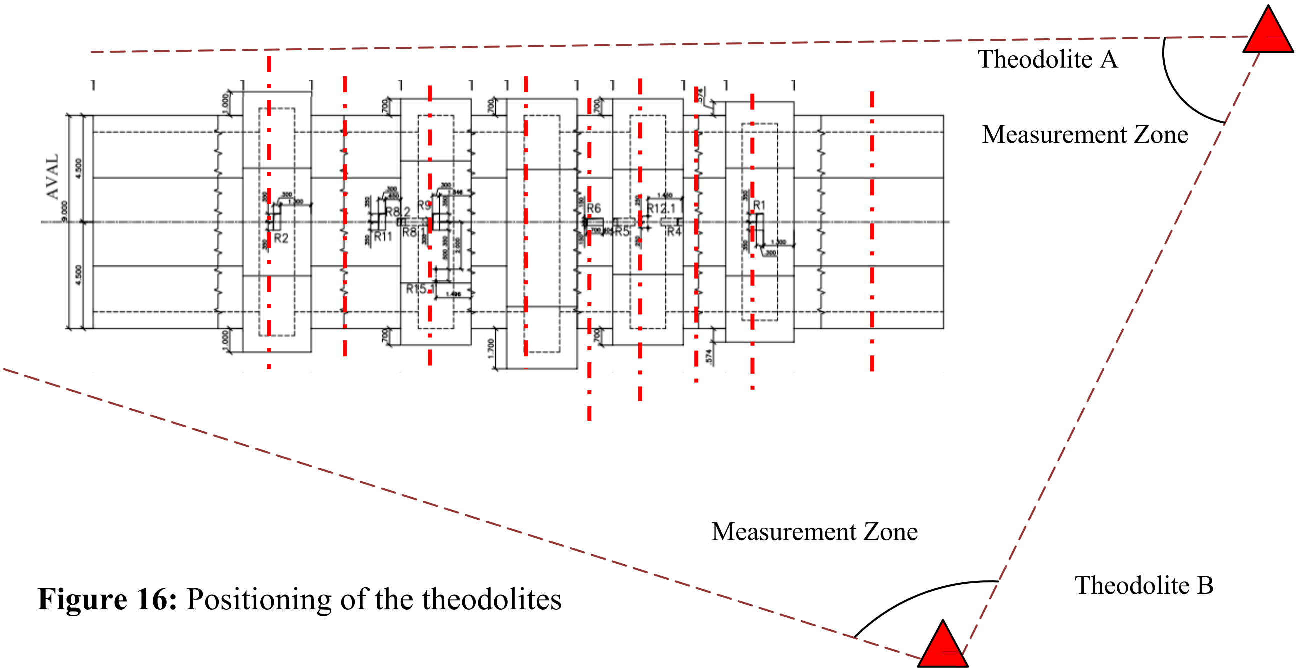

Figure 16: Positioning of the theodolites

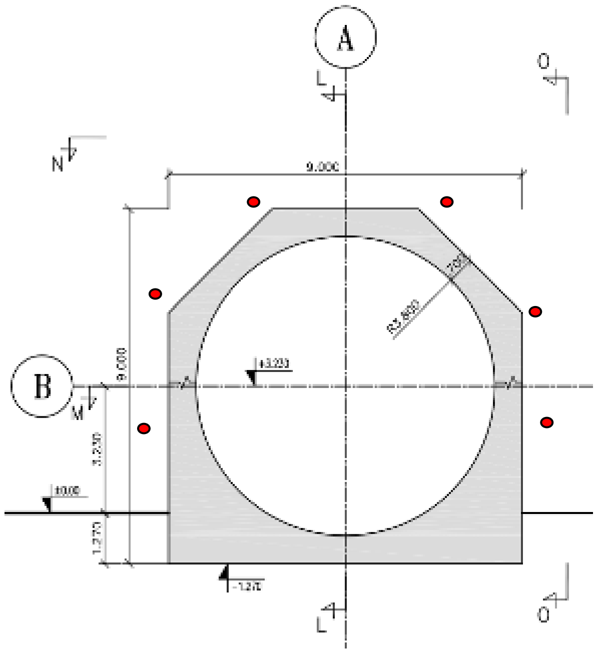

Figure 17: Principle of prism positioning per section

4.3 Equipment Description

Deformation measures are provided by 2 automatic "Leica 1800" theodolites (Figure 18) linked to a GeoMonitor data acquisition system. Accuracy of measure is around 1mm, with a display resolution of some 0.01mm.

Data acquisition (implemented during filling phases only) is made possible every one hour.

Figure 18: View of Leica 1800 theodolite c/w prisms

Alarms

Two alarm levels are set on the GeoMonitor system, initializing an E-mail alert on the GME representatives' smart phone:

- Level 1 for any displacement greater than 3mm,
- And Level 2 for any displacement greater than 5 mm.

5. Commissioning

The commissioning of the FSS test box was carried-out by mid-June 2013, on the basis of the "compliance document" provided by Andra's consulting company SOCOTEC.

In addition, the GME (FSS general contractor) provided a 3 D scanner of the works, providing an exact geometry of the box (cf. Figure 19).

This information is of interest to assess, as accurately as possible, the actual internal box volumes (for each section, and for each type of seal components concerned: swelling core, support wall or containment walls) to be filled in later.

The information on the volumes measured is cross-checked with the volumes of concrete and bentonite emplaced, as measured by operators at time of backfilling. This information enables to accurately assert the effective emplaced specific gravity of the material constituting the swelling clay core, in particular.

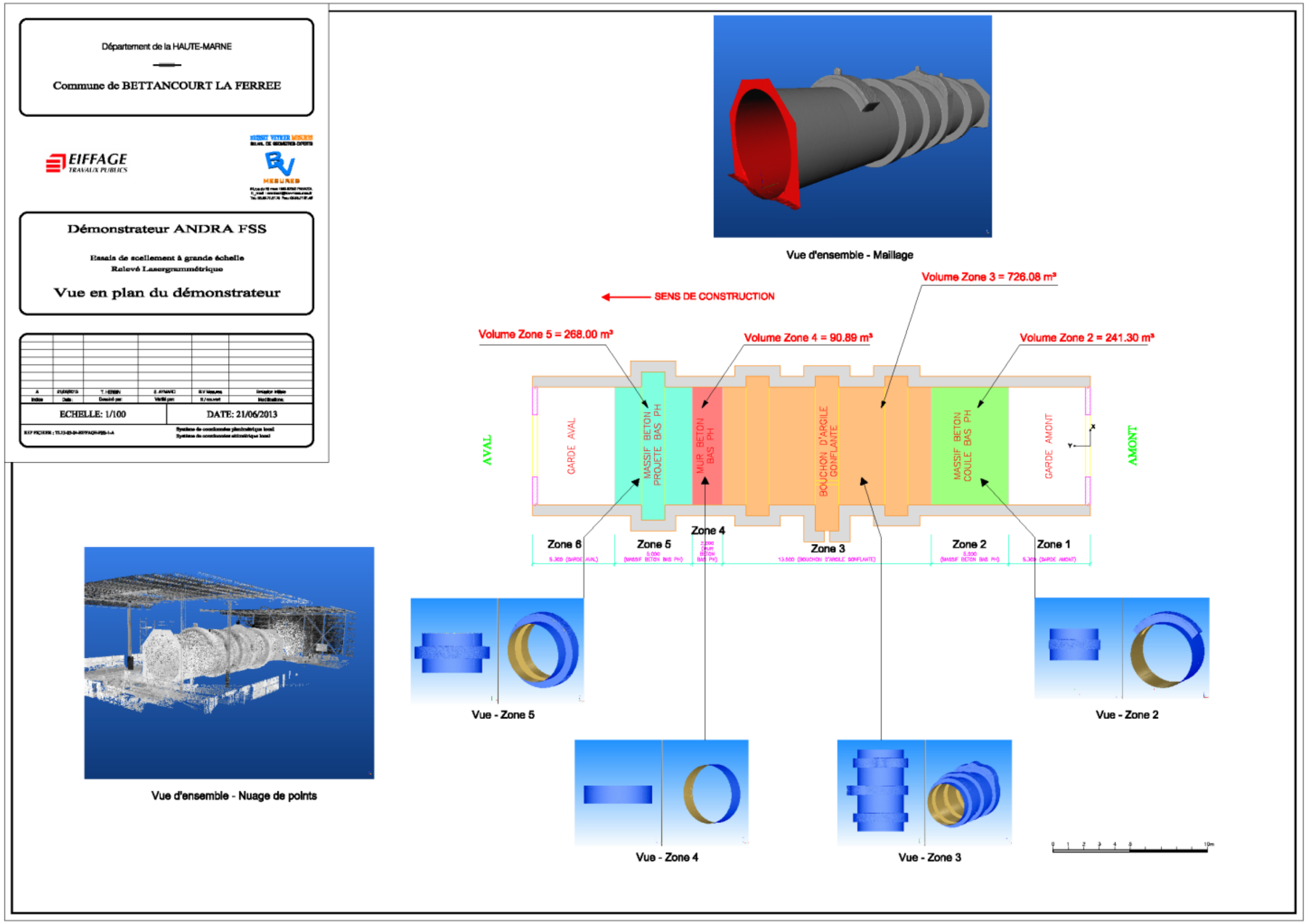

Figure 19: 3D scanner of the FSS concrete box

6. Conclusion

Based on the design documents and drawings (elaborated between July and October 2012), the construction of the test box was started on 29 October 2012 and was completed on 23 May 2013.

The test box construction was successfully commissioned as “test ready” by mid- June 2013, paving the way for the first step of the seal construction test campaign, i.e. building the first component of the FSS seal (the upstream low pH self-compacting concrete containment wall).

The construction of the upstream low pH self-compacting concrete containment wall, which started by mid-July 2013, is detailed in the DOPAS Deliverable D3.11 “Report on FSS cast concrete plug construction”.

7. References

- Andra 2005 - Dossier 2005 Argile: “Safety evaluation of a geological repository”.
- Andra 2012 - Cahier des charges FSS1: “Etude et réalisation du démonstrateur technologique de scellement à pleine échelle (Full Scale Seal)” - ref. CG.TE.F.CDC.AMOA.GC0.2000.12.0014.
- DOPAS Deliverable D2.4 “Design Bases and Criteria”.
- DOPAS Deliverable D3.2 “FSS Tunnel model design report”.
- DOPAS Deliverable D3.11 “Report on FSS cast concrete plug construction”.