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Expert staff visit travel reports
Report no 1 - FSS experiment in France

Author(s) **Slimane Doudou, Galson Sciences Limited; Pasi Rantamäki and Jouni Tiainen, Posiva Oy**

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ABSTRACT:
As a part of DOPAS project's Work Package 6, three staff exchange visits are organised with the intention of sharing the practical experiences from the DOPAS tests within the consortium and between the consortium organisations. The experts for the visits are selected from the consortium staff members who are not directly working in the project. The visit's aim is also to promote knowledge transfer of the project experience to other demonstration and design work of the consortium partners. Further the expert staff visits provide input in general for designing the learning outcomes of the DOPAS training workshop under Work Package 7.

This report is a Deliverable within WP6, and describes the objectives and outcomes of a staff exchange visit to the FSS test in Saint Dizier (France) on 10-13 June 2014. The objectives of the visit were to:

- Provide an opportunity to members of DOPAS organisations to observe the filling operations of the swelling clay core of the FSS test.
- Provide feedback and recommendations from the visit participants on the procedures used to fill the swelling clay core to Andra, with a view to improving these procedures in future implementations.

In the staff exchange three consortium staff members participated: One from Galson Sciences Limited (Great Britain) and two from Posiva Oy (Finland).

RESPONSIBLE:

REVIEW AND OTHER COMMENTS:
WP6 leader Marjatta Palmu has reviewed the report written on 22 September 2014 on 21 October 2014 after the review of report by the visit host (R. Foín). Deliverable cover template has been added by M. Palmu.
The report status has been changed by the approval of the DOPAS General Assembly number 3 from RE to PP with the limitation that the report will be available during the project duration only on request to persons: This report will be posted to the DOPAS web site after the project has ended and it has been approved by the European Commission.

APPROVED FOR SUBMISSION:
Johanna Hansen, Posiva Oy, DOPAS coordinator on 7 January 2015.

DOPAS Work Package 6
FSS Staff Exchange Visit

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Executive Summary

The Full-Scale **D**emonstration **O**f **P**lugs **A**nd **S**eals (DOPAS) Project is a European Commission (EC) programme of work jointly funded by the Euratom Seventh Framework Programme and European nuclear waste management organisations (WMOs). A set of full-scale experiments, laboratory tests, and performance assessment studies of plugs and seals for geological repositories will be carried out in the course of the project.

The DOPAS Project focuses on tunnel, drift, vault and shaft plugs and seals for crystalline, clay and salt rocks. The project is coordinated by Posiva Oy, Finland. Work Package 6 (WP6) of the DOPAS Project aims to integrate critical analyses of the achievements and results from the implementation and monitoring of the plugs and seals being tested in DOPAS by cross-review of partner activities. WP6 includes the use of the Expert Elicitation process, including a pilot of the process, exchange visits, and preparation of the final public technical summary report.

As part of WP6, staff exchange visits have been proposed with the intention of sharing the practical experiences from the DOPAS tests within the consortium and between the consortium organisations. This report is a Deliverable within WP6, and describes the objectives and outcomes of a staff exchange visit to the FSS test in Saint Dizier (France) on 10-13 June 2014.

The objectives of the visit were to:

- Provide an opportunity to members of DOPAS organisations to observe the filling operations of the swelling clay core of the FSS test.
- Provide feedback and recommendations from the visit participants on the procedures used to fill the swelling clay core to Andra, with a view to improving these procedures in future implementations.

The learning outcomes from the three participants at the visit are documented and can be summarised into the following points:

- The visit was provided an opportunity to obtain a greater understanding of the bentonite material used in the swelling clay core and the development of its specification.
- Discussion on various aspects of the FSS test were held with staff at the site, including requests for clarifications on the filling procedure and the challenges encountered at the various steps of the process. One of the main challenges was the presence of large amounts of dust from bentonite at the test site. Learning points regarding the possible use of similar devices in Posiva's programme were noted.
- A visit to the Bure underground laboratory was organised to demonstrate other experiments being carried out in conjunction with the FSS test to investigate other aspects of the seal behaviour (e.g. experiment to test the hydro-mechanical performance of a drift seal and another experiment to test the hydro-mechanical performance of an excavation-damaged zone (EDZ) cut-off).
- A visit to the Bure Technology Centre was also organised to provide insights into the overall waste disposal concept envisaged by Andra, including observation of waste container handling and emplacement devices.

At the end of the visit, a presentation from the three participants was given to the host organisation, Andra, listing recommendations and comments on the main aspects of the test

that Andra were seeking feedback on. The feedback focused on the following three topics. Example recommendations are also included:

1) Transferability of procedures and experience between surface and underground conditions: the main observations concerned the large size of the tunnels in Andra's concept compared to other disposal concepts such as Posiva's and the availability of storage underground compared to the warehouse facility on the surface.
2) The swelling clay core material density: a couple of techniques that could be used to increase the density of the bentonite mixture used for the swelling clay core were proposed, including the possibility of using screws to push the material and compact it and the potential of using vibrating equipment to allow material to settle and fill the voids between the pellets more efficiently.
3) The swelling clay core filling procedure: a number of comments and recommendations were made under this topic. These are summarised below in four sub-topics: density variation, recesses, dust, and risks.
    a. Density variation: it was noted that it is possible for the density throughout the clay core to vary due to material drop height initially being large compared to later stages of the process. The large drop height will result in better compaction of material at the bottom of the clay core.
    b. Recesses: it was suggested that blockages may happen when filling recesses caused by bentonite pellets resulting in non-filled recesses. It may be possible for certain configurations of pellets to cause such blockage between the two walls of a recess. The use of shotclay to fill recesses was also proposed as a possible alternative to using bentonite pellets and powder.
    c. Dust: a few recommendations to reduce dust resulting from bentonite powder were made, including the use of a scraper conveyor to transfer material instead of forklift trucks and the possibility of adding a curved tube at the end of the auger tubes to reduce dust.
    d. Risks: a couple of issues were raised concerning possible risks to material and equipment during the filling procedure of the clay core, including the lifting of hoppers quite close to the control panel of the filling machine and the risk of dust on equipment, especially electrical equipment.

List of Acronyms

ÄHRL:	Äspö hard rock laboratory
CEA:	French Alternative Energies and Atomic Energy Commission
DOMPLU:	Dome Plug
DOPAS:	Full-scale Demonstration of Plugs and Seals
EC:	European Commission
EDZ:	Excavation damaged zone
EE:	Expert Elicitation
ELSA:	Entwicklung von Schachtverschlusskonzepten (development of shaft closure concepts)
EPSP:	Experimental Pressure and Sealing Plug
FSS:	Full-scale Seal
GDF:	Geological disposal facility
POPLU:	Posiva Plug
URCF:	Underground rock characterisation facility
URL:	Underground research laboratory
WMO:	Waste management organisation
WP:	Work package

List of DOPAS Project Partners

The partners in the DOPAS Project are listed below. In the remainder of this report each partner is referred to as indicated:

Posiva	Posiva Oy	Finland
Andra	Agence nationale pour la gestion des déchets radioactifs	France
DBE TEC	DBE TECHNOLOGY GmbH	Germany
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit	Germany
Nagra	Die Nationale Genossenschaft für die Lagerung Radioaktiver Abfälle	Switzerland
RWM	Radioactive Waste Management Limited	UK
SÚRAO	Správa Úložišť Radioaktivních Odpadu (Radioactive Waste Repository Authority – RAWRA)	Czech Republic
SKB	Svensk Kärnbränslehantering AB	Sweden
CTU	Czech Technical University	Czech Republic
NRG	Nuclear Research and Consultancy Group	Netherlands
GSL	Galson Sciences Limited	UK
BTECH	B+ Tech Oy	Finland
VTT	Valtion Teknillinen Tutkimuskeskus (Technical Research Centre of Finland)	Finland
UJV	Ustav Jaderneho Vyzkumu (Nuclear Research Institute)	Czech Republic

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1 Introduction

1.1 Background

The Full-Scale **D**emonstration **O**f **P**lugs **A**nd **S**eals (DOPAS) Project is a European Commission (EC) programme of work jointly funded by the Euratom Seventh Framework Programme and European nuclear waste management organisations (WMOs). The DOPAS Project is running in the period September 2012 – August 2016. Fourteen European WMOs and research and consultancy institutions from eight European countries are participating in DOPAS. The project is coordinated by Posiva Oy, Finland. A set of full-scale experiments, laboratory tests, and performance assessment studies of plugs and seals for geological repositories will be carried out in the course of the project.

DOPAS aims to improve the industrial feasibility of plugs and seals, the measurement of their characteristics, the control of their behaviour over time in repository conditions, and their performance with respect to safety objectives. The DOPAS Project is being carried out in seven Work Packages (WPs). WP1 includes project management and coordination. WP1 is coordinated by Posiva Oy, Finland. WP2, WP3, WP4 and WP5 address, respectively, the design basis, installation, compliance testing, and performance assessment modelling of the five full-scale experiments and laboratory tests. WP2, WP3, WP4 and WP5 are coordinated by SKB, Sweden; Andra, France; RWM, UK; and GRS, Germany, respectively. WP6 and WP7 address cross-cutting activities common to the whole project through review and integration of results, and their dissemination to other interested organisations in Europe and beyond. WP6 and WP7 are coordinated by Posiva Oy, Finland.

The DOPAS Project focuses on tunnel, drift, vault and shaft plugs and seals for crystalline, clay and salt rocks:

- *Crystalline rocks*: experiments related to plugs in horizontal tunnels, including the Dome Plug (DOMPLU) experiment being undertaken by SKB at the Äspö Hard Rock Laboratory (ÄHRL) in Sweden, the Posiva Plug (POPLU) experiment being undertaken by Posiva at the ONKALO underground rock characterisation facility (URCF) in Finland, and the Experimental Pressure and Sealing Plug (EPSP) experiment being undertaken by SÚRAO and the Czech Technical University (CTU) at the Josef underground research laboratory (URL) in the Czech Republic.
- *Clay rocks*: the Full-Scale Seal (FSS) experiment, being undertaken by Andra in a warehouse of a surface facility at St Dizier, is an experiment of the construction of a drift and intermediate-level waste disposal vault seal.
- *Salt rocks*: tests related to seals in vertical shafts under the banner of the Entwicklung von Schachtverschlusskonzepten (development of shaft closure concepts – ELSA) experiment, being undertaken by GRS and DBE TEC.

Each experiment represents a different state of development. The Swedish experiment was started prior to the start of the DOPAS Project. The Finnish, Czech and French experiments are being designed and constructed during DOPAS. The German tests focus on the early stages of design basis development and on demonstration of the suitability of designs through performance assessment studies, and will feed into a full-scale experiment of some shaft seal components to be carried out after DOPAS.

WP6 aims to integrate critical analyses of the achievements and results from the implementation and monitoring of the plugs and seals being tested in DOPAS by cross-review of partner activities. WP6 includes the use of the Expert Elicitation (EE) process, including a pilot of the process, exchange visits, and preparation of the final public technical summary report.

As part of WP6, staff exchange visits have been proposed with the intention of sharing the practical experiences from the DOPAS tests within the consortium and between the consortium organisations.

This report is a Deliverable within WP6, and describes the objectives and outcomes of a staff exchange visit to the FSS test in Saint Dizier (France) on 10-13 June 2014. The attendees of the visit were:

- Slimane Doudou from Galson Sciences Limited.
- Pasi Rantamäki from Posiva Oy.
- Jouni Tiainen from Posiva Oy.

1.2 Objectives of, and Programme for, the Staff Exchange Visit

The overall objectives of the visit were to:

- Provide an opportunity to members of DOPAS organisations to observe the filling operations of the swelling clay core of the FSS test.
- Provide feedback and recommendations from the visit participants on the procedures used to fill the swelling clay core to Andra, with a view to improving these procedures in future implementations.

The programme of the visit is shown in Table 1.

Table 1: Programme of the FSS staff exchange visit.

Tuesday 10 June 2014	12:00	Lunch
	14:00	Presentations about the FSS experiment: • FSS context and main objectives of the experiment • Conception of the bentonite filling material • Filling procedure
	16:00	Presentation of the staff exchange reporting attempts
	16:30	Safety information
	17:00	First visit of the swelling clay core filling
Wednesday 11 June 2014	8:30	Fitting of working clothes
	9:00	Safety information for URL access
	9:30	URL visit
	12:00	Lunch
	14:00	Free swelling clay core inspection
Thursday 12 June 2014		Free swelling clay core inspection
Friday 13 June 2014	10:00	Presentation of the first observations and recommendations
	12:00	Lunch

1.3 Report Structure

The remainder of this report is set out as follows:

- Section 2 lists the learning objectives and learning outcomes of the visit to the FSS test from each participant.
- Section 3 describes the expectations of Andra from the visit.
- Section 4 presents the overall outcomes of the visit including major learning points and feedback provided to Andra.
- Section 5 provides a self-assessment from each participant on the learning outcomes of the visit.
- Section 6 presents conclusions and a summary of lessons learned.
- Section 7 provides ~~a~~ reference to the FSS test filling procedure.

2 Visitors' Learning Objectives and Outcomes

This section lists the learning objectives and outcomes of the visit from each participant.

2.1 Learning Objectives

Slimane Doudou

The main objectives set out before the visit were to:

- Observe the filling procedure for the swelling clay core in order to have a clearer idea of the technical challenges encountered.
- Learn more about the bentonite materials used in the swelling clay core and the process used to achieve the final material specification.
- Have the opportunity to meet and discuss FSS in more detail with people closely related to the running of the test.
- Help in the reporting of the FSS test in various DOPAS deliverables that GSL are responsible for under WP2 and WP4.

Pasi Rantamäki

The main objectives set out before the visit were to:

- Observe how the technical part of the test is carried out and how the plans have been realized.
- Learn about the material logistics of the full scale test.
- Observe and understand how this type of filling method works with the type of material chosen.
- Find out how environmental conditions affect the filling procedure (e.g., machine malfunctions).

Jouni Tiainen

The main objectives set out before the visit were to:

- Enable benchmarking of technical solutions of the filling equipment and other devices, and possibly use them in future as a basis in Posiva's product development projects.
- Learn about the practical environmental conditions the equipment is expected to work under.
- Become more familiar with the filling procedure used in the FSS test.

2.2 Learning Outcomes

The visit was well organised and there was plenty of time to observe the filling operations, ask questions and comment on the activities carried out to staff present at the site. The learning outcomes for each participant are listed below.

Slimane Doudou

The main learning outcomes from the visit are as follows:

- Obtained a greater understanding of the bentonite material used in the swelling clay core and the development of its specification. A large number of laboratory experiments were carried out to test different bentonite mixture compositions (pellets of different sizes, powder and different combinations of pellets and powder).
- Learned more about bentonite material and its behaviour in general. The aim for the swelling clay core material was to achieve a swelling pressure of 7 MPa, similar to that of the clay host rock. A requirement on the equivalent dry density of bentonite was set in order to obtain the specified swelling pressure.
- Had the opportunity to discuss various aspects of the FSS test with staff at the site, including requests for clarifications on the filling procedure and the challenges encountered at the various steps of the process. One of the main challenges was the presence of large amounts of dust from bentonite at the test site.
- Had the opportunity to visit the Bure underground laboratory to learn about other experiments being carried out in conjunction with the FSS test to investigate other aspects of the seal behaviour (e.g. experiment to test the hydro-mechanical performance of a drift seal and another experiment to test the hydro-mechanical performance of an excavation-damaged zone (EDZ) cut-off). It was observed that the EDZ cut-off reduces in width over time as the clay host rock creeps in very slowly. These experiments contribute to the understanding of seal behaviour and their results will be used in conjunction of the FSS test observations to develop the seal design and specifications further.

It is expected that the information gathered and experience gained during this visit will be valuable in future reporting of the FSS test in the DOPAS deliverables that GSL are responsible for.

Pasi Rantamäki

The main learning outcomes from the visit are as follows:

- It was observed that the handling of relatively dry bentonite powder is very challenging. Bentonite must be handled in a "closed system" to avoid large amounts of dust in the air (occupational safety, machine malfunctions) in long running operations.
- Pre-studies and testing of the materials and machines of the test is very important. It was shown that there has been a considerable programme of laboratory work to select the best solution.
- Material logistics usually plays a big role if work is time-limited. Continuous feeding of the filling machine can save time.
- Visits to Bure URL and Technology centre were very interesting and informative. Posiva's KBS3 concept is different to Andra's concept but I gained some understanding of the test set-ups.

Jouni Tiainen

The main learning outcomes from the visit are as follows:

- Visits to the FSS test site, to the Bure URL and to the Bure Technology Centre were very interesting and instructive. Very likely technical solutions proposed by Andra can be modified to be suitable for future devices of Posiva. Although it is too early to propose any concrete solutions, a number of interesting ideas came up (e.g., Posiva considers changing its tunnel backfill device; the pellet installation unit of the device (powered by pressurized air) can be replaced with an auger conveyor similar to that used in the filling machine by Andra, but much smaller).

- The environment of the test was very challenging due to the dust generated and this could get worse when the equipment is used underground. The bentonite dust makes it difficult to keep machinery working efficiently and it endangers employees' safety at work. These issues have to be taken in account when similar devices and procedures are designed by Posiva.

3 Andra's Expectation of the Visit

Andra's expectations from the visit were for the three visitors to provide observations and feedback on various aspects of the FSS test. These concern the following three areas:

1) Representativeness of the FSS test which is realised on the surface to simulate underground construction.
2) The swelling clay core material specification and density.
3) The swelling clay core filling procedure.

Other observations and suggestions on the FSS test in general were also encouraged.

The following clarifications and questions by Andra were provided for each of the three points above:

1) The dimensions of the URL drifts do not allow for the experiment to be carried out underground. Andra, therefore, decided to build the experiment on a surface facility while taking the constraints of the underground environment into account. Do you think that we should have taken other dispositions to simulate the underground realization? In other words, are there any other physical or chemical boundary conditions that are relevant to underground conditions not considered in the test?
2) In the laboratory, Andra defined a swelling core material with two components. The main difficulties were: to have the best dry density for the two components, and to have a powder which can evenly mix with the pellets. Do you think that the material chosen to fill the core is appropriate to ensure a swelling pressure of 7 MPa (equivalent density of ~ 1.62 g/cm^3) is achieved?
3) For the filling procedure, the following questions were asked by Andra:
    a. Do you think that the filling machine is appropriate for an underground realization?
    b. Do you think that the filling method needs to be different?
    c. Do you have some ideas on how to improve the speed of the filling activities?
    d. What are your recommendations for a future experiment?
    e. If at the end, the result was under the expected value (<1.5 g/cm^3), what ideas do you have to increase this result?

A meeting between the three participants at the visit was held and various issues were discussed to address the points raised above. Feedback and recommendations provided to Andra were presented on the final day of the visit. These are documented in Section 4.3.

4 Outcomes of the Expert Staff Site Visit

This section describes the major learning points from the visit and the feedback provided to the host organisation at the end of the visit.

4.1 Major Targets Visited and Observed

The main aim of the visit was to observe the clay core filling procedure. The filling procedure starts with emptying octabins (containing bentonite pellets) and big bags (containing bentonite powder) into separate movable hoppers. The movable hoppers are then lifted by forklift trucks and emptied into fixed hoppers positioned on a dedicated filling machine. Filling of the majority of the clay core volume (lower part: about 2/3) is done with the two filling machine augers one above the other to reproduce the laboratory experiments in which the best results were obtained. Filling of the remaining part of the clay core (higher part: about 1/3) is done with the augers side by side to enable the filling of the recesses (best pressure). Photographs of the different steps in the process are given in Figure 1, Figure 2, and Figure 3. More details about the filling procedure can be found in [1].

Figure 1: Emptying of octabin containing bentonite pellets (left) and bag with bentonite powder (right) into hoppers.

Figure 2: Transferring the bentonite into the filling machine using forklift trucks.

Figure 3: Bentonite materials transferred into filling machine and deposited into the core of the seal using augers.

The process of transferring bentonite powder into hoppers and then to the forklift trucks followed by placement in the concrete test box generates high-levels of dust. Verification of the ventilation system the following day identified non-ideal performance of the filter, which was then cleaned, resulting in lower levels of dust in the warehouse facility.

The process of transferring the bentonite pellets from octabins into hoppers does not result in pellet breakage since the pellets are specified to have a minimum resistance to breaking of ~ 800 N.

4.2 Major Learning Points from the Targets/Tasks

The major learning points have been given in section 2.2 and a summary of these is given in the Conclusions and Executive Summary sections of the document.

4.3 Major Feedback to the Host by the Visitors

At the end of the visit a presentation by the three visitors was made to the Andra representatives at the FSS test and one representative of the contractors carrying out the test. The attendees from Andra were Régis Foin (FSS experiment leader) and François Gérardin. The attendee from the contractors was Claude Gatabin (engineer at the French Alternative Energies and Atomic Energy Commission – CEA).

The following observations and feedback was provided under each of the three points listed in Section 3.

1) For the transferability of procedures and experience between surface and underground conditions, the following issues were raised:

    a. The tunnels in Andra's concept are quite big and this results in major challenges for seal construction. From Posiva's perspective, using smaller tunnels would be cheaper and can lower amount of filling material needed for the core. Régis Foin responded that in Andra's concept, it is currently not possible to envisage using smaller tunnels. In fact, bigger tunnel dimensions may be used in the final repository to allow for more waste in a smaller area.

    b. It was observed the warehouse used to store bentonite before usage in the core is quite big and such space may not be available underground for storage of material and equipment. Régis Foin commented that this is not a major issue as a dedicated storage room can be constructed for this specific purpose underground. Régis also pointed out the possibility of ensuring progressive supply of material as needed to minimise storage requirements.

2) For the swelling clay core material density, it was suggested that a couple of techniques could be used to increase the density:

    a. Possibility of using screws to push the material and compact it to increase density. Régis Foin made the point that this is actually done at the top of the swelling clay core when filling the recesses.

    b. Possibility of using vibrating equipment to settle material and fill the voids between the pellets with bentonite powder. Régis Foin stated that vibration was tested in in metric tests and it was found that this results in separate layers of pellets and powder forming, and thus creating segregation.

3) For the filling procedures, a number of comments and recommendations were made. These are listed below in four sub-topics: density variation, recesses, dust, and risks.

    a. Density variation: it is possible for the density throughout the clay core to vary due to:

        i. Bentonite material being dropped from a large height initially, meaning that the bottom of the clay core may be better compacted than the material at the top, since the dropping height decreases as the core is filled. Régis Foin pointed out that compaction at the top of the clay core volume is achieved through the pressure applied by the screws.

   ii. The bigger pellets dropping faster than powder which may result in separate layers of pellets and powder forming. Régis Foin clarified that laboratory experiments have shown that the procedure followed for filling the core results in good mixing of pellets and powder. This provides confidence in the procedures used in FSS which will establish the efficiency of mixing of pellets and powders at full-scale.

b. Recesses: the following observations and recommendations on filling the recesses were made:

   i. It was suggested that blockages may happen when filling recesses caused by bentonite pellets resulting in non-filled recesses. It may be possible for certain configurations of pellets (bridging) to cause such blockage between the two walls of a recess. Claude Gatabin and François Gérardin commented that it is unlikely for a blockage to happen through this bridging phenomenon. Such blockages may occur in small openings, but given the dimensions of the recess (~ 1.5 m-long), this is considered unlikely. However, there will still be potential of small breakouts forming in the host rock after lining removal.

   ii. The possibility of using shotclay instead of bentonite pellets and powder to fill recesses was suggested. This might have an effect on the density of material and will require extra equipment. Claude Gatabin noted that using shotclay may not be ideal as the clay host rock is quite dry which reduces the stickiness of the shotclay to the host rock. Wetting the shotclay to ensure better stickiness could compromise the strength of the host rock. Régis Foin added that shotclay will have a lower dry density than the bentonite admixture.

   iii. It was also suggested that it may be possible to remove all lining at the seal location, and therefore have no recesses present, and use shotclay on the host rock. The use of shotclay is not considered to be ideal as noted in the previous point. Régis Foin responded that removal of all lining is a very delicate operation and may not be feasible as support to the argillite rock will have to be provided on a substantial length.

c. Dust: during the visit, one of the main challenges was dealing with the vast amount of dust generated by handling bentonite in the warehouse. A few recommendations to reduce dust were made, including:

   i. The use of a scraper conveyor to transfer material into the filling machine instead of forklift trucks. This would reduce the dust generated during unloading of bentonite into the forklift truck hoppers and also reduce the transfer time of material. Régis Foin commented that this is an option to be considered by Andra in the future.

   ii. The possibility of a special hooded vacuum tube with a filter to remove dust.

   iii. The possibility of adding a curved tube with a telescoping tube at the end of the augers to reduce dust. This may require more engine power and increase the density of the core material. Régis Foin observed that this solution would cause problems at the top of the core when retracting the augers out of the swelling clay core.

d. Risks: a couple of issues were raised concerning possible risks to material and equipment during the filling procedure of the clay core:

   i. It was noted that the forklift truck hoppers were being lifted quite close to the control panel of the filling machine. This can result in accidental damage to equipment.

   ii. The effect of the large volumes of dust on equipment in the warehouse needs to be considered, especially electrical equipment. Régis Foin responded that this had been done by ensuring special protection of electrical equipment against dust.

4.4 Other Activities Carried out During the Visit

A visit to the Bure URL was also carried out during the visit. The visit was valuable and provided an opportunity to see the various experiments being undertaken underground, including those related to the FSS test (see Section 2.2).

A visit to the Bure technology centre was also organised. This is a demonstration centre for public engagement and outreach where waste package prototypes are on display. Prototypes of other experimental equipment were also on display (e.g., the high-level waste package emplacement robot).

5 Self-Assessment of Achievements of the Visitors' Learning Outcomes and the Host's Expectations

This section provides a self-assessment from each visitor on the outcomes of the visit using the template provided in the Staff Exchange information documents.

Slimane Doudou

Was my staff exchange visit successful?

Yes, it was successful in achieving the objectives initially set out, as well as providing an opportunity to visit the Bure URL and technology centre.

What did I learn?

Level of Learning outcomes (EQF level, the most applicable level varies from 4-8):	EQF-level: 4

Give also a free text assessment of the achievement of your learning objectives and learning outcomes:

See Section 2.2

KNOWLEDGE *(described as theoretical and/or factual.)*

KNOWLEDGE	EQF Level 1-8
Bentonite material and properties	4
Filling procedure of FSS	4

SKILLS. *(described as cognitive (involving the use of logical, intuitive and creative thinking) or practical abilities (involving manual dexterity and the use of methods, materials, tools and instruments).*

SKILLS	EQF Level 1-8
Evaluation of practicability and implementation of desk-based designs using full-scale tests	5

COMPETENCE *(described in terms of responsibility and autonomy.)*

COMPETENCE	EQF Level 1-8
Experience of evaluating work carried out by Andra and providing review feedback on future improvements	5

How did my expertise contribute to the host's experiment during or after the visit?

Feedback was provided to Andra at the end of the visit to further improve the filling procedure of the swelling clay core and various other aspects of the FSS test (see Section 4.3).

What would I like/need to learn after this visit experience? How did the visit assist me in my work?

The visit will enable me to:

- Use the knowledge gained on bentonite material in future work supporting development and assessment of repository designs.

- Report the FSS test in future DOPAS deliverables.

I would like to suggest the following development ideas for any future staff exchange visits. Also any other free text feedback is appreciated.

- Provision of visit information and host expectations well ahead of the visit would enable better preparation and acquaintance with the experiment.

- The self-assessment part of the post-visit reporting could be made clearer and more efficient if more details and information were provided on the EQF scheme and grading system.

Pasi Rantamäki

Was my staff exchange visit successful?

Yes, it was successful in achieving almost all the objectives initially set out. This type of full-scale test is usually impressive and generally gives good perspective when planning new tests.

What did I learn?

Level of Learning outcomes (EQF level, the most applicable level varies from 4-8):	EQF-level: 5

Give also a free text assessment of the achievement of your learning objectives and learning outcomes:

See Section 2.2

KNOWLEDGE *(described as theoretical and/or factual.)*

KNOWLEDGE	EQF Level 1-8
Bentonite material and properties (pellets and granules)	4
Filling procedure of FSS	5
Material handling	5

SKILLS. *(described as cognitive (involving the use of logical, intuitive and creative thinking) or practical abilities (involving manual dexterity and the use of methods, materials, tools and instruments).*

SKILLS	EQF Level 1-8
Evaluation of practicability and implementation of desk-based designs using full-scale tests	5

COMPETENCE *(described in terms of responsibility and autonomy.)*

COMPETENCE	EQF Level 1-8
Experience of evaluating work carried out by Andra and providing review feedback on future improvements	5

How did my expertise contribute to the host's experiment during or after the visit?

Feedback was provided to Andra at the end of the visit to further improve the filling procedure of the swelling clay core and various other aspects of the FSS test (see Section 4.3).

What would I like/need to learn after this visit experience? How did the visit assist me in my work?

- See section 2.2

I would like to suggest the following development ideas for any future staff exchange visits. Also any other free text feedback is appreciated.

- Provision of visit information and host expectations well ahead of the visit would enable better preparation and acquaintance with the experiment.

- The self-assessment part of the post-visit reporting could be made clearer and more efficient if more details and information were provided on the EQF scheme and grading system.

Jouni Tiainen

Was my staff exchange visit successful?

Yes, it was. Especially seeing several devices (developed by Andra) during the visit which was very interesting and instructive.

What did I learn?

Level of Learning outcomes (EQF level, the most applicable level varies from 4-8):	EQF-level: 5

Give also a free text assessment of the achievement of your learning objectives and learning outcomes:

See Section 2.2

KNOWLEDGE *(described as theoretical and/or factual.)*

KNOWLEDGE	EQF Level 1-8
Bentonite material handling devices	5
Filling procedure of FSS	6
Environment	4

SKILLS. *(described as cognitive (involving the use of logical, intuitive and creative thinking) or practical abilities (involving manual dexterity and the use of methods, materials, tools and instruments).*

SKILLS	EQF Level 1-8
Evaluation of practicability and implementation of desk-based designs using full-scale tests	5

COMPETENCE *(described in terms of responsibility and autonomy.)*

COMPETENCE	EQF Level 1-8
Experience of evaluating work carried out by Andra and providing review feedback on future improvements	5

How did my expertise contribute to the host's experiment during or after the visit?

Feedback was provided to Andra at the end of the visit to further improve the filling procedure of the swelling clay core and various other aspects of the FSS test (see Section 4.3).

What would I like/need to learn after this visit experience? How did the visit assist me in my work?

See 2.2

I would like to suggest the following development ideas for any future staff exchange visits. Also any other free text feedback is appreciated.

If the number of participants can be increased, then the subcontractors of Posiva will be able to participate next time.

In reviewing this document, Jean-Michel Bosgiraud of Andra clarified that Andra has the industrial property of equipment and methodology used in the FSS test, and that this can be shared with DOPAS participants. However, this cannot be shared with other subcontractors without a financial compensation.

6 Conclusions

This report has described the objectives and outcomes of a staff exchange visit to the FSS test in Saint Dizier (France) on 10-13 June 2014. The objectives of the visit were to:

- Provide an opportunity to members of DOPAS organisations to observe the filling operations of the swelling clay core of the FSS test.
- Provide feedback and recommendations from the visit participants on the procedures used to fill the swelling clay core to Andra, with a view to improving these procedures in future implementations.

The learning outcomes from the three participants at the visit are documented and can be summarised into the following points:

- The visit was provided an opportunity to obtain a greater understanding of the bentonite material used in the swelling clay core and the development of its specification.
- Discussion on various aspects of the FSS test were held with staff at the site, including requests for clarifications on the filling procedure and the challenges encountered at the various steps of the process. One of the main challenges was the presence of large amounts of dust from bentonite at the test site. Learning points regarding the possible use of similar devices in Posiva's programme were noted.
- A visit to the Bure underground laboratory was organised to demonstrate other experiments being carried out in conjunction with the FSS test to investigate other aspects of the seal behaviour (e.g. experiment to test the hydro-mechanical performance of a drift seal and another experiment to test the hydro-mechanical performance of an excavation-damaged zone (EDZ) cut-off).
- A visit to the Bure Technology Centre was also organised to provide insights into the overall waste disposal concept envisaged by Andra, including observation of waste container handling and emplacement devices.

At the end of the visit, a presentation from the three participants was given to the host organisation, Andra, listing recommendations and comments on the main aspects of the test that Andra were seeking feedback on. The feedback focused on the following three topics.

Example recommendations are also included:

1) Transferability of procedures and experience between surface and underground conditions: the main observations concerned the large size of the tunnels in Andra's concept compared to other disposal concepts such as Posiva's and the availability of storage underground compared to the warehouse facility on the surface.
2) The swelling clay core material density: a couple of techniques that could be used to increase the density of the bentonite mixture used for the swelling clay core were proposed, including the possibility of using screws to push the material and compact it and the potential of using vibrating equipment to allow material to settle and fill the voids between the pellets more efficiently.:
3) The swelling clay core filling procedure: a number of comments and recommendations were made under this topic. These are summarised below in four sub-topics: density variation, recesses, dust, and risks.

a. Density variation: it was noted that it is possible for the density throughout the clay core to vary due to material drop height initially being large compared to later stages of the process. The large drop height will result in better compaction of material at the bottom of the clay core.

b. Recesses: it was suggested that blockages may happen when filling recesses caused by bentonite pellets resulting in non-filled recesses. It may be possible for certain configurations of pellets to cause such blockage between the two walls of a recess. The use of shotclay to fill recesses was also proposed as a possible alternative to using bentonite pellets and powder.

c. Dust: a few recommendations to reduce dust resulting from bentonite powder were made, including the use of a scraper conveyor to transfer material instead of hoppers instead of forklift trucks and the possibility of adding a curved tube at the end of the augers to reduce dust.

d. Risks: a couple of issues were raised concerning possible risks to material and equipment during the filling procedure of the clay core, including the lifting of hoppers quite close to the control panel of the filling machine and the risk of dust on equipment, especially electrical equipment.

7 References

[1] Legentil, PH. and Gatabin, C. (2014). FSS-1: Procédure pour la réalisation du noyau de bentonite, CG-TE-F-NTE-CFS1-GC0-4000-14-0003/2, 16 May 2014 (in French).