

MOBILITY MISSION REPORT

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KLIKNETE NEBO KLEPNETE SEM A ZADEVTE TEXT.

MISSION TITLE

Collaboration in THM-coupled simulation in geological media related to repository research problems

DESCRIPTION

Concerned organisations

Research entities:

- Universidad Politècnica de Catalunya (UPC), Barcelona, Spain
- Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH, Braunschweig, Germany

Concerned infrastructures or facilities


None

Concerned phases

Phase 2: Site characterisation

Themes and topics

Theme 3: Engineered barrier system (EBS) properties, function and long-term performance



- Salt backfills
- EBS system understanding

Keywords

Crushed salt compaction; backfill performance; numerical simulation; constitutive modelling.

EXECUTIVE SUMMARY

In Germany, rock salt is a possible host rock for a repository for heat-emitting radioactive waste. The safety concept for this repository type is based on a multi-barrier system consisting of the geological barrier, the waste canisters and engineered barriers. For backfilling and sealing measures of drifts and shafts crushed salt will be used due to its favorable properties as mined-off material.

Due to the paradigm change in the safety case and the necessity of a qualified prognosis of its long-term behavior, the requirements on the process understanding and numerical simulation of the crushed salt compaction behavior were extended. In the current state, some uncertainties with respect to the existing database and process understanding of crushed salt compaction still remain.

The objective of the mobility mission was aimed to support the improvement of knowledge and numerical skills by a strong scientific exchange contributing to the progress in the PhD which deals with the improvement of the numerical simulation of crushed salt compaction with the FEM code CODE_BRIGHT. This internship was important, since CODE_BRIGHT is developed at the Polytechnical University of Catalunya and a direct discussion and knowledge transfer with the code developer was possible.

During the four weeks of internship several meetings between the PhD and the host supervisor took place. It was started with a presentation of the numerical work done by the PhD student and a following discussion of general questions related to numerical modelling with CODE_BRIGHT and improvement potential in the field of the crushed salt constitutive models.

Improvement potential for crushed salt simulation was seen in formulation of the creep equations. During the internship an approach for the modification of the creep equations was carved out and it was started to investigate this idea.

Since four weeks are quite short for this amount of discussion potential, the work will be followed up by regularly online meetings.

1. MISSION BACKGROUND

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1.1. R&D background

In Germany, rock salt is a possible host rock for a repository for heat-emitting radioactive waste. The safety concept for this repository type is based on a multi-barrier system consisting of the geological barrier, the waste canisters and engineered barriers. For backfilling and sealing measures of drifts and shafts crushed salt will be used due to its favorable properties as mined-off material.

Due to the paradigm change in the safety case and the necessity of a qualified prognosis of its long-term behavior, the requirements on the process understanding and numerical simulation of the crushed salt compaction behavior were extended. In the current state, some uncertainties with respect to the existing database and process understanding of crushed salt compaction still remain.

1.2. Mission objectives

Improvement of knowledge and numerical skills by a strong scientific exchange and contribution to the progress of the PhD.

1.3. Mission request

I applied for your mobility program for getting the possibility of an internship at CIMNE/UPC Barcelona for a duration of four weeks. I wanted to improve my knowledge and skills in the field of numerical modelling by being present, discussing topics of interest and having many personal exchanges with the experts on site. Further, I wanted to use the time for deepening my professional contacts.

1.4. Mission composition

Host organisation

CIMNE/UPC

Host facility

Polytechnical University of Catalunya

Mission dates

04 Oktober 2022 – 28 Oktober 2022

2. MAJOR PRACTICES, TECHNIQUES, METHODS, TOOLS OR SYSTEMS OPERATED OR STUDIED

Tool: CODE_BRIGHT (FEM code)

Method: Analysis of triaxial test simulations and crushed salt constitutive models

Practice: Investigation of improvement potential

2.1. Practice, technique, method, tool or system operated or studied during the mission

Tool: CODE_BRIGHT

Description

CODE_BRIGHT is a finite element code developed at the UPC in Barcelona. It is designed for handling thermal-hydraulic-mechanical (THM) coupled problems in geological media.

Usage

The objective of the PhD is to improve the numerical simulation of crushed salt compaction. Therefore, CODE_BRIGHT and the implemented constitutive models are in use.

Benefits

In CODE_BRIGHT, an extensive constitutive model for crushed salt is available which was developed during the PhD of Sebastià Olivella (host).

Limitations

Several triaxial compression test were re-simulated, however, the numerical reproduction was not always satisfying and specific relationships were not met.

Applicability

The basis of this PhD is to improve the numerical simulation of crushed salt using CODE_BRIGHT.

2.2. Practice, technique, method, tool or system operated or studied during the mission

Method: Analysis of triaxial test simulations and crushed salt constitutive models.

Description

During the PhD, various simulations of triaxial compaction tests were executed for showing the reproducibility of results. In discussion between the PhD student and the host, the numerical results were reviewed and analyzed.

Usage

The analysis of the numerical results serves for detection of possible improvement potential in constitutive models for crushed salt.

Benefits

Due to the execution and analysis of the several simulations, the PhD got a deepened understanding of the mechanical behaviour of crushed salt and the constitutive models, as well as, the numerical handling of CODE_BRIGHT.

Limitations

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Applicability

The method is a key point in the course of the PhD process.

2.3. Practice, technique, method, tool or system operated or studied during the mission

Practice: Investigation of improvement potential

Description

Within the discussions between PhD student and host potential improvement in the creep models was carried out in form of functions which are fixed implemented in the code. These functions were plotted and compared against triaxial test data with the results that the trend isn't bad in general, however, the fit is not good. The PhD developed a simple mathematical equation which could be simply modified to fit the experimental data.

Usage

The functions developed by the PhD need some more time for improvement. Afterwards they will be implemented by the CODE_BRIGHT team and the PhD will proof the applicability.

Benefits

With the modification of the functions it is aimed to improve the numerical simulation of crushed salt compaction.

Limitations

Due to time limitations this work couldn't be finished within the internship, however, it will be continued in strong exchange between PhD student and host.

Applicability

This work will contribute to the PhD.

2.4. Practice, technique, method, tool or system operated or studied during the mission

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Description

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Usage

Klikněte nebo klepněte sem a zadejte text.

Benefits

Klikněte nebo klepněte sem a zadejte text.

Limitations

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Applicability

Klikněte nebo klepněte sem a zadejte text.

3. MISSION FINDINGS AND CONCLUSIONS

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3.1. Lessons learned and conclusions

During my internship, I was able to improve my knowledge in the field of CODE_BRIGHT and learn some new numerical skills in the handling of the code. Due to the extensive personal exchange and discussions with Sebastià, I gained a deepened understanding of the constitutive models for crushed salt in CODE_BRIGHT. Every meeting with Sebastià was valuable for me since the input and the learning progress were huge. For me, the personal contact within the four weeks supplied a big contribution to the progress of my PhD.

3.2. Relevant findings and conclusions for home organisation

For the GRS the internship was valuable. Due to the personal exchange between Larissa and Sebastià, the cooperation of both organizations is strengthened.

3.3. Relevant findings and conclusions for host organisation

This section is not mandatory but can be prepared with the mission supervisor or mentor from the host organisation. If applicable, replace this entire field with a description of about 200 words of findings and conclusions that are specifically relevant to the host organisation. If not applicable, remove the entire section.

3.4. Relevant findings and conclusions for other organisations

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4. POTENTIALS FOR IMPROVEMENT OR DEVELOPMENT

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4.1. Generic potentials

Potentials for improvement were figured out in the formulation of the crushed salt constitutive models. An approach was developed during the internship and will be followed up beyond. It is strived for regular virtual meetings for discussing the progress.

4.2. Potentials for home organisation

Agree with potentials in Section 4.1.

4.3. Potentials for host organisation

This section is not mandatory but can be prepared with the mission supervisor or mentor from the host organisation. If applicable, replace this entire field with a description of about 150 words of specific potential improvements and developments you can suggest for the host organisation. If not applicable, remove the entire section.

APPENDICES

Mission journal

<u>04.10.2022</u>	Arrival, welcome by host, getting my workspace
05.10.2022	1 st meeting: presentation by PhD student about work done and open questions related to the numerical simulation with CODE_BRIGHT
06.10.2022	2 nd meeting: Continuation of presentation and discussion of general questions
07.10.2022	Working on applying the double creep model
10.10.2022	3 rd meeting: discussing the progress of the double creep model
11.10.2022	4 th meeting: discussing the progress of the double creep model
12.10.2022	Working on applying the double creep model
13.10.2022	Virtual meeting with supervisor from Germany together with CODE_BRIGHT team
14.10.2022	Preparation of numerical data from triaxial tests following the outcomings of the discussions
17.10.2022	Preparation of numerical data from triaxial tests following the outcomings of the discussions
18.10.2022	5 th meeting: discussing the way of simulating the crushed salt triaxial tests
19.10.2022	6 th meeting: discussing one specific triaxial tests which couldn't reproduced by CODE_BRIGHT with one parameter set and starting the analysis of improvement potential in the crushed salt models
20.10.2022	Following up the identified improvement potential in the crushed salt models
21.10.2022	Following up the identified improvement potential in the crushed salt models
24.10.2022	7 th meeting: explicit discussion about my contribution to the improvement of crushed salt simulation by implementing a new function
25.10.2022	Development of the function for improvement potential
26.10.2022	8 th meeting: First evaluation of my approach
27.10.2022	Following up the approach
28.10.2022	Last day at UPC, handling of organizational things

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MISSION BENEFICIARY

Larissa Friedenberg
 Junior research scientist and PhD student
 Repository Research Department
 Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH, Germany

PARTNER EXPERTS CONTRIBUTING TO THE MISSION

Host organisation experts

- Sebastià Olivella Pastalle, Professor at the Department of Civil and Environmental Engineering at the Politechnical University of Catalunya

Home organisation experts

- Oliver Czaikowski, Head of the Repository Research Department at the Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) gGmbH

Other organisations experts

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REPORT APPROVAL

Date	Beneficiary	Home mentor/supervisor	Host mentor/supervisor
Date of last signee	Larissa Friedenberg	Oliver Czaikowski	Sebastià Olivella Pastalle
	Visa  13.01.2023	Visa  12.01.2023	Visa Signed by SEBASTIAN OLIVELLA PASTALLE - DNI 46329892A (TCAT) with date 02/01/2023 using a certificate issued