MEASUREMENT OF THE EXCAVATION DISTURBED ZONE IN THE ZEDEX PROJECT IN THE CONTEXT OF REPOSITORY POST-CLOSURE PERFORMANCE ASSESSMENT

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ABSTRACT

Consideration of deep disposal of radioactive wastes in the UK and France involves undertaking Post-Closure Performance Assessments of the proposed disposal system for a potentially suitable site. The results of such assessments include measures of the radiological risk that may result in the long term to members of the public, which can be compared with the relevant regulatory requirements. In France, the "Regle Fondamentale De Surete No III-2-f" produced by the French Authority for the Safety of Nuclear Installations (D.S.I.N), defines the regulations for safe disposal of medium and high level waste. In the UK, the regulatory requirements are specified under the terms of the Radioactive Substances Act 1993.

An element of the Performance Assessment of a potential repository at a given site involves considering the disturbance to the host rock induced by excavation. In France, the D.S.I.N. specifies that the Excavation Disturbed Zone (EDZ) must be as limited as possible, in particular in and around access tunnel seals. It should also be verified that the evaluated excavation disturbance around the opening remains acceptable according to the quality of the confinement barriers. In the UK, Her Majesty's Inspectorate of Pollution has published, under the Radioactive Substances Act 1993, draft guidance on requirements for authorisation for disposal facilities on land for low and intermediate level radioactive wastes. This states that investigations of the site should allow the effects of disturbance to the site from construction of the disposal facility to be assessed and the consequences for radiological safety to be evaluated.

In-situ measurements of excavation disturbance therefore play an important role in the design and construction of radioactive waste repositories. In order to prepare for the development of their own underground testing facilities, ANDRA, the French agency responsible for radioactive waste disposal, and UK Nirex Limited, responsible for the disposal of the UK's intermediate level and some low level radioactive waste, entered into a joint agreement with SKB (Swedish Radioactive Waste Management Company) to undertake excavation disturbance measurements within SKB's Äspö Laboratory in Sweden. The project was termed ZEDEX (Zone of Excavation Disturbance EXperiment).

Rock mechanical, geophysical, hydrogeological and geological data were gathered around a phased data acquisition programme before, during and after a drill and blast and a tunnel boring machine (TBM) drift excavation. The primary objectives of the ZEDEX project were to understand better the development of excavation disturbance and excavation damage, and to test the methodology and instruments employed to acquire the data to enable ANDRA and Nirex to adapt the experimental configuration to their own requirements. The role of EDZ validation in the context of repository post-closure performance assessment is discussed in relation to the planning and implementation of the ZEDEX project.

1. INTRODUCTION

Creating an excavation in rock at depth by any method removes material which was previously bearing some of the load of the adjacent and overlying rocks. Removal of this material therefore causes a redistribution of the stresses around the excavation. This redistribution may be accompanied by some physical movement of the rocks around the excavation, include movements on existing fractures and the creation of new fractures. This phenomenon is termed excavation disturbance. The excavation disturbance is confined to a volume, or zone, of rock which surrounds the excavation. The method employed to excavate the rock can degrade the quality of the rock to a certain extent in terms of permeability increase in the immediate proximity of the excavation. This phenomenon is termed excavation damage. These disturbed and damaged zones of rock surrounding shafts and drifts might provide additional paths for transport in groundwater of radionuclides from the repository.

In both the United Kingdom and France the potential for deep geological disposal of radioactive waste at a particular site is assessed using Post-Closure Performance Assessments. These assessments include quantification of the radiological risk that may result in the long term to members of the public following the closure of a deep repository. A part of the methodology of Post-Closure Performance Assessments involves considering the consequences of disturbance to the rock mass caused by excavation. It is therefore important to have a general understanding of the physical behaviour of the zone of excavation disturbance likely to develop around repository excavations. The regulatory regime in both the United Kingdom and France requires that the zone of excavation disturbance is properly taken into account.

2. FRANCE

In France, the "REGLE FONDAMENTALE DE SURETE n° III-2-f" (RFS III-2-f), written by D.S.I.N. (Direction de la Sûreté des Installations Nucléaires), the French authority for the safety of nuclear installations, linked to the Ministry of Industry and External Trade, defines, for the final disposal of radioactive waste in deep geological formation, the objectives to be retained in order to guarantee safety after the disposal exploitation period. Concerning the zone of excavation disturbance, the RFS III-2-f states that, in terms of disposal concept:

> *"disturbance resulting from excavation must be as limited as possible, in particular in and around shafts and access tunnel seals that will be emplaced at the end of the exploitation,"*
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> Also, in terms of the demonstration of disposal safety, the RFS III-2-f states that:
> *"in order to verify that the objectives of the concept for disposal are achieved, the post-closure safety assessment will have to apply to the following aspects:*
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> - *the justification of the favourable performances of each of the confinement barriers (including the geological barrier),*
> - *the evaluation of the disturbance created by the opening of the underground disposal and the verification that this disturbance remains acceptable according to the level of quality chosen for each barrier, in particular the geological barrier; and more precisely the disturbance caused by excavation,..."*

In order to meet these requirements during construction of the laboratory, ANDRA expects to have to find a practical way to limit the development and extension of the zone of excavation disturbance. This in turn means that ANDRA will need to

define a method of excavation that will represent the best compromise between efficiency and cost in order to minimise the extension of the EDZ according to the response of the rock as observed and measured in the laboratory. Also, given that certain conditions of excavation such as misfire or variations in the characteristics of the rock will increase its extension, ANDRA must be able to avoid sudden variations in the extension of the EDZ.

In terms of making in situ measurements and observations of the zone of excavation disturbance, ANDRA needs to be able to define its geometry, both around and along the opening, and to be able to measure its hydraulic transmissivity and subsequently be able to assess its influence on the performance of the geological barrier.

3. UNITED KINGDOM

In the United Kingdom, Her Majesty's Inspectorate of Pollution has published, under the Radioactive Substances Act 1993 (RSA 93), a consultation document[1] setting out guidance on the requirements for authorisation for disposal facilities on land for low and intermediate level radioactive wastes. This draft guidance states that information on the geological characteristics of the site will be progressively extended through the site investigation phase and during construction of the repository. Information supplied to the regulatory authorities may include results from research, from continuing environmental and geotechnical investigations, and from monitoring during the site investigation, construction and operating phases of the facility. These investigations should be aimed at improving understanding of the geology, hydrogeology, geochemistry and other relevant characteristics of the site and at improving confidence in assessments of the long-term performance of the system. They should also allow the effects of disturbance to the site from construction of the facility and related activities to be assessed and the consequences for radiological safety to be evaluated.

Nirex is currently evaluating the suitability of a site at Sellafield, in West Cumbria, to host a deep waste repository for intermediate and some low level radioactive wastes. Currently, views as to the extent and nature of the excavation disturbed zone are based on past precedent of excavation projects at other sites and a knowledge of the in situ stresses and rock quality measured in boreholes at the Sellafield site. On this basis, it is assumed that the hydraulic conductivity within the zone of excavation disturbance may increase by a factor of up to a hundred over a distance equivalent to twice the diameter of the excavation. This is believed to be a conservative description of the hydraulic characteristics and extent of the excavation disturbed zone. However, it remains an assumption to be tested during construction of the Rock Characterisation Facility (RCF)at the potential repository site at Sellafield.

4. THE ZEDEX PROJECT

ANDRA will construct at least two underground laboratories under the Law N° 91-1381 of December 30 1991 on Radioactive Waste Management Research. They will give site-specific information about a number of subjects including the development of the zone of excavation disturbance. Similarly, Nirex has applied for planning permission to construct the RCF, and currently awaits planning permission to begin shaft sinking which could commence during late 1997. However, both ANDRA and Nirex also participate in the ZEDEX Project at Äspö because:

i) ZEDEX allows early opportunities for practical "hands on" experience in measurement of excavation disturbed zone characteristics in advance of both the ANDRA and the Nirex underground laboratories.

ii) the comparison, in terms of development of the EDZ, of different ways of excavating granitic rocks, using a TBM and different types of drill and blast,

iii) the qualification of instruments permitting the quality assurance of the drill and blast method, in order to ensure the reproducibility of the blast and the constancy of the results in relation to the extension of excavation disturbed and damaged zones,

iv) the qualification of instruments and methods to quantify the excavation disturbed and damaged zones in terms of hydraulic transmissivity in order to be able to better define the performance of the geological barrier,

More generally, ZEDEX has permitted development of a better understanding of the EDZ by:

(v) identifying the mechanisms at the origin of the excavation disturbed and damaged zones linked to different techniques of excavation and to the geological environment of the openings,

(vi) increasing the knowledge concerning the relations between the excavation disturbance and the modification of confinement within the geological barrier, hydraulic properties of the EDZ having an influence on the performance of seals.

5. CONCLUSIONS

In both the United Kingdom and France, it is recognised that it is important to be able to assess the effect which the excavation disturbed and damaged zones may have on repository post-closure performance. Both the United Kingdom and France plan to undertake such assessments in underground laboratories in the future. Before this happens, collaborative research with SKB on the ZEDEX Project at Äspö forms an important step towards these assessments.

6. REFERENCES

[1] Radioactive Substances Act 1993 Consultative Document (Revised Issue: October 1995). Disposal Facilities on Land for Low and Intermediate Level Radioactive Wastes: Guidance on Requirements for Authorisation.