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Research Project Report
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Relationship between Overbrining and Subsidence

by

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SUMMARY

This report finalises a study on subsidence carried out by GEOSTOCK and *Ecole des Mines de Paris* and sponsored by the Solution Mining Research Institute. A first phase has been carried out by SOFREGAZ in 1998 and the present step is its follow-up.

In the new study, a numerical tool to model subsidence under overbrining conditions is developed and used for a practical application on an ICI brinefield near Teesside (East Coast of England).

The underground of the site is composed roughly, starting from surface, of 270 m of sandstones (first 30 metres being unconsolidated), a three-layer Marl-Anhydrite-Marl sandwich of 30 metres and salt rock from depth 300 m to 330 m.

The bedrock is Billingham Anhydrite.

Prior to the present study, laboratory testing enabled to fit behaviour law on the rock found: CAMCLAY for Marls, LEMAITRE for salt and POST-FAILURE behaviour models for Sandstones and Anhydrite.

With the available data, and to elaborate a Finite Element Model, assumptions have been made on joint characteristics and anisotropy of sandstones and *in-situ* initial stresses. These assumptions will have to be confirmed by new site measurements.

Using the Finite Element Code VIPLEF, a sensitivity study is carried out on three sets of key parameters:

- Geometry of the cavern
  I.e. cylindrical cavern, 30 metres high with a diameter ranging from 80 to 400 metres

- Initial *in-situ* stress
  Stress ratio $k = \sigma_H / \sigma_V = 1$ and $K = 0.5$

- Rock characteristics
  Sandstones mechanical characteristics are modified from laboratory results (R_e = 25 to 30 MPa; R_t = 6 to 7.5 MPa; C = 6.5 to 8 MPa; $\varphi = 35°$) to a compressive strength of 5 to 6 MPa, tensile strength of 0.1 MPa, a cohesion of 1.3 to 1.6 MPa. The value of the friction angle is kept at 35°.

The sensitivity study reveals that, with the laboratory parameters, a 400-metre diameter cavern does not "Fail" and that failure takes place in a 280-metre diameter cavern using the modified parameters.

In order to model the supporting effect of fallen material in the cavern, a strain hardening material object is introduced in the Finite Element Code. This material follows a hyperbolic law that takes into account the mechanical parameter of filling material, its bulk and geometry. The initial parameters of the strain hardening material Finite Element object have to be chosen properly to fit actual rock condition.

For that purpose, site measurements have to be carried out. Two classes of measurements are foreseen. The first ones concern the confirmation of modelling assumption: rock jointing and initial stresses. The second type of measurements is required to validate the model. They will monitor cavern shape, bulk factor, roof falls, surface subsidence and the results will be confronted to the model. The means of investigation foreseen are: hydraulic fracturing, core description, levelling, sonar and seismic monitoring.

The results of the present study are promising as a numerical model taking into account the supporting effect of filling material is now available. Going ahead with the next phase focusing on data acquisition and model matching is deemed justified.