Solution Mining Research Institute Fall 2013 Technical Conference

Avignon, France, 30 September – 1 October 2013

AN INTERESTING CHALLENGE: THE IMPLEMENTATION OF EUROCODE-7 IN THE DESIGN OF UNDERGROUND GAS STORAGE CAVERNS

Dr Evan Passaris, Technical Director, Atkins Limited, UK

Abstract

Eurocodes have synchronised the engineering design methodologies across Europe and in particular Eurocode-7 has been the primary geotechnical design code in the UK since 2010. The design methods that were used in the past employed primarily a single safety factor – the global safety factor method. These methods have now been replaced by the Eurocode-7 partial safety factor method, whereby a number of partial safety factors are implemented separately on the applied loads and the material properties.

The implementation of Eurocode-7 in geotechnical design requires a risk analysis approach that incorporates the use of the limit state concept in conjunction with partial factors. As a result, the introduction of Eurocode-7 in the UK had a significant effect on the design of conventional geotechnical structures. Although tunnelling is not explicitly mentioned in Eurocode-7, the application of the Eurocodes in the numerical calculations of tunnel construction has been the subject of several investigations and the limits of this application have recently been assessed by various researchers and practitioners.

As an example of the potential implementation of Eurocode-7 in the design of underground gas storage caverns, consideration is given to the case of a gas storage facility which is planned for development in the Northwich Halite formation in Cheshire, UK. As part of the investigations, a series of finite element analyses were carried out by adopting a minimum gas pressure corresponding to 30% of the geostatic stress and a maximum allowable pressure corresponding to 80% of geostatic stress at the depth of the shoe of the last cemented casing. In applying the Eurocode-7 design principles it was evident that only the GEO limit state was relevant for the geomechanical analysis of a gas storage cavern. Furthermore, taking into consideration the specifications of the UK's National Annex for Eurocode-7, the analyses incorporated Design Approach 1 for Combinations 1 and 2.

For Combination 1, all material strength properties remained unfactored, the factored geostatic loading was set as a permanent unfavourable action, the permanent favourable action was the cushion gas pressure and there were no variable unfavourable actions. Furthermore, the differential gas storage pressure was set as the variable favourable action. For Combination 2, all permanent actions remained unfactored, there were no variable unfavourable actions and the variable favourable action was the differential gas storage pressure. Moreover, all material strength properties were reduced accordingly by employing the respective partial factors. The analysis for Combination 2 was carried out using the strength reduction method whereby the analysis starts with the characteristic strengths directly, without modification, and then at relevant stages of the analysis the strength is gradually reduced until failure in the ground is fully mobilised. The results of the analyses have shown that Eurocode-7 may be considered potentially to be a useful tool for the geomechanical design of underground gas storage caverns. However, this tool must prove itself in practice and will certainly has to be improved in a number of points, namely the introduction of the thermal loading and the implementation of the creep response of halite. To this extent, we ought to see the use of Eurocode-7 in the design of underground gas storage caverns as an interesting challenge that needs to be exploited to its full extent.

Key words: Eurocodes, Bedded Salt Deposits, Caverns for Gas Storage, Computer Modelling, Rock Mechanics, United Kingdom.