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Short Communication

Effect of the variations of clinker composition on the poroelastic properties of hardened class G cement paste

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ABSTRACT

The effect of the variations of clinker composition on the poroelastic properties of class G oil-well cement pastes is studied using a multiscale homogenization model. The model has been calibrated in a previous work based on the results of a laboratory study. Various compositions of class G cements from literature are used in a hydration model to evaluate the volume fractions of the microstructure constituents of hardened cement paste. The poroelastic parameters such as drained bulk modulus, Biot coefficient, and Skempton coefficient are evaluated using the homogenization model. The results show that the variations in chemical composition of class G cements have no important effect on the variations of the poroelastic properties.

1. Introduction

Oil-well cements have a wide application in exploration and production of oil and gas, as well as for sealing water wells, waste disposal wells and geothermal wells. The American Petroleum Institute (API) Standard specifies eight classes of oil-well cements for use at different well depths and conditions. Oil-well cements are specified in classes A–H and different grades corresponding to ordinary (O), medium sulphate-resistant (MSR) and high sulphate-resistant (HSR) [1]. These classes of oil-well cement have different requirements in terms of chemical composition and physical properties. For example, the HSR class G cement requires, among other specifications, a C_3S volume fraction between 0.48 and 0.65, C_3A volume fraction smaller than 0.03 and C_4AF volume fraction smaller than 0.24. Among these oil-well cements, the classes G and H are the most widely used ones.

The knowledge of the poromechanical behaviour of the oil-well cement is essential for the prediction of the well performance during the life of the well. Recently, Ghabezloo et al. [2–5] studied experimentally the thermo-poro-mechanical behaviour of a hardened oil-well cement paste. The evaluated poroelastic parameters are presented in Table 1 in which K_d and K_u are respectively drained and undrained bulk modulus, G is shear modulus, b and B are respectively Biot and Skempton coefficients. The definitions of these parameters are presented in [3]. These parameters are evaluated for a cement paste prepared with a class G cement at w/c = 0.44 and hydrated at 90 °C for at least 90 days in saturated condition. It is known that the physical and mechanical properties of cement paste vary with clinker composition, water-to-cement ratio, cement age and curing conditions. Because of its very low permeability, the complete characterization of the poromechanical properties of the hardened cement past in an experimental study would be very expensive and time consuming. It is thus interesting to find alternative ways to evaluate the poroelastic properties of cement pastes corresponding to different conditions. This is done by Ghabezloo [6,7] by association of the experimental results of Ghabezloo et al. [2–4] with micromechanics modelling and homogenization method. A multiscale homogenization model is calibrated on the experimental results and is used to extrapolate the thermo-poro-elastic parameters to cement pastes with different water-to-cement ratios. These parameters, which are evaluated experimentally for w/c = 0.44, are predicted using the homogenization model for w/c between 0.4 and 0.65. The predictive capacity of the model is verified in [6] by comparing the evaluated Young's modulus with some experimental results from literature. The model permits also the evaluations of pore volume bulk modulus and thermal expansion which are difficult to evaluate experimentally. This homogenization model is used here to study the effect of the

Table 1
Experimentally evaluated poroelastic parameters of hardened class G cement paste [2,3] (w/c = 0.44, hydrated at 90 °C and tested at laboratory temperature).

K_d (GPa)	b (–)	G (GPa)	B (–)	K_u (GPa)
8.7	0.59	5.7	0.4	11.2

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