Ultrasonic sound speed and hydration of gypsum

RESEARCH SCHOOL
INTEGRAL DESIGN OF STRUCTURES

Speerpunt BOUW

Subject

The current PhD-research focuses on the modelling of hydration and fire behaviour of gypsum plasterboards.
This part of the research analyses the sound velocity through slurries as well as non-porous and porous materials. The focus is on using the sound velocity for the microstructure prediction of porous materials, especially gypsum plasterboards, during and after hydration as tool to assess the hydration.

Fig. 1, Experimental ultrasonic setup

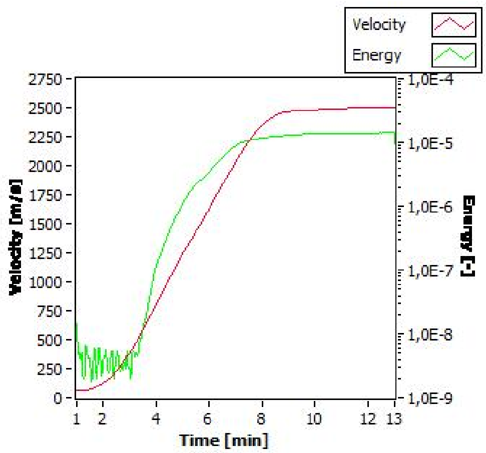

Fig. 2, Experimental results

Results

For slurry, the model of Robeyst (2008) showed a good agreement with experimental data when taking into account an air content 10 ml per kg of hemi-hydrate or an average air layer of 32.8 nm on the surface of hemihydrates particles. This model is based on the theoretical model of Harker and Temple (1988) for ultrasonic propagation in colloids. It takes into account the bulk moduli of the continuous (fluid) and discontinuous (solid) phase as well as the size and shape of the solid particles. The bulk modulus of the fluid is corrected for the presence of entrapped air.

For gypsum materials the 'direct' methods gave the best results. These methods use fixed sound velocity for the different phases instead of sound velocity based on the bulk and shear moduli in case of the 'indirect' methods. The best agreement was found between the experimental and theoretical values using serie arrangement according to Ye (2003) with solid sound velocity of 6800 m/s.

The reliability of this method was also proved during the reverse analysis. This analysis showed that the differences in the prediction of void fraction are in the range of +1.4% and -2.4%. Besides the equation proposed by Ye, the equation of Dalui et al. (1996) with $n = 0.84$ and $c_s = 4571$ m/s also gave good results for the lower void fractions, but unfortunately it is not suitable for higher void fractions.

Finally, the sound velocity during the hydration of gypsum is studied. The use of linear relation between the amount of hydration-product (gypsum) formed and sound velocity gives a reasonable result.

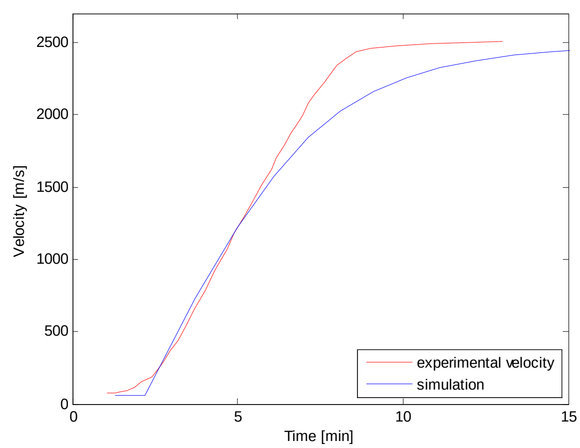

Fig. 3, Experimental results versus simulated sound velocity

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Ultrasonic sound speed and hydration of calcium sulphates
The relation between ultrasonic sound speed and hydration degree

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Subject: The relation between ultrasonic sound speed and hydration of gypsum
The subject is part of the current PhD-research which focuses on the modelling of hydration and fire behaviour of gypsum plasterboards.

Goals
The ultrasonic measurements are use as a tool to measure the hydration rate of calcium sulphates.

Strategy
The research analyses the sound velocity through slurries as well as non-porous and porous materials. The focus is on using the sound velocity for the microstructure prediction of porous materials, especially gypsum plasterboards, during and after hydration.

Results
For slurry, the model of Robeyst (2008) showed a good agreement with experimental data when taking into account an air content 10 ml per kg of hemi-hydrate or an average air layer of 32.8 nm on the surface of hemihydrates particles. This model is based on the theoretical model of Harker and Temple (1988) for ultrasonic propagation in colloids. It takes into account the bulk moduli of the continuous (fluid) and discontinuous (solid) phase as well as the size and shape of the solid particles. The bulk modulus of the fluid is corrected for the presence of entrapped air.
For gypsum materials the 'direct' methods gave the best results. These methods use fixed sound velocity for the different phases instead of sound velocity based on the bulk and shear moduli in case of the 'indirect' methods. The best agreement was found between the experimental and theoretical values using serie arrangement according to Ye (2003) with solid sound velocity of 6800 m/s. The reliability of this method was also proved during the reverse analysis. This analysis showed that the differences in the prediction of void fraction are in the range of +1.4% and -2.4%. Besides the equation proposed by Ye, the equation of Dalui et al. (1996) with $n = 0.84$ and $c_s = 4571$ m/s also gave good results for the lower void fractions, but unfortunately it is not suitable for higher void fractions.
Finally, the sound velocity during the hydration of gypsum is studied. The use of linear relation between the amount of hydration-product (gypsum) formed and sound velocity gives a reasonable result.

Preferred Partners Applications / Sponsors
The research is sponsored by the 6th framework project "The Integrated Safe & Smart Built Concept" (proposal No. 026661-2) and user-group cement-immobilisates-concrete at the University of Twente.

Prime Publication / Prototyping

1. de Korte, A. C. J., and Brouwers, H. J. H. (2009). Calculation of thermal conductivity of gypsum plasterboard at ambient and elevated temperature. Fire and Materials. doi: 10.1002/fam.1009.
2. de Korte, A. C. J., and Brouwers, H. J. H. (2009). Production of non-constructive concrete blocks using contaminated soil. Construction and Building Materials, 23(12), 3564–3578. doi: 10.1016/j.conbuildmat.2009.06.022.
3. de Korte, A. C. J., and Brouwers, H. J. H. (2009). Multi-scale hydration modeling of calcium sulphates. In H. B. Fischer and K. A. Bode (Eds.), 17th Internationale Baustofftagung (Vol. 1, pp. 413-418). Weimar, Germany: F.A. Finger-Institut fur Baustoffkunde, Weimar.
4. Korte, A.C.J. de (2008). Hydration modelling of calcium sulphates. In R. Eligehausen and C. Gehlen (Eds.), 7th fib international PhD symposium in Civil Engineering. Stuttgart, Germany (vol. 8, pp. 3-13). Stuttgart, Germany: Universitat Stuttgart. Available from: 2008 Universitat Stuttgart, Germany

Research Period
January 2007 – March 2011