DETECTION OF ALKALI-SILICA REACTION BY MEANS OF ULTRASONIC SOUNDING – A PILOT STUDY

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Alkali-silica reaction (ASR) originates in highly alkaline conditions in concrete in which reactive forms of aggregates are presented. During last three decades it has been widely discussed topic due to large damages observed on concrete structures caused by ASR. The goal of this contribution is design of new approach based on one of commonly used nondestructive technique – ultrasonic sounding to evaluate the degree of the mortar bar deterioration due to the ASR. There was designed and constructed new measuring heating chamber, which enables semi-continues ultrasonic sounding of two mortar bars by means of time of flight method affected by 80 °C 1 M NaOH solution (Figure 1). Ultrasonic sounding was carried out every 10 minutes during 34 days of experiment. As input data of mortar bars deterioration evaluation, there were used not only ultrasonic pulse velocity ones, but also signal amplitude, energy and its frequency content. Experimental measurements proved that method of ultrasonic sounding can be one of effective methods used for ASR studies. Ultrasonic results are compared with the accelerated mortar bar test (according to ASTM C1260), for which the same rocks have been used as an aggregate (Figure 2). There is observed very good correlation between ultrasonic and expansion tests of different mortar bars. Ultrasonic tests show very high sensitivity to the deterioration degree of the sample. Whereas expansion tests have maximum 1% of sensitivity, ultrasonic data exhibit 10 to 80 % of sensitivity. Figure 3 shows example of the data obtained – P-wave velocity dependence of ultrasonic signal. This dependence shows fast increase of velocity due to the mortar material stiffness at the very beginning of bar production. But after two days there is observed different behavior of P-wave velocity propagation according to the type of mortar bar treatment. We believe that ultrasonic sounding could be used as one of very efficient methods suitable for understanding and predicting ASR expansion behavior and developing effective testing procedure.

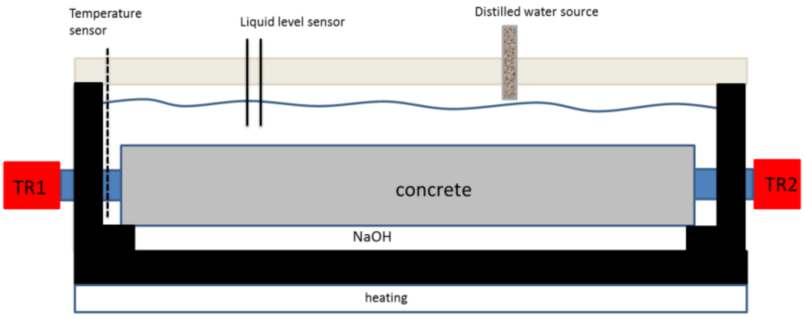

Figure 1: Technical layout of heating chamber equipped with waveguides and ultrasonic sensors.

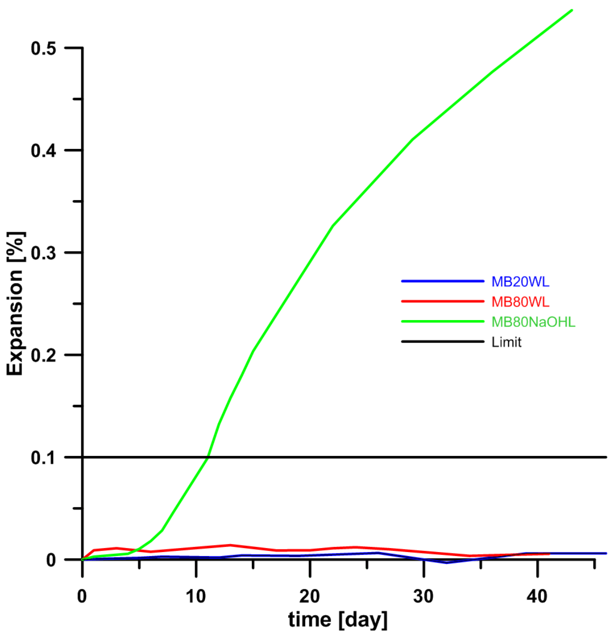

Figure 2: Expansion curves of mortar bars. MB20WL - mortar bars stored in water at 20°C (blue), MB80WL - mortar bars stored in water at 80°C (red), MB80NaOHL - mortar bars stored in 1 M NaOH solution at 80°C (green).

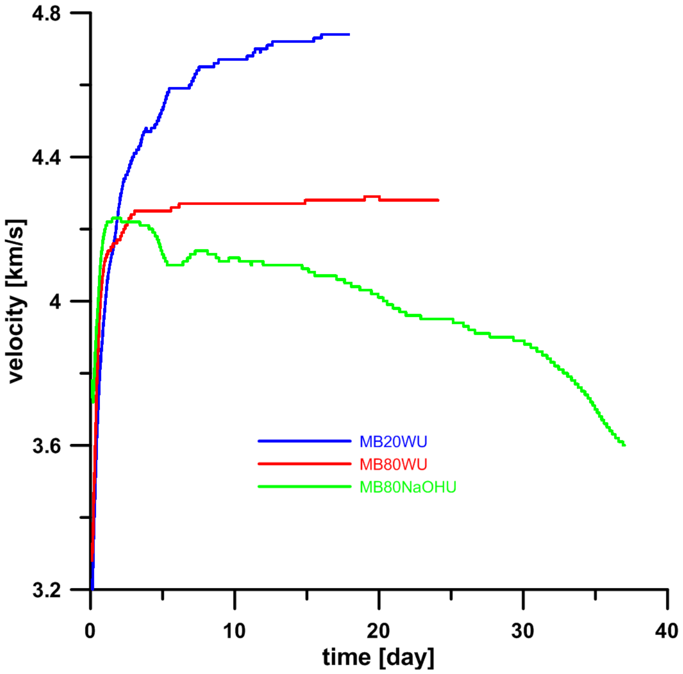

Figure 3: Experimental data of mortar bars obtained by measurements in a temperature-controlled heating chamber – velocity/time dependence.

Conclusions

A newly designed test chamber allowed semi-continuous ultrasonic sounding of econcrete mortar bars for the evaluation of aggregate's ASR potential in 1N NaOH solution at 80°C over long time (40 days) without necessity to remove the mortar bars from the experimental solution. Evaluation of measured ultrasonic signals showed that ongoing deterioration of microstructure of mortar bars can be detected by time domain analysis of recorded signals.

The parameters recorded and computed - P-wave velocity during the experiment show different development of concrete microstructure (hardening of concrete mixture) and/or degradation of microstructure due to developing ASR. Measured expansion of the test mortar bars of 0.5 % in 40-days lasting experiment corresponded to a drop in P-wave velocity of about 400 m/s (approx. 9 % of maximum value) in case of the specimens subjected to the effect of 1N NaOH.