Is It Possible to Applied Acoustic Emission Method during Concrete Hardening?

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Abstract

The article describes the laboratory tests which make the first stage of the study concerning the use of the AE method to determine the concrete hardening and setting processes.

Concrete is essential material for civil engineering. It is the most used material in the world. Its properties depend on mixture components (cement, sand, water, chemical admixtures and etc.) and its curing. Physical and chemical processes (guided heat release) proceed into concrete during hydration and hardening, at which concrete obtains mechanical strength and hardiness and creates chemical stability in material. Cracks rise in concrete over its lifetime especially in initial stage. Temperature and structural changes are sources for crack initiation. These changes can locate by help acoustic emission method. However set up the method is not easy.

The article will describe experiments on concrete samples 10 cm width 10 cm high and 40 cm longer. Acoustic emission system LOCAN 320 (see Fig. 1) uses four acoustic emission sensors to indicate acoustic emission hits – two on a sample. Simultaneously these sensors serve as guard. Acoustic emission sensitivity is obliged to be set high but so that acoustic emission hits are a little above noise. Temperature into samples was measured too. Two samples ware measured simultaneously. Article describes some result from chosen measurement.

Introduction

Concrete is one of the most widespread building materials all over the world. It can be regarded as a composite building material, consisting of filler, in this case aggregates, and a binder, here the hydraulic binder (mostly cement). In addition, the material includes a certain amount of pores. It is already during the concrete setting period that there arise shrinking cracks in it in consequence of the water content reduction. The crack generation is a natural behaviour of any concrete structure. These cracks arise and develop throughout the concrete structure life usually. [6,10,11]

As a non-destructive method of tracing the crack generation, propagation and activity, the acoustic emission method has been used to study the behaviour of selected concrete mixes during the first stage of their life, i.e., in the course of the concrete setting and hardening. [1,2,5]

The measurements have been carried out on two standard-sized specimens at a time. Several embedded resistance sensors have been used to measure the temperature inside the standard-sized beams in the course of their setting and hardening. The acoustic emission activity is picked up by two acoustic emission sensors placed on each specimen. The sensor output voltages are fed into a factory-made measuring system. It is to be noted that the sensor sensitivity has been set to be very high. To a certain extent, the sensors serve as guard at a time. Consequently, a lot of spurious...
signals arise, which are removed during the subsequent analysis. The above mentioned acoustic emission and temperature measurement is carried out continuously during several days. The measurement starts a few hours after the specimen has been produced, at the time when the sensors can be fitted to the specimen surface. [4,7,9]

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**Experimental set-up**

The specimens are in the form of concrete blocks of dimensions 100 mm x 100 mm x 400 mm. They are fabricated in special moulds whose oblong wall is uncovered. After the fabrication and final vibration are completed, temperature sensors (and resistance and capacitance measuring electrodes) are inserted into the mould.

Negative resistance coefficient resistors, i.e. NTC thermistors, whose resistance decreases with increasing temperature, are used to measure the temperature. The sensors are placed inside the specimen. The temperature is calculated from the measured resistance using the following equation:

\[ \nu = 12.8 \cdot \log^2(R) - 129 \cdot \log(R) + 280 \]  

where \( \nu \) is the temperature [\(^\circ\)C] and \( R \) is the resistance [\( \Omega \)].

<table>
<thead>
<tr>
<th>Mixture</th>
<th>Weight [kg]</th>
</tr>
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<tbody>
<tr>
<td>Ordinary Portland Cement</td>
<td>390</td>
</tr>
<tr>
<td>Water</td>
<td>125</td>
</tr>
<tr>
<td>Plasticizer, water reducing admixture</td>
<td>6.4</td>
</tr>
<tr>
<td>Sand 0/4</td>
<td>780</td>
</tr>
<tr>
<td>Crushed aggregates 4/8 mm</td>
<td>1165</td>
</tr>
</tbody>
</table>

The tested concrete mixture has made by Table 1. Basically following has been on covered and uncovered concrete specimens (see Fig. 1). Peak of temperature into sample without protection is higher than into covered sample (see Figs. 2 and 3). The temperature \( \Delta \nu \) in Figs 2 and 3 (right axis) means differences between temperatures into sample and surrounding. It is possible to expect a lot of cracks into samples without protection.
Acoustic emission activities (see Fig 2 and 3, left axis) of samples with and without foil covered are similar up to 10 hour. Then acoustic emission activities of sample without protection increases more than activities of covered sample. The acoustic emission activities increase after 28 days. Consequently, concrete structure is designed a long time. Cracks into concrete probably arise and grow up during whole life time.

Similar results are shown in Figs. 4, 5 and 6. Time history $t$ of amplitudes $A$ (see fig 4 – solid line means temperature and circle amplitudes) shows big activities about 7 hour meaning unmolding samples. 3D graphs in Fig. 5 show time history $t$ of amplitude $A$ distribution $N$. There are many lower amplitudes up to 50 dB. Graphs in Fig. 6 show time history $t$ of frequency $f$ cumulative distribution $N$. 
Fig. 3 Covered and uncovered samples up to 1 day after making

Fig. 4 Time history (up to 1 day) of acoustic emission amplitude and temperature of covered (left) and uncovered (right) samples

Fig. 5 Time history of acoustic emission amplitude distribution of covered (left) and uncovered (right) samples
Since the costs of failures of combustion engines caused by the failures of slide bearings are very high, intensive theoretical and experimental tests of the slide bearings properties have been undertaken. [1, 2]

Conclusions

Acoustic Emission Method, Impedance Spectroscopy and Non-Linear Ultrasonic Spectroscopy can well suite for studying the quality of hydration and hardening concrete structure. This non traditional application of non destructive method can show possibility improving quality concrete structures. Thus it is not easy to apply non destructive techniques for civil engineering structures. [5,8]

Good handling of concrete is basically part for long life. Constructions could be covered over long time, and then construction contains few cracks and defects.

New mathematics methods applied on experimental data can help to evaluation. [3]

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