Monitoring Micro Defects of Thermally Loaded Specimens Using the Acoustic Emission Method

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Abstract: The Acoustic Emission Method has been used to identify the thermal damage evolution in tar binders composites. Two specimen groups have been monitored. One formed by compounds based on tar while the other comprising phenolic resins and both its types, novolacs and rezoles. The signals of acoustic emission from the specimens tested in the oven at 800 degrees Celsius have been recorded during the thermal testing in order to investigate the micro change in structure.

Keywords: acoustic emission; thermally loading; micro defect; non-destructive testing; tar; phenolic resins.

1 Introduction

From the non-destructive acoustic-analysis methods the acoustic-emission method as a non-traditional method for civil engineering, was used for this experiment. The acoustic emission technique is one of the promising methods for detecting the formation of stress cracks in tests. [1] Originating in the field of structural monitoring in civil engineering, the acoustic emission testing method has the unique ability to evaluate an entire structure and locate a discontinuity as it forms and propagates. [2] It is known that, as monitoring high thermal processes is very complicated, the number of testing methods decreases with increasing temperature, which lowers the chances of getting a detailed description of the inner material structure behaviour. [3] The acoustic emission method is an applicable method that does not affect the processes occurring inside the furnace while monitoring the microscopic behaviour of the structure. [4] An acoustic emission based laboratory test was also applied to several types of asphalt materials to evaluate the low-temperature cracking performance. [5] The acoustic emission could be measured using a waveguide shaped for the signal not to change while the thermal protection of the sensor was sufficient. [6]

2 Experimental set-up

Four different types of samples were monitored under thermal loading. Each specimen of 20 ºC was placed in a furnace with a loading temperature of 800 ºC. The specimen was 50 mm long with a diameter of 50 mm. The experimental set-up is shown in Fig. 1. During the thermal loading, the acoustic emission activity was monitored. The acoustic emission sensor was placed on the waveguide as shown in Fig. 2. This position was chosen for its temperature to be less than 100 ºC but while the detection of the acoustic emission activity is optimal.

The four types of specimens were labelled

- IS - a mixture using only tar binder (containing pitch and other products of tars distillation)
- IL - a mixture of tar binder with the highest phenolic resins content,
- KO – material similar to IL but containing another kind of resin,
- DN - composite material containing a tar binder and all phenolic resins used in IL and KO.

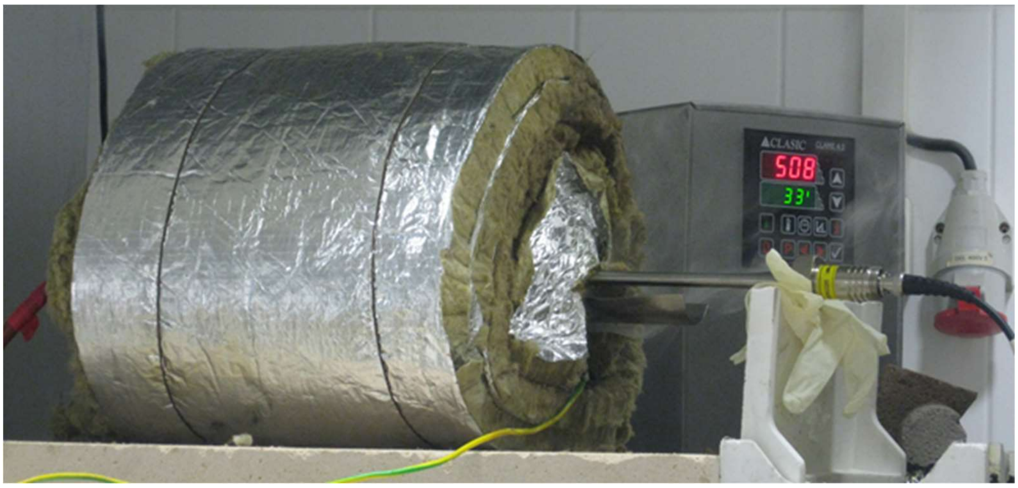

Fig. 1: The temperature loading of the specimen into a special oven and the position of the acoustic emission sensor on the waveguide

Fig. 2: The acoustic emission sensor on the waveguide

3 Results

The number of overshooting is a basic parameter of acoustic emission method. The dependence of the cumulative number of overshooting on time or temperature was used to evaluate different types of specimens. Further analyses were concerned with other acoustic emission parameters such as acoustic emission amplitude, acoustic emission energy, etc.

The acoustic emission activities during the hardening of all specimen types are shown in Figs. 3 and 4. Samples without resin (IS) took the longest time, i.e. 20 minutes to harden. The acoustic emission activities show two significant periods of changes in the mass, particularly, the first six minutes and from 8 minutes to 14 minutes. These structural changes were very slow. The specimens containing the mixture with the highest resin content (IL) change their structure very fast during the first minutes, the decline in activity follows up to the third minute when hardened. The structural changes during the hardening of similar types of specimen material (KO) are similar, there the changes occur in the first minute and the next about two minutes as the acoustic emission activity shows. There are probably two reasons for this behavior. The first one is the faster hardening of phenolic resins as compared with a tar binder. The second one is associated with the evaporation of solvents of phenolic resins, which creates a large amount of gas destroying the microstructure.

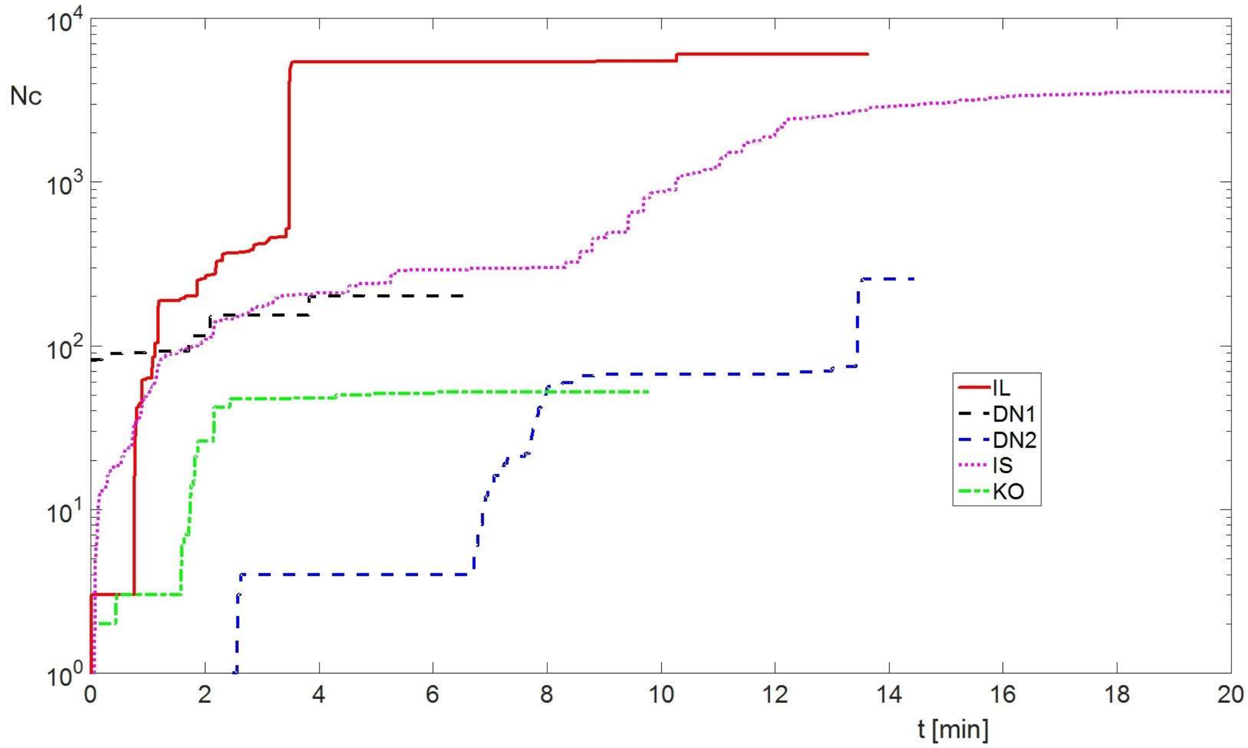

Fig. 3: The history of the cumulative acoustic emission activity of the specimens

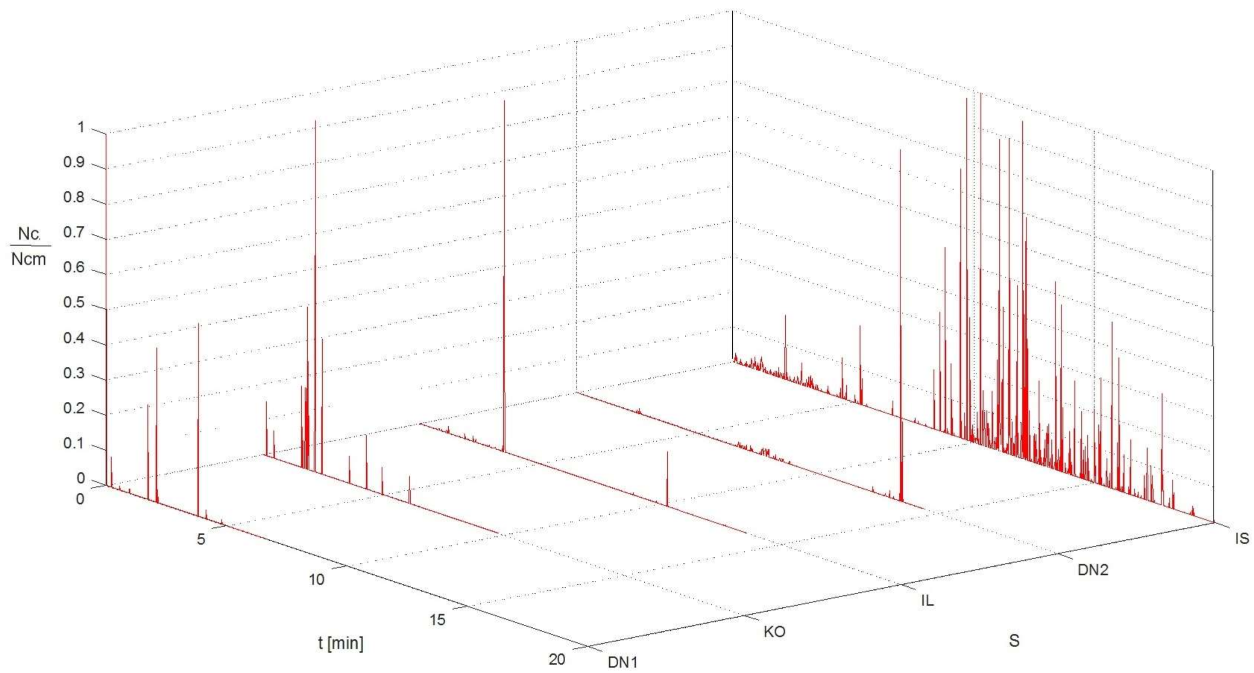

Fig. 4: The relative acoustic emission activity of specimens

Thus, in the first part (up to 5 min.), the specimen softens and settles and only in the second part (from 10 minutes) it begins to harden. As the other materials contain resin, the hardening behaviour is different. The solvents they contain are evaporated at lower temperatures, which means that the resin on the surface gets hardened fast. In the DN sample, this is given by the fact that different resins in a mixture hardening gradually, this provides ample time for a system of pores to be created through which the gas generated can escape. Thus, the material itself hardens only later when the gland varnish gets involved in the hardening, but, as compared with the IS mixture, the hardening is accelerated by resins.

4 Conclusion

Evaluation of the acoustic emission activity during thermal loading of different specimens is the focus of the paper. Acoustic emission method shows an interesting viewpoint of the thermal loading of different specimens. The chemical changes during thermal loading of specimens may be monitored with the help of the acoustic emission method. Resins mixed with tar make possible the fast hardening of the structure in a shorter time.

This method will be applied to monitoring micro changes and micro defects during thermal loading of concrete specimens. The acoustic emission method can simply be used for determining the stiffening of the matter. Therefore, when the acoustic emission activity has finished, there are no longer any chemical changes of the matter.

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