An Acoustic Emission Method for Detecting Aggregated Regions in RC Decks: A Fundamental Experimental Verification

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1. Introduction

Nowadays, many aggregation (doshaka in Japanese) problems are reported on existing RC bridge decks. Aggregation is known as the final deterioration phase of RC decks occurring beneath asphalt pavements, where the surface of concrete deteriorates into aggregates (sands and gravels). It is one of the main factors that cause deck stiffness reduction, and therefore appropriate detection techniques and fast countermeasures are demanded to tackle it. Due to the fact that the deteriorated regions are invisible from pavement surfaces, current countermeasures can take place only after the deterioration is as severe to the apparently visible level. Facing this challenge, this study is devoted to develop a non-destructive testing (NDT) method that the deck aggregated regions can be detected from pavement surfaces by capturing the acoustic emissions (AE) when the deck is subjected to normal vehicle loads. This paper reports the results of a fundamental laboratory experiments with focus on the feasibility of the present method.

Photo 1. A specimen with asphalt pavement.

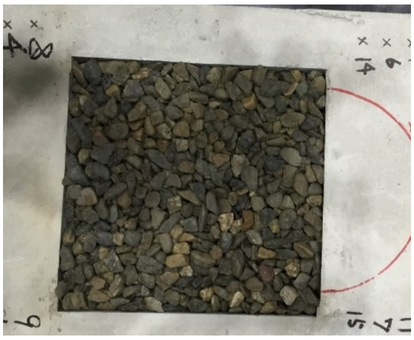

Photo 2. Modeled aggregation

2. Experiment Description

A reinforced-concrete specimen (see Photo 1) of 30x70x20 cm in size, paved with asphalt of 8 cm in depth, was designed to model a portion of deck. Before pavement, a cavity of 20 cm in both width and length and 4.5 cm in depth was filled with gravels of 2 cm in maximum size to model the aggregated region (see Photo 2).

Both before and after asphalt pavement was performed, the specimen was loaded above the aggregated region by a universal loading machine, with a designed static load (DSL) of 2.5, 10 and 25 kN. During the loading tests, AE activities were continuously monitored, with three types of AE sensors, each of 30, 60 and 150 kHz in resonance frequency. The layout of those sensors is shown in Figure 1.

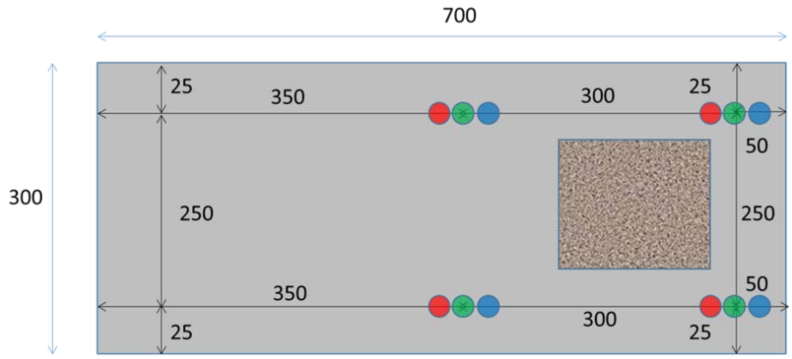

Figure 1. Sensor layout (red: 30 kHz, green: 60 kHz, blue: 150

3. Results and Discussions

Let us first take the data measured from asphalt paved specimen by the 30 kHz sensors for example. From the curve of accumulated energy with respect to the elapsed time during all loading procedures, as shown in Figure 2, it is observed that AE hits were measured

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during the 2nd and 3rd run loading (DSL= 10 and 25 kN, respectively) and that the initial AE hits were measured at about 5 kN, implying that the minimum load for AE activities to take place or become observable is around 5 kN. Similarly, the minimum load such defined is summarized in Table 1 with respect to the three loading conditions and three types of sensors. From the table, it can be said that the minimum loads for AE activities in the aggregated region to take place and become observable from the asphalt surface is about 5 kN, irrespective of loading steps and sensor types. This is a reasonably small load equivalent to a vehicle weighing 2 tons. Moreover, 30 and 60 kHz AE sensors could be more preferable to detect AE activities taking place in aggregated regions. .

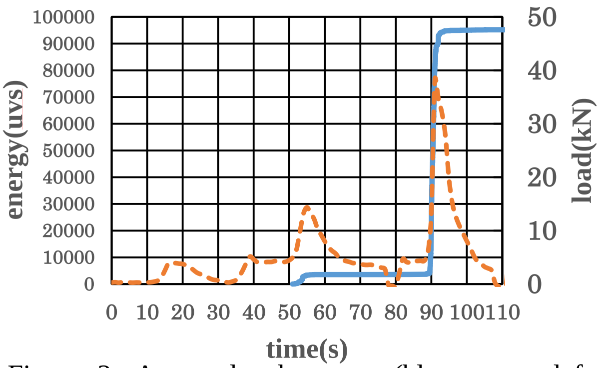

Figure 2. Accumulated energy (blue curve, left axis) vs. loading (red curve, right axis).

The histograms of dominant frequencies of AE activities during the loading and unloading stages are plotted in Figures 2 and 3, respectively. It is observed that the frequencies ranging from 10 to 25 kHz (regarded as low frequencies in AE measurements) dominates the measured activities during both loading and unloading stages. In acknowledging the facts that the source of AE activities could take place due to two major mechanisms: one is the slippage between particle interfaces and the other is the fracture of particles, the former of which generally produces a frequency lower than the latter does, it can be said that slippage was more dominantly occurred than the fracture was throughout the loading test.

4. Concluding remarks

The following concluding remarks could be drawn from this fundamentally experimental study.

1) From the surfaces of asphalt pavements, it is feasible to measure AE activities taking place in the aggregated regions under normal traffic loading.
2) 30 and 60 kHz AE sensors could be preferable sensors to undertake the above task.
3) Slippage between aggregates was the dominant mechanism that generates AE hits throughout the loading test.

Reference

Wojciech Sikorski (Ed.), *Acoustic Emission*, InTech, 2012.

Table 1. Minimum loads (in kN) for AE activities to be observable.

	Loading step	Sensor type 30 kHz	60 kHz	150 kHz
Unpaved	1	1.26	0.82	2.075
	2	2.03	1.06	1.06
	3	3.92	1.31	25.16
Paved	1	N	N	N
	2	5	5	10.2
	3	5.2	5.2	5.2

Note: 'N' denotes that AE were not observed in such loading duration.

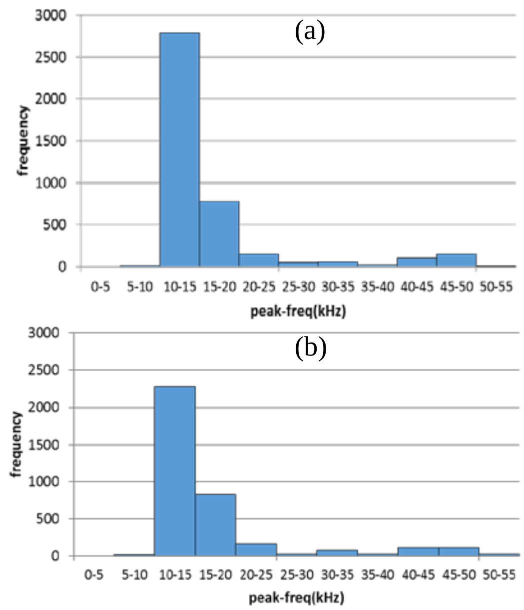

Figure 2. Histograms of dominant frequencies of AE activities: (a) loading; (b) unloading.