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Nondestructive identification of delaminations in concrete floor toppings with acoustic methods

Jerzy Hola, Lukasz Sadowski, Krzysztof Schabowicz *

Institute of Building Engineering, Wroclaw University of Technology, Plac Grunwaldzki 11, 50-377 Wroclaw, Poland

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ABSTRACT

This paper presents an original methodology for the nondestructive identification of delaminations in concrete floor toppings by means of the combined impulse-response and impact-echo acoustic methods. It is demonstrated that the impulse-response method is highly suitable for the fast exploration of large stretches of concrete floor and rough location of defective areas while the impact-echo method is ideal for the precise location of the boundaries of the areas. If the surface area of the tested floor topping is large, the nondestructive tests can be automated by mounting the equipment on a special scanner or robot. An example of the practical use of the proposed methodology is presented. It confirms the usefulness of the methodology for the nondestructive identification of delaminations in large-area concrete floor toppings.

1. Introduction

The durability of concrete floor toppings is to a large degree determined by their pull-off (from the concrete base) strength. In practice there are cases in which, because of serious errors made during the laying of the topping, this strength may be equal to zero in some areas. This is tantamount to delamination at the concrete base/floor topping interface. The defective areas reduce the durability of the floor topping whereby the latter is shortly put out of service. For this reason (among others), prior to accepting and putting floor toppings (particularly ones covering large areas and heavily loaded) into service, tests are carried out to early detect any areas in which delamination may have occurred. Drill cores are pulled off the concrete base in the way described in American standard ASTM D 7234 [1] and European standard EN 12504-3:2006 [2]. The pulling off force equal to zero indicates that a delamination is present in the tested place.

The effectiveness of the pull-off method in such tests significantly depends on the number of drill cores. In order to precisely determine the size and boundaries of a detected faulty area for repair planning purposes, a denser test grid should be used (by increasing the number of boreholes). But then the labour intensity of such tests increases. In addition, the areas in which boreholes are drilled need to be repaired. These drawbacks become particularly apparent when floor toppings covering large areas (from a few to tens of square meters) are tested.

An interesting alternative is the use of nondestructive test methods to test floor toppings (particularly large ones). In order to precisely locate delaminated areas in the topping it is recommended to use jointly two nondestructive test methods: the impulse-response method and the impact-echo method. These state-of-the art acoustic methods were described by Davis [4], Sansalone and Strett [5] and in the ACI 228.28–98 report[6].

2. State of the art

The identification of delaminations in concrete toppings was investigated by Delatte et al. [7]. They proposed a way for making a map of delaminations determined by the pull-off method. Also Garbacz et al. [8] proposed the use of the pull-off method to produce a delamination map on the surface of layered concrete elements, including floor toppings with an overlaid repair layer. Davis et al. [9] and Hertlein and Davis [10] recommended the nondestructive impulse-response method to search for delaminations in concrete floor toppings. Ottosen et al. [11] and Garbacz [12] proposed the use of the nondestructive impact-echo for this purpose. They successfully applied the impact-echo method to small-area floors. Nevertheless, cases of applying combined impulse-response and impact-echo methods to delamination identification are hard to find in the literature on the subject. It was Oh at al. [13] who came up with this observation.

On the basis of their own experience Hola et al. [14] concluded that the nondestructive impulse-response and impact-echo methods combined are complementary and highly useful in identifying delaminations, particularly in large-area floor toppings. From amongst the arguments for this conclusion one should mention the fact that in the

* Corresponding author.
E-mail addresses: jerzy.hola@pwr.wroc.pl (J. Hola), lukasz.sadowski@pwr.wroc.pl (L. Sadowski), krzysztof.schabowicz@pwr.wroc.pl (K. Schabowicz).

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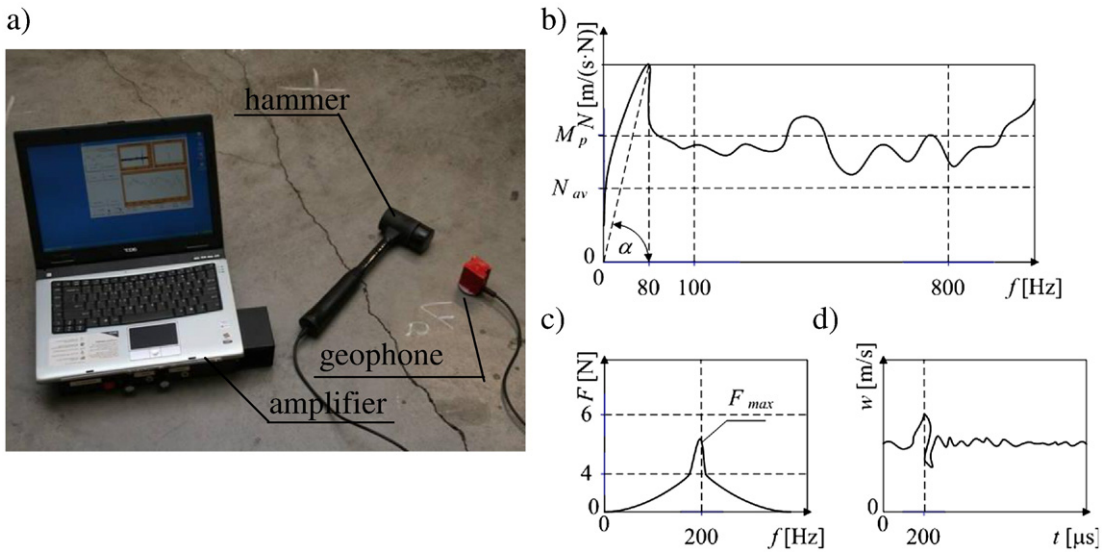

Fig. 1. Idea of impulse-response method: a) measuring system, b) typical mobility *N* versus frequency curve, c) typical trace of elastic force *F* generated by hammer, d) typical trace of elastic wave velocity *w* recorded by geophone.

impulse-response method test points can be as far apart as 2000 m whereby this method is not very accurate. However, it is suitable for quick searching of large flat surfaces and for the approximate identification of areas in which delaminations occurred. As regards the impact-echo method, the measuring points are closely spaced (a few tens of millimetres apart). For this reason, in the case of larger floors this method is more labour-intensive. But it is ideal for the precise identification of the boundaries of the area previously detected by the

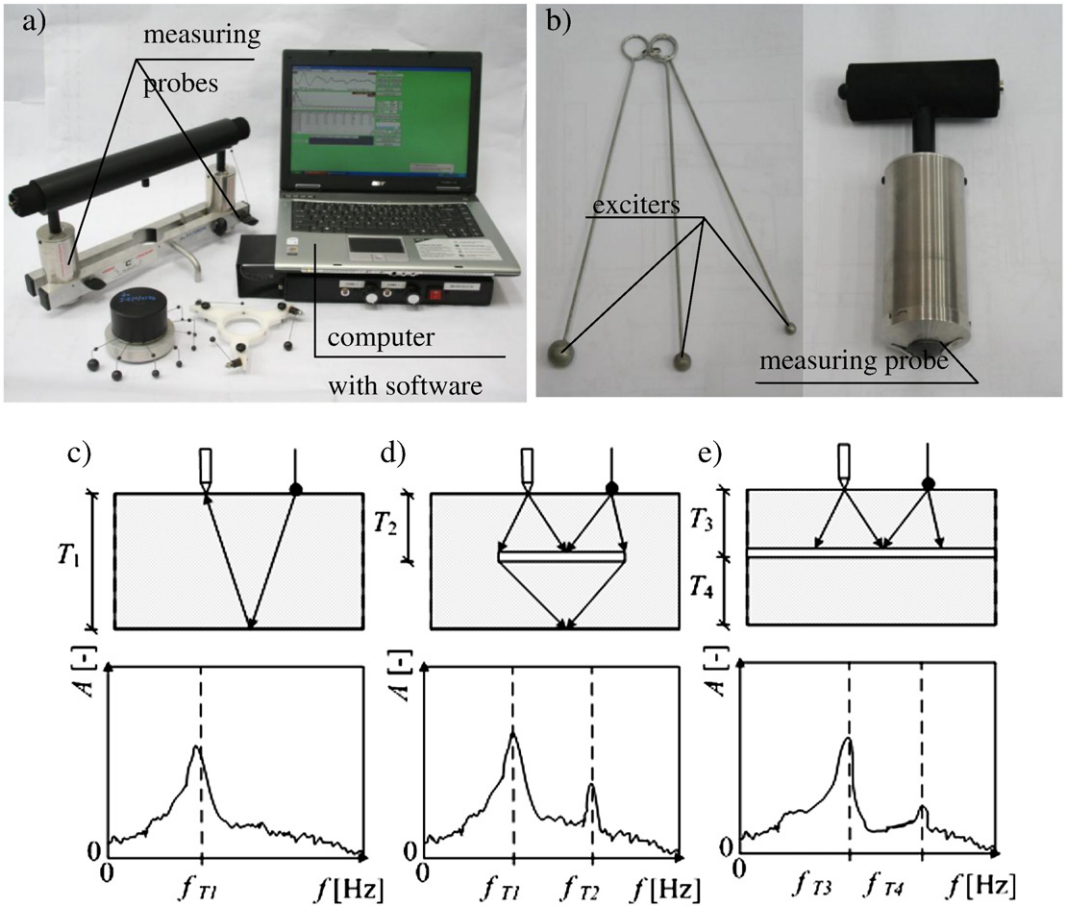

Fig. 2. Idea of impact-echo method: a) measuring kit, b) exciters and measuring probes, c) typical amplitude-frequency spectrum for floor topping thickness measurement, d) typical amplitude-frequency spectrum indicating defect in floor topping, e) typical amplitude-frequency spectrum indicating delamination in floor topping (when topping and base are made of different materials).