DAMAGE ASSESSMENT OF SEMI-PRECAST SLABS USING IMPACT-ECHO METHOD

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Abstract. *Semi-precast slabs are widely used in precast concrete constructions in China nowadays.However the construction quality of them are often hard to control, and the constructoion quality of the upper in-situ concrete of them is difficult to be guaranteed, as a result, how to detect the construction defects correctly and timely become more and more important. In this paper a traditional method Impact-Echo (IE) method is used to detect the flaws between the precast concrete and the upper in-situ concrete of the semi-precast slabs. Firstly one experimental slabs with many designed flaws was constructed, and than IE method was used to detect these flaws, fially the detected results were analysed to evaluate the proposed method. The results were processed using a mapping strategy, which indicated suspicious points where core extraction was undertaken. All cores taken from points derived from IE method results were found to have flaws providing evidence. The experimental results show that IE method may be a suitable tool to assess the construction quality of Semi-precast slabs.*

Keywords: Damage assessment, Semi-precast slabs, Impact-Echo, Defect.

1 INTRODUCTION

Semi-precast slabs consists of large format reinforced concrete slabs that are 50 to 80 mm thick. It is delivered as semi-finished floor, installed on the construction site and filled with a concrete topping. The bottom of the lattice girder floor has no pores and is fair faced; this eliminates the need for time and cost-intensive cleaning. Thanks to the significantly smaller on site formwork requirement, substantial cost reductions and a shortening of construction time can be achieved, and due to the high efficiency and flexibility of semi-precast slabs compared to in-situ concrete structures, the use of these slab systems increase greatly in building and industrial construction practice. However there are some tricky problems to be solved immediately. The quality of the concrete topping is hard to control when casting the cast-in-situ concrete, and there would be many defects in semi-precast slabs during casting the upper concrete. These defects such as honeycombing, voids, cracks etc. are often not visible and hard to be noticed, however the defects can lead to sever quality problem, and now civil engineers are focusing on the issue that how to detect these defects correctly and timely to guarantee the quality of the floor.

The Impact-Echo (IE) method is introduced by Sansalone and Carino [1]. It is based on the use of impact-generated compression waves that travel through the structure and are reflected by internal flaws and external surfaces. Impact Echo can be used to measure the thickness of slabs, plates, columns and beams, and hollow cylinders. It can also be used to determine the location and extent of flaws such as cracks, delaminations, void, honeycombing and debonding in plain, reinforced and post-tensioned concrete structures [2-3]. Hidden faults can be detected early and can be remedied while access to the structure is still possible without major inconvenience. Impact-echo method can disclose problems at an early state and provides valuable information of the actual condition of the structure. In the past the IE method is usully used in traditional building field, and few men use IE method to detect the flaws in semi-precast slabs. In this paper the author try to use this method in this new structural componentsp[4-5].

2 PRINCIPLE OF THE METHOD

The view of Impact-Echo equipment has been presented on Figure 1. The basic principle of the IE technique is illustrated in Figure. 2. Impact-Echo is a method for nondestructive evaluation of concrete and masonry, based on the use of impact-generated stress (sound) waves that propagate through the structure and are reflected by internal flaws and external surfaces. The standard set includes measurement heads with raisers and portable computer with special software, which is able to register the graphic stress wave aroused in investigated element as the amplitudetime and amplitude-frequency spectrum. On the other side, when in evaluated element the void does not exist, it is possible to specify the element thickness as it has been presented on the figure 2a. Otherwise, when there is a void like delaminations, then the amplitude frequency spectrum is looking like it has been shown on the figure 2b. In case of a large void the amplitude-frequency spectrum looks like on the figure 2c.

Figure 1. The view of Impact-Echo equipment.

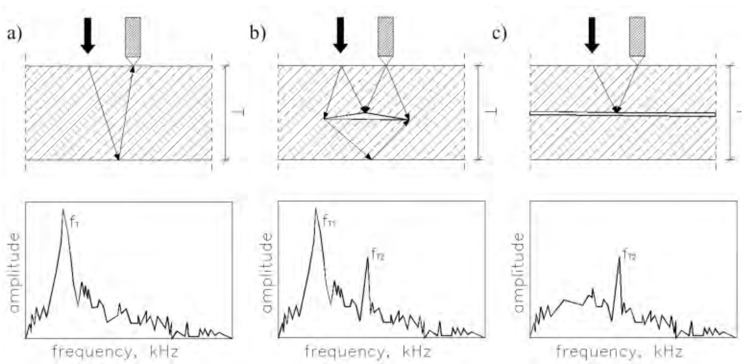

Fig. 2. The amplitude-frequency spectrum given by the investigations of the concrete element using Impact-Echo method in case of: a) no void, b) void, c) large void.

3 EXPERIMENT PROGRAM

3.1 Experimental design

In order to verify the validity of the proposed method, a verification experiment was designed: a semi-precast slab with designed defects was designed and constructed (shown in Figure. 3) and then tested in the laboratory. The tested semi-precast slab is 1780mm long and 1880 wide. Firstly be prefabricated with a thickness 60mm, and then the man-made defects and decorated, the defects geometry and detailing are listed in Table 1.

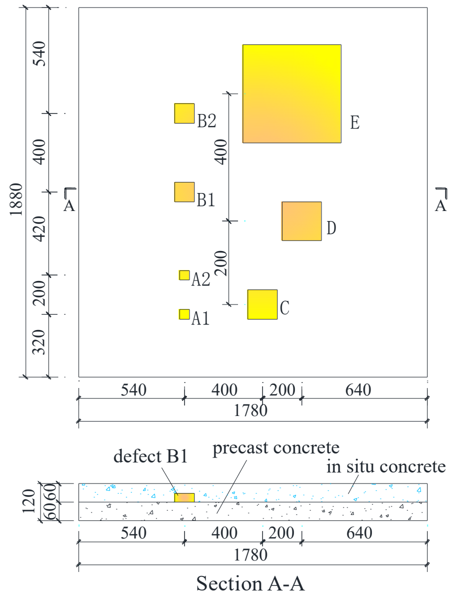

Figure 3: Location of the defects in the slab.

Table 1: Description of the objects used to induce defects in the slab

Defect number	Defect material	Size (in mm)	Type of defect simulated
A1	Foam plastic	50×50×5	Partial void
A2	Aerated concrete blocks	50×50×20	Concrete vibration defect
B1	Foam plastic	100×100×5	Partial void
B2	Aerated concrete blocks	100×100×20	Concrete vibration defect
C	Foam plastic (local digging holes)	150×150×20	Honeycomb
D	construction rubbish	200×200×10	debris
E	Foam plastic	500×500×5	Very large air void

When the man-made defects installation was completed, in-situ concrete with a thickness 60mm was poured upper the precast concrete layer. The finished semi-precast slab specimen is shown in figure 4. The specimen was cured in naturalatmosphere when the in-situ concrete had been poured. When the curing is finished the in-situ measurements were conducted. The in-situ measurements photo is shown in Figure 4, the tested results were recorded, and then analysed in a computer later.

Figure 4. In-situ test photo.

3.2 Experimental results

The test path is shown in Figure 5, seven grids with Interval distance of 200 mm has been created on the semi-precast slab, named Line 1 to Line 7. When the Impact-Echo meter tracked the path line it will scan the flaws under the the line, the stress wave signals will convert to the slab thickness signals and can be displayed on the screen, using this method the specimen slab thickness detected in the location of Line 7 can be obtained, which is shown on the figure 6, It has been investigated that the slab thickness on Line 7 is almost the same, which means that there was no obvious flaws under the Line 7. However when the thickness value is different, it usually infer that there may be some flaws under the test line. When we get the thickness value we can also get amplitude-time spectrum and amplitude-frequency spectrum curves. By analyzing the shape of the curves above, we can evaluate the shape and position of the defects roughly.

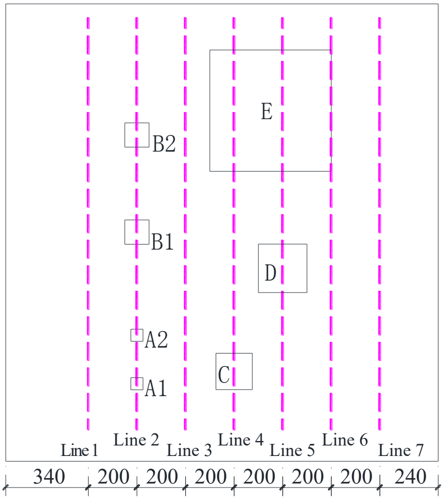

Figure 5. The test line layout on the slab.

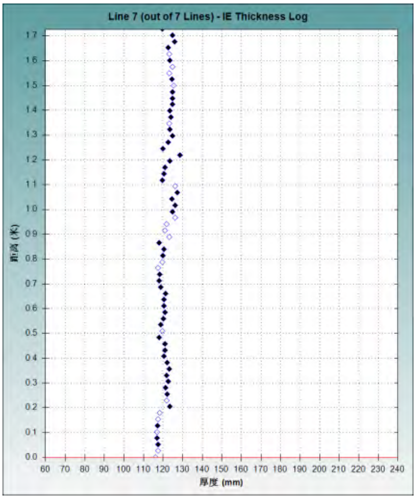

Figure 6. Tested slab thickness in Line 7.

Based on preliminary investigations given by IE method the area with probable defects has been localized. In that region the grid with measurement points, which has been presented on the Figure 5, has been marked. After that on every line a stress wave using Impact-Echo heads has been generated. It has given the opportunity to evaluate the area and depth of the defect. Then by professional software using fast Fourier transform the amplitude-frequency spectrum has been generated. The values of a velocity of a stress wave, frequency of the element thickness and frequency of a void for characteristic situations have been obtained on the Figure 7 and 8.

During the measurements the acoustic signal, which has been presented as an amplitude-time spectrum and an amplitude-frequency spectrum, have been generated. This kind of signal is usually given in situation when generated stress wave is reflecting from the bottom and from a void. These two characteristic frequencies have been analyzed.

An amplitude-time spectrum of the tested slab of Line 6 is shown in Figure 7, and an amplitude-frequency spectrum of the tested slab of Line 6 is shown in Figure 8. On every test line the non-destructive measurements have been performed. After that using the export of a data the charts of characteristically parameters have been generated. This maps have been the base to analyze the results of measurements performed on the object and to preliminary localize the areas with potential voids on semi-precast slab. In analysis of the results the most remarkable have been the concrete slab no. 2 with another parameters of the mobility and stiffness. The results of the measurements have been shown on the figure 9. Probable shape and locations of defects have been presented on the Figure 9. We can see that the analysed resuts are in good agreement with the real experimental results, it demonstrates that the Impact-Echo (IE) method has simplified or improved the accuracy in examination of a wide array of problems in semi-precast slabs, it is convenient and effective to check the construction quality of semi-precast slabs.

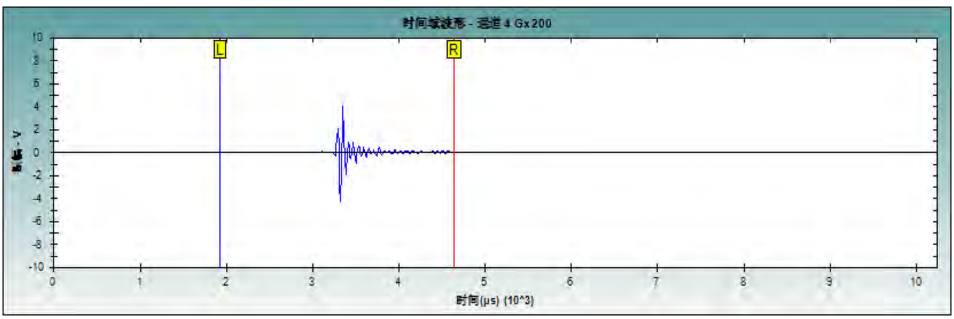

Figure 7. Typical amplitude-time spectrum of the slab in Line 6.

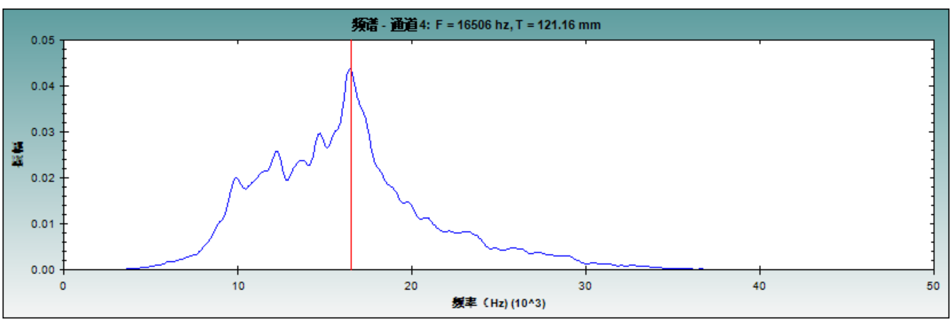

Figure 8. Typical amplitude-frequency spectrum of the slab in Line 6

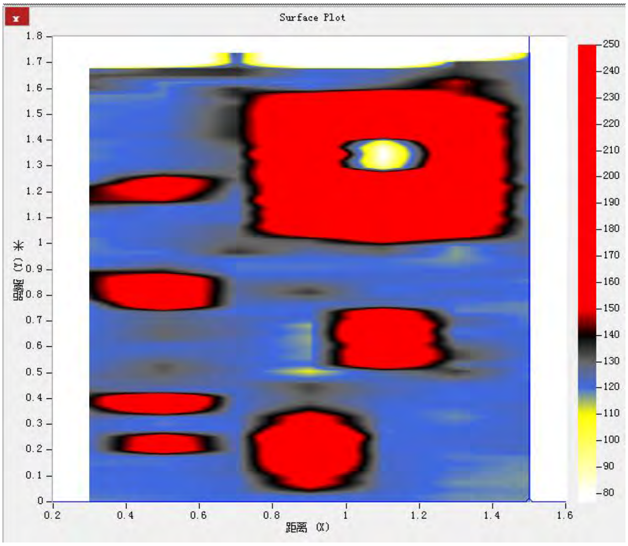

Figure 9. View of IE results showing void and location in the slab

4 CONCLUSION

The performed measurements of the semi-precast slab using IE method shows that this method can be successfully applied as a non-destructive evaluation of semi-precast slabs to localize regions of the defects between the layers. The results obviously confirmed the defects between the precast concrete layer and the cast-in-situ layer of the semi-precast slab. The impact-echo is simple to perform and gives immediate information of the condition of the semi-precast slabs right below transducer. Once the fundamental frequencies are understood, the testing can take place very quickly, within 1-2 seconds for each test. The experimental results show that IE method may be a suitable tool to assess the construction quality of Semi-precast slabs.

ACKNOWLEDGEMENT

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