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RELIABILITY OF IMPACT-ECHO METHOD AS A TOOL TO DETECT THE REINFORCED CONCRETE ELEMENT CORROSION

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Abstract: *The paper deals with the plausibility and reliability of the readings taken, the effect of the fixing and interfacing media, the position of the exciting impulse application point, and the exciting impulse intensity on the response signal predominant frequencies for the Impact-echo-method-based study of the reinforced concrete corrosion.*

Key words: *Impact-echo, acoustic emission, corrosion, reinforced concrete*

1. Introduction

One of the heaviest problems of reinforced concrete structures consists in the steel armature corrosion. The steel armature condition affects, above all, the properties of horizontal structures. It is to be noted that the corrosion process itself may not be observable from the outside in many cases. This is why studies of non-destructive methods allowing the researchers to detect the degree of corrosion for the built-in armatures are being paid much attention currently.

The armature corrosion is particularly dangerous in the cases where the concrete cover layer is not disintegrated. This corrosion type is not due to the concrete being attacked by its environment, but, rather, to the concrete – in a modified chemical form – having attacked the steel armature. Whereas the strength of concrete increases in time, its ability to protect the armature, based on a process called the concrete passivation, decreases in time. The reduction of the protecting capacity is connected with the natural carbonation of insufficiently dense concrete, in consequence of atmospheric carbon dioxide absorption. Featuring the capacity to increase the concrete strength and corrosion resistance, the carbonation bereaves – at the same time – the concrete of its capacity to protect the steel armature.

The acoustic emission method, providing for a continuous internal structure damage evolution and degree detection, appears to be a convenient method to monitor the internal building structure condition.

2. Principle of the Impact-echo method

The principle of the method consists in the following: A short-time mechanical pulse (a hammer blow) is applied to the specimen under test, the response being detected by means of piezoelectric sensors placed on the specimen surface Thus generated impulse is reflected by the surface but also by micro-cracks and defects being present in the specimen under investigation. The originating resonance frequency is determined by means of frequency analysis. Significant frequencies of the response spectrum can be determined by means of Fourier transform.

3. Measuring procedure

Reinforced concrete armature rods of a diameter of 8 mm and 50x50x360 mm armature-free reference concrete beams made the subject of our studies. To generate the exciting impulse, a steel hammer hit the specimen surface. An S3 piezoelectric sensor was used to pick up the response, the respective impulses being fed into the input of a Yokogawa 1540-CL four-channel, eight-bit digital oscilloscope. Having been recorded by the oscilloscope, the response impulses were subsequently analyzed by means of an SW package called AE-proc.

First of all, a series of 20 measurements were carried out to determine the method reliability.

Subsequently, the effect of the exciting impulse application point positron was evaluated. In the first step, the blow was directed just to the central point of the specimen under test (a concrete beam, no armature inside). Subsequently, the application point was shifted one centimetre to either sides from the centre. A change in the predominant frequencies was recorded. The effect of the blow strength was studied, too. The blow intensity was controlled by using various weight hammers, all hammers being dropped from the same height above the surface invariably.

The study dealt also with the effect of selected fixing/interfacing media on the response signal predominant frequencies. The fixing/interfacing media were: beeswax (as a standard), petroleum jelly and sealing wax.

4. Measurement Results

Table 1 Reference measurement series used to examine the method reliability and reprodicibility (interface: beeswax, standard intensity of the blow, exciting impulse application point: specimen centre)

configuration type and No.	f1 (Hz)	f2 (Hz)
004NV-8-0-m+0a-SK0-SS07-UP3-Kl2_4_001.wav	5793	7233
004NV-8-0-m+0a-SK0-SS07-UP3-Kl2_4_002.wav	5791	7231
004NV-8-0-m+0a-SK0-SS07-UP3-Kl2_4_003.wav	5787	7237
004NV-8-0-m+0a-SK0-SS07-UP3-Kl2_4_004.wav	5795	7237
004NV-8-0-m+0a-SK0-SS07-UP3-Kl2_4_005.wav	5785	7243
004NV-8-0-m+0a-SK0-SS07-UP3-Kl2_4_006.wav	5783	7233
004NV-8-0-m+0a-SK0-SS07-UP3-Kl2_4_007.wav	5779	7237
004NV-8-0-m+0a-SK0-SS07-UP3-Kl2_4_008.wav	5789	7237
004NV-8-0-m+0a-SK0-SS07-UP3KL2_4_009.wav	5785	7237
004NV-8-0-m+0a-SK0-SS07-UP3-Kl2_4_010.wav	5765	7237
004NV-8-0-m+0a-SK0-SS07-UP3-Kl2_4_011.wav	5791	7233
004NV-8-0-m+0a-SK0-SS07-UP3-Kl2_4_012.wav	5795	7257
004NV-8-0-m+0a-SK0-SS07-UP3-Kl2_4_013.wav	5787	7229
004NV-8-0-m+0a-SK0-SS07-UP3-Kl2_4_014.wav	5799	7237
004NV-8-0-m+0a-SK0-SS07-UP3-Kl2_4_015.wav	5791	7237
004NV-8-0-m+0a-SK0-SS07-UP3-Kl2_4_017.wav	5801	7235
004NV-8-0-m+0a-SK0-SS07-UP3-Kl2_4_018.wav	5783	7235
004NV-8-0-m+0a-SK0-SS07-UP3-Kl2_4_019.wav	5787	7275
004NV-8-0-m+0a-SK0-SS07-UP3-Kl2_4_020.wav	5785	7229
Predominant frequency mean value	5788	7238
Root-mean-square deviation	7,9	12,9

5. Objective of the study

The present research aimed at examining the reliability of the measurement results and assessing the effect of the fixing and interfacing medium, the exciting impulse intensity and application point position on the predominant frequencies.

Table 2 Effect of the exciting impulse intensity: lower-intensity blow than the reference one

configuration type and No.	f1 (Hz)	f2 (Hz)
004NV-8-0-m+0a-SK0-SS07-UP3-Kl1_4_001.wav	5745	7219
004NV-8-0-m+0a-SK0-SS07-UP3-Kl1_4_004.wav	5745	7207
004NV-8-0-m+0a-SK0-SS07-UP3-Kl1_4_005.wav	5743	7299
004NV-8-0-m+0a-SK0-SS07-UP3-Kl1_4_003.wav	5743	7203
004NV-8-0-m+0a-SK0-SS07-UP3-Kl1_4_002.wav	5747	7211
Predominant frequency mean value	5745	7228
Root-mean-square deviation	1,5	6,9

Table 3 Effect of the exciting impulse intensity: heavier blow than the reference one

configuration type and No.	f1 (Hz)	f3 (Hz)
004NV-8-0-m+0a-SK0-SS07-UP3-Kl3_4_005.wav	5740	7229
004NV-8-0-m+0a-SK0-SS07-UP3-Kl3_4_002.wav	5743	7221
004NV-8-0-m+0a-SK0-SS07-UP3-Kl3_4_001.wav	5917	7207
004NV-8-0-m+0a-SK0-SS07-UP3-Kl3_4_004.wav	5841	7254
004NV-8-0-m+0a-SK0-SS07-UP3-Kl3_4_003.wav	5807	7248
Predominant frequency mean value	5810	7232
Root-mean-square deviation	6,6	3,4

Table 4 Effect of the exciting impulse application point position: 1 cm to the left from the reference position

configuration type and No.	f1 (Hz)	f2 (Hz)
004NV-8-0-m-1a-SK0-SS07-UP3-KL2_4_003.wav	5789	7205
004NV-8-0-m-1a-SK0-SS07-UP3-KL2_4_002.wav	5795	7253
004NV-8-0-m-1a-SK0-SS07-UP3-KL2_4_005.wav	5799	7273
004NV-8-0-m-1a-SK0-SS07-UP3-KL2_4_004.wav	5793	7205
004NV-8-0-m-1a-SK0-SS07-UP3-KL2_4_001.wav	5799	7257
Predominant frequency mean value	5795	7239
Root-mean-square deviation	3,8	3,2

Table 5 Effect of the exciting impulse application point position: 1 cm to the right from the reference position

configuration type and No.	f1 (Hz)	f2 (Hz)
004NV-8-0-m+1a-SK0-SS07-UP3-KL2_4_003.wav	5780	7206
004NV-8-0-m+1a-SK0-SS07-UP3-KL2_4_005.wav	5778	7258
004NV-8-0-m+1a-SK0-SS07-UP3-KL2_4_001.wav	5776	7270
004NV-8-0-m+1a-SK0-SS07-UP3-KL2_4_006.wav	5778	7205
004NV-8-0-m+1a-SK0-SS07-UP3-KL2_4_004.wav	5776	7251
004NV-8-0-m+1a-SK0-SS07-UP3-KL2_4_002.wav	5780	7217
Predominant frequency mean value	5778	7218
Root-mean-square deviation	1,6	2,1

Table 6 Effect of the interfacing medium on the method sensitivity: sealing wax

configuration type and No.	f1 (Hz)	f2 (Hz)
004NV-8-0-m+0c-SK0-SS07-UP3-Kl2_4_003.wav	5733	7265
004NV-8-0-m+0c-SK0-SS07-UP3-Kl2_4_005.wav	5733	7212
004NV-8-0-m+0c-SK0-SS07-UP3-Kl2_4_006.wav	5733	7222
004NV-8-0-m+0c-SK0-SS07-UP3-Kl2_4_004.wav	5723	7241
004NV-8-0-m+0c-SK0-SS07-UP3-Kl2_4_008.wav	5739	7218
004NV-8-0-m+0c-SK0-SS07-UP3-Kl2_4_001.wav	5725	7223
004NV-8-0-m+0c-SK0-SS07-UP3-Kl2_4_009.wav	5739	7201
004NV-8-0-m+0c-SK0-SS07-UP3-Kl2_4_002.wav	5729	7222
004NV-8-0-m+0c-SK0-SS07-UP3-Kl2_4_010.wav	5733	7241
004NV-8-0-m+0c-SK0-SS07-UP3-Kl2_1_001.wav	5731	7234
004NV-8-0-m+0c-SK0-SS07-UP3-Kl2_4_007.wav	5732	7214
Predominant frequency mean value	5432	7249
Root-mean-square deviation	4,9	1,1

Table 7 Effect of the interfacing medium on the method sensitivity: petroleum jelly

configuration type and No.	f1 (Hz)	f2 (Hz)
004NV-8-0-m+0b-SK0-SS07-UP3-Kl2_4_004.wav	5817	7214
004NV-8-0-m+0b-SK0-SS07-UP3-Kl2_4_005.wav	5807	7211
004NV-8-0-m+0b-SK0-SS07-UP3-Kl2_4_002.wav	5811	7222
004NV-8-0-m+0b-SK0-SS07-UP3-Kl2_4_001.wav	5812	7207
004NV-8-0-m+0b-SK0-SS07-UP3-Kl2_4_003.wav	5805	7243
Predominant frequency mean value	5810	7219
Root-mean-square deviation	4,1	4,4

6. Conclusion

The present paper shows the Impact-echo method to provide reproducible results, being quite reliable even under variable measurement conditions.

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