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USING NON-DESTRUCTIVE METHODS TO OBTAIN THE STRENGTH OF CONCRETE SAMPLES

Catalin BOTEA, Ramona PIRLOG, Ioan MARGARINT

Scientific Coordinator: **Lect. PhD. Eng. Claudiu-Sorin DRAGOMIR**

University of Agronomic Science and Veterinary Medicine, Faculty of Land Reclamation and Environment Engineering, Marasti 59, 011464, Bucharest, Romania, tel./fax. (+40) 21 3183076
E-mail:catalin_r3tro@yahoo.com, ramona.pirlog@yahoo.com, linkin_park1375@yahoo.com

Corresponding author: catalin_r3tro@yahoo.com.

Abstract

The paper deals with non-destructive methods for determination of physical and mechanical characteristics of concrete specimens. The devices used for these determinations as Pundit Lab and Hammer Digi-Schmidt are in according with European and Romanian norms. The Pundit Lab is an ultrasonic pulse velocity (UPV) test instrument which is used to examine the quality of concrete. It features online data acquisition, waveform analysis and full remote control of all transmission parameters. The Schmidt Hammer Digi-Schmidt was developed for the non-destructive measurement of the concrete compressive strength and controlling the uniform concrete quality. The authors emphasizes that the use of non-destructive testing provides plausible values on compressive strength of concrete specimens. This statement is proved by results obtained from tests according to SR EN 12390-3: Testing hardened concrete - Part 3: Compressive strength of test specimens. For experimental determinations presented in this paper the devices belong of Concrete Laboratory of Land Reclamation and Environmental Engineering Faculty were used.

Key words: *concrete specimens, hardened concrete, non-destructive tests.*

INTRODUCTION

Non-destructive test are great for new and old constructions. From old construction is necessary to know the concrete strength to know what strengthening measures to take, and for the new ones to know each execution errors. Measurements were performed with Digi Schmidt and Pundit Lab devices, and these measure the rebound index, respectively the propagation speed of the ultrasounds.
Rebound surface hardness testing of concrete is one of the most widespread NDT methods for in situ strength estimation of concrete structures. Rebound surface hardness methods are available in the civil engineering testing practice for more than 60 years. However, understanding and modelling of the rebound surface hardness of concrete as a time dependent material property is not available in the technical literature.

MATERIALS AND METHODS

The first set of the test consisted in finding the concrete rebound index. The Sclerometer sits perpendicular on the test surface. After impact the rebound index is recorded, but for measurements to be valid are needed 10 attempts, after that are averaged together. Minimum distance between two attempts is 25 mm and should not be tried at a lower distance than 25 mm from the edge of the specimen or the structural element. After measurements are also observed footprints left by the hammer, to take into the account the results hit area should not be broken or punctuated due to an air gap.
This type of testing is in accordance with SR EN 12501-2:2002 (Dragomir C.S., 2012).
The second sets of measurements consisted in determining the propagation speed of ultrasounds. The speed is influenced by a series of factors:
Humidity has a physical and chemical effect on the propagation speed of the impulse. Between a standard specimen and a structural element of concrete from the same class, there

are significant differences of speed. Thermal range in which it is assumed that the concrete does not change his properties would be 10^{o}-30^{o} C. For temperatures not included in the interval, corrective actions will be taken using guidance from literature. Length of road where speed is measured should be enough so as not influence the propagation speed of the impulse. It is recommended that the length would be 100 mm for concrete. Small defects have little or no effects on the transmission time.

Contour of equal velocity of propagation schedule often provides information on concrete quality. Examining the attention signal, it can provide us useful information. In cracked elements, when broken surfaces are maintained in close contact with compressive strength, the energy of the impulse can pass without being stopped along the cracking. If the crack is filled with liquid or solid particles, then it is undetectable. In this case the mitigation measures of the impulse can offer us useful information.

Although the direction in which the maximum energy propagates perpendicular transmitting transducer surface, it is possible to detect the impulses that are crossing standard in another direction.

So it is possible to make measurements of the impulses by placing on the opposite surface (direct method), on the adjacent (semi-direct method) or on the same surface (indirect method) of the structure or of the sample.

For direct transmission, the length of the path is the shortest distance between the probes, the accuracy of the path lengths must be registered with an accuracy of ± 1%.

For direct transmission (Figure 1) , the length of the path is the shortest distance between the probes, the accuracy of the path lengths must be registered with an accuracy of ± 1%.

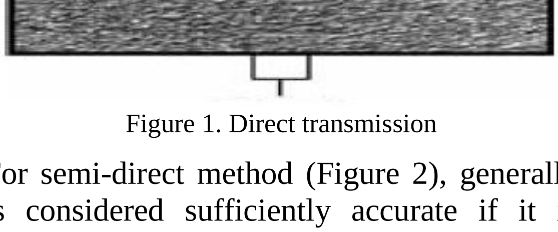

Figure 1. Direct transmission

For semi-direct method (Figure 2), generally is considered sufficiently accurate if it is taken as the length of the path, the distance measured between the centers transducer and surfaces.

Accuracy of the path length depends on the probe size compared with the distance from center to center. For indirect transmission method (Figure 3), the path length is not measured, but a series of separate measurements are performed with probes placed at a distance x from each other.

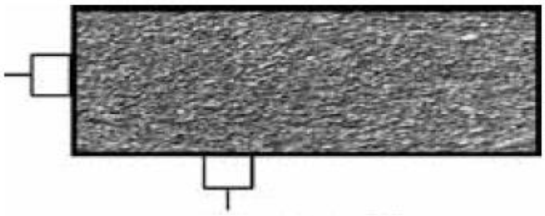

Figure 2. Semi-direct transmission

Coupling probes must be adequate in terms of acoustic. So to have a good acoustic environment we can use glycerol, petroleum jelly or liquid soap. For the concrete surfaces that are rough, is used grinding to make them smothered and levelled, or using a special transmitters for this type of surface. This device is compliant to SR-EN 12504-4:2004.

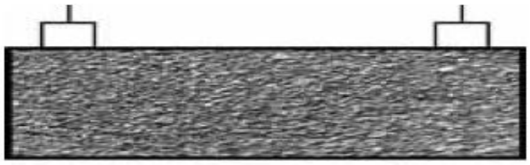

Figure 3. Indirect transmission

Finally, a measurement was performed to verify the concrete specimen was subjected to a destructive test in universal pres (Dragomir C.S., 2013). The surface of the turntable was cleared from foreign bodies. The cubes was placed so that compressive strength to fall perpendicular in the casting direction of the sample. It is centered on the turntables, after which it was applied a load without shock. After that the load was gradually increased until the sample fails. After the sample fails it is checked if the form it is yielding. If it has a satisfactory form, the results are registered.

RESULTS AND DISCUSSIONS

Measurements were performed on samples of concrete cubes shaped with dimensions of 150x150x150 mm, from different classes of concrete according with Romanian Standards harmonized with European standard EN 12390-1:2002 (Figure 4).
First measurement was made with digital Sclerometer Digi Schmidt, Proceq (Figure 5 - left).

Figure 4. Concrete samples

Using this equipment was determined rebound index and compression resistance specimen surface. Values of compression strength are shown in Table 1. For determining these values have been carried out 4 determinations for each of the 3 samples separately. Each result represents an average of 10 recordings. In addition resistance value, the device indicates the minimum and maximum recoil index, the standard deviation and the value of the recoil. On the basis of conversion curve recorded in the internal memory of this device has the capacity to show compression strength value determined at the specimen surface.

Figure 5. The equipment Digi Schmidt (left) and Pundit Lab (right)

The second set of measurements was to determine the speeds of propagation of ultrasound with equipment Pundit Lab (Figure. 5 - right) that were obtained the values given in Table 2. In this case, attempts have been made based on the direct method. The values shown in Table 2 correspond to periods of time recorded in microseconds, required signal to travel the distance of 150 mm cube imposed by side. On the other hand velocities were recorded with the signal travelled that distance, in m/s Depending on the values of velocity can be determined as in the first test case, the corresponding compressive resistance.
For this type of test were performed 4 attempt for each of the 3 samples and the graphical representation of the results in terms of speed is highlighted in Figure 8.

1 2 3

Figure 6. Images from the tests: 1. Digi Schmidt, 2. Pundit Lab, 3. Pundit Lab device calibration

Table 1. Results obtained with Digi Schmidt equipment

	Sample no. 1				Sample no. 2				Sample no. 3			
No.	**i**	**ii**	**iii**	**iv**	**I**	**Ii**	**iii**	**iv**	**i**	**ii**	**iii**	**iv**
Min	30	34	33	32	35	33	35	36	27	25	23	23
Max	39	41	39	38	40	39	40	41	32	31	31	30
S	3	2.6	1.9	2.1	2	2	1.8	2	1.9	2	2.6	2.5

$\bar{x}$	37	37.8	35.5	34.6	37	35.9	36.9	38.3	29	27.9	26.3	23.1
f (N/mm^2)	37	38.4	34.4	32.8	37	35	36.8	39.3	23.5	21.7	19.1	18.9

Table 2. Results obtained with Pundit Lab equipment

	Sample no. 1				**Sample no. 2**				**Sample no. 3**			
No.	**i**	**ii**	**iii**	**iv**	**i**	**ii**	**iii**	**iv**	**I**	**ii**	**iii**	**iv**
t (μ sec.)	34.2	35	34.7	34.1	34.3	31.6	30.3	30.3	29.9	30.7	30.6	29.4
v (m/s)	4999	4310	4323	4399	4950	4777	4950	4950	5017	4886	4950	5019

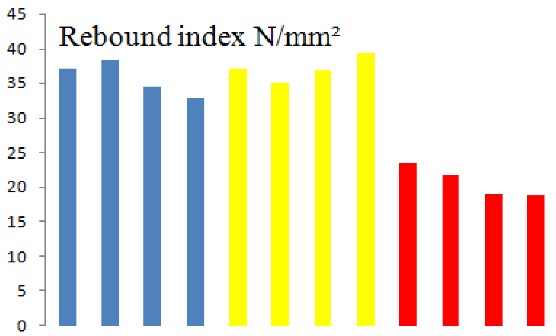

Figure 7. Compressive strength value determined on the surface of specimens

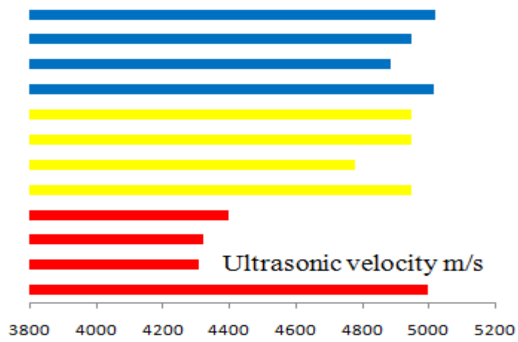

Figure 8. Velocity value

To validate the results obtained by non-destructive tests, an attempt was made to determine the compression strength. So, one of the cubes was introduced in the universal press, with high compressive capacity of 1500 kN. After testing, the compression strength was displayed on the display device. Resistance value as an indication Figure 9 was 43.83MPa.

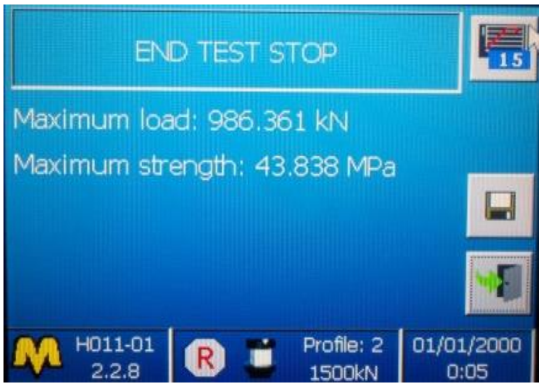

Figure 9. Results displayed on the main unit of universal press

Figure 10. End of the test sample

CONCLUSIONS

After the measurements, the results of the non-destructive test were very close to the destructive test. By combining the two methods it can give similar results. For this article we used a small number of samples. Therefore using the non-destructive methods of checking concrete is as safe as the destructive method.

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