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CONCRETE SAMPLE PRISM - BENDING RESISTANCE DETERMINATION TEST

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Abstract

This paper presents the results of the research that were performed in the Laboratory of Reinforced Concrete, Faculty of Land Reclamation and Environmental Engineering. The studies are based on theoretical aspects of the concrete prism bending resistance determinations. Using static analysis, the formula for bending resistance was determined. In the laboratory, Tests were performed on three standardized test-samples: three prisms made of concrete having the dimensions 150x150x600mm. In the first stage, non-destructive tests were made using the Schmidt sclerometer and the Pundit Lab device. Based on the formula was measured an approximate value of the loading force for which the effort is reaching the corresponding resistance of the concrete rank; this approximate value of the loading force was achieved by nondestructive tests. In the final stage, results validation was performed by effective test on three standardized test-samples concrete prisms. The samples were tested with a bending load up to 250 kN in the SERVO PLUS EVOLUTION universal pressing device. The three tests and the standardized test-samples concrete prisms were performed and made according to the actual Romanian standards.

Keywords**:** *nondestructive testing, resistance to bending, static loads, stresses and strains.*

INTRODUCTION

During the execution of concrete structures there are made compressive and flexural destructive testing but also nondestructive testing.

Practical calculation of pure bending is done by verification of the bending strength which is calculated by relations (1):

$$\sigma_{max} = \frac{M_z}{I_z} y_{max} = \frac{M_z}{W_z} \leq f_c \quad (1)$$

where:

Mz - is the largest bending moment on the beam value.

Wz - minimum modulus calculated without sign so without taking into account the sign of y_{max}.

fc - calculating resistance to tension and compression if the material behaves as in tension and compression. Otherwise consider both resistance calculation - the tension and compression - and thus determine σ_{max} and $Ó_{min}$ in extreme fibers stretched and compressed.

By passing to limit of the above relationship it results sectional dimensions and maximum load capable of bending. At dimensioning (2)

$$W_{znec} \geq \frac{M_z}{f_c} \quad (2)$$

and after choosing size is calculated W_{zef} and the verification is made with the relationship (3)

$$\sigma_{max} = \frac{M_z}{I_z} y_{max} = \frac{M_z}{W_z} \leq f_c \quad (3)$$

The maximum able load results from the condition (4):

$$\mathbf{M}_{\mathbf{zmax}} \leq W_z f_c \quad (4)\ (\text{Vacarescu, 2011})$$

These attempts at bending are both for new construction and for old buildings, for which there is no documentation on the physic-mechanical properties that includes them.

The nondestructive attempts will be achieved thought determination of the rebound parameter (the concrete strength) with the Digi Schimidt sclerometer (Figure 1) and by determining the propagation velocity of the ultrasonic waves through concrete using the ultrasonic concrete Pundit Lab device.

METHODS AND MATERIALS

The determination of the rebound parameter is based on measuring the rebound that a mobile body suffers from the impact with the concrete surface of the attempted item; this rebound is an indicator of the concrete surface hardness and can be used to estimate concrete strength, within the limited guaranteed precision. The application domain of the method is especially the phasic control (molding, transfer, delivery) into elements with small and medium relative thicknesses, usually with age under 60 days. The obtained information mainly refers to the concrete quality, during the first 2-3 cm, from the concrete surface. The attempt equipment is represented by one of the Schmidt sclerometer with linear or angular rebound. The operation of the method is basically as follows: under the action of springs system, a mobile crew strikes the concrete, through a rod of percussion. After the impact the crew rebounds training a cursor which points the rebound on a scale size.

The attempts technique involves the following steps:

- establishing the setting elements (test-samples) over which control is required.
- choosing the attempt areas on the element shall conform to the following guidelines.
- avoiding the casting face and if possible its opposite face.
- avoiding the areas with surface defects (macro porous areas, cracks, joints);
- avoiding the areas which corresponds fittings especially when they are close to the concrete surface (d < 3 cm);
- avoiding the edge adjacent areas until at least 5 cm items;
- avoiding areas on which exists foreign inclusions(shell splinters, soil, dust etc.).
- The surface preparation is attempted by friction with hardness rock will be removed thickness of 1 mm;
- The hits number in an area can vary between 6-9. After selective processing of results should remain at least 4 valid measurements.
- the minimum distance between the attempt points of the same area is 3 cm (between centers)
- The minimum distance between attempt points and the edge of the element is 50 mm for shell molded items made of wood or metal and 30 mm for test samples cast in metal casing.
- The elements with different curing conditions on the two opposite sides will be tested on both sides.
- It is recommended that the attempted areas to be chosen on the framing element surfaces.
- During the test the sclerometer should be strictly kept perpendicular on the test surface.
- The arming and the triggering of the sclerometer should be done by a slow pressing, progressive, without jerking.
- The reading of the device is made on its scale, in integer, without decimals, after the outbreak hit, but before releasing the rod pressure of the sclerometer (Standard C26-85, 1985).

Figure 1. Digit Schmidt Sclerometer

Determination of the speed propagation of waves through concrete

The ultrasonic pulse method on test samples, elements and concrete structures, reinforced concrete and prestressed concrete is used to determine:

- Elastic dynamic propertyes of concrete
- Defects of elements or structures
- Mechanical strenghts of concrete especially compressive strength in work;
- The modification of concrete structure during curing under the action of chemical agent or physically aggressive,or under the action of mechanical stress;
- The concrete uniformity in work;

The method is based on measuring the propagation time of ultrasonic pulses in concrete, between transmitter and receiver, by transmission from this measurement is usually deducted in the first stage, the longitudinal propagation speed of ultrasound in concrete and subsequently, if the application requires, concrete strength, taking the composition into account.

Inside a solid element the speed propagation of ultrasound depends on the compactness; the more the compactness is higher, the medium propagation speed will approach the corresponding value of a perfect compact body, and the higher the goals volume is the greater speed drops. In a concrete element, the propagation velocity of longitudinal ultrasound is determinate by measuring the travel time (t) of the ultrasonic pulse on the propagation length (d), it results the relation (5):

$$V_L = d / t \quad (5)$$

As the concrete strength is directly related to its compactness, the propagation velocity of ultrasound though concrete can give a measure of its resistance RC and can establish a relation of the form (6):

$$f_c = f(V_L) \quad (6)$$

Therefore, using ultrasound we can detect and locate some internal defects of concrete, such as segregation areas, goals, etc. The devices for determining the propagation velocity of ultrasound in concrete there are several types, but the operating principle is the same. So an ultrasonic signal with frequency 40-100 kHz is produced by a pulse generator (G). The signal is sent to a transmitter (E), into contact with the test item. The transmitter is placed in contact with the concrete piece though a thin layer of soft material. The ultrasonic signal is received by a receiver (R), then it is amplified (A)and then viewed analogue or digital (C) (Figure 2 and Figure 3).

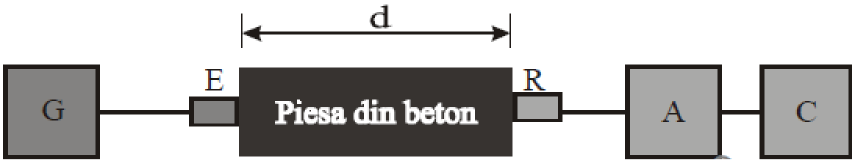

Figure 2. The principle of ultrasonic measuring

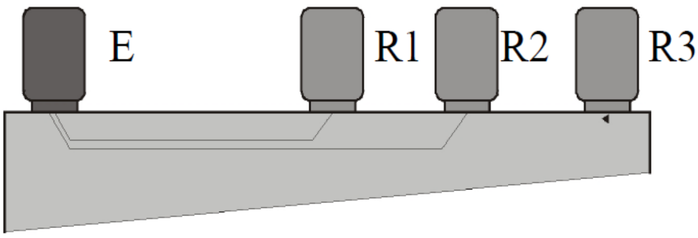

Figure 3. Measuring on the same side

The propagation velocity calculated with the relation V_L=d/t is valuable if only (7):

$$d > 1{,}6\lambda \quad (7)$$

when:

d – is the minimum dimension of attempt element, perpendicular on the propagation direction of ultrasounds.

λ – the wavelength of vibration which is calculated with the relation (8):

$$\lambda = V_L/f \quad (8)$$

in witch:
V_L – is the propagation velocity,
f – the frequency oscillations.
The transverse dimension of the element (direction on which determination is made) in our case is less or more than 16 cm is not necessary any correction.
If λ < d < 1,6λ disturbances occur that distort the measured speed, so it is less real then about 6-7% which can lead to an error in assessing resistance minus 30-40%.
If the ratio L_S / Le < 0,4 , where Ls is the cube side on which were made for calibration measurements(our case LS=16cm) and Le is the length of journey ultrasonic signal, the measured speed is lower than the standard rate and a correction must be made. The chart below gives the correction values for different ratios Ls/Le (Figure 4).

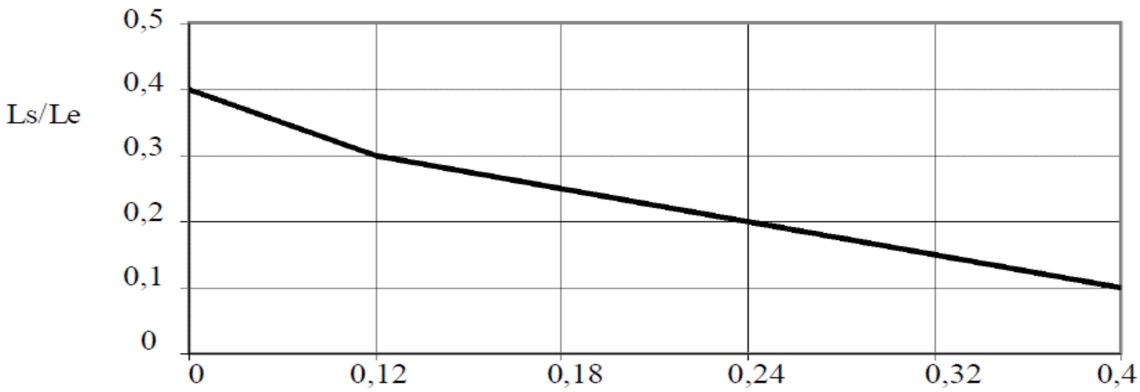

Figure 4. Variation of the propagation velocity of ultrasound by LS/Le

The ambient temperature in which it is the attempt element also influences the ultrasonic pulse propagation velocity. Thus, at temperatures ranging from +4^{0}C and +6^{0}C it is being produced cracks of the concrete, which although not lead to a decrease in resistance, they decrease the velocity pulse. At temperatures below 0^0 C the free water in the concrete pores freezes and the propagation velocity in ice is higher than the speed in water, which makes the measured speed to be higher than of concrete located at standard temperature (+20±50C). All these corrections are detailed in technical instrumentation of measurement devices and regulations (Budescu, 2011).
For distructive test the test samples should be in prisms in accordance with EN 12390-1. The test samples molded into patterns must conform to EN 12350-1 and EN 12390-2 it must be identified on test samples the mold direction. The cut test samples, which are fulfilling the requirements of EN-12390-1 can also be tried. The test samples should examine any observed irregularities and must register.
It is cleaned all surfaces of the machines and removing the bearing free particles or other materials on the test samples surfaces which will be in contact with rollers.

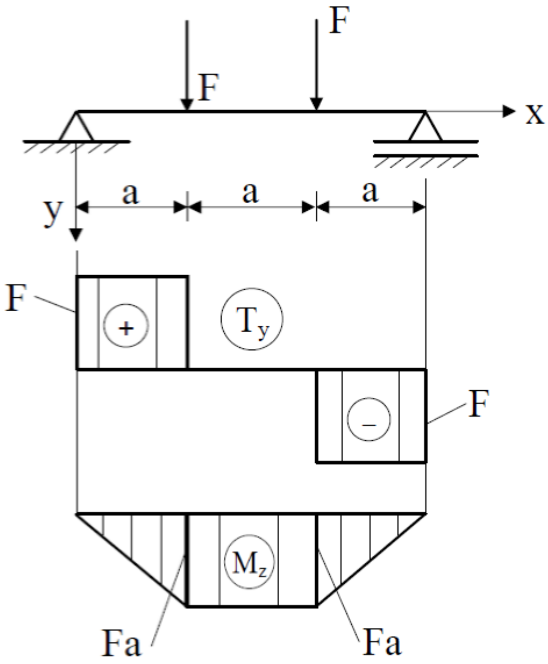

Figure 5. Bending test diagram

For the test samples stored in water, it is removed the excess moisture from the surface of the test samples before placing them on the test drive.

It is being placed the test samples on the machine, it is being focused correctly and with the longitudinal axis of the test sample at right angles to the longitudinal axis of the upper and lower rollers. It is being ensured that the reference test perpendicular to the direction of casting of the test sample (Figure 5).

RESULTS AND DISCUSSIONS

For determination of the rebound parameter using the Digi Schmidt sclerometer, was used a concrete prism with class C16/20, with dimensions 150X150X600 mm.The test areas, in number of 4, where chosen on formwork surfaces of the element. The test results are as follows (Tabel 1):

Tabel 1. Test result using the Digi Schmidt sclerometer

Încercarea nr.	1	2	3	4
min	43	45	34	41
max	50	49	39	47
S	2,4	1,6	1,7	2
$\bar{x}$	46,1R	47,1R	36,3R	44,9R
t [N/mm^2]	54,2	56,2	35,7	51,8

To determine the propagation velocity of ultrasonic waves thought concrete using Pundit Lab concrete device, it was used a concrete prism with dimensions 150X150X600 mm (Fig. 6). Four test areas at a distance of 15 cm where chosen on formwork faces. Test results are presented in Figure 7 and Figure 8.

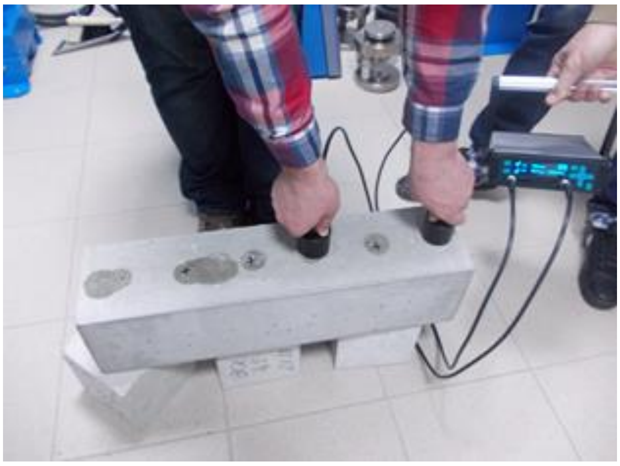

Figure 6. Making determinations on the concrete prisms

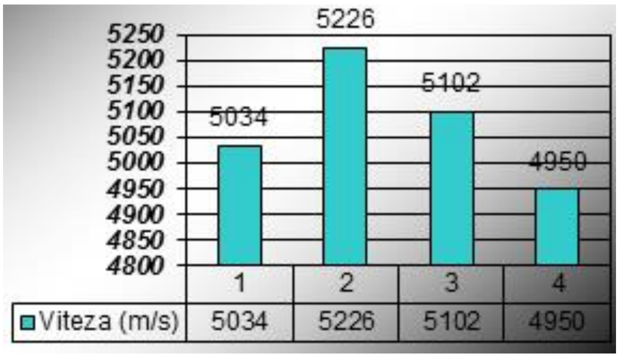

Figure 7. Determination of the propagation velocity of ultrasound

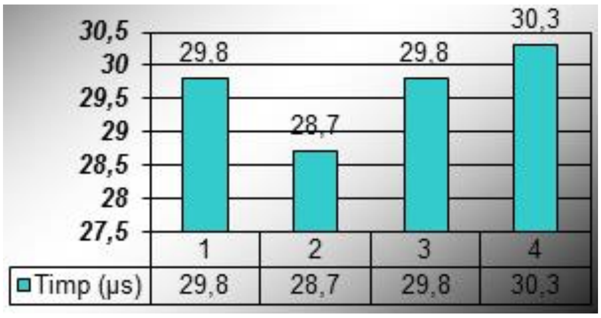

Figure 8. Determination of the propagation time of ultrasound

For determination of resistance to bending, we used a concrete prism sized 150x150x600 mm. We chose a constant speed of constant effort in implementing of 0.04 MPa/s (N/mm^2.s) up to 0.06 MPa/s (N/mm^2.s). After applying the initial load, which shouldn't exceed 20% of the breaking load is applied the load on test samples, without shock is growing, at selected constant speed + - 10% until it can't support a higher load. The result of measurement are emphasized in Figure 8 and Figure 9.

Figure 9. Bend testing on universal press SERVO PLUS Evolution

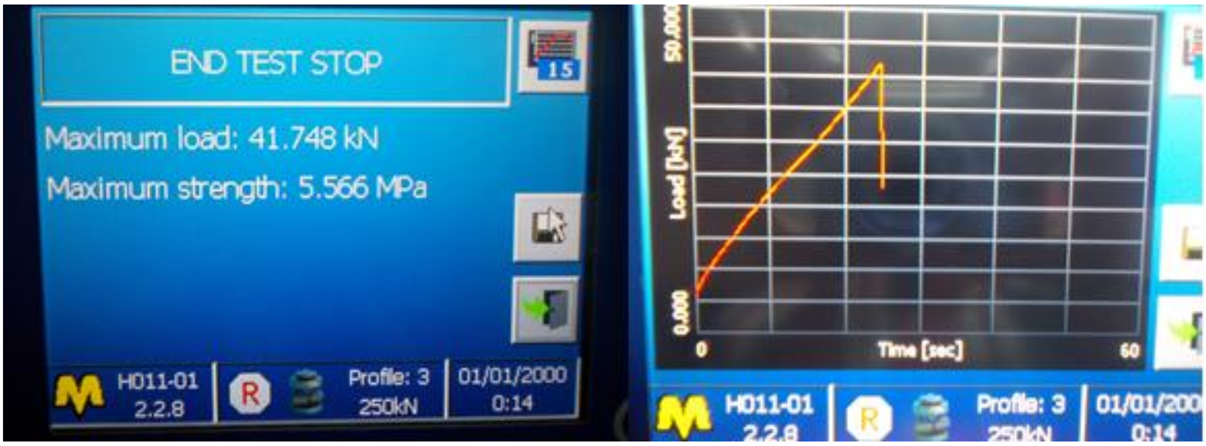

Figure 10. Showed results on central display unit

CONCLUSIONS

By the obtained results it was demonstrated that the measurements efficacy made with Digi Schmidt Sclerometer, for determination of rebound parameter, with the Pundit Lab ultrasonic concrete device for propagation velocity of waves though the concrete prism.

Also the theoretical formulas were validated with the results obtained by non-destructive methods also by trying to bend on universal press which has a maximum load capacity of up to 250kN (Dragomir, 2013).

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