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Comparison of the Compression Test and the Rebound Test for Evaluating the Brand of Concrete in Precast Reinforced Concrete Elements

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ABSTRACT: This paper will provide information about the concrete brand produced in the factory for the prefabricated elements and the comparison of the results given by the test of resistance to compression and the results of the test of the hammer impact of the sclerometer.

The idea and the need to conduct this study arose for 2 main reasons: first, from the poor results often obtained from sclerometer impact to the elements in the field, despite the compression resistance test with cubic samples taken in the concrete cast and the carrot test directly on the element assembled in the building provides good results.

Secondly, to have a connection between the values of the concrete brand resulting from the pressure resistance test with a press performed in the laboratory and the impact test with the sclerometer hammer which is often performed in the field under different conditions.

The sclerometer impact tests will be performed on each cube sample before it is broken, in the press, and the sclerometer impact tests will be performed on the concrete elements from which the cube sample was taken on the day that this sample will be destroyed. The predicted results are relatively close values related to the age between 14th day and the 28th day of the concrete maturity, as determined by the manual of the sclerometer that the study is going to use, and other close values for the other days (1, 3,7,14,28). But in fact, just like in the field tests done before, it is noticed that the results obtained from the blows with the sclerometer hammer are weak. The aim of the paper is finding a logical connection between the results of these 2 types of tests.

This study will contain information on the composition of the concrete produced in the IXHEM SHPK factory (ltd) located in Durres - Albania, the brands of concrete on different days for different elements, and the comparison of the results between the 2 methods mentioned above.

KEYWORDS: precast, prefabricated concrete element, sample, rebound test, sclerometer hammer, sclerometer impact, compression test.

1. INTRODUCTION

1.1 Prefabricated concrete elements. Case study the IXHEM SHPK factory (ltd) located in Durres, Albania

Nowadays, the requests for reinforced constructions made with prefabricated elements are always increasing. The prefabricated buildings have to meet 2 main requirements such as: high quality and speed of realization of the production-assembly of the building, which also creates the possibility of fast building operation.

Figure 1. Prefabricated buildings;
Source: authors

Considering the high speed of work and the required quality, it is very important to keep under control the concrete brands. The elements are produced inside the factory and in their storage or at the final destination (facility) where they will be placed. For this reason, it is necessary for each element, according to the importance and the way of work or the position that the element will have in the building, in order to produce concrete with the necessary components and to achieve the desired brand within the required time as quickly as possible. It is necessary that from time to time, even for various interventions and modifications, the brand of concrete is tested on the spot for the elements, through sclerometer impact.

The mechanical properties of concrete at an early age, nowadays are very important in civil engineering [1–3]. The curing conditions of concrete can be optimized according to the development law of early-age mechanical properties. It's very important to obtain the relevant mechanical parameters of early-age concrete in advance. Recently, many scholars have carried out pieces of research on the mechanical properties of early-age concrete.

Kim et al. [4] studied the concrete strength related to the influences of curing time points with given temperatures, and found that concrete with a high temperature at an early age attains a higher early-age strength but eventually attains a lower later-age strength.

Gu et al. [5] studied the concrete strength development by inspecting the harmonic response of the embedded piezoelectric sensor at early ages. It was found that the concrete strength increases for the first few days and decrease after the first week.

Lee et al. [6] studied a new model of the compressive strength of early-age concrete based on ultrasonic pulse velocity testing. The relationships among parameters in different concrete samples resulted to be linear during the initial and final setting periods and parabolic after the final set at early ages, embedded piezoelectric transducers.

This study takes into consideration, the prefabricated reinforced concrete elements that are part of industrial silo buildings and according to their position and their static role in the building, they are classified as: Columns, Beams, Covering Elements, Panels as structural elements and facades.

Figure 2. IXHEM storage;
source: authors

The study carried out in the production factories is very important and unique because the elements in the first days after concreting will be subjected to conditions and stresses that are not present in cases of cast-in-place buildings. These elements cover large spaces such as beams or other covering elements or reinforced concrete with prestressed cables. The concrete of the element must have reached the necessary mark to withstand the stresses coming from the cable, before they are freed from the pull of the machine and concreting the element.

Figure 3. Factory production and concrete transportation;
Source: authors

In the case when the element is not reinforced with cables, it will still have to withstand its weight and the stresses arising from the lifting by crane during the transportation of the element to be stored, vacating the formwork in order to leave the place for concreting the next element.

According to the above-mentioned criteria, the concrete of these elements must reach significant marks to withstand these stresses in the first day if possible. This is achieved by using different additives in concrete, mainly accelerators.

2. METODOLOGY

2.1 Tools and machines usage. Sampling of concrete

Figure 4. Tools and instruments used for sampling and compressive strength of concrete; source: authors

The concrete samples were taken in the middle of the casting of the element, placed in a wheelbarrow and re-mixed. The cube mold was cleaned, paper was placed to allow air to the bottom hole of the mold, and all internal surfaces were coated with disarming oil, including the upper contours on the leveling side. The mold was filled with 3 layers of 5cm each and each layer was manually vibrated with about 25 vertical strokes with a 16mm diameter uncoated iron rod. The last layer was filled to the brim and leveled with a trowel. A label is placed on the leveled layer, which becomes part of the concrete, containing the data for the identification of the cube, such as: the date and time of concreting and the corresponding concrete element. For about 36 hours, the cube was stored in the same conditions as the element that was concreted, i.e. covered with geotextile. After 36 hours, the cube is molded and immersed in a bath of water. 24 hours before the day of breaking, the cube is taken out of the water and left to dry. At the end of drying, the fixed weight of the cube is marked, measured in all directions with a metal ruler in order to be a valid sample with a difference in dimensions not greater than +(-) 1.5mm.

For each of the concrete maturity days (1,3,7,14,28) 12 cubic samples were taken in total, respectively 3 cubes for each sample of the 4 different elements for each date. A total of 60 cubic samples.

Figure 5. Cubic negative samples and sclerometer;
source: authors

2.2 Description of sclerometer impact on cubic samples [11; 12; 13]

A classic sclerometer was used for concrete with normal weight and energy that set the hammer in motion = 2,207 Nm.

Preliminary tests were done on existing elements and the preservation of the ratio of the results of the impact values with the sclerometer was verified according to the positions and graphs A, B, C. as seen in Figure 6.B [11; 12; 13].

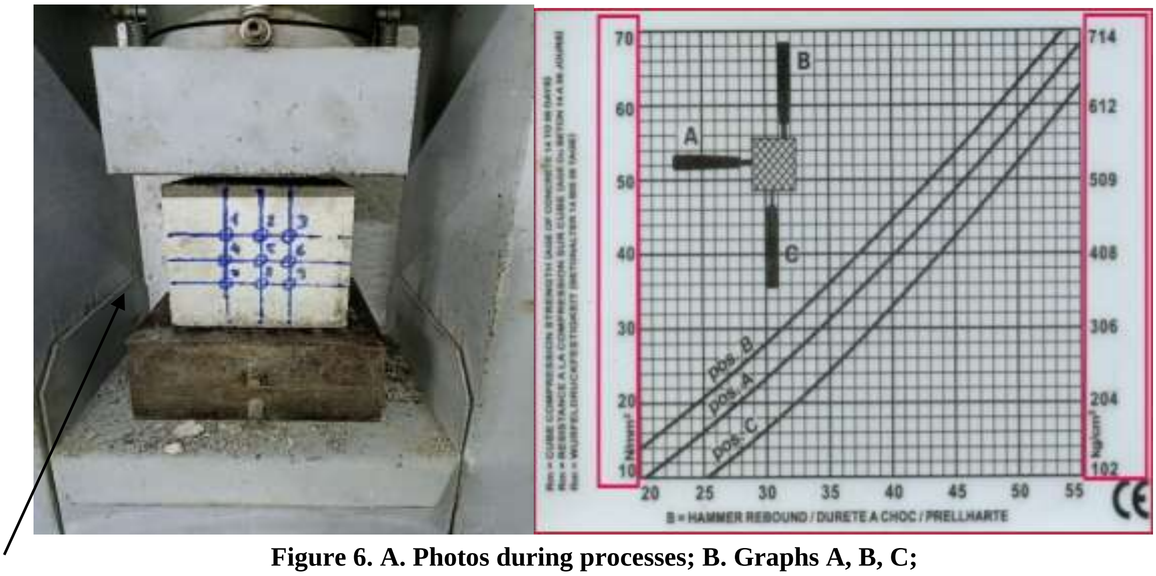

Figure 6. A. Photos during processes; B. Graphs A, B, C;
source: authors

The cube was placed in the press under the stress of 7 N/mm2 with the corresponding force of 157 KN. 9 points were marked in the form of a square for hitting with a sclerometer at a distance of 50 mm from each edge of the cube and the distance of the points from each other = 25 mm, as seen in Figure 6.A. The cube was struck at these points according to the instructions of chart A of

the horizontal impact device on the vertical face of the cube where the points were also noted. Each value of the impact with the sclerometer was recorded and according to the graph the corresponding value of the compressive strength (N/mm2) was returned [12].

2.3 Description of press fracture

The weight of the cube was measured. The cube was placed in the press in such a way that the load falls exactly in its center. The level page was placed in the visible direction. The maximum breaking force of the cube was noted and the conversion was made according to the surface area of the cube (Rck = F/A). The shape of the destruction of the cube was checked to be according to the standard [9] as seen in Figure 7.

Figure 7. Photos during various processes;
source: authors

2.4 Description of sclerometer impact on precast elements of reinforced concrete

First the impact area was cleaned from dust, sand and possible water. [11; 12; 13]. The element was struck on its longitudinal sides approximately mid-length according to the instructions of chart A of the horizontal impact device on the vertical face of the cube where the points were also noted. The notes were made on a square surface (300x300) mm with a distance of 150 mm from one point to another as seen in Figure 8.A. The impact area was moved for tests in which 2 or more values with a deviation of 5 units from the average value resulted. During the test only one of the values with such a deviation resulted, and it was not taken into account during the calculation of the average values of the impacts.

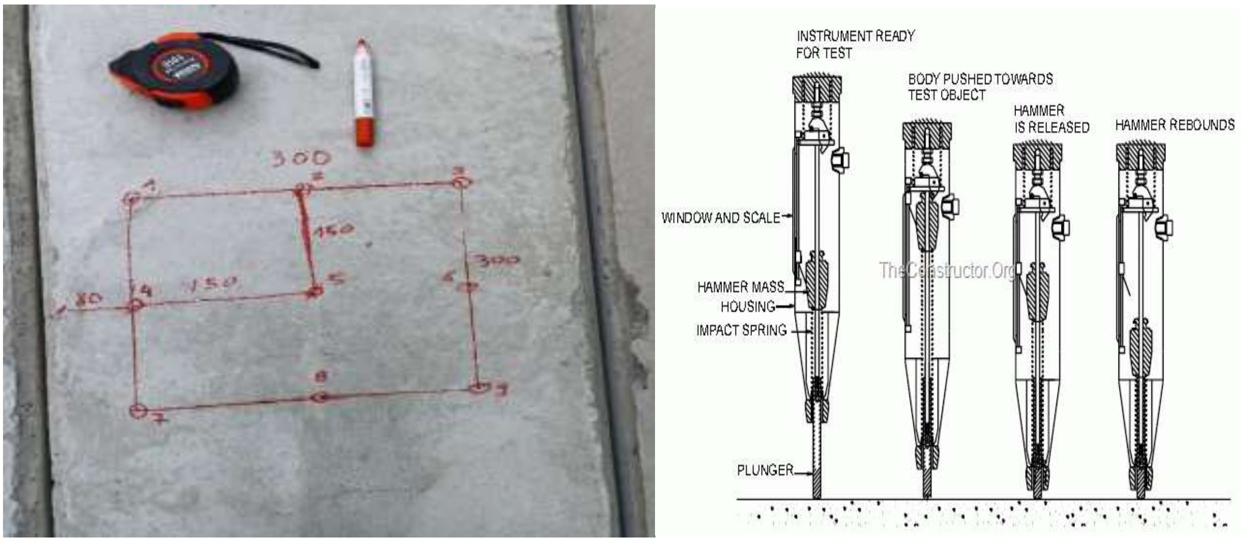

Figure 8. A. Photo during processes;
Source: authors; B. Explaining rebound hammer effect [11; 12; 13]

Average Rebound Number	Quality of Concrete
>40	Very good hard layer
30 to 40	Good layer
20 to 30	Fair
<20	Poor concrete
0	Delaminated

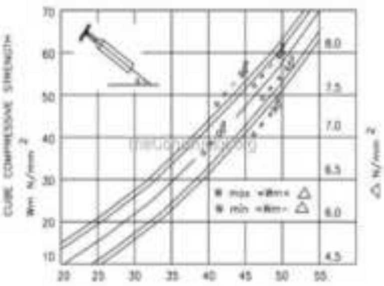

Table 1. A. Values according to rebound effect; B. Values according to rebound method [12]

9 points were marked in the form of a square ready for hitting with a sclerometer at a distance of 80 mm from each edge of the cube and the distance of the points from each other was equal to 150 mm. The element was struck at these points according to the instructions of charts A or B painted on the hammer itself, of the horizontal or vertical impact device on the vertical or horizontal face of the cube where the points were also noted. Each value of the impact with the sclerometer was recorded and according to the graph the corresponding value of the compressive strength (N/mm2) was returned. [11; 12; 13]

2.5 Type of Concrete used for the test

NORD - COMAT
Nord Construction Materials Laboratory

DA
LT 063 27.12.16
Kodi dokumentit:5-1-1

FORMULA E PERZIERJES
JOB MIX FORMULA

Standarti referues/ Referred standard: *S SH EN 206:2013*
Nr. I Faqes/Page 4/5.

KLASA E REZISTENCES SE BETONIT *RESISTANCE CLASS OF CONCRETE*		C45/55
EMERTIMI I INERTVE DENOMINATION OF AGGREGATES	% ne kurbe	[Kg/m³]
rere elumit Mat 0/6 mm	48	895
Granil I lumit Mat 4/12.5 mm	24	446
Granil I lumit Mat 8/20mm	28	524
0	0	0
Dozimi total i agregatit (I ngopur e me siperfaq. te thate) *Total Aggregate Dosage (at saturated surface dry)*		1865
Normalizated Denomination of Cement and Dosage	Cimento 42.5R	460
Emertimi dhe dozimi i aditivit ne *Additive Denomination and Dosage in*	CEMENTOL Hiperplast 463	3.63 [l/m³] 3.85 [kg/m³]
Emertimi dhe dozimi i aditivit ne *Additive Denomination and Dosage in*		
Shtesa te perdorura *Additionals used*	-	
Ngjyrues *Pigments*		
Uji efektiv (Uji total minus absorbimi i agregateve) *Effective Water (Total water minus aggregate absorption)*		147
Raporti Uje/Cimento *Water/Cement Ratio*		0.32

KARAKTERISTIKAT E BETONIT TE FRESKET
CHARACTERISTICS OF FRESH CONCRETE

Masa e volumit *Mass of volume*	SSH EN 12350-6	[Kg/m³]	2488
Permbajtja e ajrit *Air Content*	SSH EN 12350-7	[%]	1.5
Kosistenca (pas perzierjes) *Consistence (after mixing)*	SSH EN 12350-2	[mm]	150
Kosistenca (pas 30 min) *Consistence (after 30 min)*	SSH EN 12350-3	[mm]	110
Yield	AASHTO T 121	m³	1.0

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DA LT 063 27.12.16

Kodi dokumentit:5-1-1

PERCAKTIM I REZISTENCES NE SHTYPJE TE MOSTRAVE TE BETONIT
COMPRESSIVE STRENGTH OF TEST SPECIMENS

KLASA E REZISTENCES C45/55
Metoda e testimit/ Test Method: S SH EN 12390-1: 2000,S SH EN 12390-3:2009

Mosha e mostrave (ne dite)	Thyerja (Tipi i thyerjes)	Ngarkesa (Kn)	Rezistenca ne shtypje (Mpa)
Age of sample (days)	*Crushing (break type)*	*Load (Kn)*	*Compressive strength(Mpa)*
1	Normal	670.8	29.8
1	Normal	658.7	29.3
1	Normal	660.9	29.4
3	Normal	1025.8	45.6
3	Normal	1036.9	46.1
3	Normal	1018.7	45.3
7	Normal	1212.2	53.9
7	Normal	1232.5	54.8
7	Normal	1221.7	54.3
28	Normal	1368.4	60.8
28	Normal	1375.2	61.1
28	Normal	1358.7	60.4
e : **R mes** = (R1+R2+...+Rn)		1 day	**29.5**
R mes = (R₁+R₂+...+Rₙ)		3 days	**45.7**
		7 days	**54.3**
		28 days	**60.8**

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Table 3. Date of test, age of sample; crushing; load and compressive strength; Source: Nord Construction Materials laboratory.

Table 3. explain the results of the test taking into consideration the date, the age of the sample, the crushing method, the load and the compressive strength.

The results of our tests are as follows :

Table 2. Test results;

1	**2**	**3**	**4**
age of concrete(days)	**compressive strength of concrete cube (N/mm2)**	**rebound on reinforced concrete elements**	**rebound on concrete cubes**
1	**23.7**	**-19.89%**	**-29.11%**
3	**44.9**	**-18.63%**	**-28.74%**
7	**52.4**	**-17.72%**	**-27.80%**
14	**57.3**	**-16.25%**	**-26.25%**
28	**61.2**	**-14.87%**	**-25.09%**

source: authors

All the data's reported above were performed on the same corresponding date according to the age of the concrete.
Column 1: Age of concrete as seen in Table 2.
Column 2: Average of compressive strength of 12 pressed concrete cubes on the day of the respective row as seen in Table 2.

Column 3: The difference in % between the class of concrete resulted by the rebound on the reinforced concrete elements and the compressive strength resulted in column 2 as seen in Table2.

Column 4: The difference in % between the class of concrete resulted by the rebound on the concrete cubes and the compressive strength resulted in column 2 as seen in Table 2.

CONCLUSION

From the analysis of the above results, it is observed that:

1. The results of the laboratory tests of resistance to compression with a press for the cubic concrete samples taken for the prefabricated elements in this factory are very satisfying.

2. Regardless of the age of the concrete and regardless of the slump required depending on the type of element, the values obtained from the hammer blows of the sclerometer for the compressive strength of concrete are always smaller than the values obtained from the compressive strength test as for blows directly on the element as well as for blows on cubic samples.

3. The greater the age of the concrete up to 28 day old, the greater the difference between the values of the compressive strength obtained from the impacts and the values of the compressive strength obtained from the compressive test, respectively:

a) value -25% in the case of impact of the cubic sample

b) value -15% in the case of impact of the concrete element

This result confirms once again that the sclerometer impact tests are only indicative of the minimum values that the concrete brand can get, in cases when there are doubts or different problems and to evaluate whether it is worth or not to perform the carrot sample test and various studies in the laboratory. Even after the 28th day of concrete age, random tests showed that these differences (according to the 28th day) between the 2 types of tests were maintained.

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