TECHNICAL TRANSACTIONS | **CZASOPISMO TECHNICZNE**
CIVIL ENGINEERING | BUDOWNICTWO

1-B/2014

SANITA RUBENE, MARTINES VILNITIS*

USE OF THE SCHMIDT REBOUND HAMMER FOR NON DESTRUCTIVE CONCRETE STRUCTURE TESTING IN FIELD

WYKORZYSTANIE MŁOTKA SCHMIDTA DO NIENISZCZĄCYCH BADAŃ KONSTRUKCJI BETONOWYCH W PRAKTYCE

A b s t r a c t

The paper is a comparison between destructive and non destructive testing methods of site concrete structures through a series of tests using a rebound hammer and concrete cube destructive testing in the laboratory.

Keywords: Non destructive testing, rebound hammer, on site concrete testing

S t r e s z c z e n i e

Artykuł jest porównaniem metod badań niszczących i nieniszczących konstrukcji betonowych poprzez wykonanie serii testów w terenie przy użyciu młotka odbicia i niszczących badań betonowej kostki sześciennej w laboratorium.

Słowa kluczowe: Metody nieniszczące, młotek odbicia, testowanie betonu w terenie

* M.Sc. Eng. Sanita Rubene, D.Sc. Ph.D. Eng. Martins Vilnitis, Faculty of Civil Engineering, Riga Technical University.

1. Introduction

One of the most popular non-destructive methods of concrete testing in the Baltic States is carried out by using the Schmidt rebound hammer. The use of this method is practised on large scale on building sites throughout Latvia, Lithuania and Estonia. This method has gained its popularity by its simple use and the possibility of using it on a single concrete surface without requiring access to the construction from both sides, as is necessary for ultrasonic testing methods. The main question lies in the credibility of results acquired by the Schmidt rebound hammer testing method. It is often a problem to determine the correlation between the rebound number and the actual compression strength of the construction, as a large number of variables influence the correlation between the rebound number and actual compression strength. These variables must be taken into consideration in order to acquire credible testing results.

2. Schmidt rebound hammer

The Schmidt rebound hammer is principally a surface hardness tester. It works on the principle that the rebound of an elastic mass depends on the hardness of the surface against which the mass impinges. There is little apparent theoretical correlation between the strength of concrete and the rebound number of the hammer. However, within limits, empirical correlations have been established between strength properties and the rebound number [1].

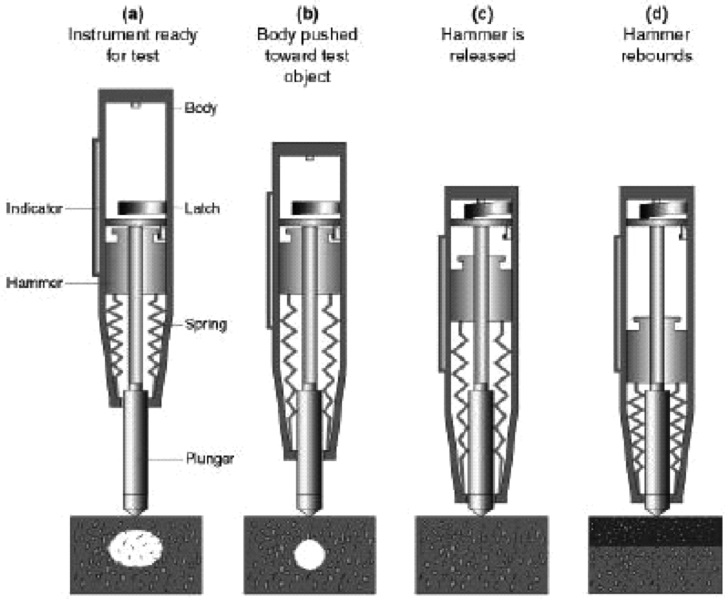

Fig. 1. Principal scheme of Schmidt rebound hammer
(http://www.ce.berkeley.edu/~paulmont/241/NDT_OK.pdf)

In order to examine the credibility of the Schmidt rebound hammer, it was tested in the field by way of two experiments, which demonstrated the impact of different variables on the testing results.

3. First experiment

In the field 20 cubes 100 × 100 × 100 mm were taken from concrete which was used for slab construction. The cubes were sent to a certified laboratory and compression tests were carried out on the 28 day old cubes. The slab structures themselves were also tested with a Schmidt rebound hammer using two different impact directions on each testing point – horizontal and vertical impact. A series of 10 rebounds were carried out for each test. To diversify the experiment, the test was performed in different places on the slab – the slab edge, in the middle of the span length, by the column and on a massive reinforced concrete beam. All results have been summarized in Table 1.

Table 1

Results of concrete cube destructive test and non destructive test of reinforced concrete slab

No.	Destructive load kN	Compression strength Mpa (Destructive method)	Compression strength Mpa (DigiSmidt result)	
			Impact direction ↑	Impact direction →
1 (edge of slab)	417	39,60	59,40	47,20
	436	41,50	51,20	48,50
	444	41,70	56,40	48,90
	439	41,30	49,10	48,90
average	434	41,025	54,025	48,375
2 (by the column, edge of slab)	456	43,30	49,90	49,90
	444	42,20	51,80	47,70
	451	42,40	53,20	49,10
	439	41,30	50,30	47,40
average	447,50	42,30	51,30	48,525
3 (middle of the span length)	444	42,20	49,30	42,60
	429	40,80	48,70	40,60
	441	41,90	37,40	54,40
	436	41,00	41,50	48,50
average	437,50	41,475	44,225	46,525

cd. tab. 1

No.	Destructive load kN	Compression strength Mpa (Destructive method)	Compression strength Mpa (DigiSmidt result)	
			Impact direction ↑	Impact direction →
4 (massive reinforced concrete beam)	449	42,60	46,20	48,70
	444	42,20	49,50	45,50
	449	42,60	43,80	48,90
	456	42,90	48,90	45,10
average	449,50	42,575	47,1	47,05
5 (middle of the span length)	432	41,00	47,00	46,60
	444	42,20	47,60	48,50
	439	41,70	46,80	42,50
	432	40,60	44,10	43,70
average	436,75	41,375	46,375	45,325

As we can see from (Table 1) the test results obtained by the Schmidt rebound hammer are significantly higher than the results obtained by lab destructive testing of the concrete cubes. It is also evident that the results gained from tests on the slab edge are more dissipated than the results gained from tests in the middle of the span length and on the massive beam.

Analysing the results from the test series No. 1 and No. 2 (Table 1) it is obvious that non destructive test results are significantly higher than the results obtained in destructive testing. These results prove that rebound tests, performed on non massive structures which are subjected to resonance of the rebound hammer, are not fully credible and can be used only for comparison purposes. In the results from test series No. 3; No. 4 and No. 5 (Table 1) it can be observed that the structures are not as susceptible to resonance the more massive they become, and in such a way it can be concluded, that the results obtained from the rebound hammer tests carried out on massive concrete structures are more trustworthy than the results obtained from tests on thin constructions which are most likely subject to resonance of rebound hammer.

4. Second experiment

As mentioned, 27 cubes 100 × 100 × 100 mm made from concrete used for load bearing wall constructions were sent to a certified laboratory for compression testing. The cubes were 28 days old when the tests were performed. Before compression testing, the cubes were first tested with the rebound hammer in the same way as testing was carried out on site. On the other hand the wall structures were tested with Schmidt rebound hammer. It was not possible to use two different impact directions on each testing point – horizontal and vertical as it is a wall and the top of construction was not reachable. Therefore the test was performed using only one impact direction – horizontal. The test was made using a series of 10 rebounds for each test. All results have been summarized in Table 2.

Table 2

Results of concrete cube destructive test and non destructive test of reinforced concrete walls

No.	Destructive load kN	Compression strength Mpa	Compression strength Mpa (DigiSmidt result)	
			Impact direction →	Cube test result
1	461,60	46,16	45,30	18,50
	339,80	33,98	49,30	16,50
	347,70	34,77	45,80	22,10
	458,10	45,81	43,20	16,20
average		40,18	45,90	18,33
2	461	46,10	41,40	15,70
	443	44,30	46,60	13,00
	361,70	36,17	47,20	20,30
average		42,19	45,07	16,33
3	314,40	31,44	37,30	22,10
	385,50	38,55	38,30	17,20
	359,80	35,98	41,00	21,10
	474,40	47,44	41,70	18,20
average		38,35	39,58	19,65
4	439,90	43,99	43,60	20,30
	422,20	42,22	42,70	11,80
average		43,11	43,15	16,05
5	404,90	40,49	39,90	17,00
	386,40	38,64	43,60	11,60
average		39,57	41,75	14,30
6	318,00	31,80	44,50	10,90
	428,20	42,82	46,00	13,50
average		37,31	45,25	12,20
7	438,00	43,80	42,80	14,50
	447,70	44,77	47,20	13,30
average		44,29	45,00	13,90

cd. tab. 2

No.	Destructive load kN	Compression strength Mpa	Compression strength Mpa (DigiSmidt result)	
			mpact direction →	Cube test result
8	359,20	35,92	38,80	17,20
	463,40	46,34	43,20	17,70
	465,00	46,50	44,40	18,20
average		42,92	42,13	17,70
9	453,40	45,34	45,30	15,70
	447,80	44,78	44,00	18,20
average		45,06	44,65	16,95
10	388,80	38,88	42,10	16,20
	474,20	47,42	44,90	16,20
average		43,15	43,50	16,20

As we can see from the second test result (Table 2) the average results for test series obtained by the Schmidt rebound hammer are close to the results obtained by the destructive testing of the concrete cubes. But the results of the cube testing with rebound hammer significantly differ from the compression test results and the on site test results with rebound hammer.

From analysing the concrete cube test series results it is obvious that the non destructive test results performed on site are significantly higher than the results obtained in the non destructive laboratory tests. These results prove that the rebound tests, performed on small structures which are subjected to the resonance of the rebound hammer, are not fully credible and cannot be used for further research work. From results in the test series it can be seen that the wall structures are not as susceptible to resonance as the slab structures which were used in the first experiment as they are much larger. The non destructive on site testing and the destructive compression tests performed in the laboratory provided similar results. For the results of both tests performed on the slabs and walls it can be concluded, that the results obtained from rebound hammer tests on massive concrete structures are more trustworthy than the results obtained from tests on thin constructions which are most likely are subjected to resonance of rebound hammer.

5. Conclusions

Both experiments show, that in field non destructive testing using the Schmidt rebound hammer must be performed by experienced engineers who can analyse side issues or other variables which occur during the testing of concrete constructions in different on site situations, such as the quantity of reinforcement bars in the tested concrete area, the distance of the reinforcement bars from the test surface, the location of the test surface, thickness of the construction tests are performed on e.t.c. and its impact on the total test results. If tests are performed by persons with a lack of qualification, the results can be interpreted wrongly what can result in serious faults due to poor quality control. Prior to testing concrete constructions with a rebound hammer, serious research must be carried out. As the results depend on factors such as the thickness of the construction, quantity and emplacement of the reinforcement bars etc. test areas must be carefully selected in order to obtain credible test results.

References

[1] International atomic energy agency, Guidebook on non-destructive testing of concrete structures, Vienna 2002, 61.

[2] Wiggenhauser H., *Advanced NDT Methods for Quality Assurance of concrete Structures*, NDTCE'09, Non-Destructive Testing in Civil Engineering Nantes, France 2009.

[3] Hannachi S., Guetteche M.N., *Application of the Combined Method for Evaluating the Compressive Strength of Concrete on Site*, Open Journal of Civil Engineering, 2012, 2, 16-21.

[4] ACI Committee 228, Nondestructive Test Methods for Evaluation of Concrete in Structures, 1998.

[5] http://www.proceq.com/en/site

[6] Гулунов В.В., Мотовилов А.В., Гершкович Г.Б. *Особенности применения новых приборов неразрушающего контроля прочности бетона*, Журнал „В мире Неразрушающего контроля" №2 2005.

[7] Коревицкая М.Г., *Неразрушающие методы контроля качества железобетонных конструкций. М.*, 1989.

[8] EN 12504-2:2002 Testing concrete in structures – Part 2: Non-destructive testing – Determination of rebound number.

[9] Malhotra V.M., Ed. *In Situ/Nondestructive Testing of Concrete*, ACI Spec. Publ., SP-82, American Concrete Institute, Detroit 1984.

[10] Samarin A., Dhir R.K., *Determination of in situ concrete strength: rapidly and confidently by nondestructive testing*, ACI SP-82 (Ref. 12), Detroit 1984, 77.