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Analysis of Compressive Strenghts of Concrete Determined by Different Types of Sclerometers

Jiri Brozovsky
Institute of Building Materials and Components , Faculty of Civil Engineering, Brno University of Technology, 602 00Brno, Czech Republic

Summary

One of the way of finding out the surface of concrete in construction are impact hammers in building practise the most widespread resilient impact hammers of Schmidt system. Sometimes there are also used nonnorm impact hammers for exmaple Masek impact hammer and Ciganek prong. By teoretical we can suppose that for same surrfaces will be at same trial place found same values of surfaces, but this presumption wasn't confirmed yet. In case of nonconfirmed tests of concrete it's needed to use only one type of impact hammer. For searching more accurate results is needed to make accurates tests of concrete, everytime for concretes which are more than 1year old and for using different types of impact hammers for classification the surface of construction.

KEYWORDS: concrete, strength, impact hammer.

1. INTRODUCTION

Non-destructive testing methods, most frequently the hardness test methods, have been used for operative compression strength measuring of concrete, already built-in in construction. Building industry currently uses hardness drop testers of Schmidt system. The processing methods are described in international standard ISO/DIS 8045, European standard EN 12504-2 and in many a national standards, such as CSN 73 1373; ASTM C 805; BS 1881, part 202; NFP 18-417 or JGJ/ T 23-2001. Sometimes, the concrete strength has been measured by means of non-standard methods. In the Czech Republic, we do often use pickaxe tools, concretely the Mašek or Cigánek pointed hammers.

For results of concrete strength measuring by sclerometers, a theoretical assumption should be valid, according to which concrete testing by different hardness test methods at a place should bring about the same values, i.e. when evaluating all the results based on calibration relations for the given test methods, the values of concrete compression strength should be equal. To verify plausibility

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of this assumption, we have done an analysis of compression strength values measured by Schmidt impact hammers, types N / L and by Mašek pointed hammer.

The paper deals with analysis of test results, gained by trial of strength done on load-bearing structures; the age of concrete ranged between 25 and 30 years. The package contained 502 values for Schmidt hammers of both types and 90 values for Mašek pointed hammer.

2. DESCRIPTION OF THE USED TEST DEVICES

The text below specifies basic characterization of the used sclerometers, namely of the Schmidt hammers, types N / L, and of the Mašek pointed hammer.

2.1 Mechanic Hardness Drop Tester, Schmidt System

Strength measuring by a hardness drop tester is based on resilient punch rebound from the tested concrete surface resulting in determining of the rebound value.

– The Schmidt impact hammer, type N, gives blow energy of 2.25 J; according to the manufacturer's information, it enables compression strength measuring in the range of 10 – 70 MPa; the ČSN 731373 specifies it as a device, suitable for testing of structures with thickness of 100 mm as a minimum.

– The Schmidt impact hammer, type L, gives blow energy of 0.75 J; according to the manufacturer's information, it enables compression strength measuring in the range of 10 – 70 MPa; the ČSN 731373 specifies it as a device, suitable for testing of structures with thickness of 60 mm as a minimum.

The Schmidt impact hammer is depicted in Figure 1.

2.2.1 Process of Measuring and Evaluation of Test Results

– <u>Test surface</u>: firstly, the dry test surface was rubbed in order to reach smoothness and flatness and to make visible the aggregates grains. 8 trials of rebound measuring on each test surface were done in order to reach at least 5 valid values.
– <u>Calibration relations concrete strength determining:</u> CSN 73 1373 specifies different positions for each type of Schmidt impact hammer in dependence on the calibration relations. The Tables 1 and 2 show concrete compression strength in relation to the detected rebound values. The values are valid for current concrete at the age of 14-56 days, using natural compact aggregates.

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- Evaluation of test results: Concrete compression strength f_{be} with not guaranteed accuracy was determined on the base of common calibration relation valid for the given Schmidt impact hammer type according to the ČSN 731373, whereas the sclerometer position was taken into account.
- Correction coefficients: For older concretes, the strength value has been reduced by a α_t coefficient in the range between 0.95 and 0.90. Regarding the concretes at the age of above one year, the α_t coefficient value amounts to 0.90 which, however, does not correspond to the reality. For the concretes at the age of 10 – 30 years, this coefficient value moves between 0.5 and 0. 65 as a rule. There is also an intention to introduce a coefficient expressing or reflecting the concrete condition. In order to gain plausible concrete strength values, it is necessary to do so called „nail down” tests, whereas the selected places have been subjected to non-destructive tests and consequently, specimens in the form of core wells have been sampled for determining of précised coefficient in compliance with the CSN 73 1370.

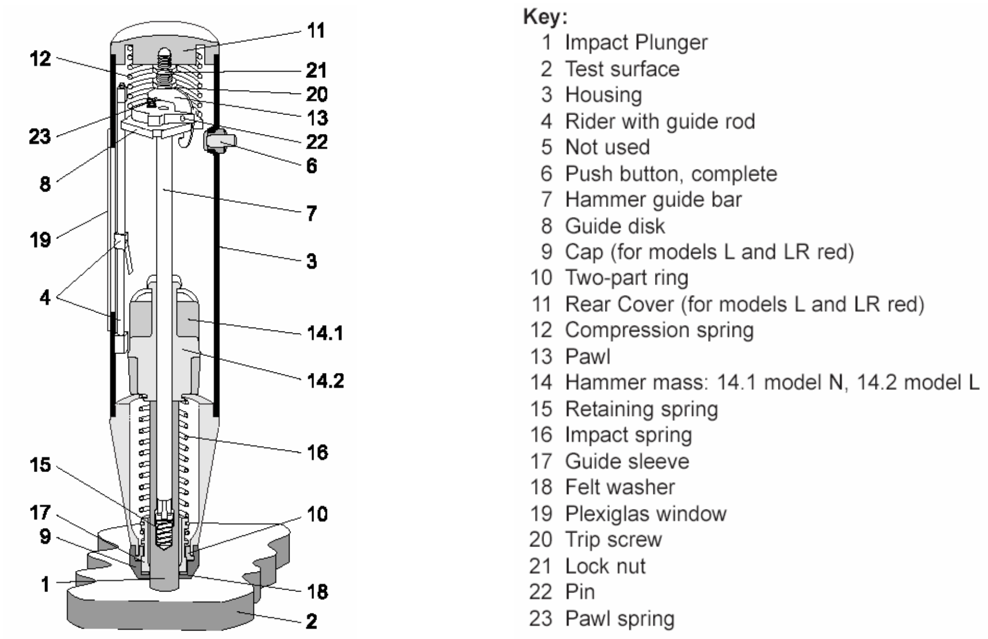

Figure 1: Schmidt Impact Hammer, Types N/ L (Spring of Information: www.proceq.com)

Table 1: Compression Strength Values f_{be} Based on Rebound ***R*** of Schmidt Impact Hammers, Types N/L (CSN 73 1373)

Rebound Number	Impact Hammer – type N			Impact Hammer – type L		
	horizon-tally	vertical-ly down	vertical-ly up	horizon-tally	vertical-ly down	vertical-ly up
14				9	14	
15				10	15	
16				12	17	
17				13	18	
18				15	20	
19				16	21	9
20				18	23	10
21				19	24	11
22				21	25	13
23				22	27	14
24		19		23	28	16
25	16	21		25	30	18
26	18	22		26	32	19
27	19	24		28	33	21
28	21	26	14	30	35	22
29	22	27	15	31	36	24
30	24	29	17	33	38	25
32	27	32	20	36	41	29
33	28	33	21	38	43	30
35	32	37	25	41	46	34
36	33	39	26	43	48	36
37	35	40	28	44	49	37
39	39	44	32	48	52	41
40	41	46	34	49	54	43
41	42	47	35	51	56	45
42	44	49	37	53	57	46
43	46	51	39	54	59	48
45	50	54	43	58	62	52
46	52	56	45	60	64	54
47	53	58	47			56
48	55	60	49			57
49	57	62	51			
50	59	64	52			
51	61		54			
52	63		56			
53			58			
54			60			

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2.2 Mašek Pointed Hammer

The sense of the test is, to detect the depth of pointed hammer penetration into the concrete under the consideration of defined number of strokes and the tool weight. Both, the relevant pointed hammer form and size are shown in Figure 2.

The concrete strength determination follows from the depth of pointed hammer penetration, whereas 20 strokes by the tool in the weight of 2 kg from a distance of 700 mm or 500 mm have been performed.

3 valid measure tests were done in the selected place, whereas the depth of pointed hammer penetration might not differ by more than 20 % in the average.

The concrete compression strength with not guaranteed accuracy for stroke travel of 700 resp. 500 mm is to be reckoned from the common calibration relations (1) and (2):

– *Stroke Travel* of 700 mm

$$f_{be} = 456{,}4h^{-0{,}99346} \quad h \in \{120;\ 18\ [\mathrm{mm}] \quad f_{be} \in \{4;\ 25\}\ [\mathrm{MPa}] \tag{1}$$

– *Stroke Travel* of 500 mm

$$f_{be} = 88{,}4 - 4{,}6865h + 0{,}06478h^2 \quad h \in \{40;11\}[\mathrm{mm}] \quad f_{be} \in \{4;48\}\ [\mathrm{MPa}] \tag{2}$$

kde :
f_{be} - pevnost betonu v tlaku s nezaručenou přesností
h - hloubka vniku špičáku do betonu

Při provádění zkoušek byl aplikován postup s dráhou úderu 500mm, z důvodu prostorových omezení zkoušených konstrukcí.

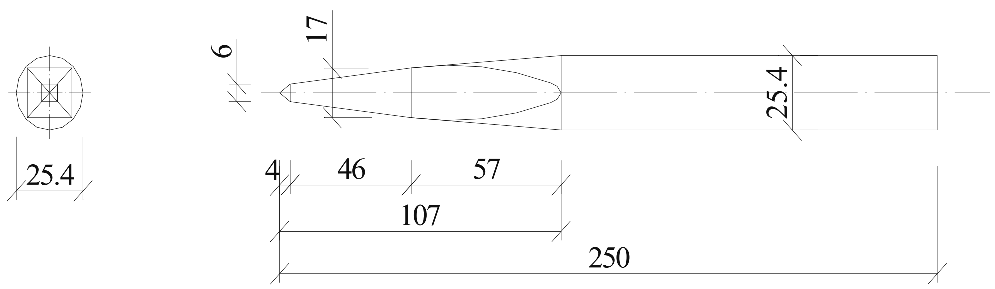

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Figure 2: Mašek Pointed Hammer, Form and Size

3. COMPARISON OF CONCRETE COMPRESSION STRENGTH VALUES MEASURED BY DIFFERENT SCLEROMETER TYPES

The comparison is based on results of non-destructive test methods. 502 values gained by measuring in the selected place by means of each Schmidt hammer type were available to be compared with 90 values gained by application of Mašek pointed hammer in the same place of testing.

The f_{be} compression strength values gained from non-destructive testing parameter under the consideration of common calibration relation for the given sclerometer have been compared. For this comparison, the Schmidt impact hammer, type N, was preferred, as this hammer is most frequently used in the building industry.

Coherence between compression strength values based on the tests by Schmidt impact hammers, types N / L, is shown in the Figure 3. Comparison of testing by Schmidt impact hammer, type N, with Mašek pickaxe is shown in the Figure 4; the results having followed from tests by Schmidt impact hammer, type L, and by Mašek pointed hammer are compared in the Figure 5.

Figure 6 shows a comparison of concrete strength values reckoned from the gained relations in dependence on the theory.

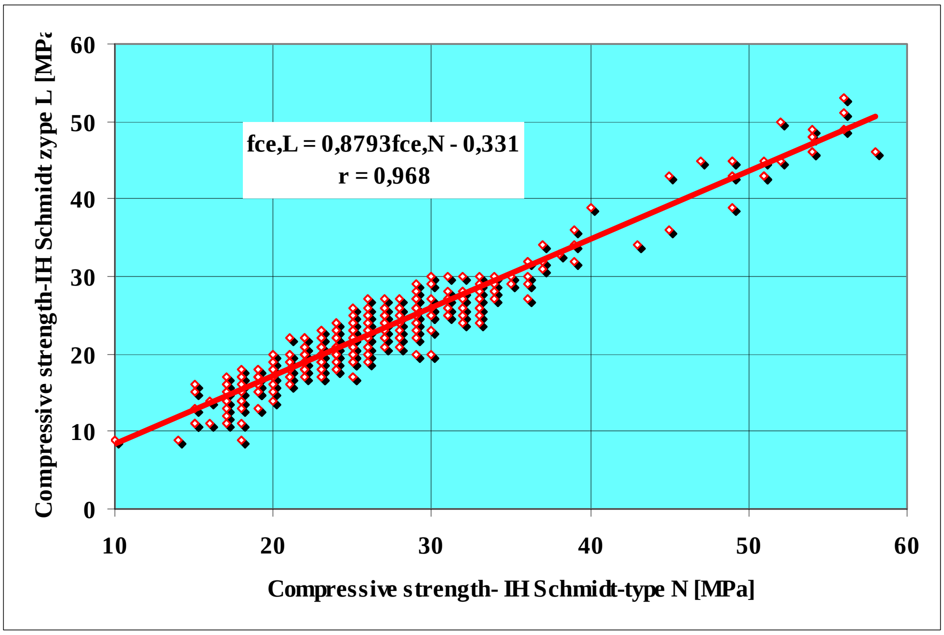

Figure 3: Coherence between f_{be} Compression Strength Values of Non-Guaranteed Accuracy and Values Gained by Schmidt Impact Hammers, Types N/L

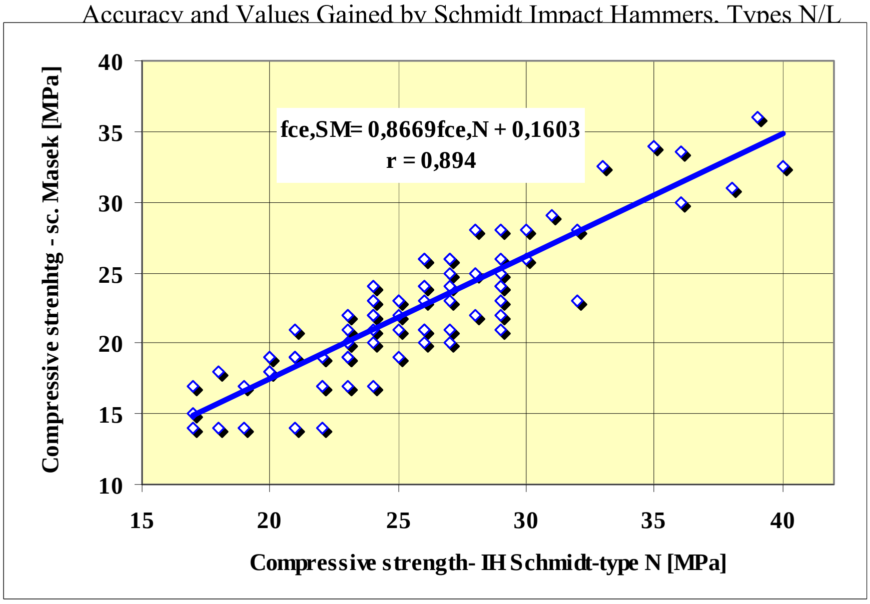

Figure 4: Coherence between f_{be} Compression Strength Values of Non-Guaranteed Accuracy and Values Gained by Schmidt Impact Hammer, Type N, and by Mašek Pointed Hammer

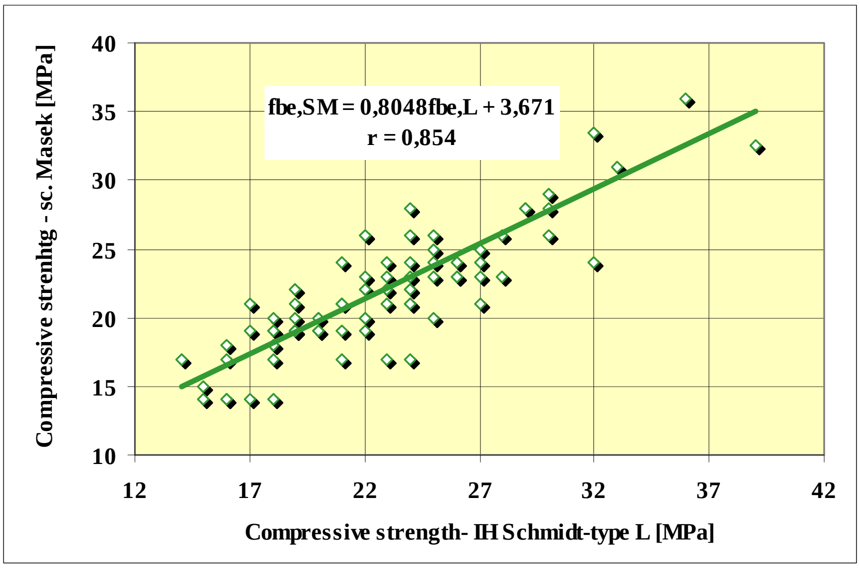

Figure 5: Coherence between f_{be} Compression Strength Values of Non-Guaranteed Accuracy and Values Gained by Schmidt Impact Hammer, Type L, and by Mašek Pointed Hammer

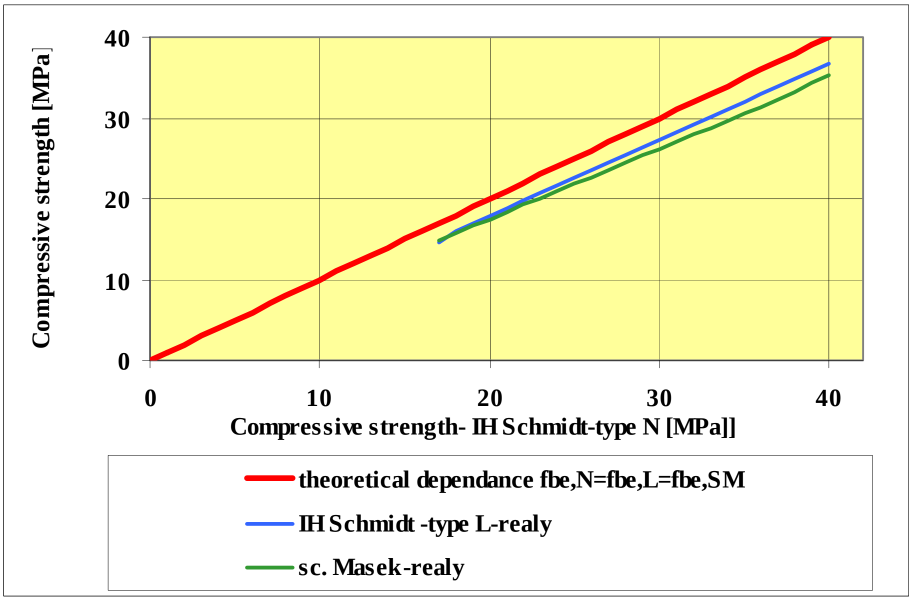

Figure 6: Comparison of f_{be} Compression Strength Values Gained by Schmidt Impact Hammer, Type L, with Results of Mašek Pointed Hammer Testing

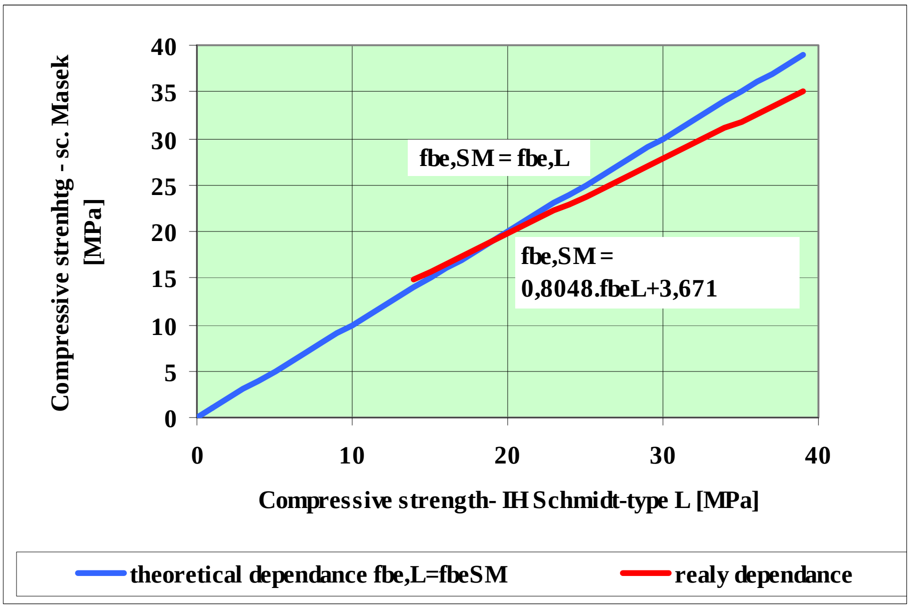

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Figure 7: Comparison of f_{be} Compression Strength Values Gained by Schmidt Impact Hammer, Type N, with Results of Mašek Pointed Hammer Testing

4. CONCLUSION

With respect to the analysed results of measured concrete strength values gained by using of different sclerometer types, we may claim,

- That, a conformity of the concrete strength values gained on the base of measuring by different sclerometer types in the same place with evaluation of the same according to the common calibration relation for the given method has not been vindicated.
- There is a high correlation degree between the strength values gained by means of Schmidt impact hammers, types N/L, or by Mašek pointed hammer. The Figure 6 shows that 98 % of strength values based on measuring by Schmidt impact hammer, type L, undergo by 0.6 MPa the values traced by Schmidt impact hammer, type N, and 99 % of strength values measured by Mašek pointed hammer are lower by 0.9 MPa in comparison with the same strength values measured by Schmidt impact hammer, type N.
- Comparing the results of measuring by Schmidt impact hammer, type L, with those of Mašek pointed hammer, the top strength values of 18 MPa are sinking consequently (the deviation is expressed in an absolute value ranging between 0 and 8 MPa), see the Fig. 7. It is recommendable, to use always one and a single type of sclerometer in order to measure the concrete strength within a construction. This rule may be avoided, when a usage of more sclerometer types is necessary, e.g. for the ground that parameters of non-destructive testing lie beyond the measured common calibration relation to be interpreted as the test results.
- An accuracy coefficient should always be set in order to fix the most précised values of concrete strengths (see the proceedings specified in CSN 73 1370). The coefficient is always to be set for concretes at the age of above 1 year.
- In case that different sclerometer types are used for the tests, it is always necessary to quote accuracy coefficients relating to each method.
- The Mašek pointed hammer is recommendable for testing of concrete strength up to 12 MPa.

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