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Two Type of Impact Load Tests, Tested on Fibre Reinforced Concrete Specimens

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Abstract

Fibre-reinforced composite materials are becoming important in many areas of technological application. In addition to the static load, such structures may be stressed with short-term dynamic loads or even dynamic impact loads during their lifespan. Dynamic effects can be significant especially for thin-walled shell structures and barrier constructions. Impact loading of construction components produces a complex process, where both the characteristics of the design itself and the material parameters influence the resultant behavior. It is clear that reinforced concrete with fibers has a positive impact on increasing the resistance to impact loads. However, the assessment of the increase of this resistance has not been sufficiently verified experimentally. Results of impact load tests carried out on prisms with different amount of the fibers and drop-weight impact tests are presented in this paper.

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Keywords: Impact load test; concrete; drop-weight test; fibres; specimen; CMOD;

1. Introduction

The goal of the project is to try new procedures for evaluating the impact resistance of cementitious composites. An

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appropriate shape of test specimens, ways to support the test specimens [4] and the method of measurement were chosen on the basis of experiments [1-3], [5]. The load tests of specimens reinforced with different amount of reinforcement were made afterwards. The specimens in shape of standardized prisms (100x100x400 mm) and rectangle specimens 700x300 mm, of thickness 50 mm were selected for further examination on bases of the tests results. The prisms were used for impact load test and the rectangle specimens for drop-weight test.

2. Mixture

Each recipe, with different amounts of reinforcement used for the load tests, is given in Table 1. The steel wire Fibres with hooked ends (KrampeHarex DE50/1.0 N) of diameter 1.0 mm and length of 50 mm were used.

Table 1. Mixtures A - C

MIXTURE	A	B	C
Concrete component	[kg/m^3]	[kg/m^3]	[kg/m^3]
CEM II/A-S 42,5 R – Čižkovice	350	350	350
Fine 0 – 4 mm, Kaznějov	1195	1189	1181
Aggregate Coarse 4 – 8 mm, Kaznějov	644	641	636
Superplasticizer, Chysofluid Optima 208	8.75	8.75	8.75
Steel wire Fibers KampeHarex DE50/1.0 N	20	40	80
Water	157.5	157.5	157.5

3. Specimens

All test specimens were made into wood moulds, compacted on vibratory table. Specimens were demoulded after 24 hours and then stored in water according to ČSN 12390-2 [6] for 28 days. The test specimens were stored in dry place up to the test. Before testing, the specimen were measured and weighed.

4. Load tests

4.1. Dynamic load tests (prisms)

Dynamic loads tests were carried out on the prisms (size 100x100x400 mm). Prisms were provided with a notch depth of approximately 16 mm and a width of approximately 4 mm. The prism rested on two supports 300 mm apart (three-point bending load test). When loaded, the opening of the crack (CMOD - crack mouth opening displacement) and deflection were monitored depending on the load force. Dynamic load test was carried out at loading speed 70 mm/s. The maximum force at the failure and the CMOD up to 5 mm were monitored. The prism before and during (failure pattern) the test is shown in Figure 1. Results are shown in graphic form in Figure 2. Due the limited space of this paper only A and C mixture are presented. The MTS flextest machine was used for the tests.

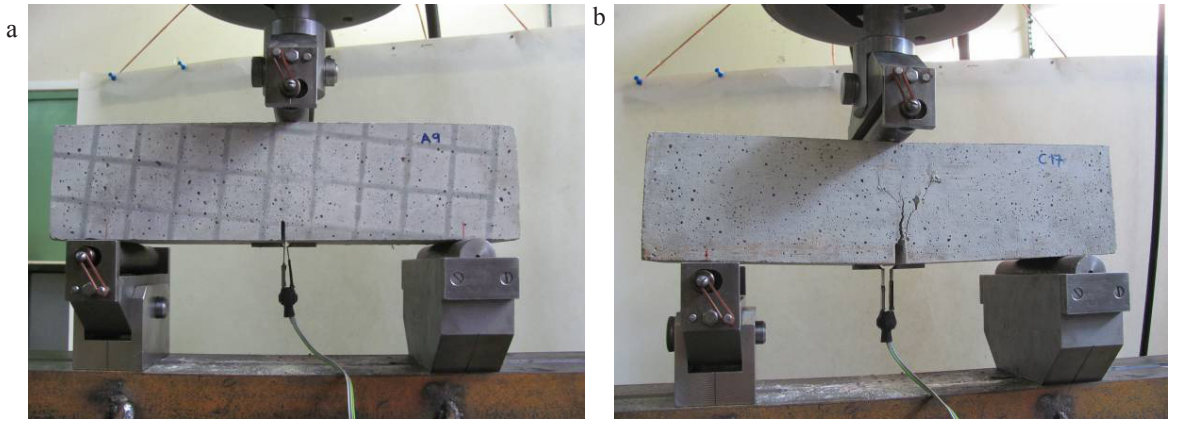

Fig. 1. (a) prism before the test; (b) prism during the test - failure pattern.

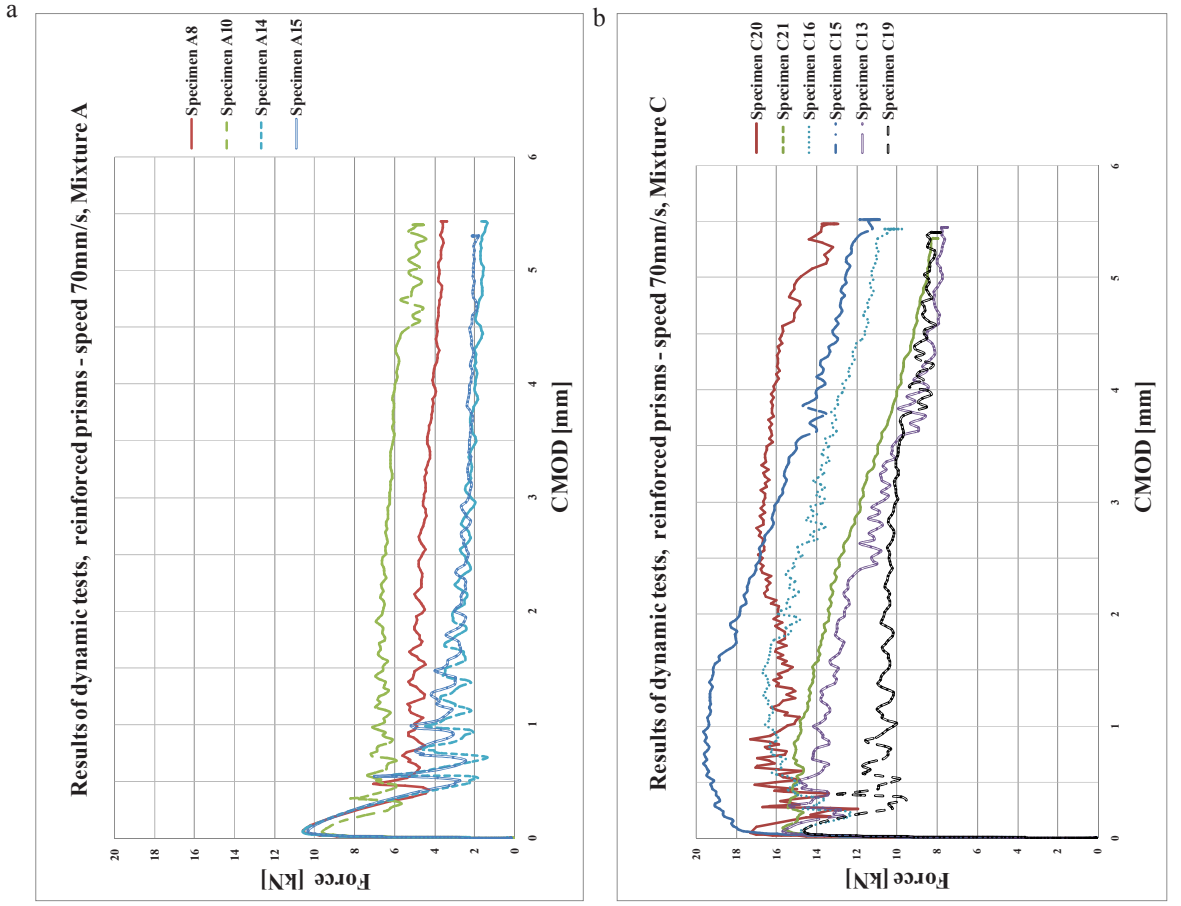

Fig. 2. (a) results of dynamic load tests of reinforced prisms - mixture A; (b) results of dynamic load tests of reinforced prisms, mixture – C.

4.2. Drop-weight test

The Drop-weight test was carried out in Drop-weight test machine. The rectangle specimens (700x300x50 mm) were supported along the shorter sides. The blows were introduced through a 9.5 kg hammer, falling continually from 10 and 20 cm. The hammer head with these parameters was used - diameter 35 mm, rounding end (diameter 120 mm). The first blow was introduced from 10 cm height, all the next blows from 20 cm height. The number of blows to the first visible crack (First-crack strength) and the number of blows to the failure (Failure strength) were monitored. The test results are shown in Table 2 and Figure 3. Experimental setup is visible in Figure 4.

Table 2. Test results – Drop – weight test

Drop – weight test results			
Specimen No.	Fall from 10 cm, No. of blows	Failure from 20 cm	
		First-crack strength (blows)	Failure strength (blows)
A1	1 – no visible crack	1	10
A2	1 – no visible crack	2	8
A3	1 – no visible crack	2	8
A4	1 – no visible crack	2	5
A5	1 – no visible crack	2	8
B1	1 – no visible crack	2	10
B2	1 – no visible crack	2	12
B3	1 – no visible crack	2	17
B4	1 – no visible crack	2	12
C1	1 – no visible crack	3	18
C2	1 – no visible crack	2	20
C3	1 – no visible crack	4	19
C4	1 – no visible crack	3	16

Fig. 3. test results - Drop-weight test.

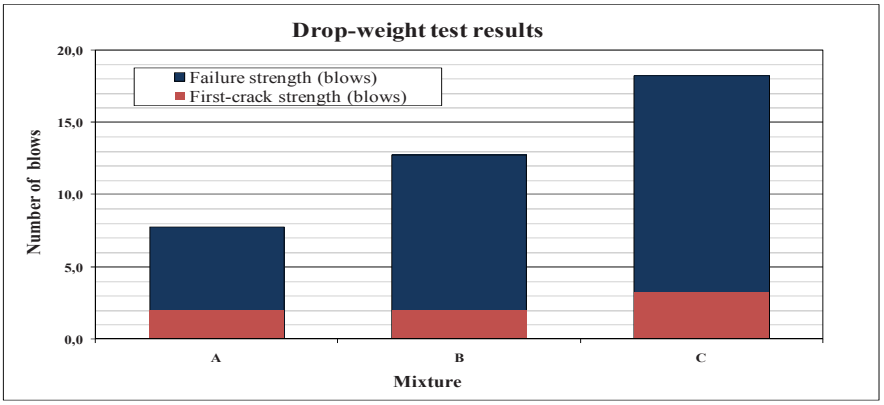

Fig. 4. Experimental setup – Drop-weight test.

5. Conclusions

The percentage increase of the different ways of loads and different mixtures are shown in Table 3. As a basis for comparison, mixture A was chosen.

Table 3. Test results.

Shape of the specimens	Type of test	Parameter	Mixture		
			A	B	C
Prism	Dynamic load test, MTS mashine	Max. force [kN]	10.3	11.2	16.6
		Increse [%]	-	**9**	**62**
		Force [kN] when CMOD 0,1 mm	9.87	10.72	15.72
		Increse [%]	-	**9**	**59**
		Energy [kNm] when deflection 3,5 mm	0.021	0.021	0.044
		Increse [%]	-	**42**	**196**
Rectangle specimens	Dynamic load test, drop-weight test	Failure strength (blows)	7.8	12.8	18.3
		Increse [%]	-	**63**	**134**

The results obtained so far can be summarized as follows:

- Prisms (100x100x400 mm) and rectangle specimens (700x300x50 mm) were selected for tests.
- Increase of the fibre reinforcement 40 kg/m^3 allows increase in deflection. It also increase dynamic load resistance of the specimens.
- Increase of the fibre reinforcement 80 kg/m^3 leads to a significant increase in dynamic load resistance of the specimens. The overall increase of strength is about 60 %, compared to specimens with reinforcement around 20 kg/m^3.
- The energy needed to reach the deflection 3.5 mm (tested on prisms) were evaluated from the force-displacement relationship. The overall increase of energy needed to reach the deflection 3.5 mm for specimens with reinforcement 40 kg/m^3 is about 40 %, compared to specimens with reinforcement 20 kg/m^3. The overall increase of energy for specimens with reinforcement 80 kg/m^3 is about 200 %, compared to specimens with reinforcement 20 kg/m^3.
- The additionally drop-weight test (Failure - strength, number of blows) confirms the overall increase of strength between the mixtures. The percentage increases discovered between mixtures B compare to A and mixture C compares to A is very similar to increases discovered by dynamic load tests in MTS flextest machine (energy needed to reach the deflection 3.5 mm).

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