EFFECT OF THE LOADING RATE TO FIBRE REINFORCED CONCRETE BEAMS

- Karoly Peter Juhasz[1,3], Peter Schaul[2,3], Lorant Nagy[3] -

JKP Static
jkpstatic.com

1 Department of Mechanics, Materials & Structures, Budapest University of Technology, Műegyetem rkp. 3, Budapest, Hungary
2 Department of Construction Materials & Technologies, Budapest University of Technology, Műegyetem rkp. 3, Budapest, Hungary
3 JKP Static Ltd, Reitter Ferenc utca 73, Budapest, Hungary

office@jkp.hu , schaul.peter@epito.bme.hu , lorant.nagy@jkp.hu

Abstract. Fibre reinforced concrete has become a widely used material since the end of the 20th century. The uniformly distributed steel or macro synthetic fibres in the concrete structures can give the concrete a residual flexural strength after the first cracks. The different behaviour of materials subjected to different loading rates is a well-known phenomenon, both with steel, synthetic and concrete materials. Standards usually present a recommendation for the loading speed in for different tests. Concrete elements show higher performance due to the high speed of loading or impact loads, their fracture energy and therefore their overall capacity appears greater than the specimens loaded at standard speeds. Fibre reinforced concrete structures are widely used in tramlines and railways, where the speed of the loading is high and therefore of impact by nature. It is important to know what the effect of this high speed loading is for fibre reinforced concrete structures: do these structures have additional capacity, or has the designer overestimated their performance? This article will present an investigation into the effect of the loading rate on case of using fibres with different materials in concrete beams.

To examine the behaviour of fibre reinforced concrete under different loading rates a three point bending beam test series was performed with steel and macro synthetic fibre reinforcement. The test matrix can be seen in table 3. The type of the reinforcement and the used dosage can be seen in table 2.
Prior to the beam tests single fibre tension test were carried out with the used fibres, to be able to verify the results of the fibre's capacity under different loading rates.

Three points notched beam tests were made according to RILEM TC162 [3]. The load, the crosshead's vertical displacement and the beam's Crack Mouth Opening Displacement (CMOD) were measured for all of the beams. To be able to measure the CMOD a 25 mm deep notch was cut into the middle of the beams and two steel knifes were glued on the bottom surface of the beam. The measuring clip was positioned between the two points. The test was performed by a universal testing machine ZWICK Z150 in the Laboratory of Department of Mechanics, Materials and Structures, Budapest University of Technology and Economics. The speed of the test was 0.2 mm/min and 900 mm/min up to 4 mm central deflection. The maximum speed of the testing machine was 900 mm/min.

Table 1. Concrete mix

Concrete name	Cement type	w/c ratio	Aggregates (kg/m³)			Admixtures
			0-4	4-8	8-16	
A	CEM-III-A-42.5	0.400	735	294	808	Dynamon NRG 1012

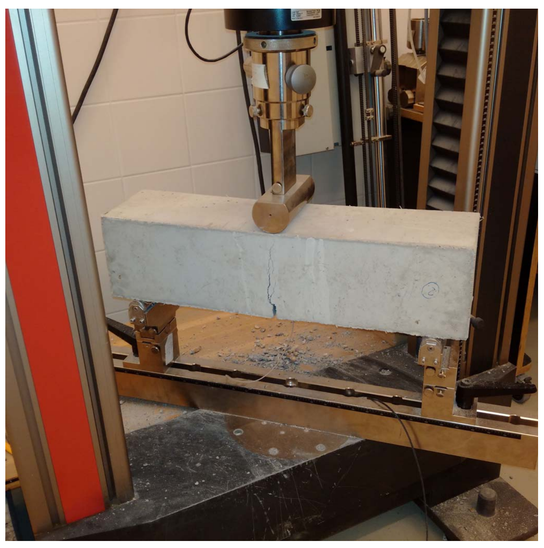
Table 2. Fibre reinforcing

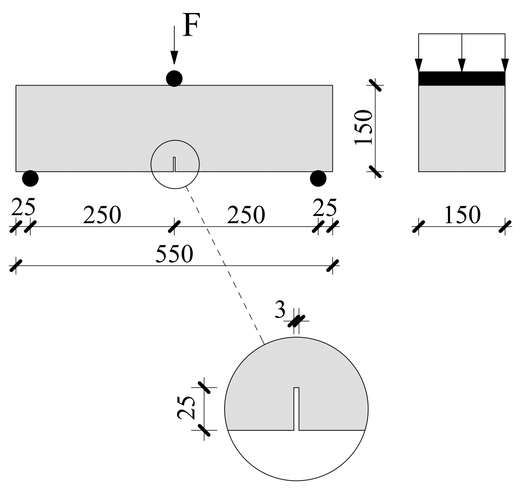
Fibre sign/name	Fibre type	Fibre length mm	Dosage kg/m³	Number of fibres Number/m³
BC48 – 4.0 Barchip48	Synthetic fibre Surface embossed	48	4.0	240 964
AF – 25.0 Armfib®	Steel fibre Hooked-end	50	25	78 150

Table 3. Test matrix

Name of the specimen	Concrete	Fibre – dosage [kg/m³]	Testing speed
AF25-A-L-number	A	AF – 25.0	0.2 mm/min
AF25-A-H-number	A	AF – 25.0	900 mm/min
BC48-A-L-number	A	BC48 – 4.0	0.2 mm/min
BC48-A-H-number	A	BC48 – 4.0	900 mm/min

Three point bending beam test according to RILEM TC 162

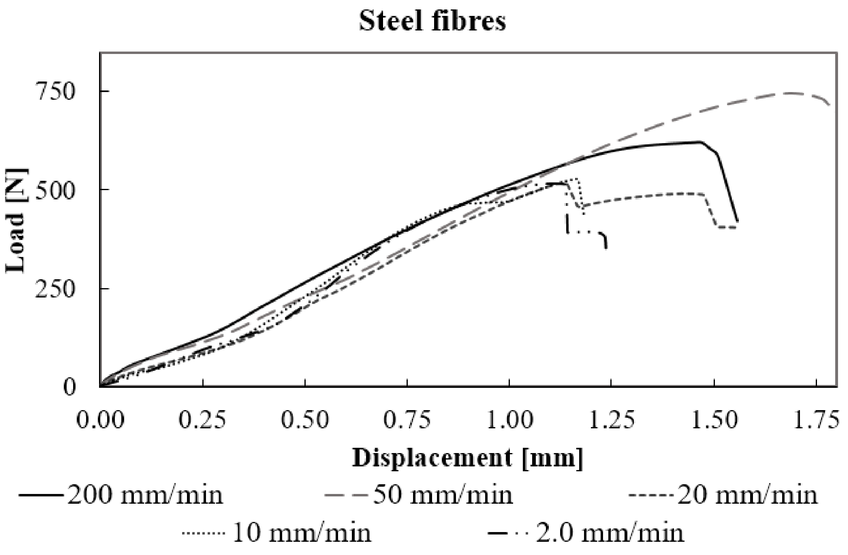


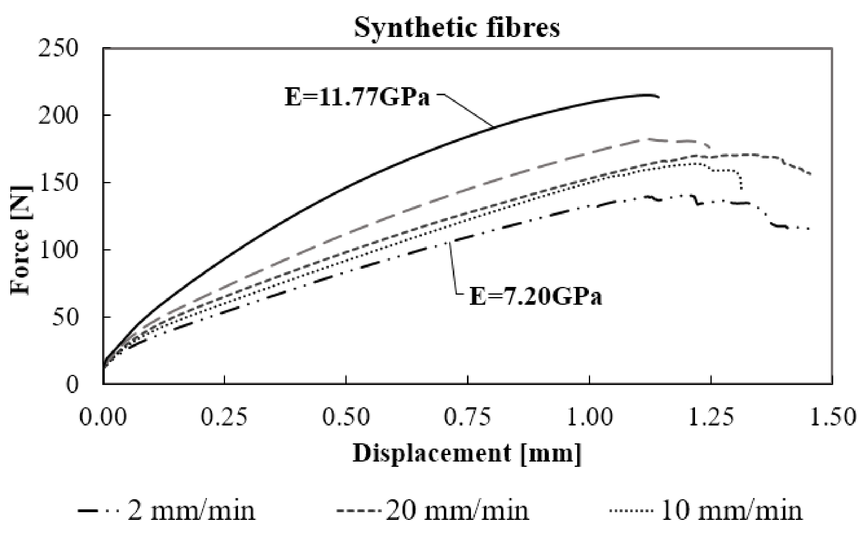


Single fibre tension test

To understand the fibre reinforced concrete's behaviour under different loading rates it was important to check the capacity of the discrete fibres under different speeds of loading. Testing of the macro synthetic fibres had to be done with some circumspection, because a local failure can occur close to the clamping head of the machine which can give misleading results. For case of every loading speed 5 pieces of fibres were tested to failure to be able to calculate the average value of the fibres' capacity.

The results shows that in case of synthetic fibres there is a high effect of the loading speed both at high and low speeds. By raising the speed of the test, the capacity and also the Elastic modulus of the fibres will be higher. This increase in the capacity is significant at more than 25%. It showed that the elastic modulus changed from 7.20 GPa to 11.77 GPa. The critical value for the loading speed which was where the strength of the fibre started to increase significantly was approximately between 20 and 50 mm/min.

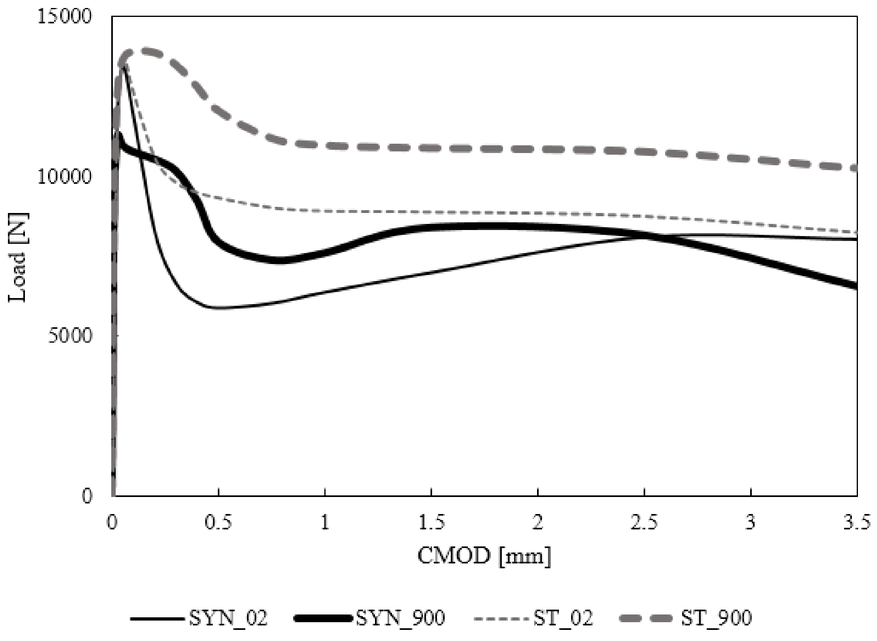


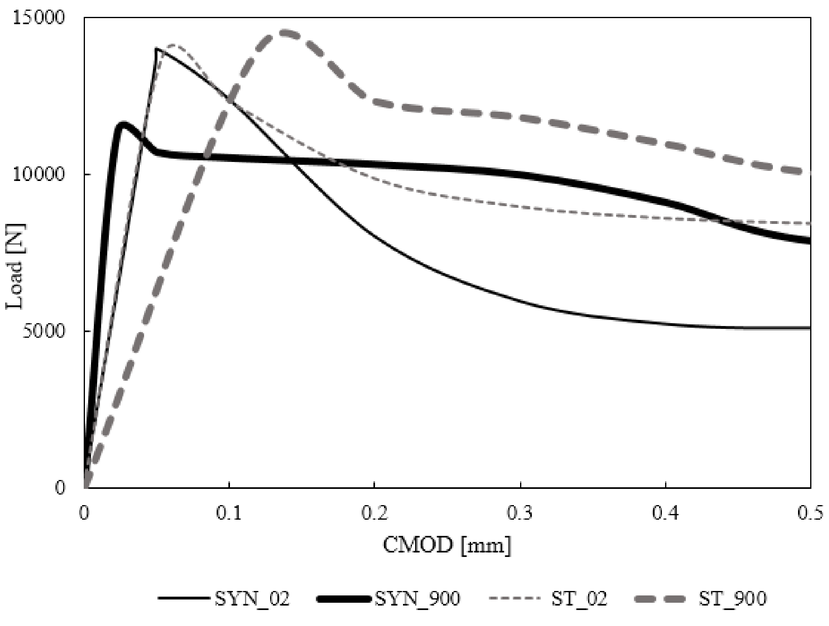


Three point bending beam test

A three point bending beam test series was done according to the RILEM recommendation with using steel and synthetic fibre reinforcement in concrete beams. The effect of the loading rate was investigated during the research. The beams were loaded with the standardized 0.2 mm/min speed and with a maximum loading capacity of the machine, i.g. 900 mm/min. The behaviour of the beams changed with both fibre reinforcement if the loading speed was increased. Using synthetic fibre reinforcement, the elastic modulus and the residual flexural strength of the SYFRC beams increased, but the value of the peak load was lower than with the low loading rate. Also, the capacity at 0.5 mm CMOD almost reached the performance of the SFRC at low speed. The residual flexural strength of the SFRC also increased, but not as significantly as in the case of SYFRC. With steel fibres the elastic modulus of the FRC decreased significantly.

The research showed that the effect of the loading rate is significant for steel and synthetic fibre reinforced concrete. The fibre reinforced concrete's capacity increased in both cases and it can be seen that the structures under high speed loading have a higher capacity than in static loading.





FC 2017
9th International Conference
FIBRE CONCRETE 2017
September 13-16, 2017
Prague, Czech Republic

CZECH TECHNICAL UNIVERSITY IN PRAGUE
Faculty of Civil Engineering
Department of Concrete and Masonry Structures