DEFORMATION PROPERTIES AND TESTING OF SYNTHETIC FIBRES

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Abstract

Structural members that are primary non-loadbearing (e.g. lining panel) are sometimes designed for residual tensile strength (i.e. tensile strength after cracking). Members designed in this way are more economical than members without cracks. For this reason behaviour of FRC member after cracking must be dealt with. Synthetic fibres have lower tensile strength and modulus of elasticity than steel fibres and that is why they have bigger deformations than steel fibres.

The article is focused on tensile and deformation properties of synthetic fibres, which are commonly used in Czech Republic. Further results of deformation properties of cement-based composite reinforced by synthetic fibres are presented in the article.

Keywords: fibre reinforced concrete, synthetic fibres, creep, long-term loading, tensile test of fibres

1. Introduction

Fibre reinforced concrete – material which is becoming well known in engineering community recently. The structural use of fibre reinforced concrete is becoming more common. Its outstanding tensile and compressive characteristics are a big advantage. Thanks to possibility of minimising or omitting of conventional rebar reinforcement the benefit is also economical with regards to price, life cycle and durability of the structure. The material is interesting also because of its tensile and deformation properties after creation of macrocrack. These properties are attractive with respect to efficiency of fibre reinforced structures. The properties must be inquired into especially for fibre reinforced concretes with synthetic fibres. The reason is higher deformation, lower tensile strength and lower elastic modulus compared to steel fibres. Tests and results of deformation characteristics of fibre reinforced concretes with synthetic fibres are presented in subsequent items. Tensile test of particular fibres are presented as well.

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2. Deformation properties of cement-based composite

The issue has not been investigated yet so the methodology of testing and measurement of creep of fibres had to be prepared. The experimental program is realised in cooperation with VŠB TU Ostrava where are performed the experiments proposed by Department of Concrete and Masonry Structures from CTU in Prague.

Four samples were manufactured with dimensions 150x150x700 mm (see *Fig. 1:*). The samples have the same composition and the same dosage of fibres. Fibres of producers FORTA FERO (FF), BENESTEEL (BS), STRUX (D) were used and waste fibres manufactured by fibrillating of PET bottles (PET). The PET fibres were tested to verify properties of the waste material and find possible utilisation of PET fibres in construction industry. The tests showed that PET fibres are problematic in terms of anchoring of fibres in the cement matrix.

Fig. 1: Picture of the manufactured specimens 150x150x700 mm

The specimens were cut after 28 days to quarters. Thus the resulting dimensions of the specimens are 75x75x700 mm. The cutting was performed to decrease the needed force in the long-time loading.

Fig. 2: Picture of the specimens for experiments 75x75x700

A macro-crack was created in each test specimen before the long-term load is applied. The macro crack was created in a three-point bending test. The load in the three-point bending was applied until the deflection 10 mm was reached. This value was determined in previous experiments. The main criteria were sufficient crack width and sufficient load-bearing capacity of the disturbed specimen for the long-term loading.

Fig. 3: Creating of a flexural macro-crack in a three-point bending test

Fig. 4: Control measuring of the crack width after three-point bending test

The specimens are loaded and the deflection is measured by the electronic gauge. After a required 10 mm deflection is reached the flexural test is interrupted and the specimens are equipped for the long-term testing and loaded with the long-term load (see *Fig. 5:*).

Fig. 5: Specimens with long-term load

Creating of the crack and loading of specimens was performed in set containing four specimens (each specimen in a set had different type of fibres) FORTA FERO (FF), BENESTEEL (BS), STRUX (D) a PET bottles (PET). Several days elapsed between setting of sets. The picture of the measurement of deflections is in the Fig. 6: and Fig. 7: .

Fig. 6: Measuring of the initial deformation before the long-term loading of the specimen

Fig. 7: Measuring of the increase of deformation

3. Testing of synthetic fibres

The tensile tests were performed on tear machine FP 10/1 with maximum force 10 kN and movement rate 5mm/min [4].

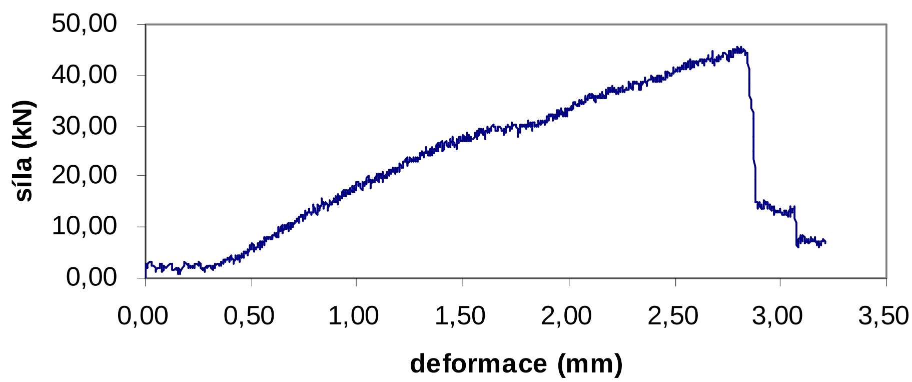

Fig. 8: Diagram of tensile strength of fibre FORTA FERRO

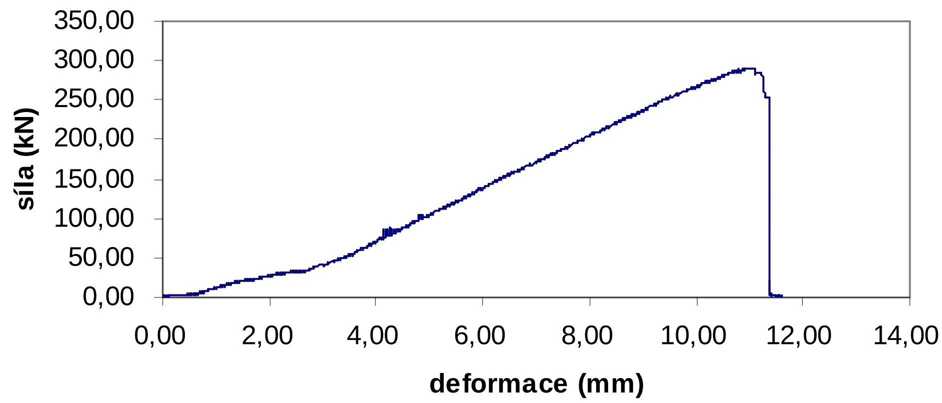

Fig. 9: Diagram of tensile strength of fibre BENESTEEL

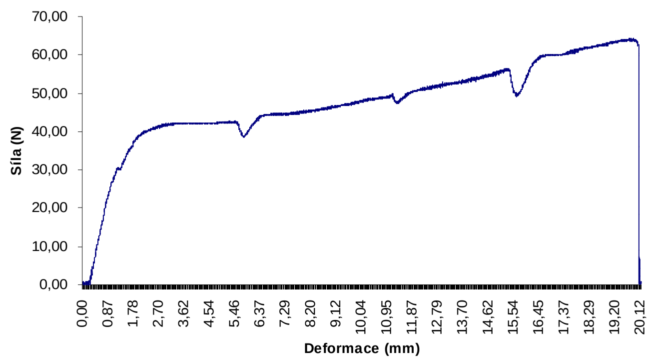

Fig. 10: Diagram of tensile strength of fibre from PET bottle, width 2,15mm

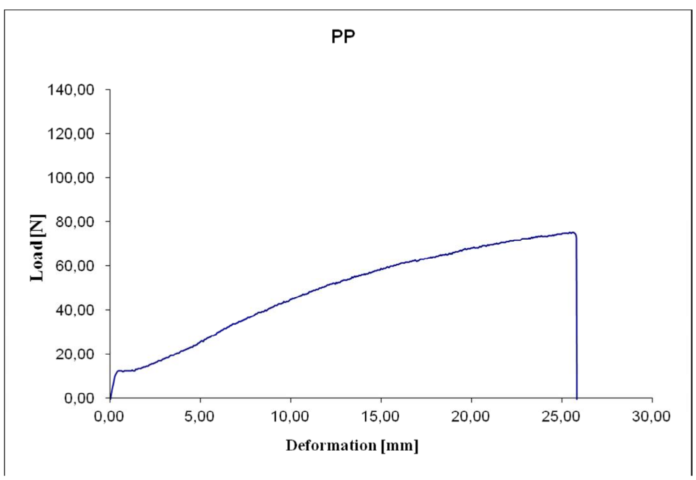

Fig. 11: Diagram of tensile strength of PP fibre (originally intended for brooms)

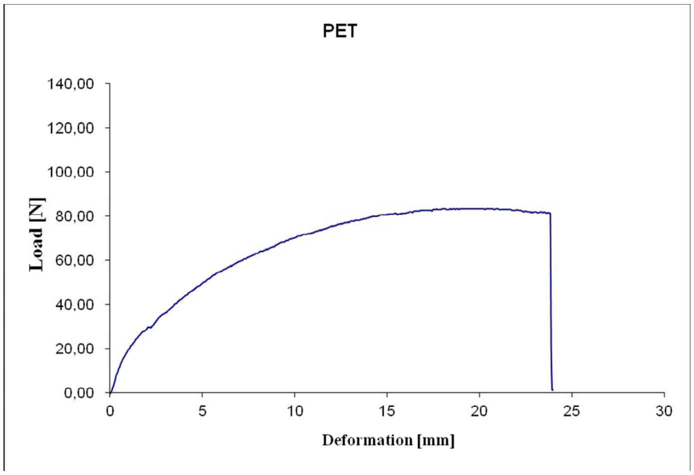

Fig. 12: Diagram of tensile strength of PET fibre (originally intended for brooms)

4. Results

In the paper a new methodology of testing of long-term behaviour of FRC with synthetic fibres is presented. The pilot sets of specimens proved the feasibility of the testing procedure. The specimens with different types of synthetic fibres were tested with the established testing procedure. The results of the first 285 days of the measurement are shown in Table 4. The measured values show increasing deflection of the specimen, what confirms the theory of the long-term deformation of FRC with synthetic fibres. The measured values also show different creep of different types of fibres.

Real process of the method and comparable results confirm that the method is suitable for investigating the long-term behaviour of synthetic fibres.

Table 1: Results of testing of pilot sets of specimens

Fibres	Specimen	Specimen deflection during the bending test in the time of … … creation of a flexural crack [mm]	… activation of fibres going through the crack [mm]	Long-term loading values [kg]	Specimen deflection during the long-term measurement: Before loading [mm]	After loading, Days: 0 [mm]	25	80	110	126	133	178	200	235	265	285
FF	1	0,36	1,25	-												
	2	0,24	1,00	52,1	0,91	1,63	2,15	3,38	3,65	3,78	3,81	3,87	4,50	4,59	collapsed	
	3	0,98	1,53	58,3	1,77	-	2,00	3,52	3,76	3,87	3,92	4,20	4,42	4,94	collapsed	
	4	0,48	0,92	35	1,61	-	no measurement									
BS	1	0,33	1,15	-												
	2	0,25	1,10	49,2	0,72	1,70	1,75	1,80	1,85	2,21	2,27	2,32	2,41	2,55	2,55	2,55
	3	0,86	1,64	55,3	1,71	-	2,05	2,88	3,18	3,31	3,46	4,14	4,35	4,85	4,84	terminated
	4	0,72	0,99	45	1,13	-	-	1,63	1,48	1,61	1,67	2,02	terminated			
D	1	0,46	1,20	-												
	2	0,39	1,15	81,4	0,49	0,82	0,86	1,01	1,11	1,18	1,24	1,24	1,24	1,49	1,60	1,77
	3	0,34	0,94	76,3	1,87	-	2,06	3,09	3,11	3,12	3,34	4,02	4,26	4,83	collapsed	
	4	0,49	1,02	96,5	1,32	-	no measurement									
PET	1	0,52	1,75	-												
	2	0,25	1,05	9,4	0,88	1,05	1,10	1,25	1,68	1,75	1,96	2,04	2,22	2,22	collapsed	
	3	0,94	1,58	27,5	1,72	-	1,86	1,96	2,03	2,07	2,22	2,57	2,63	2,08	2,96	terminated
	4	0,90	1,53	27	0,42	-	-	1,51	collapsed							

5. Conclusions

The results show that residual strength of fibre reinforced concrete with synthetic fibres is an important property of the material. A new type of fibres (PP and PET; originally intended for brooms) was verified in tensile tests; in further stage these fibres will be used as dispersed reinforcement in tested prisms. Thanks to their surface finish bond with cement matrix should be better and the durability shall be positively affected.

Acknowledgements

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