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SYNTHETIC FIBRES WITH IMPROVED ANCHORING IN CONCRETE

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Abstract

Synthetic macro-fibres for lower strength concrete class used for ground floors. Polymer fibres made from recycled PP, pure PP, pure PP/PE, recycled PET and PES. Anchorage improvement of the polymer fibre in concrete by corrugating shape (sinusoidal wave). Flexural toughness obtained from test methods by Japanese standard and. prEN 14845-2:2005.

Keywords: synthetic polymer macro-fibres for concrete

1 Introduction

Fibre reinforced concrete with steel fibres in the Czech Republic has quite a long history thanks to the research made at CTU in Prague. With the synthetic macro-fibres for concrete the history is shorter. At the beginning of the century we introduced to the Czech market structural synthetic fibres BeneSteel 80/55. These fibres are made from a blend of polypropylene and polyethylene, they have a very high tensile strength (660 MPa) and their shape is specially designed to match the concrete technology demands. However the BeneSteel fibres are mostly used in concrete industrial ground floors where lower strength concrete is more commonly used. The practice in Czech Rep. is to use the concrete strength classes C 20/25, occasionally C 25/30 and also C 16/20. In such low strength concrete the high tensile strength of the fibres is not fully exploited and great parts of the fibres are pulled out from the cracked concrete by mode c in Fig. 1.

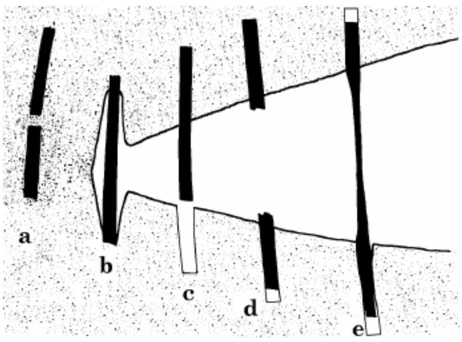

Fig. 1 Fibre engagement in crack crossing

Fig. 2 Pulled fibres on the sample surface

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For synthetic fibres the anchorage mechanism seems to be the first problem to be solved. The second one is to ensure regular and easy distribution of the fibres in a concrete volume. And finally the cost of the synthetic fibres reinforcement should be competitive to all other ways of concrete reinforcing.

2 Tested polymer fibres

2.1 Material base

We limited the material base in our research to several types of polymers only: to those which are the most common on the market. We selected polypropylene (PP), blend of polypropylene and polyethylene (PP/PE), PET and polyester (PES). For our research purposes fibres from the following kinds of polymers were produced:

- recycled substandard PP,
- pure special PP for draw fibres,
- blend of pure PP and PE,
- recycled PET (polyethylene terephtalate) from bottles
- and PES with high crystalline contend.

All these polymers are of those mentioned in European Standard EN 14489-2:2006 Fibres for concrete – part 2: Polymer fibres – Definitions, specification and conformity

PP and PP/PE fibres are well known and our results show no surprise. The gradation in tensile strength of the fibres is from the lowest: substandard PP→ recycled PET → pure PP → pure PP/PE → PES.

Modulus of elasticity of the fibre is of great importance. Tested fibres are low modulus fibres and it was suspected to be valid for all polymers. But fibres made from PES showed an important difference compared to the other tested fibres. The PES fibre exhibited a higher modulus of elasticity in the beginning of the load to elongation curve (see Fig. 3 and 4) which is significant for good fibre efficiency in concrete.

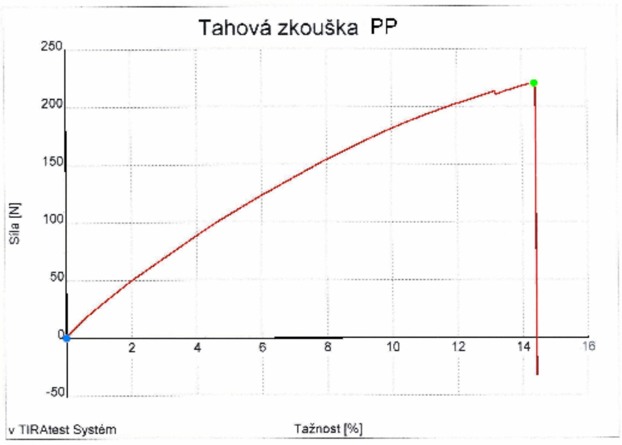

Fig. 3 Tensile load to elongation PP

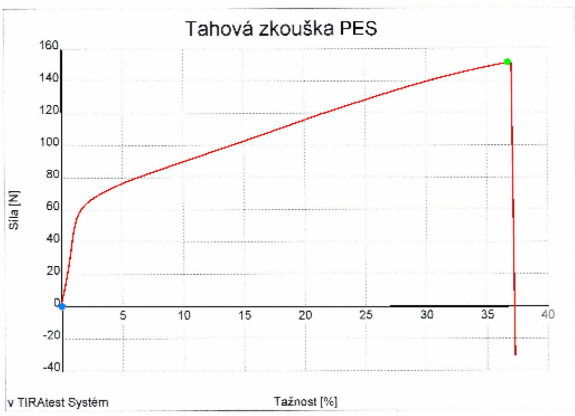

Fig. 4 Tensile load to elongation PES

2.2 Shape – anchorage mechanism

All tested fibres had a round cross section and were deformed to have a sinusoidal wave shape. The frequency and amplitude of the waves were verified by pull-out test. The test were carried out on PP corrugated fibres. PES fibre is supposed to have even better anchorage because of its water absorbtion rate 0,15%.

Fig. 5 BeneSteel W pull-out test

2.3 Packing of the fibres

Easy mixing of the fibres and uniform distribution in concrete is a fundamental requirement. That is why we have a unique two step way of introducing the fibre into concrete. The bundle of the fibres of diameter 5 cm approx. is wrapped in water dispersible foil. Several tens of such bundles are added into the concrete and mixed. Only then the foil begins to dissolve and the number of fibres multiply to tens of thousands of individual fibres (see Fig. 6 and 7)

Fig. 6 BeneSteel W (PP) –50 mm

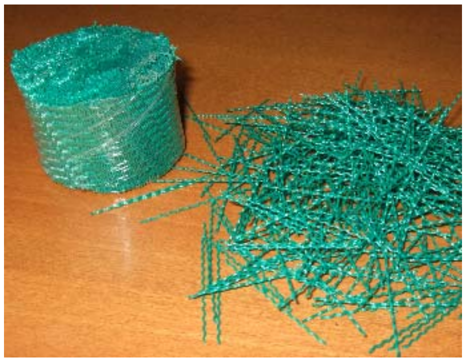

Fig. 7 BeneSteel W (PES) –40 mm

3 Effect on concrete

The flexural toughness of the BeneSteel W fibre reinforced concrete was tested in the Laboratory of building materials VŠB TUO. Up to February 07 six beams 150 x 150 x 600 mm were cast and tested using substandard PP, pure PP and PP/PE fibres. The tests were done mostly with 50 mm long fibres. One set of 6 pcs with 30 mm fibres and one set was prepared with hybrid fibres – blend of 4,40 kg/m^3 BeneSteel W (PP/PE)–50 mm and 0,6 kg/m^3 of alkaliresistant glass fibre ANTI-CRAK HD. The fibre dosages used are shown in table 1. All together 60 beams were tested. The concrete mix design has been chosen to be comparable to the mix proportion used in the test programme described in [1] and at same time to be close to the concrete mix used in practice in ground floors in Czech Rep.

Material	Quantity
Cement Hranice Cem32,5 R B-S	290 kg/m^3
Sand 0-4 Tovačov	946 kg/m^3
Crushed stone Hrabůvka 8-16	873 kg/m^3
Water	175 l
Plasticizer FM 787	2,44 kg/m^3
BeneSteel W (subst. PP, PP, PP/PE) 50 mm(30 mm)	3,0 4,4 5,0 and 6,0 kg/m^3
AR glass fibre ANTI-CRAK HD	0,6 kg/m^3

Table 1. Concrete mix proportions

Specimen and test machine configuration can be seen from the Fig. 8. The four-point bend test method used was by JSCE – SF4 and prEN 14488-3:2006.

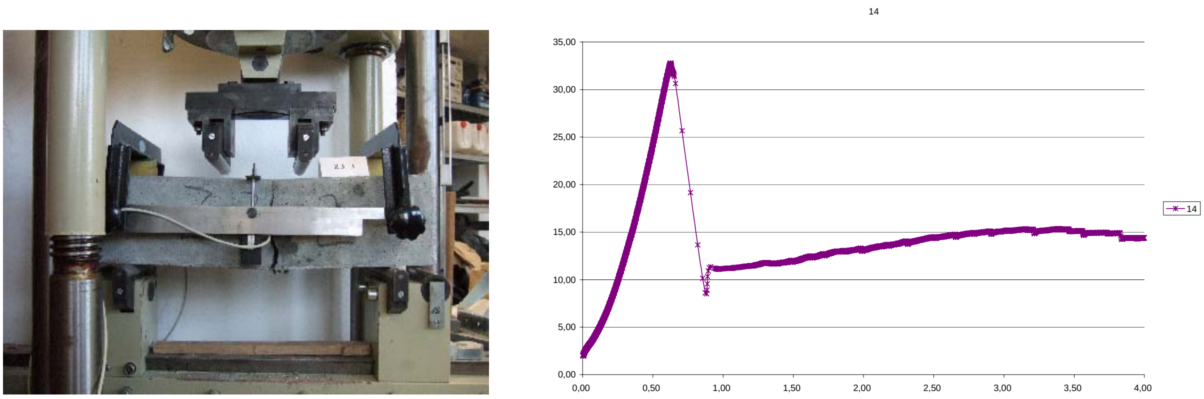

Fig. 8 Four-point bending test configuration and typical load deformation curve for mix with 5 kg/m^3 of BeneSteel W (PP/PE) – 50 mm

4 Conclusions

The result of the test programme verified that the wave (corrugated) shape of synthetic macro-fibre improves the anchoring capacity of the fibre. The two step process of incorporating fibres during mixing should be a great advantage for routine work on site. The PES fibres showed promising properties following research based on prEN 14845-2:2005 Test methods for fibre in concrete – part 2. Its effect on concrete should be investigated further.

Aknowledgements

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References

[1] Beneš T., Vařeka B.: *Vláknitá výztuž pro průmyslové podlahy,* Sborník příspěvků ke konferenci 10. Betonářské dny 2003, ČBS, Pardubice 2003