RESEARCH OF PROPERTIES OF STEEL FIBER CONCRETE DEPENDING ON KIND OF STEEL FIBER

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KEYWORDS: Steel turning fiber, steel wire fiber, steel sheet fiber, steel milling fiber, steel fiber concrete, properties, comparative estimation, mathematical evaluation.

SUMMARY: The properties of steel fiber concrete and constructions with its application depend on quantity and quality of a steel fiber. The given operation is devoted to research of properties and definition of rational area of application of a building composite - steel fiber concrete, prepared with application of four types fiber: wire smooth (base variant), turning, sheet with anchors on the ends and steel milling fiber.

INTRODUCTION

The world and domestic research practice, experimental and practical use of construction composite steel fiber concrete showed high efficiency, reliability and durability of construction made of it. Composite nature of the material allows adjusting its properties within enough wide range. But even more effect can be reached by SFC properties control.

Besides other factors SFC and constructions with SFC characteristics depend on quantity and quality of steel fiber. Fiber – steel fiber – is determined by geometry (d₀, l₀), section shape, configuration, temporary resistance to tension (Rₛₜ₀), modulus of elasticity (Eₛ), ability to provide cohesion with concrete matrix (the condition of the surface, presence of anchors), production technology and price.

MODELING

In order to study the properties of SFC made out of four different kinds of fiber and to determine the rational field of its application, experimental and theoretical research is conducted, which includes:

- Production of experimental samples in small quantities (cubes 10*10*10 cm, beams 10*10*40 cm and small beams 4*4*16 cm);
- Sample testing in order to determine temporary resistance to pressure (Rₛₚ), bend tension (Rₛₜ), and cleaving tension (Rₛₜ₉₀), as well as modulus of elasticity (Eₛ) and modulus of complete deformation (Eₛₜ₉₀), Poisson coefficient (µ), maximum tensility (εₛₜ₉₀) and compressibility (εₛ₉₀) of material depending on kind of fibers;
- Mathematical evaluation of testing results for making the models of dependence of durability and deformation properties of SFC on kinds of fibers taking into account samples geometry and its correlation with parameters of fiber reinforcement, and control of adequacy and statistical evaluation of mistake;
- Formulating of suggestions on rational application each kind of fiber for specific kind of SFC design.

Smooth wire fibers, sheet fiber with anchors in the ends, milling and turning fiber were used in the research (Table 1). Percentage by volume of fiber reinforcement equal to 1.0 and 2.0 were assumed in research.

Out of listed types of fiber primary attention is given to study of characteristics of SFC reinforced with turning fiber.

Table 1: Characteristics of Steel Fiber

<table>
<thead>
<tr>
<th>Kind of Fiber</th>
<th>Diameter of fibers d, mm</th>
<th>Length of fibers l, mm</th>
<th>Length/Diameter l/d,</th>
<th>Calculated resistance R_{s,f}, MPa</th>
<th>Modulus of elasticity, E_{s,f}, MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Turning</td>
<td>0.24</td>
<td>20</td>
<td>83</td>
<td>400</td>
<td>2.0*10^5</td>
</tr>
<tr>
<td>Wire</td>
<td>0.39</td>
<td>32</td>
<td>82</td>
<td>500</td>
<td>2.0*10^5</td>
</tr>
<tr>
<td>Sheet</td>
<td>0.60</td>
<td>35</td>
<td>58</td>
<td>400</td>
<td>2.1*10^5</td>
</tr>
<tr>
<td>Milling</td>
<td>0.60</td>
<td>34</td>
<td>57</td>
<td>300</td>
<td>1.8*10^5</td>
</tr>
</tbody>
</table>

Turning fiber is worked out by the specialists of Saint-Petersburg Technical University and is of special interest, since it can be produced in the process of turning machining of parts, which provides not so high cost while having very good physical and mechanical characteristics of SFC. In publications and research authors have data on the use of different types of fiber, primarily wire fiber. Data on SFC with turning fiber is very scarce.

As raw material for preparation of a SFC mix were used cement Î500 of a Iskitim cement factory, sand with gradation factor 2 of Shulginsk opencast with the characteristics: bulk density 1.57 t/m^3, true density 2.74 t/m^3, hollowness - 43 %.

All samples for testing were made of the same materials. Their preparation, hardening and testing was held under the same conditions. The class of a concrete matrix was accepted Â30. A ratio of components of a concrete matrix of fine-grained concrete and control concrete was accepted constant: Cement: Sand =1:2, W/C = 0.44. On everyone SFC batch control concrete samples of the same structure are made. Laboratory samples hardened in normal conditions, at t = 18 ±3°Ñ and humidity 100 % current 28 day. After a set of durability samples were kept in air dry conditions.

**RESULTS**

SFC tests on compression were held. During the tests observations of nature of failure of the samples with SFC were held: samples with wire and turning fiber failed smoothly and viscously without sample loosing its shape; samples with milling fiber failed with fragility with typical crack and significant failure; the nature the samples with sheet fiber reacted occupied the middle position between the samples with wire and milling fiber.

The results of tests have shown an insignificant incremental of density SFC in comparison with control concrete, which has made from 2% up to 5%. Some growth of density with increase of the fiber contents was observed for all fiber types, of exception milling fiber. However strength characteristic of SFC with milling fiber had thus the tendency of growth.
Table 2. Average values of density SFC depending on a fiber type and percent of an armoring

<table>
<thead>
<tr>
<th>Fiber type</th>
<th>Average density SFC $\rho_f$ ± m (kg / m$^3$) at volumetric percent of an armoring</th>
<th>$\mu$=1.0 %</th>
<th>$\mu$=1.5 %</th>
<th>$\mu$=2.0 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheet</td>
<td></td>
<td>2266,64 ± 162</td>
<td>2275,63 ± 162</td>
<td>2304,64 ± 170</td>
</tr>
<tr>
<td>Turning</td>
<td></td>
<td>2275,55 ± 170</td>
<td>2266,74 ± 169</td>
<td>2307,26 ± 171</td>
</tr>
<tr>
<td>Milling</td>
<td></td>
<td>2261,19 ± 162</td>
<td>2258,48 ± 158</td>
<td>2063,97 ± 148</td>
</tr>
<tr>
<td>Wire</td>
<td></td>
<td>2279,57 ± 171</td>
<td>2281,71 ± 162</td>
<td>2304,89 ± 178</td>
</tr>
</tbody>
</table>

Table 3: Tension durability of SFC depending on kind of fiber and portion of reinforcement

<table>
<thead>
<tr>
<th>Percentage by volume of reinforcement, $\mu$</th>
<th>Durability of SFC at compression $R_f$ ± m (MPa) for fiber</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Turning</td>
</tr>
<tr>
<td>1,0</td>
<td>49,06 ±1,02</td>
</tr>
<tr>
<td>2,0</td>
<td>57,65 ±1,20</td>
</tr>
</tbody>
</table>

Mathematical evaluation of testing results was done using the special software, which allowed besides basic statistical procedures to analyze the properties of SFC depending on discrete and continuous parameters.

CONCLUSION

The comparative analysis of results of tests SFC on durability with different fiber's types has shown, that the incremental of durability SFC on compression ($R_f$) in the ratio with durability of control concrete ($R$) has made 10-50%, that corresponds to the literary data. Comparison SFC durability characteristics with wire fiber (the base variant) with the similar SFC characteristics with other types of fiber has shown some excess of the SFC characteristics at 1% of an armoring of a material with sheet fiber, small difference - with turning fiber and lowest parameters of a material with milling fiber.

Preliminary results of SFC compression testing (Table 2,3) showed that nature of SFC reinforced with turning fiber and its durability characteristics allow supposing the wide use in the future of such kind of fiber for important construction elements, particularly bridges. The same is true for SFC with milling fiber that can be used in constructions that undertake static load. SFC with sheet fiber needs further research.

REFERENCES