Fiber Concrete on Composite Knitting and Industrialsand KMA for Bent Designs

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Abstract: In article questions of application of a steel fiber for disperse reinforcing of fine-grained concrete are considered. As knitting was floured cement and knitting low water requirement. Main filler of a fiber concrete mix was the KMA industrial sand enriched with Tavolzhansky sand. The carried-out researches showed advantage of a steel wave fiber before the anchor and flat milled. It is established that application composite knitting and high density packing of grains of filler considerably is increased by indicators of durability. Rational selection of filler allowed to receive on the KMA industrialsand steel fiber concrete with strength at compression– 84.8MPa, at a bend of 19.8 MPa for bent designs.

Key words: Fine-grained concrete • Industrialsand • Fiber concrete

INTRODUCTION

Today high-strength and high-quality concrete by V.P. Nekrasov at the beginning of the XX century. In Russia, the basis of knowledge about steel fiber concrete was created by scientists: U.M. Bazhenov, I.V. Volkov, V.P. Vylekzhanin, L.G Kurbatov, I.A. Lobanov, A.P. Pavlov, U.V.Pukharenko, F.N.Rabinovich, V.P. Romanov, K.V. Talantova, G.K. Haydukov, O.N. Hegay, etc. [7-12]. Scientists of Austria, Australia, Belgium, Germany, Holland, Spain, Canada, China, Poland, the USA brought in science development about steel fiber concrete a big contribution, France, the Czech Republic, Switzerland, the Republic of South Africa, Japan and other countries, from them it should be noted J.P. Romualdi, B. Gordon, G.B. Batson, M. Jeffrey, L.A. Mandel, I.L. Carson, W.F. Chen, D.I. Hannant, B. Kelly, P.S. Mangat, A.E. Naaman, R.N. Swamy, D. Colin Johnston, D.R. Lankard, V. Ramakrishnan, G. Ruffert, K. Kordina, W.A. Marsden, J. Vodichka, etc. [13-19].

The researches devoted to disperse reinforced concrete were executed by the Russian engineer of V.P. Nekrasov at the beginning of the XX century. The researches devoted to disperse reinforced concrete were executed by the Russian engineer of V.P. Nekrasov at the beginning of the XX century. In Russia, the basis of knowledge about steel fiber concrete was created by scientists: U.M. Bazhenov, I.V. Volkov, V.P. Vylekzhanin, L.G Kurbatov, I.A. Lobanov, A.P. Pavlov, U.V.Pukharenko, F.N.Rabinovich, V.P. Romanov, K.V. Talantova, G.K. Haydukov, O.N. Hegay, etc. [7-12]. Scientists of Austria, Australia, Belgium, Germany, Holland, Spain, Canada, China, Poland, the USA brought in science development about steel fiber concrete a big contribution, France, the Czech Republic, Switzerland, the Republic of South Africa, Japan and other countries, from them it should be noted J.P. Romualdi, B. Gordon, G.B. Batson, M. Jeffrey, L.A. Mandel, I.L. Carson, W.F. Chen, D.I. Hannant, B. Kelly, P.S. Mangat, A.E. Naaman, R.N. Swamy, D. Colin Johnston, D.R. Lankard, V. Ramakrishnan, G. Ruffert, K. Kordina, W.A. Marsden, J. Vodichka, etc. [13-19].

However, above-mentioned researches were carried out on cement and quartz sand. In this work as the main filler it is offered to use the KMA industrialsand – elimination of crushing of a quartzitesandstone (elimination of crushing of QSS) and as knitting – knitting low water requirement (KLWR-70) and floured cement (FLC-70).
Table 1: Physico-mechanical characteristic of fillers

<table>
<thead>
<tr>
<th>Indicator name</th>
<th>Crushing elimination QSS</th>
<th>The Tavolzhansky sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module of coarseness</td>
<td>3.50</td>
<td>1.38</td>
</tr>
<tr>
<td>Bulk density, kg/m³</td>
<td>1490</td>
<td>1448</td>
</tr>
<tr>
<td>True density, kg/m³</td>
<td>2710</td>
<td>2630</td>
</tr>
<tr>
<td>Hollowness, %</td>
<td>47.8</td>
<td>44.9</td>
</tr>
<tr>
<td>Water requirement, %</td>
<td>5.5</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 2: Physicomechanical characteristics of the composite knitting

<table>
<thead>
<tr>
<th>Activity</th>
<th>CEMI 42,5H</th>
<th>FLC – 70</th>
<th>KLWR -70</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name of the knitting</td>
<td>The specific surface, sq.m/kg</td>
<td>H17, %</td>
<td>Beginning of a setting, hour</td>
</tr>
<tr>
<td>CEMI 42,5H</td>
<td>320</td>
<td>25.2</td>
<td>2.30</td>
</tr>
<tr>
<td>FLC – 70</td>
<td>504</td>
<td>23.8</td>
<td>2.15</td>
</tr>
<tr>
<td>KLWR -70</td>
<td>520</td>
<td>22.5</td>
<td>1.50</td>
</tr>
</tbody>
</table>

The main objective of this work is development of principles of design and production technologies of the disperse reinforced fine-grained concrete taking into account features of mineralogical structure, a structure and properties of industrialsand.

Properties of industrialsand, concrete mixes and concrete on their basis depend on many factors caused by properties of initial breeds, ways of their crushing and methods of enrichment of the received product. The most essential influence is rendered by durability, structure and breed structure. By comparison of properties of natural and industrialsand attract attention the main, basic distinctions of these materials. If the first are generally quartz, with a roundish form of grains and a smooth surface, the second have essential distinctions on structure and properties of initial breeds, a form of grains and a roughness of their surface (Fig. 1).

Knitting floured cement (FLC-70) received by grinding to a specific surface of $S_{con}=500$ of m$^2$/g a Portland cement of CEM I of 42,5 N. Knitting low water requirement (KLWR-70) received by a joint grinding to a specific surface of 500 m$^2$/kg a Portland cement and water

Fig. 1: Grain: a) industrial sand; b) natural sand
reducing admix SP-1 in an optimum dosage. The main characteristics of developed knitting (Table 2) were defined. Apparently from results of researches knitting KLWR-70 it is characterized by higher activity in comparison with CEM I cement of 42,5 N and FLC-70.

On SEM-pictures borders between particles and a time (Fig. 2) that favors to carrying out the quantitative analysis of a microstructure accurately differ.

For the purpose of an assessment of possibility of application of an optimum type of a fiber by production high-quality fine-grained steel fiber concrete structures in which as filler elimination of crushing of a quartzitic sandstone was applied were developed. For optimization of structure of a matrix and receiving high density packing of grains of filler Tavolzhanskysand was entered into composition of concrete. As the knitting CEM I of 42,5 N, FLC-70 and KLWR-70 were applied.

Also three types of a fiber were entered into structures (Fig. 3):

- Fiber steel, wavy length of 30 mm, diameter of 0,8 mm;
- Fiber steel, anchor length of 50 mm, diameter of 0,8 mm;
- Fiber steel flat length of 32 mm, width of 3,2 mm.

Pilot studies were connected with studying of behavior of concrete elements, disperse reinforced by a steel fiber at definition of mechanical strength and deformation characteristics.

Fiber concrete mix prepared in two stages. In the beginning received a concrete mix in a mortar mill. Mixing dry components was originally made, then small portions shut water. Hashing lasted 5-10 minutes depending on a mix consistence.

At the second stage reinforcing was carried out. For this purpose experimentally defined the quantity of a concrete mix necessary for formation of one sample. Further in the prepared concrete mix the fiber which has been in advance measured according to percent of reinforcing was added.
Table 3: Results of tests of fine-grained concrete samples, including disperse rein for ced by a steel fiber

<table>
<thead>
<tr>
<th>The defined characteristic</th>
<th>Dimension</th>
<th>Without a fiber</th>
<th>The flat milled</th>
<th>The anchor</th>
<th>The wave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kubikovy durability MPa</td>
<td></td>
<td>50,2</td>
<td>56,3</td>
<td>55,8</td>
<td>57,4</td>
</tr>
<tr>
<td>The prismatic durability MPa</td>
<td></td>
<td>35,0</td>
<td>39,2</td>
<td>38,7</td>
<td>39,9</td>
</tr>
<tr>
<td>Durability on stretching at bend MPa</td>
<td></td>
<td>13,7</td>
<td>15,9</td>
<td>16,6</td>
<td>16,8</td>
</tr>
<tr>
<td>Elasticity module MPa</td>
<td></td>
<td>35,8</td>
<td>41,1</td>
<td>39,8</td>
<td>41,7</td>
</tr>
</tbody>
</table>

Table 4: Physicomechanical characteristics of fine-grained concrete, reinforced by a steel fiber

<table>
<thead>
<tr>
<th>Look the knitting</th>
<th>The knitting</th>
<th>Crushingelimination KBP</th>
<th>The Tavolzhansky sand</th>
<th>Water</th>
<th>Steel wave fiber</th>
<th>Durability of blocks, MPa</th>
<th>Prismaticdurability, MPa</th>
<th>Durability on stretching at a bend, MPa</th>
<th>Moduleofelasticity, Mpa</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEMI 42,5H</td>
<td>510</td>
<td>1180</td>
<td>555</td>
<td>170</td>
<td>-</td>
<td>50,2</td>
<td>35,0</td>
<td>13,7</td>
<td>35,8</td>
</tr>
<tr>
<td>CEMI 42,5H *HDP</td>
<td>510</td>
<td>1185</td>
<td>555</td>
<td>172</td>
<td>72</td>
<td>56,5</td>
<td>38,7</td>
<td>14,2</td>
<td>40,8</td>
</tr>
<tr>
<td>CEMI 42,5H</td>
<td>510</td>
<td>1180</td>
<td>555</td>
<td>172</td>
<td>72</td>
<td>57,4</td>
<td>39,9</td>
<td>16,8</td>
<td>41,7</td>
</tr>
<tr>
<td>FLC-70</td>
<td>510</td>
<td>1180</td>
<td>555</td>
<td>160</td>
<td>72</td>
<td>63,4</td>
<td>44,6</td>
<td>17,4</td>
<td>41,9</td>
</tr>
<tr>
<td>FLC-70 *HDP</td>
<td>510</td>
<td>1185</td>
<td>555</td>
<td>162</td>
<td>72</td>
<td>69,7</td>
<td>48,6</td>
<td>18,2</td>
<td>43,1</td>
</tr>
<tr>
<td>KLWR-70</td>
<td>510</td>
<td>1180</td>
<td>555</td>
<td>150</td>
<td>72</td>
<td>76,2</td>
<td>53,2</td>
<td>19,1</td>
<td>43,6</td>
</tr>
<tr>
<td>KLWR-70 *HDP</td>
<td>510</td>
<td>1185</td>
<td>555</td>
<td>152</td>
<td>72</td>
<td>84,8</td>
<td>59,3</td>
<td>19,8</td>
<td>44,3</td>
</tr>
</tbody>
</table>

- - - - - *HDP – high density packing of grains fine-grained steel fiber concrete

Fig. 4: A microstructure of a contact zone a cement stone – a fiber:
a) on KLWR-70; b) on CEM I 42,5H

After that the mix mixed up in the mechanized way and in the manual kept within the cleared forms carefully oiled. Consolidation of a fiber concrete mix was carried out on a vibrating table before emergence of cement milk. After formation and consolidation samples were been at temperature not below 15°C within 24 hours. Then forms were removed and concrete samples were in the set chamber with temperature 20°C and humidity more than 90 % that corresponds to GOST requirements.

Test of samples for definition of above-mentioned characteristics were carried out by the universal test car by a standard technique. The concrete matrix for all types of a fiber was made of one composition of fine-grained concrete. Results of pilot studies are given in Table 3.

For 3 types of fibers 36 samples were tested. The analysis of Table 3 shows that steel fiber concrete with use of a wave fiber, as a reinforcing material, possesses the best mechanical strength characteristics. It is recommended to apply a wave fiber to further research of disperse reinforcing of fine-grained concrete [3].

The perspective direction of increase of efficiency fine-grained steel fiber concrete is application composite knitting. In this work as the composite knitting it is applied FLC-70 and KLWR-70 (Table 4).

Researchers showed expediency of use of high density packing of grains (HDP) of fine-grained concrete and disperse reinforcing for receiving high-strength steel fiber concrete.
Despite achievements of higher physico mechanical characteristics expediently application composite knitting such as FLC-70 and KLWR-70.

For studying of a microstructure of a contact zone of a steel wave fiber and a cement stone researches by means of SEM (Fig. 4) were carried out. Apparently from microstructure researches and also proceeding from results of tests and visual survey of samples after tests, a contact zone the composite knitting – the fiber has more dense communication and durability of coupling. The fiber in samples after tests had more equal appearance.

The microstructure a cement stone – a fiber has less strong interrelation. Structure of a contact zone friable, scaly. The fiber, in samples after tests on CEM I 42,5H, considerably differed from a fiber in the samples executed with application KLWR-70.

At the following investigation phase it is studied influences of a look knitting and genetic features of the main filler on durability and mechanical strength characteristics steel fiber concrete (Fig. 5).

Extent of hydration of studied structures estimated on change of intensity of reflections alite and belite (2,76 and 2,78 Å) in the field of interplane distances 20-32-33°, being the most informative for these systems.

The analysis is exemplary fine-grained steel fiber concretes on CEM I 42,5 showed that in it more clinker minerals, in comparison with a sample on KLWR-70 fine-grained steel fiber concretes remain. In fine-grained steel fiber concretes with high density packing on KLWR-70, in comparison with other samples, there was more complete hydration of initial clinker minerals. It allowed to receive concrete with the maximum durability, owing to the most optimum distribution of minerals in a sample body.

CONCLUSION

Possibility of increase of efficiency of the disperse reinforced fine-grained concrete at the expense of use of high density packing of grains of fine-grained concrete and application of the composite knitting is established. Rational selection of filler allowed to receive on the KMA industrialsand steel fiber concretes with strength that compression – 84,8MPa, at a bend 19,8Hha for bent designs.

The algorithm of calculation of multipurpose system «a clinker – a filler – filler – an organic additive – water» allowing to vary is developed by parameters by optimization of composition of fine-grained concrete for...
the purpose of increase mechanical strength, deformation and operational characteristics of a composite. Its realization in experimental conditions allowed to increase above-mentioned characteristics by 20-30 % [6].

The microreinforcing effect of a filler composite knitting at the expense of siliceous components of a matrix that speaks lengthening of habit of particles, a microroughness of a surface and high adhesion of particles of a filler to a cement stone which predetermines the best coupling of a cement stone with a fiber is revealed. External manifestation of this coupling is straightening of a wave fiber in a stretching zone.

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REFERENCES