Research Journal of Applied Sciences 10 (10): 696-701, 2015
ISSN: 1815-932X

The Development of Textile Fine-Grained Fiber Concrete Using Technogenic Raw Materials

Ruslan V. Lesovik, Sergey V. Klyuev, Alexander V. Klyuev,
Anatoly A. Tolbatov and Andrei V. Durachenko
Belgorod State Technological University Named after V. G. Shukhov, Belgorod, Russia

Abstract: The study discusses the use of textile mesh for the reinforcement of fine-grained concrete. The experimental studies of fiber-textile concrete samples were performed using cement and various aggregates. The needs for water and cement are established for various aggregates. The technology of fine-grained concrete reinforcement with a textile mesh is presented. The efficiency of fine-grained concretes with a textile mesh is proven experimentally. It is explained by the fact that the composite based on textile fiberglass mesh in a tension zone of the sample takes the tensile force almost completely due to the concentration of fibers in this area.

Key words: Fine fiber-textiles concrete, technogenic sand, strength, aggregates, fiberglass

INTRODUCTION

Concrete is one of the most common building mass materials the production of which is characterizes the level of civilization development to a certain extent. At the same time, concrete is an extremely complex composite material which, due to its multi-component structure, has a wide range of unique properties. High-strength concrete is one of concrete types with high physical and mechanical properties (Kluyev *et al*., 2010, 2012a, b; Lesovik *et al*., 2010). The scope of high-strength concrete use is wide (Fig. 1). This scope includes:

- The construction of tall buildings, skyscrapers and structures
- The construction of tunnels and bridges
- The construction of structures with a complex technical solution (domes, spheres, tents)
- The construction of critical technical facilities
- The use of high-strength concrete for the protection from radiation, etc.

Currently, the various national and international standards and codes present high-strength concretes in different ways. A promising trend for their production, as an international experience shows, is the micro reinforcement of concretes. A dispersed reinforcement or the reinforcement by a continuous fiber reinforcement provides a three-dimensional reinforcement of composites and enables to change the properties of the cement stone and other types of artificial composites fundamentally, providing them with a high fracture toughness, increasing the resistance to impact and dynamic loads, creating the necessary safety margin, while maintaining the integrity of design, even after the appearing of through cracks, to improve the abrasion wear, to prevent the peeling of a surface, etc. (Kluyev *et al*., 2012, 2013, 2014a; Klyuyev *et al*., 2013a; Lesovik *et al*., 2014a, b).

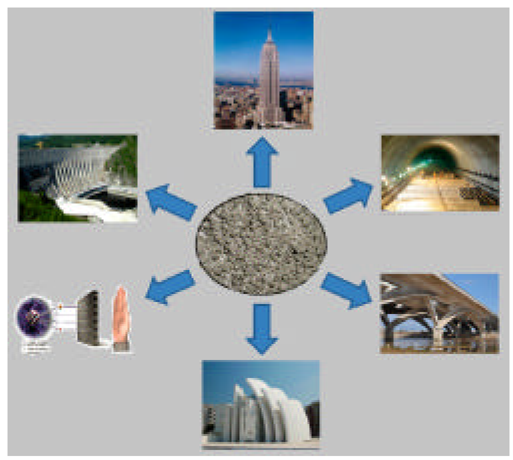

Fig. 1: The fields of high strength concrete application

MATERIALS AND METHODS

Main part: The use of textiles as the reinforcement for concrete is a relatively new area of research. The concrete reinforcement with textile structures has many advantages which allow to produce sufficiently thin

Corresponding Author: Ruslan V. Lesovik, Belgorod State Technological University Named after V.G. Shukhov, Belgorod, Russia

concrete elements because there is no risk of corrosion. Besides, the textile reinforcement is more flexible and drapeable. Therefore, the form of concrete elements may vary widely which allows the creation of sophisticated architectural forms and elements. The main advantages of textile-reinforced concrete are as follows:

- The absence of corrosion
- The creation of finer and lighter structures
- The ability to create complex shapes due to excellent drapability
- The ease of cloth handling
- Increased durability of a structure

The concrete, reinforced by fiber (2), has a lot of multidirectional fibers, a small part of which takes an effective load (Lesovik *et al*., 2014a; Kluyev and Lesovik, 2011, 2012; Kluyev *et al*., 2014b, c; Klyuyev *et al*., 2013b, 2014; Lesovik *et al*., 2014c, d, e). The reinforcement in textile-concrete (Fig. 2) may be directed and aligned. The protection of an reinforcing grid requires the concrete layer with the thickness of 3-4 mm, which allows to produce a 20 mm thick panel.

The proper implementation of the reinforcing strand properties in the concrete demands its orientation in the direction of a load impact. Therefore, there is a need to create the next structural level-textile fabric (Fig. 3). The structures of used fabrics also vary and may be used as woven and knitted. The vector of filaments in fabrics may be of two or three directions of stresses which is provided by using different types of reinforcing filaments in the structure of the same fabric. The primary purpose of such fabrics tend to be associated with mechanical, chemical and other properties.

Thus, the use of textile reinforcing fibers in the fine-grained concrete products allows to obtain composites with physical and mechanical and performance properties significantly superior of traditional concrete products that require an in-depth study and practical testing. The solution of overspending issue of a binder in fine-grained concretes is possible due to large-scale application of composite binders and man-made sands.

The obtaining of new generation high-performance binders is accompanied today by the use of components with complex compositions to obtain high-quality concrete of different functionality with an improved and sometimes with a certain, predetermined structure and fundamentally new properties. The basis for the creation of such binders is the principle of purposeful technology management during its all phases: the use of active components, the development of optimal compositions, the use of chemical modifiers, the use of mechanical and chemical activation of components and some other techniques.

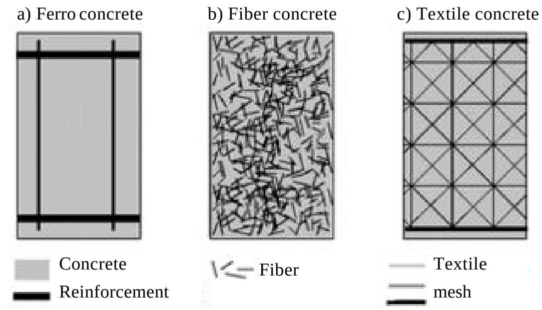

Fig. 2: Types of reinforcing concrete

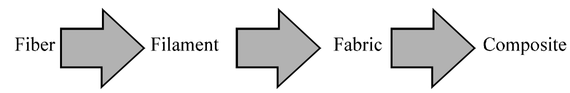

Fig. 3: Structural hierarchy of textile materials

RESULTS AND DISCUSSION

The study goal is the obtaining of efficient textile-concretes on the basis of man-made materials and composite binders. The analysis of existing data showed that the most tonnage and the least studied are man-made sands and the sands of mechanic origin. Pyrogenic sands are less common, the chemical and biogenic sands have a purely theoretical meaning.

Concrete is produced using many of additionally extracted rocks from the Kursk magnetic anomaly such as quartzitic sandstones, rarely met quartzites, granite-gneisses, amphibolites and schists. The most valuable raw material for the production of a concrete aggregate are quartzitic sandstones representing a monomineral rock of a fine-grained, massive, rarely coarse striped texture.

Technogenic raw materials, depending on the genesis of the rocks and the impact of different factors (the explosion during mining, crushing, grinding, physical, chemical and thermal effects during concentration) is different from a natural one by some significant features. The shape, surface morphology, the adhesion of the man-made sand aggregate are determined by genesis and as a result by the structural and textural characteristics as well as by mineralogical composition and typomorphic features of source rocks exposed to disintegration during technological redistribution.

The difference of man-made sands from natural ones is conditioned by technological operations, the genesis and the composition of original rocks, entails a number of fundamental changes in the parameters that influence the formation of man-made sands as highly energy components of curing systems. The use of such materials in building material science has its own specificity as in the process of raw mixture preparation and the synthesis of composites.

The significant difference is observed in the shape and surface morphology of the quartz particles in technogenic sands unlike natural quartz sand. If a natural quartz sand has a round shape with a smooth grain surface then the man-made sand has an angular shape with a high developed grain surface. This had an impact on the man-made sand surface activity. It was found out that the adhesion of a man-made sand to a cement stone is comparable to natural quartz sands and it is higher by 25-35%.

For the monolithic construction of buildings and facilities the used concretes should have high performance characteristics. In order to solve this issue, the compositions of fine grained concrete were developed using the siftings of quartzitic sandstone crushing as an aggregate produced by OJSC "Lebedinsky MPP" (Belgorod region) to obtain a more dense packing of the aggregate rich in sand of Shebekinsky deposit with the module size of 1.2 (Belgorod region) and composite binders. The main rock-forming mineral is quartz. According to chemical and particle size analysis the quartz content makes 73.4-95.0%.

The results of physical and mechanical tests for quartzitic sandstone of Lebedinsky field testify to their high quality. The rubble of quartzitic sandstone not exposed to weathering, it is characterized by high strength and density, not yielding the granite one and even surpassing it by some properties. It is used for the manufacture of traditional heavy concretes but in the process of rublle crushing 17% of fractions is developed the size of which is <5 mm. These quartzitic sandstone crushung siftings are characterized by high quartz content (94.56%) and it may be used as an aggregate for fine-grained concrete.

The analysis of KMA raw materials showed that the most promising aggregate for high quality rate fine grain is the sifting of quartzitic sandstone crushing produced by Lebedinsky deposits (Table 1).

The results of water and cement needs determination for various fractions are shown by Fig. 4 and 5. The studies of different sifting fractions influence on water and cement needs revealed that the most negative impact on these characteristics is performed by the fraction <0.315 mm, due to the fact that mica and hydromica contained in quartzitic sandstone during the process of crushing collapse and turn into dust-like fraction. An enriched sifting was used then without this fraction.

In order to obtain fine-grained fiber-textiles of concrete the use of high-level composite binders is necessary. CEM I 42,5N of OJSC "Belgorod cement" (Belgorod) production was used as the basis for these binders obtaining.

Not all fibers meet the requirements that apply to the concrete reinforcement. First of all, it is necessary to take into account such factors as strength, deformability,

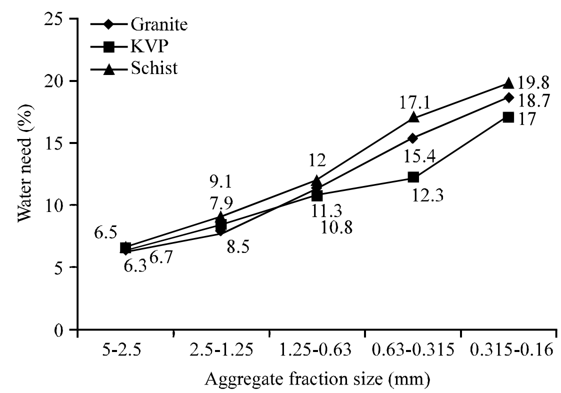

Fig. 4: Water need for different fractions of sifting

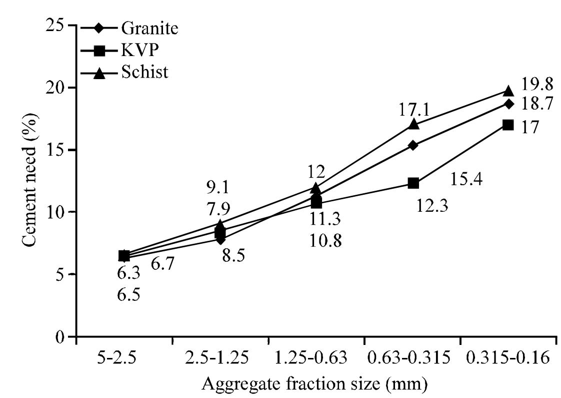

Fig. 5: Cement need for different fractions of sifting

Table 1: Comparative analysis of KMA raw materials

Material name	The need for cement	The need for water (%)	Size module	Poured density (ρ_{gac}, kg m^{-3})
Granite crushing sifting	0.71	7.8	2.89	1536
Quartzitic sandstone crushing sifting	0.52	6.5	4.72	1520
Schist crushing sifting	1.01	8.7	3.83	1700

chemical resistance of the reinforcing material, its adhesion to concrete, the coefficient of linear expansion and so on. The issues of reinforcing materials cost and the volume of their production, which in some cases play a decisive role are important. In the research, we used a textile mesh with the following characteristics:

- Bi-directional mesh
- Alkali-resistant glass
- Leno interweaving
- Polymer coating
- Cell size: 10×10
- Fiber consumption: 520 gm^{-2}
- Elongation at break: 3%

According to the results of performed research the following experimental formulations were proposed (Table 2). To study the effect on the textile mesh deformation properties of concrete, it has been decide to conduct tests on prism measuring 100×100×400 mm. To prepare the prism used the following scheme of reinforcement (Fig. 6).

The first layer of concrete with the thickness of 25 mm was molded within 10 sec. The vibration was performed at vibration site to eliminate the bubbles and voids as this layer is difficult to process during the vibration process of the entire prism. Then, let's put the first layer of reinforcing mesh (Fig. 7a) with its subsequent submerge in the concrete mixture (Fig. 7b).

A concrete layer with the thickness of 50 mm is laid uniformly by small portions in order not to change the mesh direction. We produce the vibration within 15 sec. After the elimination of bubbles and laitance on the surface of the mixture let's put the second layer of reinforcement mesh (Fig. 8) and submerge it in a similar way like the first layer.

Then, we apply a last protective layer of concrete mixture by small portions and uniformly and perform the vibration for 10 sec.

Thus, we obtained textile-concrete-a composite material reinforced with textile mesh. In order to obtain a denser packing of the filler the sand of Shebekinsky field was used with the size module 1, 2 (Table 3).

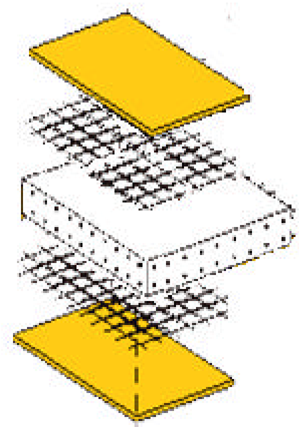

Fig. 6: Prism reinforcement scheme

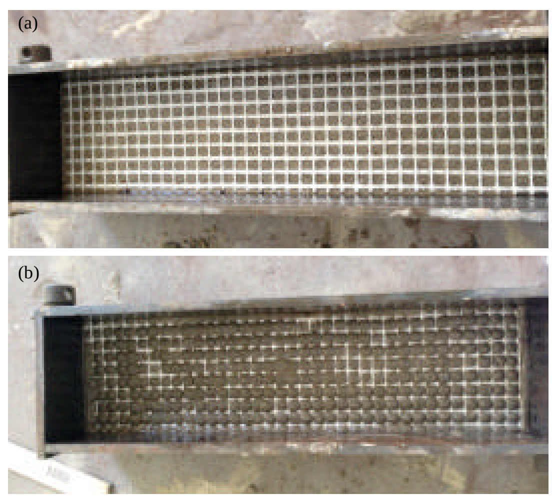

Fig. 7: a) Laying of the first layer of mesh; b) the submerge of mesh

Table 2: Experimental compositions of concretes

Composition No.	Material consumption per 1m³ — Binding (kg): TS	CП	Sifting (kg)	Water (L)	Reinforcing (Mesh (layers))	V/TS
1-1	710	-	1540	331	-	0,47
1-2	710	-	1540	331	-	0,47
1-3	710	-	1540	331	2	0,47
1-4	710	-	1540	331	2	0,47
2-1	710	2,13	1540	282	-	0,4
2-2	710	2,13	1540	282	-	0,4
2-3	710	2,13	1540	282	2	0,4
2-4	710	2,13	1540	282	2	0,4

Table 3: Physical and mechanical characteristics of fine-grained concrete depending on a binder composition

	Material consumption per 1m^3							
	Binder (kg)							
Composition No.	TS	SP	KVP crushing sifting (kg)	Sand (kg)	Water (L)	Glass mesh (kg)	Compaction strength (R, MPa)	Flexural strength (R, MPa)
1	710	-	1540	-	262	-	47,1	5,3
2	710	-	1150	390	273	-	51,3	6,1
3	710	2,13	1540	-	224	-	85,2	8,6
4	710	2,13	1150	390	257	-	93,7	10,4
5	710	2,13	1150	390	255	0,2	105,2	14,8

Fig. 8: The application of the second layer of mesh

CONCLUSION

The mechanism of the reinforcement effect of bent concrete products on composite binding products and man-made sands on their strength characteristics is established. It appears that the composite based on textile fiberglass mesh in a stretched zone of a sample almost completely takes the tensile force due to the concentration of fibers in this zone. It is proved experimentally that the strengthening of bent elements by composite allows to improve the tensile strength at a bend in 2-3 times.

ACKNOWLEDGEMENT

This research was supported by a scholarship of the President SP-5949.2013.1 and RFBR grant 14-41-08006.

REFERENCES

Kluyev, A.V., S.V. Kluyev, R.V. Lesovik and O.N. Mikhailova, 2010. Mine enterprise waste as the raw material for the production of fine grained concrete reinforced with fibers. Bulletin of the Belgorod State Technological University Named after V.G. Shukhov, pp: 81-84.

Kluyev, A.V. and R.V. Lesovik, 2011. Man-made sands as raw material for the production of fiber-reinforced concrete. A.V. Kluyev (Eds.), Innovative materials of technology; Proceedings of the International scientific-practical conference: Belgorod: 11-12 of October 2011. Belgor. State. Technol. Univ, Belgorod: BSTU Publishing House, pp: 283-285.

Kluyev, A.V. and R.V. Lesovik, 2012. Steel fiber concrete based on composite man-made KMA sands for bent structures. Bulletin of the Belgorod State Technological University named after V.G. Shukhov, pp: 14-16.

Kluyev, S.V., V.S. Lesovik, A.V. Kluyev and D.O. Bondarenko, 2012a. On the issue of several types of fibers use for dispersed reinforced concretes. Journal of Belgorod State Technological University named after V.G. Shukhov, pp: 81-83.

Kluyev S.V., R.V. Lesovik and A.V. Kluyev, 2012b. Fiber concrete based on technogenic sand KMA and composite binders for industrial and civil construction. Belgorod: BSTU publishing house named after V.G. Shukhov, pp: 124.

Klyuyev, S.V., R.V. Lesovik, A.V. Kluyev, A.V. Ginzburg and S.A. Kazlitin, 2013a. Fibrous concrete for heavy loaded floors of industrial buildings: a monograph. Belgorod: BGTU Publishing House, pp: 116.

Klyuyev, S.V., A.V. Klyuyev, R.V. Lesovik, A.V. Netrebenko, 2013b. High Strength Fiber Concrete for Industrial and Civil Engineering. World Appl. Sci. J., 24 (10): 1280-1285.

Kluyev, S.V., R.V. Lesovik, A.V. Kluyev, A.V. Ginzburg and N.V. Kalashnikov, 2013. Fibrous concrete based on technogenic sand KMA and composite binders for industrial and civil construction.-Belgorod: BSTU publishing house named after V.G. Shukhov, pp: 124.

Kluyev, S.V., R.V. Lesovik, O.V. Kazlitina, A.V. Netrebenko, N.V. Kalashnikov and A.A. Mitrokhin 2014a. Combined disperse reinforcement of fine-grained concrete based on technogenic raw material and nanodispersed modifier. Bulletin of the Belgorod State Technological University Named after V.G. Shukhov, pp: 47-53.

Kluyev, A.V., A.A. Mitrokhin, Y.N. Cherkashin and G.A. Lesovik, 2014b. The calculation of of fiber concrete structures. Collection of Scientific Works Kluyev, S.V., K.S. Rakitchenko, R.V. Lesovik, A.V. Kluyev and A.V. Ginzburg, 2014c. Fibrous concrete using composite binders and KMA raw materials to repair bridge structures. Belgorod: BSTU publishing house named after V.G. Shukhov, pp: 131. Sworld, pp: 61-65.

Klyuyev, S.V., R.V. Lesovik, A.V. Klyuyev, A.V. Netrebenko and N.V. Kalashnikov 2014c. Fiber Concrete on Composite Knitting and Industrials and KMA for Bent Designs. World Appl. Sci. J., 30 (8): 964-969.

Lesovik, R.V., A.V. Kluyev and S.V. Klyuev, 2010. Fine-grained steel-fiber concrete on the basis of technogenic sand in order to obtain prefabricated structure elements. Scientific researches, nanosystems and resource-saving technologies in the industry of building materials: Collection of Reports of Intern. Scientific and Pract. Conf. Belgorod: BGTU Publishing House, pp: 140-143.

Lesovik, R.V., A.V. Kluyev and S.V. Kluyev, 2014a. Fine-grained steel fiber concrete based on man-made sand to obtain prefabricated structural elements. Technologies of Concretes, pp: 44-45.

Lesovik, R.V., S.V. Kluyev, A.V. Kluyev and A.V. Netrebenko, 2014b. On the problem of KMA technogenic sand use for the production of fine grained fiber concrete and the products based on it. Industrial and Civil Construction, pp: 45-48.

Lesovik, R.V., S.V. Klyuev, A.V. Klyuev, A.V. Netrebenko and A.V. Durachenko, 2014c. High-Strength Fiber-Reinforced Concrete Containing Technogenic Raw Materials and Composite Binders with Use of Nanodispersed Powder/Ruslan Valeryevich Lesovik. Res. J. Appl. Sci., No. 9, pp: 1153-1157.

Lesovik, R.V., S.V. Klyuyev, A.V. Klyuyev, A.V. Netrebenko, A.A. Metrohin and N.V. Kalashnikov, 2014d. Combined Disperse Reinforcement of Fine-Grained Concrete with Steel and Polypropylene Fiber on Technogenic Raw Materials and Nanodispersed Modifier. J. World Applied Sci. C., 12 (31): 2008-2114.

Lesovik, R.V., S.V. Klyuev, A.V. Klyuev, S.A. Kazlitin, A.V. Netrebenko and A.V. Durachenko, 2014e. Fiber-Reinforced Concretes Made of Technogenic Raw Materials and Composite Binders for Industrial Building Floors. Intl. J. Appl. Eng. Res. (IJAER), 22 (9): 15811-15824.