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Properties and Design Characteristics of the Fiber Concrete

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Abstract

Under the contemporary conditions of permanent construction complication, the volume of reinforce-concrete structures that are in the process of exploitation of building function in the conditions of difficult loading is growing: they are exposed to the slanting bend, twisting and dynamic influences. These structures include foundations and ceilings of productive buildings installed with the use of vibrating equipment (flatting mills, press, metal-working machine-tools), beams for a faucet, highway coverage, bridge elements, air strips of the air fields, body elements of hydro energetic objects. The complex loaded structures shall meet the stringent requirements not only in terms of bending and compression resistance but also in terms of structural integrity maintenance (crack resistance). In case of the technological process change or formation of defects and damages, repair of these elements is not possible – they can be only replaced, and this will demand to stop the production, sort out a high-cube of reinforced-concrete structures and, consequently, lead to material expenses comparable with a new building construction. An increase of the exploitation term of the complex loaded reinforce-concrete structures is a topical and economically demanded research.

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1. Introduce

Fiber concrete - one of types of concretes, the characteristic feature of that is a presence in the structure of fibres equipartition on all volume of concrete. Reinforcement can be used in all types of concretes: heavy, cellular, on easy

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fillers et al. Fibres can be steel, glass, polypropylene, basaltic, nylon, acrylic, cotton etc. An application of fiber concrete and his descriptions domain depends on properties of material [1].

Traditional methods of basic working re-enforcement of the reinforced concrete can result steel flat frameworks in formation of heterogeneities of structure of concretes (emptiness's) and decline of deformation descriptions of constructions or wares. Introduction of fibre to the concrete eliminates the lacks of the unreinforced concretes, such as subzero durability on a bend and yes, formation of cracks at hardening and exploitation of constructions. Fiber concrete is characterized high durability on tension and bend, megascopic firmness to the cracks and viscidity of destruction. Dispersible re-enforcement allows to make the constructions of difficult geometrical form without the decline of homogeneity of structure [2-7].

Reduction of firmness to the cracks not only increases bearing strength of element of fiber concrete but also diminishes diffusion of liquids and gases in the body of concrete, consequently, carbonating of concrete and corrosion of armature ceases, longevity of construction rises due to it. Introduction of fibre the most effective method of prevention of deep excrescence and distribution of cracks in the body of the loaded constructions.

At consolidation of concrete the even by volume structure reinforced on a micro level appears due to quality distribution of fibres.

For expansion of application of fibre domain at making of reinforce-concrete constructions it is necessary to systematize the accumulated productive and scientific experience, that will allow to ground her application and forecast properties of constructions from fiber concrete. It is possible to designate next directions of researches of fiber concrete:

- study of macrostructure of fiber concrete: location, equitability, influence of fibre on a surrounding concrete;
- cooperation of fibre and concrete, showing up in descriptions of durability of the got composition and prognostication of internal tensions arising up under the action of the operating loading.

In the Institute of Civil Engineering of the "Ural federal university of the name of the first President of Russia B.N. Yeltsin" the collective of authors is conduct complex research works on creation of multivariable mathematical model of fiber concrete. Efficiency of reinforcement (increase to the desired level of durability and deformation descriptions of concrete) in every special case depends on plenty of initial descriptions that authors conditionally divided into 3 groups of parameters:

- parameters of fibre;
- parameters of structure of concrete;
- parameters of environment.

1.1. Parameters of fibre

Parameters of fibre are qualificatory efficiency of dispersible re-enforcement. To them it is possible to take properties of material of fibre, geometrical descriptions of single element of fibre and amount of fibres in unit of volume or mass. Undoubtedly, that determines materials and roughness of surface of fibre size of coupling to concrete composition and, accordingly, force of coupling of unit of armature with a concrete. A form and size of cross-sectional determine a specific surface (surface of coupling of fibre with a concrete). Like application of construction armature in the reinforced concrete, the use of fibre with anchor bulges (characteristically for steel) results in the substantial increase of durability on tear-out separate reinforcing element.

Flexibility of fibres of fibre allows by it to be situated directly in a solution layer between grains of filler, not influencing on distribution of components and homogeneity of structure. In works [3] it is shown on the example of the use of glass fibre in cellular concretes as negatively the use of inflexible fibre effects on homogeneity of structure.

At application of metallic fibre there is stratification of concrete mixture in easy concretes, and in heavy concretes recommended [3] to use concrete mixture of high mobility for providing of more complete coupling of fibre with a solution matrix without the change of structure and to formation of emptiness's in a pin zone.

Thus, flexibility of fibre can come forward a factor, qualificatory possibility of her application in the different types of concretes: application only of flexible fibre (for example, polypropylene or basaltic) is possible in lungs and cellular concretes, and in heavy - inflexible fibre (for example, metallic) on condition of high mobility of concrete mixture. Characteristics species studied fibers are shown in Table 1.

Table 1. Characteristics fibers

Option	Types fibers			
	Steel	Glass	Basalt	Polypropylene
Density, kg/m^3	7800	2500	2800	860
The diameter of the fiber, mm	0,2...1,2	0,06...0,1	0,04...0,2	0,01...0,02
Fiber length, mm	20...50	2...24	2...30	2...18
Resistance in alkaline environment	+	–	+	–
Flexibility	–	–	+	+
The recommended concrete	Heavy	Concrete with expanded clay aggregate, heavy	Light, cellular, fine-grained, concrete with expanded clay aggregate, heavy	Light, cellular, fine-grained, concrete with expanded clay aggregate, heavy, dry mixes

No less important factors it is been stability of fibre of waters by influence of terms of concrete environment in the process of formation of structure of compo and exploitation of construction. For example, a steel fibre is evenly distributed on the body of concrete without the observance of requirements of protective layer. During exploitation of constructions precipitated to permanent or variable influence of water corrosion of fibre with the increase of volume of new formation and destruction of structure of concrete are possible. The concrete made on cement is most widespread in building. Stability of polypropylene fibre in the alkaline environment of products of hydratation of cement many researchers is called in a question. To the row of constructions enhanceable requirements are produced on a fire-resistance: either they exploited at temperatures more than 100˚C or must maintain some time non-destructive at emergency influence of fire.

For these constructions efficiency of reinforcement will be observed only in case that a fibre at calculation temperatures will not lose the indexes of durability.

The quantitative parameters of application of fibre are no less important. Recommendations of producers are most widespread on the dosage of fibre in units of mass on 1 м3 of concrete. For adequate comparison of efficiency of application of fibre authors suggest to use the calculation amount of units (fibres) of fibre, what the closeness of fibre (from 7800 kg/of m3 at steel to 860 kg/of m3 at polypropylene) allows to take into account, effective diameter of cross-sectional (from 20 mcm at basaltic a to 1,2 mm at steel) and length.

As basic data the dosage of steel fibre is chosen in an amount 0,40 kg on 1 kg of cement. Comparative calculations were used for the estimation of efficiency of influence of different types of fibre on descriptions of durability of concrete (are shown in Table 2).

Table 2. Calculation of dosages of different types of fiber

Option	Types fibers			
	Steel	Glass	Basalt	Polypropylene
The diameter of the fiber, mm	0,4	0,08	0,06	0,02
Fiber length, mm	30	18	12	6
The volume of one fiber, m^3	$1{,}26\times10^{-9}$	$1{,}26\times10^{-9}$	$1{,}26\times10^{-9}$	$1{,}26\times10^{-9}$
The number of fibers, kg^{-1}	4000	4000	4000	4000
The calculated recommended dosage of 1 kg cement, gm.	40	0,9	0,38	0,0065

1.2. Parameters of structure a concrete

To the factors of structure a concrete was taken by characterizing composition, homogeneity and properties of concrete stone, through that influence comes true on efficiency of mutual work of dispersible re-enforcement and concrete. As be described before, most influence renders the type of concrete: some types of fibre it is not

recommended to use with certain fillers. The type of astringent determines the presence of ions, pH environment of collecting durability compo, determines stability of fibre in the environment of compo, coupling of material of fibre to the solution matrix. Quantitative parameters, such as maintenance astringent in mixtures and his descriptions of durability give an opportunity to judge the receipts of the set indexes of durability about possibility

Geometrical sizes, maintenance of fibre in a concrete is determined coming from properties of the used fillers: presence of large filler, his kind, factious composition and maintenance in composition; table of contents of shallow filler and his requirement is in water.

1.3. Parameters of environment

To the parameters of environment, the terms of hardening of concrete behave: temperature and humidity, presence and mode of treatment a heat and moisture, hardening of concrete at temperatures below +5˚C. Condition of exploitation also can limit possibility and efficiency of application of some type of fibre.

2. Research methods

Experiments conducted with the basaltic fibre of round section a diameter from 40 to 200 mcm and identical length 6 mm. At maintenance of identical dosage of fibre 0,6 gm. on 1 kg of cement reduction of diameter of fibres increases their amount in unit of volume of cement matrix. Before some value there is linear increasing dependence of total force of coupling of fibres with a cement stone due to reduction of diameter of fibres and increase of specific surface of fibre. At exceeding of this value distribution of fibre in a cement compo becomes chaotic, durability of coupling of separate fibre with astringent goes down from entangled of fibres, formation of shallow emptiness's in a pin zone.

At determination of length of fibre for a basaltic fibre was maximally used efficiency of her application by the diameter of 60 mcm, long fibres 2,6,8 and a 12 mm in the dosage of a 0,4 g on 1 kg of cement, as astringent is cement of class CEM 42,5, filler is the washed quartz sand of narrow faction. A basaltic fibre is made from fusions of mountain breeds at a temperature more than 1500˚C, consequently, possesses a high heat-resistance, good coupling to the solution matrix, high durability on tension and chemical firmness in an alkaline environment cement.

The components of fiber concrete (astringent, fillers and dispersible armature) must be mixed in the mixers of a force action in two stages: in a dry kind no less than 10 minutes, after addition of water - no less than 10 minutes. Such mode of interfusion allows to the bunches of fibres qualitatively and relatively quickly to fission on separate units. From cement dough made standards measuring a 4×4×16 cm, that after hardening in normal terms tested on determination of tensile strength on tension at a bend. Got results are presented on fig. 1.

3. The results of the work

Set experimentally, that for the receipt of maximal durability on tension at a bend length of fibres must exceed the middle size of large filler. In other works, [6] it is shown that the fibre of different length can render different effects on properties of fiber concrete.

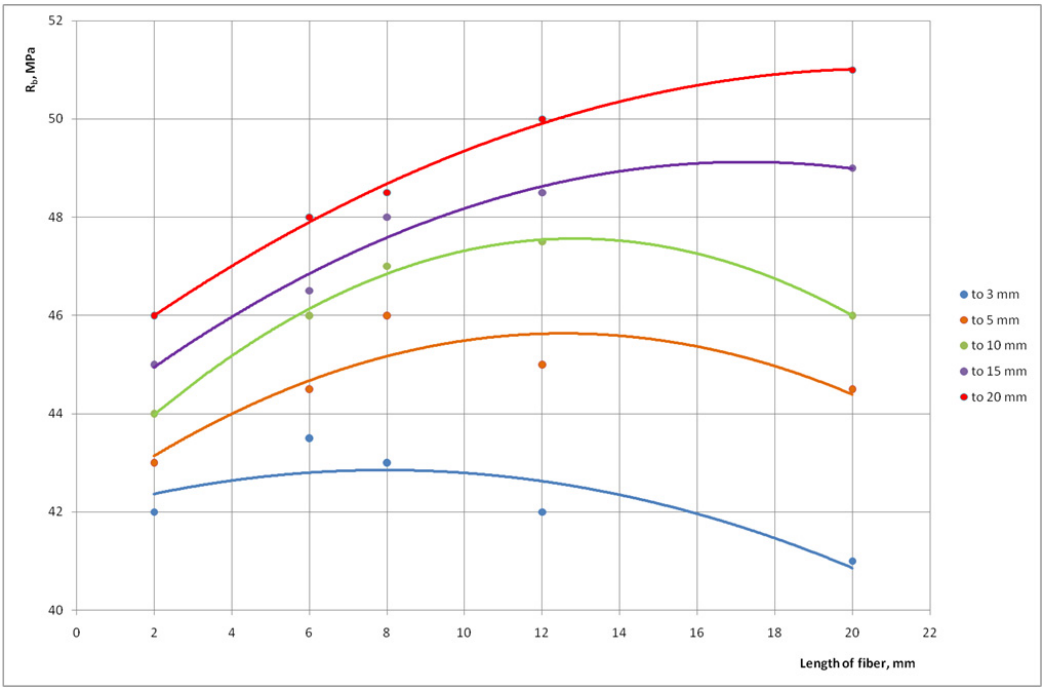

Fig. 1. Test on determination of tensile strength on tension at a bend

4. Conclusion

After systematization of the obtained experimental data a mathematical model by means of that it is possible entering the initial parameters of fibre to get the value of durability of concrete on tension at a bend and relative increase it due to dispersible re-enforcement is developed. This value at the account of it in a calculation programmatic complex (for example, ANSYS), the calculation amount of the required construction gaggers will allow to decrease.

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