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Dissertation

Master in Civil Engineering – Building Construction

Dissipated reinforce of concrete building structures

Parashchenko Artem

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Leiria, *September of 2017*

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Dissipated reinforce of concrete building structures

Parashchenko Artem

Dissertation developed under the supervision of professor Hugo Filipe Pinheiro Rodrigues, adjunct professor at Departament of Civil engineering of the Polytechnic Institute of Leiria and co-supervision of professor Sergiy Kolesnichenko , professor at the Donbas National Academy of Civil Engineering and Architecture .

Leiria, *September of 2017*

Resumo

O problema da melhoria da qualidade do betão está a tornar-se particularmente relevante em relação à necessidade de melhorar radicalmente a qualidade, reduzindo a quantidade material, laboral e energética das estruturas de betão armado.

A solução definida para habitação e para outros tipos de construção exige a criação e ampla aplicação de novos materiais e tecnologias. Na indústria da construção, um dos materiais de construção estrutural promissores continua a ser o betão armado, em particular o betão reforçado com fibras.

As variedades de fibras usadas na produção de betão reforçado com fibra, permitiram que este tipo de material de construção encontrasse uma aplicação bastante ampla na indústria da construção moderna. Os tipos modernos de fibra não permitem o reforço em massa de concreto e reforçam apenas a mistura de concreto sem levar em conta o enchimento de concreto, reduzindo a eficiência do reforço disperso. Assim esta dissertação teve como objetivo: o desenvolvimento de uma fibra para dispersar o reforço de betão, desenvolver um conjunto de amostras de betão sem fibra, com fibra com extremidades achatadas e com fibras na forma de um segmento de forma circular cilíndrica; Realizar um conjunto de ensaios das amostras para obter as características da resistência à compressão.

Os resultados dos estudos de amostras de fibra de betão com reforço disperso por fibra metálica são apresentados. Foi ainda realizada uma análise comparativa da resistência à compressão de amostras de betão sem fibra, bem como amostras usando fibra com extremidades achatadas e fibra na forma de um segmento de forma cilíndrica redonda. Para determinar as características de resistência, foram feitas amostras de betão e cubos de fibra de concreto em condições laboratoriais.

Palavras-chave: betão, fibras, fibra metálica, reforço disperso, características de resistência.

Abstract

The problem of improving the quality of concrete is now becoming particularly relevant in connection with the need to radically improve quality while reducing the material, labor and energy intensity of reinforced concrete structures.

The solution of the set tasks for housing and other types of construction requires the creation and wide application of new materials and technologies. In the construction industry, one of the promising structural building materials is dispersed-reinforced concrete - fiber-reinforced concrete.

Varieties of fiber used in the production of fiber-reinforced concrete, allowed this type of building material to find a fairly wide application in the modern construction industry.

Modern types of fiber do not allow performing bulk reinforcement of concrete and reinforces only the concrete mixture without taking into account the filler of concrete, reducing the efficiency of dispersed reinforcement.

Objective:

- Development of the design of fiber for disperses reinforcement of concrete;
- making samples of concrete without fiber, as well as samples using fiber with flattened ends and fiber in the form of a segment of circular cylindrical shape;
- Laboratory testing of samples for obtains the characteristics of compressive strength.

The results of studies of samples of fiber concrete with dispersed reinforcement by metal fiber are given. Conducted a comparative analysis of the compressive strength of samples from concrete without fiber, as well as samples using fiber with flattened ends and fiber in the form of a segment of round-cylindrical shape. To determine the strength characteristics, samples of concrete and fiberconcrete cubes were made and tested in laboratory conditions.

Keywords : fiberconcrete, metal fiber , dispersed reinforce, strength characteristics.

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Chapter 1 – DISSIPATED REINFORCE OF CONCRETE: SPHERE OF USE, TARGET AND OBJECTIVES OF RESEARCH

1.1 Introduction

The last decades of XXI century were characterized by significant achievements in the construction industry. High rates of modern buildings construction required the development of new, efficient, high-quality concretes with improved performance characteristics.

An urgent track produce high quality concrete with a broader range of properties is the use of complex multi-component additives that combine individual supplements for various applications. The multicomponent complex additives and, as a consequence, multicomponent concrete mix allows you to effectively control the processes of formation of structure at all stages of preparation of concrete composition and to receive concrete with various high performance.

With the advent of high-strength concrete made possible the emergence of new high-strength fiber-reinforced fiber concrete, combining in itself high-density and high-strength cement mixture with reinforcing elements.

A problem of fiber-reinforced concrete at this moment is of particular relevance in view of the need of radical improvement of quality while reducing in material expenses, labor expenses and energy consumption in production of reinforced concrete structures.

Currently, the dependence of strength on parameters such as the percentage of reinforcement, the length, diameter and shape of the fibers, accounting the effect of fiber orientation and strength of the matrix material of concrete. However, the deformation characteristics of fibrous concrete is not as well studied as the strength characteristics, the existing theoretical and experimental results of the study are very diverse and offer a wide scatter of values of characteristics.

An urgent task for future research is to investigate the effectiveness of the compositions of concrete with a combined reinforcement, directed at simultaneously modification of strength characteristics and deformation characteristics.

1.2. Experience of use a fibreconcrete

Cost of fibreconcrete products is dependent on specific quantity of metal framework and use concrete mixture.

Is well known that concrete is an artificial material, which has a good resistance of compression and a low of capacity to tensile stresses.

To improve this tensile stress capacity, metal elements can be used in concrete elements. Dissipated reinforce increases of hardness characteristics of concrete to tensile force, crack resistance, firmness to deterioration. It is allowing to reduces of metal consumption in concrete structure and, perhaps, replace the metal framework on the fiber [1].

Fiberconcrete - reinforced concrete from a heavy or lightweight concrete (concrete-matrix), which are used as reinforcement - fiber, evenly distributed throughout the volume of the concrete. Collaboration concrete and fibers provide traction on the surface, anchoring the fibers in the concrete due to its periodic profile, the curvature in the longitudinal and transverse directions, as well as the presence of anchors at the ends of the fibers.

Fiberconcrete constructions according to the type of reinforcement are seen as:

1) Fiberconcrete - reinforcement only with the fibers, evenly distributed in terms of the element;

2) Reinforced in combination - reinforcement of steel fiber and steel bar reinforcement.

Fiberconcrete recommended for fabrication of structures in which most effective its technical advantages compared with traditional concrete and reinforced concrete :

- Increased fracture toughness, impact strength, toughness, wear resistance, frost resistance, resistance to cavitation;
- Reduced shrinkage and creep;
- The possibility of using more technologically effective design solutions than traditional reinforced;
- Reduced labor costs for reinforcement work;
- Increasing the degree of mechanization and automation of production structures, for example, precast columns, beams, solid base plate floor industrial and public buildings;
- The possibility of new and more productive methods of molding reinforced structures, etc.

Fiberconcrete structure can be manufactured by different methods: preliminary at the factory or at the construction site , compaction via vibration and vacuum, roller molding and pressing, centrifugation and gunning.

Experience of application of fiber concrete shows that their characteristics depend on the type of fiber used. For example, steel and basalt fiber in the product have an impact for increased strength and elastic modulus, polypropylene fiber gives improved crack resistance and deformability.

The economic effect of fiber-reinforced concrete is observed mainly due to its high strength, ease of use and more reliable safety in construction.

In practice, as the fibers typically used a thin metal wire with a diameter of 0.1 to 1.5 mm and a length of 10 to 100 mm. concrete saturation volume of fiber is recommended to take in the range of 2-5% of the total. At the same time there is a sharp decrease of efficiency particulate reinforcing effect on concrete strength of fibers with a diameter of 0.6 mm or more. The reason for this effect are the adhesion properties of cement mixture with the filler material, as well as the relationship between the concrete porosity and structural dimensions of fibers and their placement [2].

One of the main flaws of modern concrete - a poor adhesion of cement mixture with fillers. All the basic properties of concrete depend on the adhesion of cement paste with fillers.

The list of successfully tested and approved fiber concretes structures presented in Table 1.

Table 1.The list of successfully tested and approved fiber concretes structures

Monolithic elements	Prefabricated elements
Roads and motorways	Railway Sleepers
Relaying of pavement	Pipeline
Fluor industrial premises	Vaults
Aligned Floor	Beams
Bridge Deck	Stairs
Irragatsionnye channels	Wall panels
Blastguard and shock-resistant building	Roof panels and roofing tiles
Dam to protect against high water	Modules floating dock

Fireproof plaster	Marine structures and installations
Reservoirs for water and other fluids	Blastguard and shock-resistant buildings
Facing the tunnel	Aerodromes slabs, road slabs and pavement slabs; slabs to strengthen channels
Defensive structures	Elements of bridge cornices
Repair of monolithic structures, floors, roads, roadway and ground runways, etc.	Piles
Installation and repair of marine structures	Heating devices

1.3. The goal, objectives, scientific novelty of the work, subject and methods of research

1.3.1. Goal of work and research Objectives

The purpose of the master's work is - improving the performance of dispersed concrete reinforcement by the micro-reinforce cement stone with concrete filler.

To achieve this goal it is necessary formulation and solution of such problems:

- Perform and organize the review of technical and design documentation for the research topic;
- Compile information on modern fiber concrete and structures based on them, to develop a classification and justify their use;
- To develop the optimum composition of the fiber-reinforced concrete awakened granulated slag;
- Develop the design and manufacture a cylindrical helical and sinusoidal fiber of;
- Manufacture fiber-concrete samples for testing;
- Develop construction manhole cover manhole of fiber-reinforced concrete with a combined fiber reinforcement;
- Manufacture and test samples hatches manholes in laboratory and pilot - industrial environments.

1.3.2. Subject of research

The subject of the research is dispersed - reinforced concrete mixes, products and structures based on them, as well as the technology of preparation blends and obtain the desired properties of fiber concrete;

1.3.3. Scientific novelty of thesis

Modern kinds of fibers is ineffective for volume reinforcement of the of concrete, since the fiber reinforces only cement mixture, filler among themselves of fiber not bound.

The objective of the master's work is to develop and test a new type of fiber, which will be reinforce of concrete structures taking into account of filler, thus creating an additional bond filler and cement mixture.

1.3.4. Methods

The methods of the research in this paper is:

- Literature search;
- Analysis and generalization;
- Design of cement mix of concrete products;
- Testing of concrete samples for strength characteristics;
- Generalization of results;
- The formation of issues of further research.

Chapter 2 – CONDITIONS OF QUESTION OF USE DISSIPATED REINFORCE OF CONCRETE

2.1. Fibers used in concrete

Fiber is a small piece of reinforcing material possessing certain characteristics properties. They can be circular or flat. The fiber is often described by a convenient parameter called “aspect ratio”. The aspect ratio of the fiber is the ratio of its length to its diameter. Typical aspect ratio ranges from 30 to 150.

Fiber reinforced concrete is concrete containing fibrous material which increases its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers.

Within these different fibers that character of fiber reinforced concrete changes with varying concretes, fiber materials, geometries, distribution, orientation and densities.

Fabre-reinforcement is mainly used in shotcrete, but can also be used in normal concrete. Fiber-reinforced normal concrete are mostly used for on-ground floors and pavements, but can be considered for a wide range of construction parts (beams, pliers, foundations etc) either alone or with hand-tied rebars.

Concrete reinforced with fibers (which are usually steel, glass or “plastic” fibres) is less expensive than hand-tied rebar, while still increasing the tensile strength many times. Shape, dimension and length of fiber is important. A thin and short fiber, for example short hair-shaped glass fiber, will only be effective the first hours after pouring the concrete (reduces cracking while the concrete is stiffening) but will not increase the concrete tensile strength

Following are the different type of fibers generally used in the construction industries.

- Steel Fiber Reinforced Concrete
- Polypropylene Fiber Reinforced cement mortar & concrete
- GFRC Glass Fiber Reinforced Concrete
- Asbestos fibers
- Carbon fibers
- Organic fibers
- Basalt fibers

2.1.1. Steel Fiber reinforced concrete

Round steel fiber the commonly used type are produced by cutting round wire in to short length. The typical diameter lies in the range of 0.25 to 0.75mm. Steel fibers having a rectangular c/s are produced by silting the sheets about 0.25mm thick. Fiber made from mild steel drawn wire. Conforming with the diameter of wire varying from 0.3 to 0.5mm have been practically used in India. Round steel fibers are produced by cutting or chopping the wire, flat sheet fibers having a typical c/s ranging from 0.15 to 0.41mm in thickness and 0.25 to 0.90mm in width are produced by silting flat sheets. Deformed fiber, which are loosely bounded with water-soluble glue in the form of a bundle are also available. Since individual

fibers tend to cluster together, their uniform distribution in the matrix is often difficult. This may be avoided by adding fibers bundles, which separate during the mixing process.

Steel fibers used in concrete show in fig. 1.

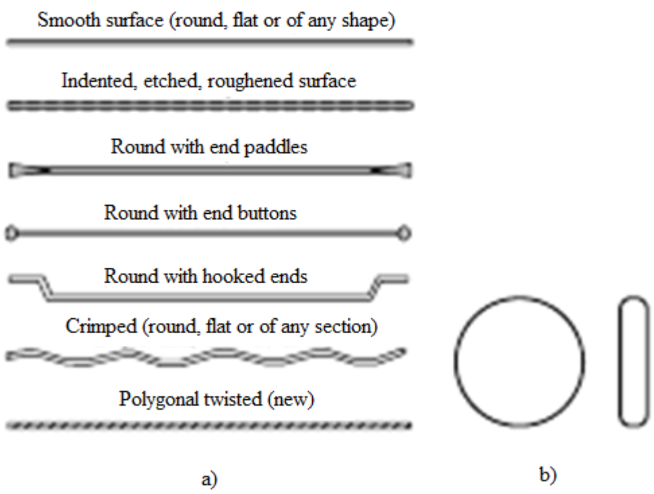


Figure 1. (a) Typical profiles of steel fibers commonly used in concrete (twisted fiber is new). (b) Closed loop fibers tried in some research studies.

Steel fiber reinforced concrete is a composite material having fibers as the additional ingredients, dispersed uniformly at random in small percentages, i.e. between 0.3% and 2.5% by volume in plain concrete.

Fiber concrete products are manufactured by adding steel fibers to the ingredients of concrete in the mixer and by transferring the green concrete into moulds. The product is then compacted and cured by the conventional methods.

Segregation or balling is one of the problems encountered during mixing and compacting SFRC. This should be avoided for uniform distribution of fibers. The energy required for mixing, conveying, placing and finishing of SFRC is slightly higher.

Use of pan mixer and fiber dispenser to assist in better mixing and to reduce the formation of fiber balls is essential. Additional fines and limiting maximum size of aggregates to 20mm occasionally, cement contents of 350 kg to 550 kg per cubic meter are normally needed.

Steel fibers are added to concrete to improve the structural properties, particularly tensile and flexural strength. The extent of improvement in the mechanical properties achieved with SFRC over those of plain concrete depends on several factors, such as shape, size, volume, percentage and distribution of fibers.

Plain, straight and round fibers were found to develop very weak bond and hence low flexural strength. For a given shape of fibers, flexural strength of SFRC was found to increase with aspect ratio (ratio of length to equivalent diameter).

Even though higher ratios of fibers gave increased flexural strength, workability of green fiber concrete was found to be adversely affected with increasing aspect ratios. Hence aspect ratio is generally limited to an optimum value to achieve good workability and strength.

Grey suggested that aspect ratio of less than 60 are best from the point of handling and mixing of fibers, but an aspect ratio of about 100 is desirable from strength point of view. Schwarz however suggested aspect ratio between 50 and 70 is more practicable value for ready mix concrete.

In most of the field applications tried out to date, the size of the fibers varies between 0.25 mm and 1.00mm in diameter and from 12mm to 60mm in length, and the fiber content ranged from 0.3 to 2.5 percent by volume. Higher contests of fiber up to 10% have also been experimented. Addition of steel fibers up to 5% by volume increased the flexural strength to about 2.5 times that of plain concrete.

As explained above, mixing steel fibers considerably improves the structural properties of concrete, particularly tensile and flexural strength. Ductility and post cracking strength, resistance to fatigue, spalling and wear and tear of SFRC are higher than in the case of conventional reinforced concrete.

Fiber concrete is therefore found to be a versatile material for the manufacture of wide varieties of precast products such as manhole covers, slab elements for bridge decks, highways, runways, and tunnel linings, machine foundation blocks, door and window frames, piles, coal storage bunkers, grain storage bins, stair cases and break waters.

Technology for this manufacture of fiber concrete light, medium and heavy duty manholes covers has been developed in India by Structural Engineering Research Centre, Chennai.

Field experiments with two percent of fiber content indicated that SFRC runway slabs could be about one half the thickness of plain concrete slabs for the same wheel load coverage.

Cement Research Institute of India also demonstrated the use of SFRC in one of the jet bays at Delhi airport. Other field experiments in which SFRC has been used are the slabs of parking garage at Heathrow airport in London, spillway deflectors in Sweden, mine cribbing in Utah, USA. [10]

2.1.2. Polypropylene Fiber Reinforced cement mortar & concrete

Polypropylene is one of the cheapest & abundantly available polymers polypropylene fibers are resistant to most chemical & it would be cementitious matrix which would deteriorate first under aggressive chemical attack. Its melting point is high (about 165 degrees centigrade). So that a working temp. As (100 degree centigrade) may be sustained for short periods without detriment to fiber properties.

Polypropylene fibers being hydrophobic can be easily mixed as they do not need lengthy contact during mixing and only need to be evenly distressed in the mix.

Polypropylene short fibers in small volume fractions between 0.5 to 15 commercially used in concrete.

Used as secondary reinforcement, polypropylene fibers help reduce shrinkage and control cracking. To use these fibers, concrete mix design does not have to be altered, and no special equipment or slump modifications are required, even for pumping or shotcreting. Only two things must be determined: how much fiber to add and what length of fiber to use. Polypropylene fibers are manufactured in small bundles. During the mixing operation, the movement of aggregate shears these bundles into smaller bundles and individual fibers. If the jobsite is more than a 30-minute drive, the fibers should be added at the site.

In fiber-reinforced concrete, cracks can open only if the tensile stresses in the concrete exceed the tensile strength or the pull-out strength of the fibers. The longer the fibers are, the stronger the bond between fibers and paste is and thus the greater the fiber pull-out strength is. If fibers are too long, uniform distribution of the fibers becomes difficult. Longer fibers can be used when larger aggregates are present to shear the bundles of fiber apart. Short fibers are used with small or lightweight aggregate.

Polypropylene fibers tend to hold the concrete mix together. This slows the settlement of coarse aggregate and thus reduces the rate of bleeding. A slower rate of bleeding means a

slower rate of drying and thus less plastic shrinkage cracking. In hardened concrete, polypropylene fibers act as crack arresters. Like any secondary reinforcement, the fibers tend to stop cracks from propagating by holding the concrete together so cracks cannot spread wider or grow longer. However, since polypropylene fibers are distributed throughout the concrete, they are effective close to where cracks start at the aggregate-paste interface. [10]

Polypropylene fibers used in concrete show in fig. 2.

Figure 2. Polypropylene fibers for concrete

Plastic concrete is susceptible to develop cracks due to shrinkage in dry and windy conditions. Addition of fibers could reduce propagation of this crack. On the other hand, permeability determines the durability properties of concrete. This study evaluated strength, plastic shrinkage and permeability (gas and water) of concrete incorporating ‘polypropylene’ fiber (aspect ratio 300) in various proportions (viz. 0.10%, 0.15%, 0.2%, 0.25% and 0.3%) by volume of concrete. Plane concrete samples were also prepared and tested for reference purpose. Inclusion of 0.1% fiber gave minor reduction (2%) in compressive strength while the tensile strength increased by 39% with same fiber content compared to the plain concrete. A significant reduction in crack generation, appearance period of first crack and crack area between plane concrete and fiber reinforced concretes was found. The experimental result with inclusion of 0.1–0.3% fiber in concrete indicated that plastic shrinkage cracks were reduced by 50–99% compared to the plain concrete. For reference concrete (without fiber), test within the high temperature and controlled humidity chamber gave higher crack width than the acceptable limit (3 mm) specified by the ACI 224. With the inclusion of 0.1% fiber

reduced the crack width down to 1 mm and the trend was continued with the addition of more fibers. However, results showed that with the addition of polypropylene fiber both water and gas permeability coefficient was increased. Therefore, it is concluded that the fiber reinforced concrete would work better for plastic shrinkage susceptible structural elements (flat elements such as slab); however, it requires careful judgement while applying to a water retaining structures. [22]

2.1.3. Glass Fiber Reinforced Concrete

Glass fiber is made up from 200-400 individual filaments which are lightly bonded to make up a stand. These stands can be chopped into various lengths, or combined to make cloth mat or tape. Using the conventional mixing techniques for normal concrete it is not possible to mix more than about 2% (by volume) of fibers of a length of 25mm.

The major appliance of glass fiber has been in reinforcing the cement or mortar matrices used in the production of thin-sheet products. The commonly used verities of glass fibers are e-glass used. In the reinforced of plastics & AR glass E-glass has inadequate resistance to alkalis present in Portland cement where AR-glass has improved alkali resistant characteristics. Sometimes polymers are also added in the mixes to improve some physical properties such as moisture movement. [10]

Glass fiber used in concrete show in fig. 3.

Figure 3. Glass fiber for concrete

2.1.3. 1. Effect of compressive strength on glass fiber concrete

This figure represents the graph between the Compressive strength vs % of glass fibre. The glass fibre is added at the rate of 0.5%, 1%, 2%, and 3%. Out of these, the compressive strength is very high at 1% having for 7 days is 20.76N/mm^2 and for 28 days is 28.46N/mm^2.

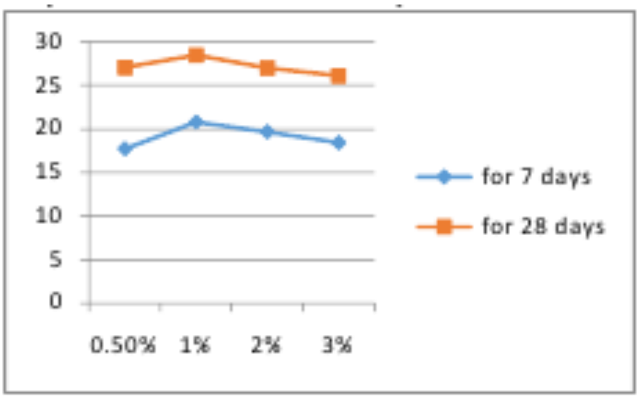


Figure 4. Compressive strength vs % of glass fibre

2.1.3. 2. Effect of flexural strength on glass fiber concrete

This figure represents the graph between the Compressive strength vs % of glass fibre. The glass fibre is added

at the rate of 0.5%, 1%, 2%, and 3%. Out of these, the tensile strength is very high at 1% having for 7 days is1.47N /mm^2 and for 28 days is 2.94N /mm^2.

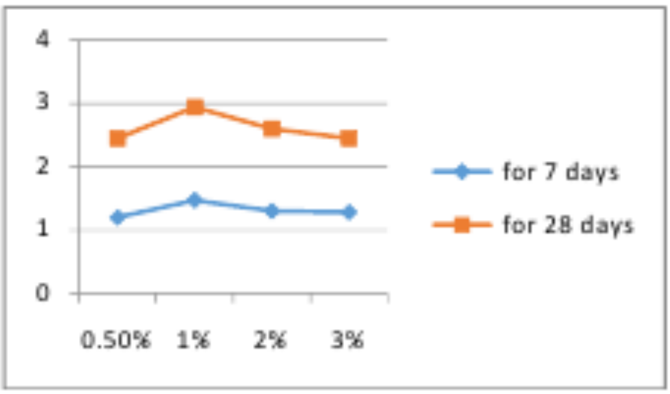


Figure 5. Flexural strength vs. % of glass fibre

2.1.3. 3. Effect of split tensile strength on glass fiber concrete

This figure represents the graph between the Split Tensile strength vs % of glass fibre. The glass fibre is added at the rate of 0.5%, 1%, 2%, and 3%. Out of these, the split tensile strength is very high at 1% having for 7 days is 2.83 N /mm^2 and for 28 days is 3.92N /mm^2 .

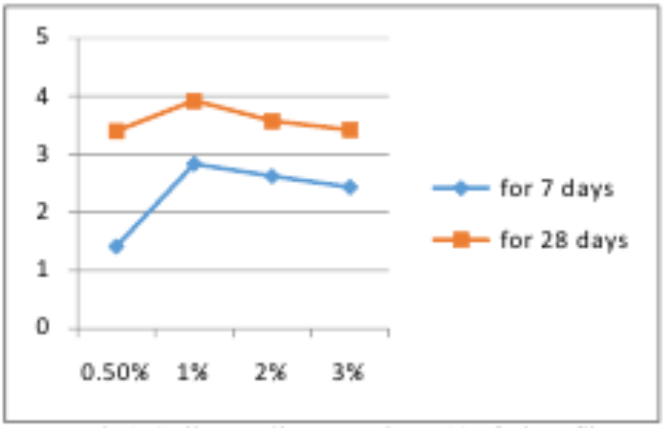


Figure 6. Split Tensile strength vs. % of glass fibre

The present study concluded that the addition of glass fibres at 0.5%, 1%, 2% and 3% of cement reduces the cracks under different loading conditions. It has been observed that the workability of concrete increases at 1% with the addition of glass fibre. The increase in compressive strength, flexural strength, split tensile strength for M-20 grade of concrete at 7 and 28 days are observed to be more at 1%. We can likewise utilize the waste product of glass as fibre. It has been observed that there is a gradual increase in compressive strength compare to the normal concrete. The workability of concrete decreases from 1% due to the addition of fibre. The compressive strength is very high at 1% having for 7 days is 20.76N/mm2 and for 28 days is 28.46N/mm2 . The tensile strength is very high at 1% having for 7 days is1.47N /mm^2 and for 28 days is 2.94N /mm^2 . The split tensile strength is veryhigh at 1% having for 7 days is 2.83 N /mm^2 and for 28 days is 3.92N /mm^2 . [20].

2.1.4 Asbestos fiber

The naturally available inexpensive mineral fiber, asbestos, has been successfully combined with Portland cement paste to form a widely used product called asbestos cement. Asbestos fibers here thermal mechanical & chemical resistance making them suitable for sheet product pipes, tiles and corrugated roofing elements. Asbestos cement board is approximately two or four times that of unreinforced matrix. However, due to relatively short length (10mm) the fiber have low impact strength.

Addition of glass fibres of about 10% by volume increased the tensile strength by roughly two times, and the impact resistance by about 10 times. The cyclic loading tests conducted on glass fibre cement laminates showed fatigue resistance of Glass fiber reinforced concrete roughly comparable with that of Steel fiber reinforced concret.

Uses of glass fibers in concrete is very limited because they suffer severe damage and loss of strength due to abrasion and impact forces generated during movement of aggregates in mixer.

Considerable attention has been paid for thorough understanding of the mechanical properties and performance characteristics of GFRC in the design of GFRC components.

Several projects were reported for building wall panels made of GFRC in UK and USA. GFRC has also been used for repair works and for industrial floors in USA. [10]

The glass fiber reinforced concrete usually finds applications in following construction works:

- Building renovation works
- Water and drainage works
- Bridge and tunnel lining panels
- Permanent formwork method of construction
- Architectural cladding
- Acoustic barriers and screens [10]

Asbestos fiber used in concrete show in fig. 7.

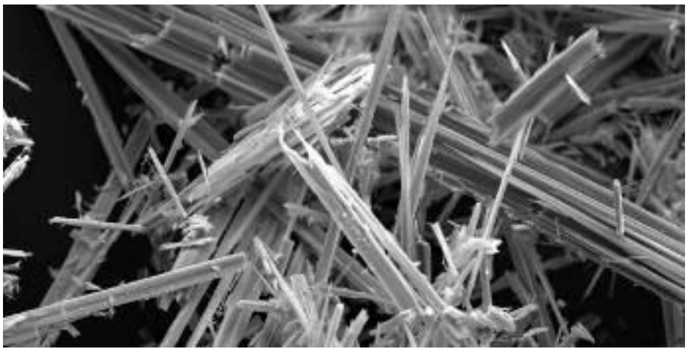


Figure 7. Asbestos fibers for concrete

2.1.5. Carbon fibers

The main impetus for development of carbon fibres has come from the aerospace industry with its need for a material with combination of high strength, high stiffness and low weight. Recently, civil engineers and construction industry have begun to realize that this material have potential to provide remedies for many problems associated with the deterioration and strengthening of infrastructure. Effective use of carbon fibre reinforced polymer could significantly increase the life of structures, minimizing the maintenance requirements.

Carbon fibre reinforced polymer is a type of fibre composite material in which carbon fibres constitutes the fibre phase. Carbon fibre are a group of fibrous materials comprising essentially elemental carbon. This is prepared by pyrolysis of organic fibres. PAN-based (PAN-poly acrylo nitrile) carbon fibres contains 93-95 percentage carbons, and it is produced at 1315°C (2400°F). Carbon fibres have been used as reinforcement for albative plastics and for reinforcements for lightweight, high strength and high stiffness structures. Carbon fibres are also produced by growing single crystals carbon electric arc under high-pressure inert gas or by growth from a vapour state by thermal decomposition of a hydrocarbon gas.

Fiber concrete materials possess good rigidity, high strength, low density, corrosion resistance, vibration resistance, high ultimate strain, high fatigue resistance, and low thermal conductivity. They are bad conductors of electricity and are non-magnetic.

Carbon fibre reinforced polymer fibre concrete is currently used world wide to retrofit and repair structurally deficient infrastructures such as bridges and buildings. Using CFRP reinforcing bars in new concrete can eliminate potential corrosion problems and substantially

increase a member's structural strength. When reinforced concrete members are strengthened with externally bonded fiber concrete, the bond between the fibre concrete substrate significantly affects the members load carrying capacity.

Strengthening measures are required in structures when they are required to accommodate increased loads. Also when there are changes in the use of structures, individual supports and walls may need to be removed. This leads to a redistribution of forces and the need for local reinforcement. In addition, structural strengthening may become necessary owing to wear and deterioration arising from normal usage or environmental factors.

The usage of composite materials like fibre concrete is still not widely recognized. The lack of knowledge of technology using fibre concrete and the simplicity of it will make some people hesitant to use it. [10]

2.1.5.1 Manufacturing of carbon fiber reinforced polymer

There are different methods of manufacturing polymer composites. They are listed as below:

- Continuous reinforcement process
- Filament winding
- Pultrusion
- Hand lay-up processes
- Moulding processes
- Matched-die moulding
- Autoclave moulding
- Vacuum bagging
- Resin injection processes
- Resin transfer moulding
- Reaction injection moulding
- Integrated manufacturing systems

Carbon fibre reinforced polymer strip is mainly manufactured by the process called pultrusion. . The pultrusion principle is comparable with a continuous press. Normally

24,000 parallel filaments are pulled through the impregnated bath, formed into strips under heat, and hardened. These strips are uni-directional; the fibres are oriented only in the longitudinal direction. Correspondingly, the strip strength in this direction is proportional to the fibre strength and, thus, very high.

The composite materials are very difficult to machine due to anisotropic, non-homogenous and reinforcing fibres tend to be abrasive. During machining defects tend to be abrasive. During machining defects are introduced in work piece and tools wear rapidly. Traditional machining techniques like drilling and screwing can be used with modified tool design and operating conditions. Also some sophisticated processes like laser and ultrasonic machining and electric discharge techniques are also used. For unidirectional CFRP, the tools are of poly crystalline diamond and carbide. For multidirectional CFRP, the tools used are made of carbide. [10]

2.1.6. Properties of carbon fibre reinforced polymer

Carbon fibre reinforced polymer is alkali resistant.

Carbon fibre reinforced polymers are resistant to corrosion; hence they are used for corrosion control and rehabilitation of reinforced concrete structures.

Carbon fibre reinforced polymer composite has low thermal conductivity.

Carbon fibre reinforced has high strength to weight ratio and hence it eliminates requirements of heavy construction equipment and supporting structures.

Carbon fibre reinforced is available in rolls of very long length. Therefore, they need very few joints, avoiding laps and splices, and its transportation is also very easy.

Carbon fibre reinforced has a short curing time. Therefore, the application takes a shorter time. This reduces the project duration and down time of the structure to a great extent.

Application of Carbon fibre reinforced does not require bulky and dusty materials in a large quantity; therefore, the site remains tidier.

Carbon fibre reinforced possess high ultimate strain; therefore, they offer ductility to the structure and they are suitable for earthquake resistant applications.

Carbon fibre reinforced has high fatigue resistance. So they do not degrade, which easily alleviates the requirement of frequent maintenance.

Carbon fibre reinforced is bad conductor of electricity and is non-magnetic.

Due to the lightweight of prefabricated components in Carbon fibre reinforced, they can be easily transported. This thus encourage prefabricated construction, reduce site errection, labour cost and capital investment requirements. [10]

2.1.7. Fibre reinforced concrete strips

Fibre reinforced concrete strips or laminates are used for strengthening of structures. The performance of fibre concrete strips depends on the strength of the adhesive used to bond the strips to the concrete surface and the degree of stress at the interface of the concrete and strips, which governs the onset of delamination. Critical modes of failure, such as, debonding of strips from the concrete (due to failure at the concrete adhesive interface) and shear-tension failure (delamination of concrete cover), can limit improvements in structures strengthened with fibre concrete. Also, these structures may require a higher factor of safety in their design. Minimizing the chances of potential failure can optimize the benefits of fibre concrete strips, allowing a strong, ductile, and durable structural system to be achieved. One possible solution to minimizing failure problems is an efficient mechanical-interlocking-anchorage system for bonding fibre concrete strips to the concrete surface. Experiments have been done and it is found that deep grooves are cut (6mm) in the top surface of beam, perpendicular to the beam length and 150mm intervals, and filling the grooves with epoxy adhesive. The grooves are intended to provide a better interlocking mechanism between the concrete surface and fibre concrete strips. To create a stronger surface at the ends of the beam for proper bonding of strips, fibre concrete fabric sheets are attached at both ends before strip application.

Fibre concrete is used to strengthen steel road bridges more easily and cheaply. The fibre concrete strips are only 20% of the weight of the strips of similar products made from high-strength steel but are at least four times as strong. Their high-strength-to- weight ratio makes the fibre concrete strips easily to handle and reduces installation costs. [10]

Carbon fiber used in concrete show in fig. 8.

Figure 8. Carbon fibers for concrete

2.1.8. Organic fibers

Organic fiber such as polypropylene or natural fiber may be chemically more inert than either steel or glass fibers. They are also cheaper, especially if natural. A large volume of vegetable fiber may be used to obtain a multiple cracking composite. The problem of mixing and uniform dispersion may be solved by adding a super plasticizer. [10]

Organic fiber used in concrete show in fig. 6.

Figure 9. Organic fiber for concrete

2.1.9. Basalt fiber

Concrete structure using basalt fibers approaching structure with reinforcement with steel mesh, but basalt concrete has a higher strength, because its reinforcing basalt fiber has a

higher degree of dispersion in the rock to be reinforced, the fiber itself has a higher strength than the steel mesh. Basalt concrete structures can withstand a lot of stress deformation, due to the fact that the very fiber tensile plastic deformation has not, as of elasticity than steel. The relative deformation of cement stone without cracks up to 0.9 - 1.1%. Such deformation in 45-55 times higher than the limit elongation of reinforced cement stone. However, the hardening of the cement stone formed an aggressive environment that destroys the fiber surface, forming a shell, and the strength of the fiber decreases slightly to 15%. But due to the strength of coupling shells stone and fiber increases and thus increases the strength of the structure itself. When using the coarse fibers (40 microns), their strength does not substantially decrease. Increasing the strength of cement is due to the effect of basalt fiber on stress concentration in places weakened by structural defects or increased porosity (in the foam materials).

Fibers made from chemically inert rocks do not react with the salts or dyes and because binding fiber admixture with additives can be used during the construction of offshore structures in the manufacture of architectural building designs with complex surfaces, decorative concrete. In the production of pavements using basalt fiber asphalt coating protects it from penetration of anti-ice salts and aggressive substances, increases surface hardness. [10]

Basalt fiber used in concrete show in fig. 10.

Figure 10. Basalt fibers for concrete

2.2. Cement mixture for fiberconcrete

To provide the required durability, concrete must have a basic characteristics corresponding to norms.

Selection of the composition of fiber-reinforced concrete mixture produced in order to obtain fiber-reinforced concrete in structures must in charge of the technical parameters adopted in the project. In the absence of the requirements of the project, the manufacturer of the concrete mix should choose the type and the class of the raw materials with proven suitability for use within specified environmental conditions.

The basis is adopted defining for specific type of concrete and type of structures determining a specific type of concrete structure and destination. This should be provided and in other quality installed indicators for concrete in project.

The specifier of the concrete shall ensure that all the relevant requirements for concrete properties are included in the specification given to the producer. The specification shall include any requirements for concrete properties that are needed for transportation after delivery, placing, compaction, curing or further treatment. The specification shall, if necessary, include any special requirements.

The specifier shall take account of:

- the application of the fresh and hardened concrete;
- the method of placing;
- the method of compaction;
- the curing conditions;
- the dimensions of the element (the heat development);
- the environmental conditions to which the element is to be exposed;
- any requirements for exposed aggregate or tooled concrete finishes;
- any requirements related to the cover to reinforcement or minimum section width, e.g. maximum aggregate size;
- any further restrictions on the use of constituent materials with established suitability [5].

Mixing of FRC can be accomplished by many methodsl21. The mix should have a uniform dispersion of the fibers in order to prevent segregation or balling of the fibers during mixing. Most balling occurs during the fiber addition process. Increase of aspect ratio, volume percentage of fiber, and size and quantity of coarse aggregate will intensify the balling tendencies and decrease the workability. To coat the large surface area of the fibers with paste, experience indicated that a water cement ratio between 0.4 and 0.6, and minimum

cement content of 400 kg/m[3] are required. Compared to conventional concrete, fiber reinforced concrete mixes are generally characterized by higher cement factor, higher fine aggregate content, and smaller size coarse aggregate. A fiber mix generally requires more vibration to consolidate the mix. External vibration is preferable to prevent fiber segregation. Metal trowels, tube floats, and rotating power floats can be used to finish the surface. [23]

2.3. Aggregate

Concrete is a mixture of cementious material, aggregate, and water. Aggregate is commonly considered inert filler, which accounts for 60 to 80 percent of the volume and 70 to 85 percent of the weight of concrete. Although aggregate is considered inert filler, it is a necessary component that defines the concrete's thermal and elastic properties and dimensional stability. Aggregate is classified as two different types, coarse and fine. Coarse aggregate is usually greater than 4.75 mm (retained on a No. 4 sieve), while fine aggregate is less than 4.75 mm (passing the No. 4 sieve). The compressive aggregate strength is an important factor in the selection of aggregate. When determining the strength of normal concrete, most concrete aggregates are several times stronger than the other components in concrete and therefore not a factor in the strength of normal strength concrete. Lightweight aggregate concrete may be more influenced by the compressive strength of the aggregates.

Other physical and mineralogical properties of aggregate must be known before mixing concrete to obtain a desirable mixture. These properties include shape and texture, size gradation, moisture content, specific gravity, reactivity, soundness and bulk unit weight. These properties along with the water/cementitious material ratio determine the strength, workability, and durability of concrete.

The shape and texture of aggregate affects the properties of fresh concrete more than hardened concrete. Concrete is more workable when smooth and rounded aggregate is used instead of rough angular or elongated aggregate. Most natural sands and gravel from riverbeds or seashores are smooth and rounded and are excellent aggregates. Crushed stone produces much more angular and elongated aggregates, which have a higher surface-to-volume ratio, better bond characteristics but require more cement paste to produce a workable mixture.

The surface texture of aggregate can be either smooth or rough. A smooth surface can improve workability, yet a rougher surface generates a stronger bond between the paste and the aggregate creating a higher strength.

The grading or size distribution of aggregate is an important characteristic because it determines the paste requirement for workable concrete. This paste requirement is the factor controlling the cost, since cement is the most expensive component. It is therefore desirable to minimize the amount of paste consistent with the production of concrete that can be handled, compacted, and finished while providing the necessary strength and durability. The required amount of cement paste is dependent upon the amount of void space that must be filled and the total surface area that must be covered. When the particles are of uniform size the spacing is the greatest, but when a range of sizes is used the void spaces are filled and the paste requirement is lowered. The more these voids are filled, the less workable the concrete becomes, therefore, a compromise between workability and economy is necessary.

The moisture content of an aggregate is an important factor when developing the proper water/cementitious material ratio. All aggregates contain some moisture based on the porosity of the particles and the moisture condition of the storage area. The moisture content can range from less than one percent in gravel to up to 40 percent in very porous sandstone and expanded shale. Aggregate can be found in four different moisture states that include oven-dry , air-dry , saturated-surface dry and wet. Of these four states, only oven-dry and saturated-surface dry correspond to a specific moisture state and can be used as reference states for calculating moisture content. In order to calculate the quantity of water that aggregate will either add or subtract to the paste, the following three quantities must be calculated: absorption capacity, effective absorption, and surface moisture.

Most stockpiled coarse aggregate is in the air-dry state with an absorption of less than one percent, but most fine aggregate is often in the wet state with surface moisture up to five percent. This surface moisture on the fine aggregate creates a thick film over the surface of the particles pushing them apart and increasing the apparent volume. This is commonly known as bulking and can cause significant errors in proportioning volume.

The density of the aggregates is required in mixture proportioning to establish weight-volume relationships. Specific gravity is easily calculated by determining the densities by the displacement of water. All aggregates contain some porosity, and the specific gravity value

depends on whether these pores are included in the measurement. There are two terms that are used to distinguish this measurement; absolute specific gravity and bulk specific gravity. Absolute specific gravity refers to the solid material excluding the pores, and bulk specific gravity sometimes called apparent specific gravity, includes the volume of the pores. For the purpose of mixture proportioning, it is important to know the space occupied by the aggregate particles, including the pores within the particles. The BSG of an aggregate is not directly related to its performance in concrete, although, the specification of BSG is often done to meet minimum density requirements.

For mixture proportioning, the bulk unit weight (a.k.a. bulk density) is required. The bulk density measures the volume that the graded aggregate will occupy in concrete, including the solid aggregate particles and the voids between them. Since the weight of the aggregate is dependent on the moisture content of the aggregate, a constant moisture content is required. This is achieved by using oven-dry aggregate. Additionally, the bulk density is required for the volume method of mixture proportioning.

The most common classification of aggregates on the basis of bulk specific gravity is lightweight, normal-weight, and heavyweight aggregates. In normal concrete the aggregate weighs 1,520 – 1,680 kg/m^3, but occasionally designs require either lightweight or heavyweight concrete. Lightweight concrete contains aggregate that is natural or synthetic which weighs less than 1,100 $kg/m^3$and heavyweight concrete contains aggregates that are natural or synthetic which weigh more than 2080 kg/m^3.

Although aggregates are most commonly known to be inert filler in concrete, the different properties of aggregate have a large impact on the strength, durability, workability, and economy of concrete. These different properties of aggregate allow designers and contractors the most flexibility to meet their design and construction requirements.

As a coarse aggregate for fibre concrete recommended gravel from dense rocks, usually with a maximum grain size of up to 10 mm and containing platelet grains form and needle form up to 25%.

Allowed to use gravel at the technical rationale with a maximum grain size of 20 mm with a limited content of 10-20 mm fraction in an amount up to 25% by weight. Increasing the amount of aggregate or a large size (relative to the length of the fibers) leads to a decrease in strength properties stalefibrobetona.

As a fine aggregate for heavy fibreconcrete and fine-grained concrete should be used quartz sand with the size is usually not less than 2.0 mm. [11]

2.4. Chemical additives

To adjust the properties of fiberconcrete mixtures to ensure their mobility and workability, it is recommended to apply the chemicals, plasticizers, water-reducing additives or complex modifiers of concrete. Chemical additives for fiberconcrete must comply with normative documents.

When choosing supplements and determining their amount in the concrete, it's necessary follow the following technological features of fiberconcrete: crowding-out effect of entrained air in the concrete mix when administered fiber reinforcement (in fiberconcrete mixtures with surfactant additives contained in 1.7-2.1 times less entrained air than the original matrix) allows the use of higher doses of plasticizers; the presence of metallic fiber reinforcement with a relatively large surface area requires the creation of high inhibitory properties of the matrix.

It is recommended to use multi-functional additives, consisting of 2-5 components that optimize together the technological and performance characteristics of fiberconcrete.

Successful use of admixtures depends on the use of appropriate methods of batching and concreting. Most admixtures are supplied in ready-to-use liquid form and are added to the concrete at the plant or at the jobsite. Certain admixtures, such as pigments, expansive agents, and pumping aids are used only in extremely small amounts and are usually batched by hand from premeasured containers.

The effectiveness of an admixture depends on several factors including: type and amount of cement, water content, mixing time, slump, and temperatures of the concrete and air. Sometimes, effects similar to those achieved through the addition of admixtures can be achieved by altering the concrete mixture-reducing the water-cement ratio, adding additional cement, using a different type of cement, or changing the aggregate and aggregate gradation.

Admixtures are classed according to function. There are five distinct classes of chemical admixtures: air-entraining, water-reducing, retarding, accelerating, and plasticizers

(superplasticizers). All other varieties of admixtures fall into the specialty category whose functions include corrosion inhibition, shrinkage reduction, alkali-silica reactivity reduction, workability enhancement, bonding, damp proofing, and coloring. Air-entraining admixtures, which are used to purposely place microscopic air bubbles into the concrete, are discussed more fully in Air-Entrained Concrete.

Water-reducing admixtures usually reduce the required water content for a concrete mixture by about 5 to 10 percent. Consequently, concrete containing a water-reducing admixture needs less water to reach a required slump than untreated concrete. The treated concrete can have a lower water-cement ratio. This usually indicates that a higher strength concrete can be produced without increasing the amount of cement. Recent advancements in admixture technology have led to the development of mid-range water reducers. These admixtures reduce water content by at least 8 percent and tend to be more stable over a wider range of temperatures. Mid-range water reducers provide more consistent setting times than standard water reducers.

Retarding admixtures, which slow the setting rate of concrete, are used to counteract the accelerating effect of hot weather on concrete setting. High temperatures often cause an increased rate of hardening which makes placing and finishing difficult. Retarders keep concrete workable during placement and delay the initial set of concrete. Most retarders also function as water reducers and may entrain some air in concrete.

Accelerating admixtures increase the rate of early strength development, reduce the time required for proper curing and protection, and speed up the start of finishing operations. Accelerating admixtures are especially useful for modifying the properties of concrete in cold weather.

Superplasticizers, also known as plasticizers or high-range water reducers (HRWR), reduce water content by 12 to 30 percent and can be added to concrete with a low-to-normal slump and water-cement ratio to make high-slump flowing concrete. Flowing concrete is a highly fluid but workable concrete that can be placed with little or no vibration or compaction. The effect of superplasticizers lasts only 30 to 60 minutes, depending on the brand and dosage rate, and is followed by a rapid loss in workability. As a result of the slump loss, superplasticizers are usually added to concrete at the jobsite.

Corrosion-inhibiting admixtures fall into the specialty admixture category and are used to slow corrosion of reinforcing steel in concrete. Corrosion inhibitors can be used as a defensive strategy for concrete structures, such as marine facilities, highway bridges, and parking garages, that will be exposed to high concentrations of chloride. Other specialty admixtures include shrinkage-reducing admixtures and alkali-silica reactivity inhibitors. The shrinkage reducers are used to control drying shrinkage and minimize cracking, while ASR inhibitors control durability problems associated with alkali-silica reactivity.

2.5. Effect of dissipated reinforce on the properties of hardness characteristics of concrete

2.5.1. Effect of Fibers in concrete

Fibres are usually used in concrete to control plastic shrinkage cracking and drying shrinkage cracking. They also lower the permeability of concrete and thus reduce bleeding of water. Some types of fibres produce greater impact, abrasion and shatter resistance in concrete. Generally fibres do not increase the flexural strength of concrete, so it can not replace moment resisting or structural steel reinforcement. Some fibres reduce the strength of concrete.

Fibres with a non-circular cross section use an equivalent diameter for the calculation of aspect ratio. If the modulus of elasticity of the fibre is higher than the matrix (concrete or mortar binder), they help to carry the load by increasing the tensile strength of the material. Increase in the aspect ratio of the fibre usually segments the flexural strength and toughness of the matrix. However, fibres which are too long tend to “ball” in the mix and create workability problems.

Some recent research indicated that using fibres in concrete has limited effect on the impact resistance of concrete materials. This finding is very important since traditionally people think the ductility increases when concrete reinforced with fibres. The results also pointed out that the micro fibres is better in impact resistance compared with the longer fibres.

2.5.2. Volume of fibers

The strength of the composite largely depends on the quantity of fibers used in Fig. 11 and 12 show the effect of volume on the toughness and strength. It can see from Fig. 11 that the increase in the volume of fibers, increase approximately linearly, the tensile strength and toughness of the composite. Use of higher percentage of fiber is likely to cause segregation and harshness of concrete and mortar.

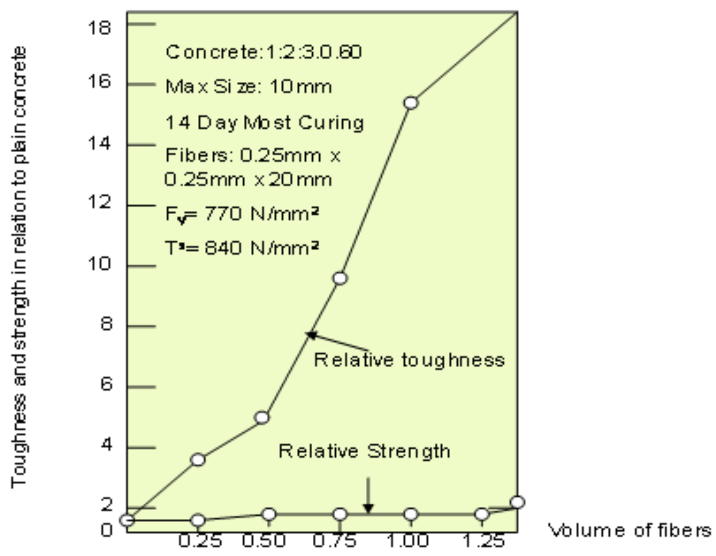


Figure 11. Effect of volume of fibers in flexure

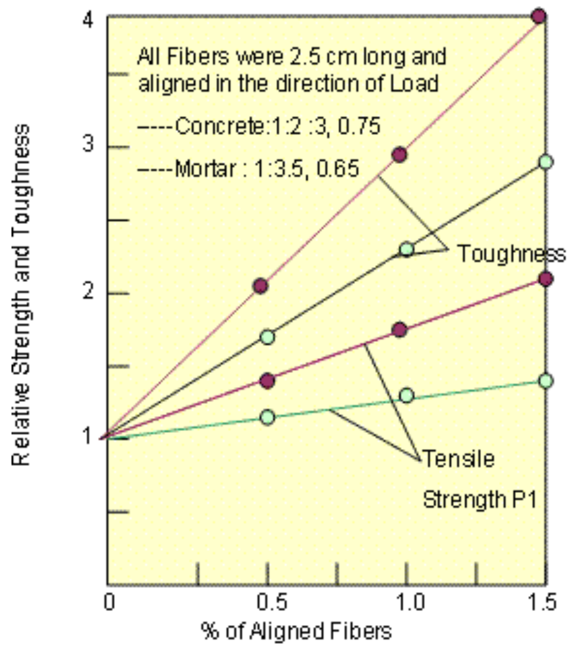


Figure 12. Effect of volume of fibers in tension

2.5.3. Aspect Ratio of the Fiber

Another important factor which influences the properties and behavior of the composite is the aspect ratio of the fiber. It has been reported that up to aspect ratio of 75, increase on the aspect ratio increases the ultimate concrete linearly. Beyond 75, relative strength and toughness is reduced. Table 2 shows the effect of aspect ratio on strength and toughness.

Table 2. Aspect ratio of the fiber

Type of concrete	Aspect ratio	Relative strength	Relative toughness
Plain concrete	0	1	1
With	25	1.5	2.0
Randomly	50	1.6	8.0
Dispersed fibers	75	1.7	10.5

2.5.4. Orientation of Fibers

One of the differences between conventional reinforcement and fiber reinforcement is that in conventional reinforcement, bars are oriented in the direction desired while fibers are randomly oriented. To see the effect of randomness, mortar specimens reinforced with 0.5% volume of fibers were tested. In one set specimens, fibers were aligned in the direction of the load, in another in the direction perpendicular to that of the load, and in the third randomly distributed.

It was observed that the fibers aligned parallel to the applied load offered more tensile strength and toughness than randomly distributed or perpendicular fibers.

2.5.5. Workability and Compaction of Concrete

Incorporation of steel fiber decreases the workability considerably. This situation adversely affects the consolidation of fresh mix. Even prolonged external vibration fails to compact the concrete. The fiber volume at which this situation is reached depends on the length and diameter of the fiber.

Another consequence of poor workability is non-uniform distribution of the fibers. Generally, the workability and compaction standard of the mix is improved through increased water/ cement ratio or by the use of some kind of water reducing admixtures.

2.5.6. Size of Coarse Aggregate

Maximum size of the coarse aggregate should be restricted to 10mm, to avoid appreciable reduction in strength of the composite. Fibers also in effect, act as aggregate. Although they have a simple geometry, their influence on the properties of fresh concrete is complex. The inter-particle friction between fibers and between fibers and aggregates controls the orientation and distribution of the fibers and consequently the properties of the composite. Friction reducing admixtures and admixtures that improve the cohesiveness of the mix can significantly improve the mix [3].

2.5.7. Effect of size and orientation of the fiber on the concrete porosity

It is generally known that the use of reinforced concrete improves the physical and mechanical properties of structures formed on its base. One of the type of reinforce is the saturation of a concrete with fiber of different materials (dispersed reinforcement). In practice, as the fibers typically used a thin metal wire with a diameter of 0.1 to 1.5 mm and a length of 10 to 100 mm. Concrete saturation volume of fiber is recommended to take in the range of 2-5% of the total. At the same time there is a sharp decrease of efficiency particulate reinforcing effect on concrete strength of fibers with a diameter of 0.6 mm or more. The reason for this effect is the adhesion properties of cement stone with the material.

One of the main flaws of modern concrete is a poor adhesion of cement mixture with fillers. All the basic properties of concrete depend on the adhesion of cement mixture with fillers.

Inclusion in concrete mixture additional elements made in the form of fibers substantially alters the physical and mechanical properties of the material increases the ductility, crack resistance and strength characteristics.

Analysis results of studies showing that increasing the fiber diameter from 0.4 mm to 0.7 mm decreases the clutch of fiber with the concrete.

To determine the causes of the phenomenon studied the structure of fixing fiber material. It is known that the strength of concrete to some extent, dependent on the density, and it in turn depends on the water and cement ratio. The cement stone when the cement mixtures are well compact (porosity of not more than 1-2%), the formation of pores is mainly due to the evaporating water. The evaporating water from the cement stone has two forms of communication: the physic-chemical and physic-mechanical. Chemical bonding usually is stronger and not violated by drying cement stone at $t < 105°C$. Solidification of concrete only part of the water is chemically bound, the remaining creates pores in the concrete body (18 volume %). When mixing with high-quality concrete mix and stirring all the water is evenly distributed, and therefore porosity will also be distributed evenly. By studying the visual sections of concrete samples revealed that the porosity is as follows:

the pores with a diameter of 0.1 mm to 0.3 - 60%; from 0.3 to 0.5 mm - 30%; from 0.5 to 1.0 mm - 8%; from 1.0 to 2.0 mm - 1.5% and more than 2 mm - 0.5% of the total pore .

The study made the following findings:

- fiber diameter of up to 0.4 mm in volume when placed almost does not have a contact with pores or has a contacted only in the considered section;

- placing fibers of diameter 0.5 to 0.8 mm is contacted with pore diameter of 5.3 to 0.3 mm and a diameter of 0.5 mm;

- with increasing fiber diameter above 1.0 mm fiber surface by contact with 5 pores have a diameter of 0.3 to 3.4 mm and a diameter of 0.5 mm.

In the first case, the loss of proportion of the contact surface of fiber is up to 3%, in the second - 20%, further not more than 27% by increasing the diameter of the fiber (Fig.13) .

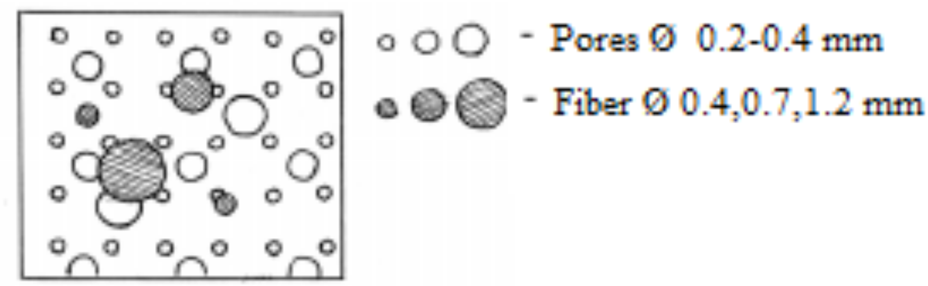


Figure 13. Placement of metal fibers with respect to the concrete pores

Analysis of the research indicates that the increase in the strength characteristics of fiber-reinforced concrete with fibers of small diameter with a high percentage of saturation has a difficulty to prepare a mixture according to technology (with a large amount of a so-called "hedgehogs"). Therefore, the choice of saturation indices should be determined taking into account the nature of the placement of fibers.

The use of bulk fibers in the form of rolled rings, helices provides better grip [4].

2.5.8. Factors Affecting Durability of Fiber Reinforced Concrete

Following are the factors which affects the durability of fiber reinforced concrete:

- Extreme temperature and fire
- Freezing and thawing
- Degradation and embrittlement due to alkali attack and bundle affect
- Weathering and scaling
- Corrosion resistance

2.5.8.1. Effect of Extreme Temperature and Fire on Durability

Generally, concrete has a reasonable resistance to severe temperature because of its low thermal conductivity, great heat capacity, and it is not burn easily while exposed to fire.

Concrete constituents for example specific aggregate types and cement clinker are not influenced by high temperature both chemically and physically. However, there are others

concrete constituents that affected by temperature changes such as hydration product. It is influenced by loss of water, micro-cracking, and damage by differential expansion.

The addition of steel fiber, synthetic fiber, or combination of both to concrete enhances structural concrete elements resistant against substantial temperature and fire.

The strength of conventional concrete is decreased considerably if it exposed to fire for long time. Cement paste and aggregate bond in concrete is damaged at a temperature of 202^{o}C and about half of the concrete strength is decline at temperature of 427 ^{o}C, and 90% of concrete strength is lost at temperature of larger than 927 ^{o}C.

Fiber provision do not impede concrete failure under this sever condition but it increases fire exposure safe time. The extension of fire exposure safe time provides more time during which evacuations and the fire extinguishment can be proceeded safely.

It is reported that, the application of hybrid combination of steel and polypropylene fibers in precast concrete fireplace hearths produced small or not explosive spalling.

Regarding concrete spalling, when concrete exposed to fire, excess water inside concrete, which used to provide workability during construction, changes to steam pressure. If the pressure inside concrete is not released and surpass concrete tensile strength, explosive spalling will occur.

The concrete spalling depends on the amount of free water and its distribution while concrete element is exposed to fire.

The damage caused by spalling may penetrate concrete to about 6 cm.

Spalling is a serious problem because it may expose steel reinforcement to high temperature. Hence, steel reinforcement is deteriorated quickly which in return ultimate load carrying capacity of concrete member is declined.

It is demonstrated that, when concrete reinforced with polypropylene fiber exposed to high temperature, the polypropylene fiber is melted and fine capillary pores will be emptied and this lead to release the accumulated steam pressure and the concrete maintain its strength.

The provision of steel fiber increases small concrete slab fire resistance to three to nine times that of the slab with no fibers.

Finally, fibers can be added to concrete to bridge cracks and keep structure integrity of the damaged structure.

2.5.8.2. Effect of Freezing and Thawing on Durability of fiber concrete

In this section durability of three fiber reinforced concrete namely steel, synthetic, and cellulose fiber concrete will be explained.

It is demonstrated that, among factors such as fiber content, air content, cement content, and water to cement ratio, the air content create significant effect on the steel fiber reinforced concrete resistance against freezing and thawing.

Moreover, the reduction of fiber concrete modulus of rupture due to freezing and thawing is smaller than that of concrete with zero fiber.

It is recommended by Rider and Heidersbach that, mix design of fiber concrete that is used in marine environment, need to have water content of no greater than 0.45, cement content should be at least 519 Kg/m^3, and air content ranges from 6-7.5%.

Regarding synthetic fiber reinforced concrete, it is pointed out that, not only does the synthetic fibers improves freezing and thawing resistance of synthetic FRC but also enhances concrete ability to withstand deicer scaling.

Moreover, freezing and thawing cause reduction of flexural strength of concrete reinforced with polyolefin micro-fiber by about 15% whereas plain concrete flexural strength reduced by 30%.

As far as cellulose fiber is concerned, it is found that, fiber reinforced cement board which is laminated material and consist of cellulose fiber, cement, silica, and water, is vulnerable to freezing and thawing deterioration due to its high porosity, hydrophilic and tabular nature of cellulose fibers, and laminated nature of the composite.

2.5.8.3. fiber concrete degradation and embrittlement due to alkali attack and bundle effect

Strength of various fibers for example glass, polymeric, and natural fibers are decreased in long term because of weathering. It is substantially important to know time-dependent reduction of durability and strength of those fibers in structurally related areas.

That is why deterioration mechanism of various fibers will be explained in this section.

Glass Fiber Concrete

Reinforced concrete commonly contains alkali resistance glass fibers between 3-5% of the whole composite weight. It is reported that, the corrosion of fiber is the major degradation mechanism.

However, it is claimed that, apart from the effect of corrosion, there are other factors that influence the durability of fiber concrete. Added to that, in most situations, calcium hydroxide, which is a product of cement hydration, is the agent that is to blame for decreasing fiber concrete durability.

That is why attempts made toward the reduction of calcium hydroxide in order t improve the durability of fiber concrete. Calcium hydroxide can be reduced by either adding admixtures for example fly ash, ground granulated blast furnace slag, and silica fume or avoid the use of conventional Portland cement especially those types which contain calcium aluminates or sulfo aluminates.

In summary, the glass fiber reinforced concrete damage mechanisms are chemical attack, mechanical attack, delayed fracture.

Cellulose Fiber Concrete

Cycles of wetting and drying lead to degrade cellulose fiber and this degradation occur in different mechanism includes change in degree of fiber cement bonding and fiber mineralization.

In the former mechanism, hydration product transportation specifically lime within the lumen of fibers and around the fibers lead to reduce interface porosity. This could be the cause of the increase of fiber cement bond and the decline of composite ductility.

In the latter mechanism, it is claimed that, the embrittlement of fiber occur as a result of the penetration of cement hydration product into the fiber.

Lastly, the durability of cellulose fiber may be increased by Fiber impregnation with blocking agents, and water repellent Agents Sealing of the matrix pore system; Reduction of Ca(OH)2 content in the matrix; and A combination of fiber impregnation and matrix modification.

2.5.8.4. Effect of Weathering and Scaling on Durability of fiber concrete

The deicer salt scaling, which its mechanics is still not clear, is merely affect a thin layer of exposed concrete which not exceed few centimeters. It is reported that, the present fiber and the type of fiber do not influence dicer salt scaling resistance. Moreover, it is pointed out that, steel fibers that in contact with concrete which suffered scaling, rusts.

Corrosion Resistance of Fiber Reinforced Concrete

Unlike ordinary reinforced concrete beam, FRC is distributed in concrete and some of them might be close or at the surface of the concrete. Therefore, those fibers which are not protected by concrete might corrode.

Factor that could lead to corrosion are chloride induced corrosion, corrosion because of PH reduction in the concrete mix.

It is showed that, low carbon steel and galvanized steel fibers do not corrode in chloride concentration that greater than 2 percent by weight. Moreover, at much greater chloride ions, melt extracted fiber does not corrode.

Chapter 3 – DESIGNING OF FIBER FOR DISSIPATED REINFORCING OF CONCRETE

3.1. Cylindrical fiber

The invention relates to the field of construction, namely the fiber to be dispersed concrete reinforcement, and can be used for reinforcing asphalt concrete and the soil mass.

Known reinforcing element to disperse reinforcement and device for its manufacture [7].

Viewed reinforcing element is a wavy wire segment in two mutually perpendicular planes, which increases its stiffness under spatial concrete reinforcement. This design reinforcing element does not allow reinforcement at volume , which reduces the efficiency of scattered concrete reinforcement fiber.

The closest technical solution to the proposed utility model is a reinforcing fiber for composite mixture formed in a bulk segment with a maximum outer diameter of the fiber equal 10 mm [8].

This fiber allows reinforce a light concrete. For reinforcement of volume of heavy concrete the use of the fiber will be ineffective since large grain fiber aggregate among themselves will not bind.

At present, basically straight steel fibers are used in concrete. However, some experimental work carried out at SERC on helical and twisted fibers indicates their superiority over plain fibers in pull-out strength and also in the elimination of balling when they are mixed with concrete (Fig. 14) [21].

The purpose of the utility model is to improve the strength characteristics of concrete with dispersed reinforcement.

This object is achieved by the fact that the fiber for reinforcement of concrete has the shape of the spiral elastic segment , with a diameter of the cylinder is greater than 10 mm and a pitch equal to the average size fractions of concrete aggregate. When using the proposed fiber for reinforcement of concrete appear additional voluminous communication of grains aggregate of concrete to each other and with cement stone, which increases the strength characteristics of concrete in comparison with existing analogues.

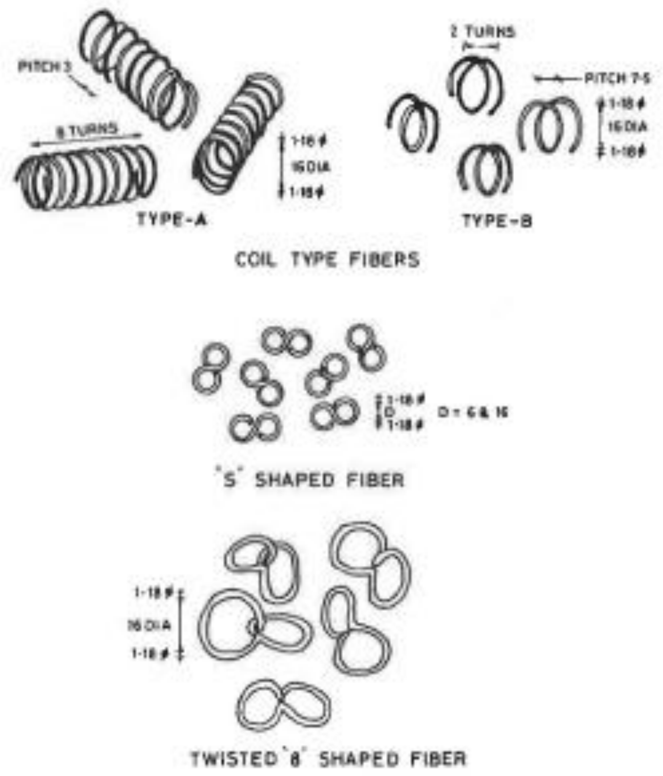


Figure 14. Different shapes of steel fibers (in mm) developed at SERC, Madras.

Figure 15 shows a general view of the fiber in plan .

The structure of fiber (Fig. 15) comprises a volumetric circular-cylindrical shaped helical segment 1, which is made of an elastic material, with a cylinder diameter "d" , and step "h" helix.

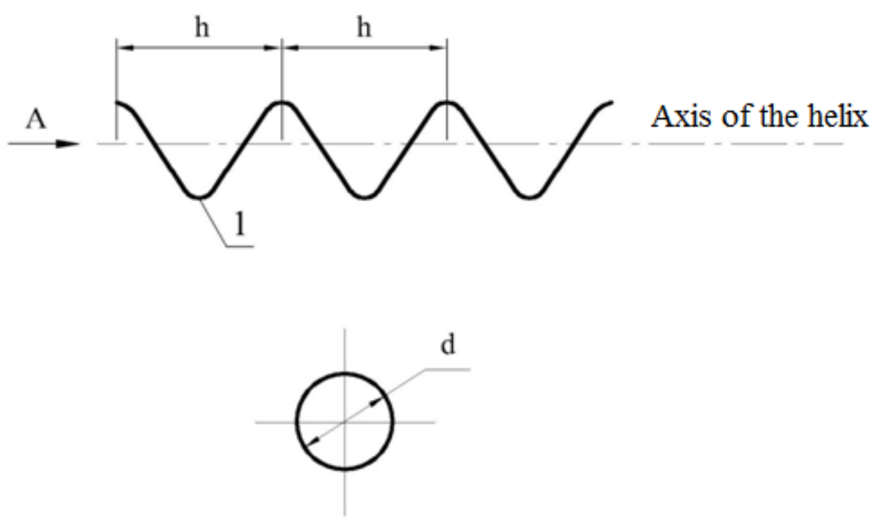


Figure 15. General view of the fiber in plan

The manufactured fiber is shown in fig. 16.

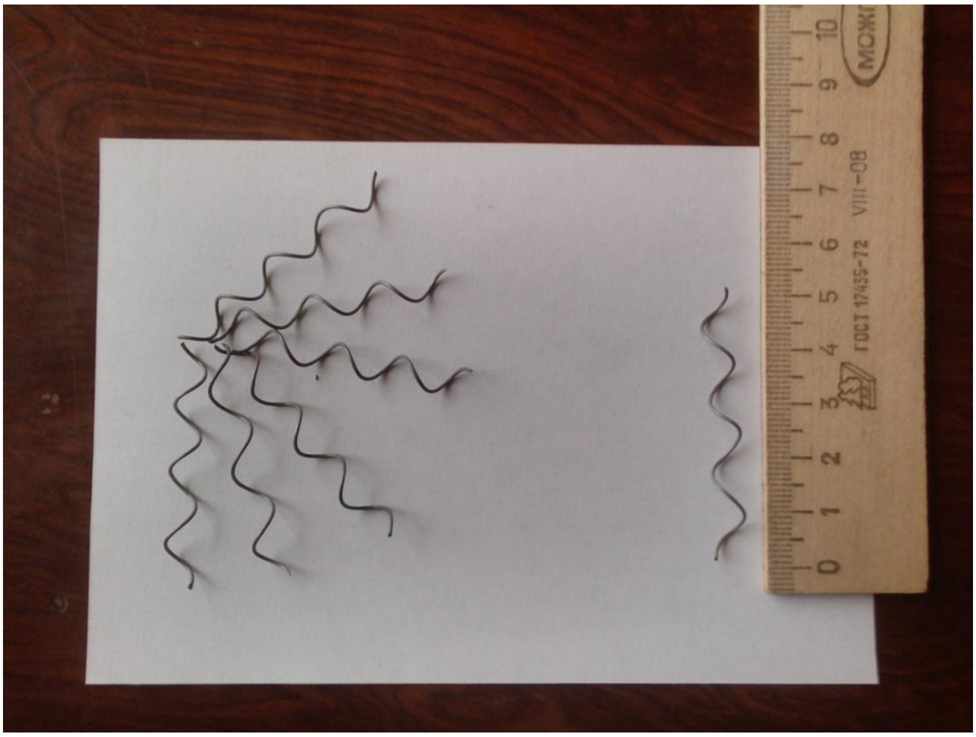


Figure 16. Manufactured fiber

3.2. Interaction of fiber and aggregate in a concrete mix

All the empirical formulas for determining the strength of concrete contain coefficients that depend on the quality of the aggregates.

First of all, these are properties that determine the adhesion of cement stone to the surface of grains of aggregates in concrete, and the inherent strength of aggregates.

In ordinary heavy concrete, the strength of a large aggregate-gravel or crushed stone is always higher than the strength of the mortar, and the strength of the fine aggregate-sand (more precisely, of the rock or minerals making up grains of sand) is greater than the strength of the cement stone. And yet, the strength of the solution is, as a rule, less than the strength of cement stone, and the strength of concrete is often below the strength of its solution part. Studies have shown that the strength of concrete depends not so much on the strength of

aggregates as on the strength of the bonding of cement stone with the surface of grains of aggregates.

This can be seen by doing the following experiment in the laboratory. Prepare as a "filler" »smooth steel balls and the same size of paraffin balls. Then we will form the same cement samples from the cement slurry, in one of which we will introduce steel balls, in the other - paraffin. After hardening under the same conditions, we will test the samples for strength. It turns out that their strength is approximately the same, despite the fact that in one "filler" of high-strength and rigid steel, in the other, from a weak plastic paraffin. In both cases, the strength of the samples will be significantly lower than the strength of the initial solution.

The lack of adhesion of cement stone with aggregates is so dramatic in reducing the strength of concrete because even when compressed, concrete breaks down from transverse stretching. In the absence of cohesion of cement stone with aggregates, the latter practically do not participate in the resistance to the action of the load and are, as it were, likened to voids that weaken the cross section. In practice, as a filler, a smooth-rolled sea pebble is sometimes used. Naturally, the strength of concrete in this case can not be high.

Applying instead of pure cement stone concretes with fine and coarse aggregate, they strive to ensure that the replacement of the aggregate of cement stone in concrete is effective in all respects. As indicated above, the aggregate takes up to 80% of the volume in the concrete. This saves the cement. But is always the introduction of concrete into aggregates effective in terms of ensuring high strength of the conglomerate?

As for the fine aggregate - sand, the experiments show that the strength of the cement-sand mortar on quartz sand is below the strength of the cement stone.

If instead of natural sand is used crushed rock, then you can achieve some increase in the strength of concrete, although in crushed sand, grains often have smooth faces, representing individual crystals of minerals.

Some crystalline minerals break down during breakage with the breakage of interatomic bonds. It has been found that freshly crushed quartz aggregates, by virtue of the ionization of the grain surface, acquire physico-chemical activity for a short time, which is manifested in an increase in the strength of concrete due to better adhesion.

However, the strength of adhesion of cement stone to the surface of grains of sand is less than the strength of cement stone, so the latter in cement-sand mortar is underutilized.

Crushed stone as a coarse aggregate is better than gravel, since it has a more grain-friendly form of grains and a developed rough surface. It is used to produce high-strength concrete.

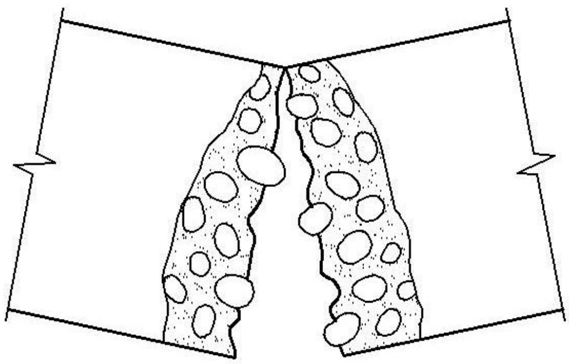
Gravel is the cheapest large aggregate, its deposits are found in many regions of the country. If using gravel, like sand, is more or less reliable its adhesion to cement stone, due only to physical and chemical interaction, then when using rubble, there is also a mechanical engagement, which is overcome when the concrete is destroyed due to the resistance of the cement stone to the slice.

In addition to the shape of aggregate grains, the strength of the surface affects the strength of bonding with the cement stone. Natural aggregates are often contaminated. For example, clayey impurities enveloping grains with a thin film interfere with adhesion. Therefore, they should be washed beforehand. In the case of the use of non-washed fillers, it is advisable to mix the water with concrete in the concrete mixer before adding cement. In this case, the impurities washed off from the surface of the aggregate will be evenly distributed in the cement test and will not have such harmful effects.

The porosity of the aggregate grains has a positive effect on the adhesion. Thanks to the suction of water by the porous aggregate in the concrete mix, the cement dough penetrates into the open pores, i.e., there is as it were a coalescence of the cement stone with the aggregate. In addition, water absorption eliminates the danger of the formation of water-filled film on the surface of aggregates, which hinder the adhesion.

Finally, the chemical and mineralogical compositions of aggregates affect the very complex and not fully studied physico-chemical processes that determine the strength of the bonding of concrete components.

If the bond of cement stone with aggregates in concrete is small, then the destruction of concrete under load begins from the contact zone, fracture cracks pass along the cement stone and the surface of the aggregate grains, bending around them (fig 17, a). If the clutch is reliable, then the destruction of the concrete occurs through cracks penetrating both the cement stone and aggregates (fig 17, b). It is this pattern of failure that occurs when testing high-strength concrete.[12]



a) b)

Figure 17. View of destruction of concrete

Modern types of fiber do not allow performing bulk reinforcement of concrete and reinforce only the concrete mixture without taking into account the filler of concrete, which reduces the effectiveness of dispersed reinforcement (fig. 18).

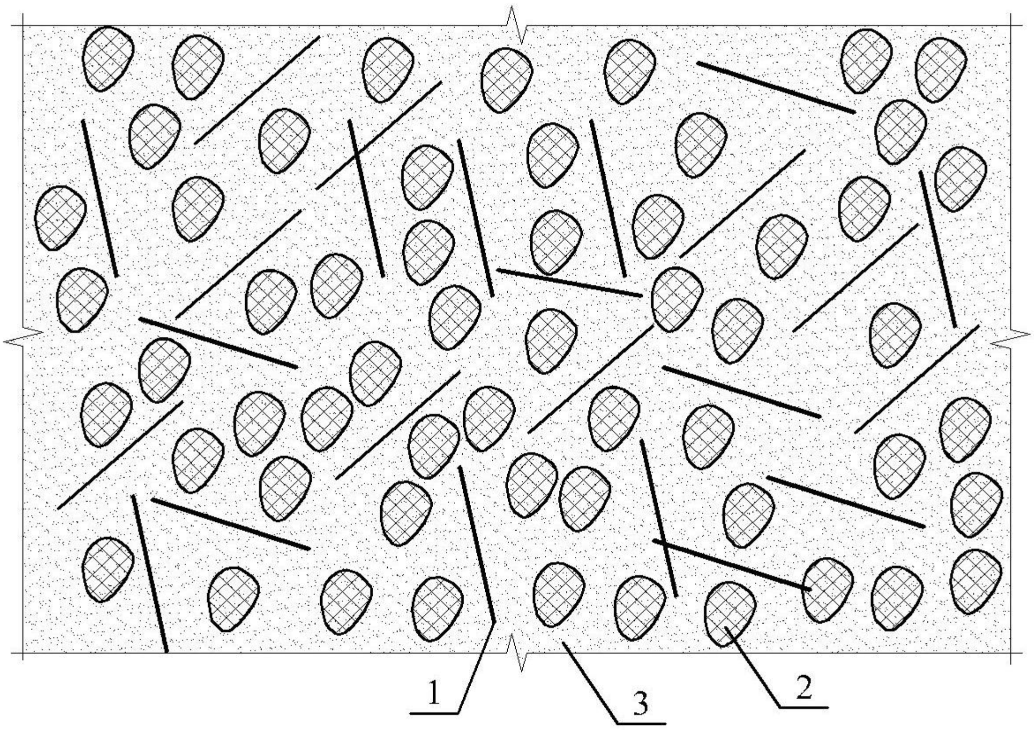


Figure 18. Location of fiber segments in concrete

1. Fiber
2. Filling concrete
3. The cement slurry

The purpose of the existing work was to increase the strength of coarse-grained concrete with scattered fiber reinforcement.

To increase the adhesion of cement stone with fillers, the design of the fiber for disperse reinforcement of concrete cylindrical profile.

Such a fiber design will create additional bonds of concrete filler and cement mixture. (Fig.19).

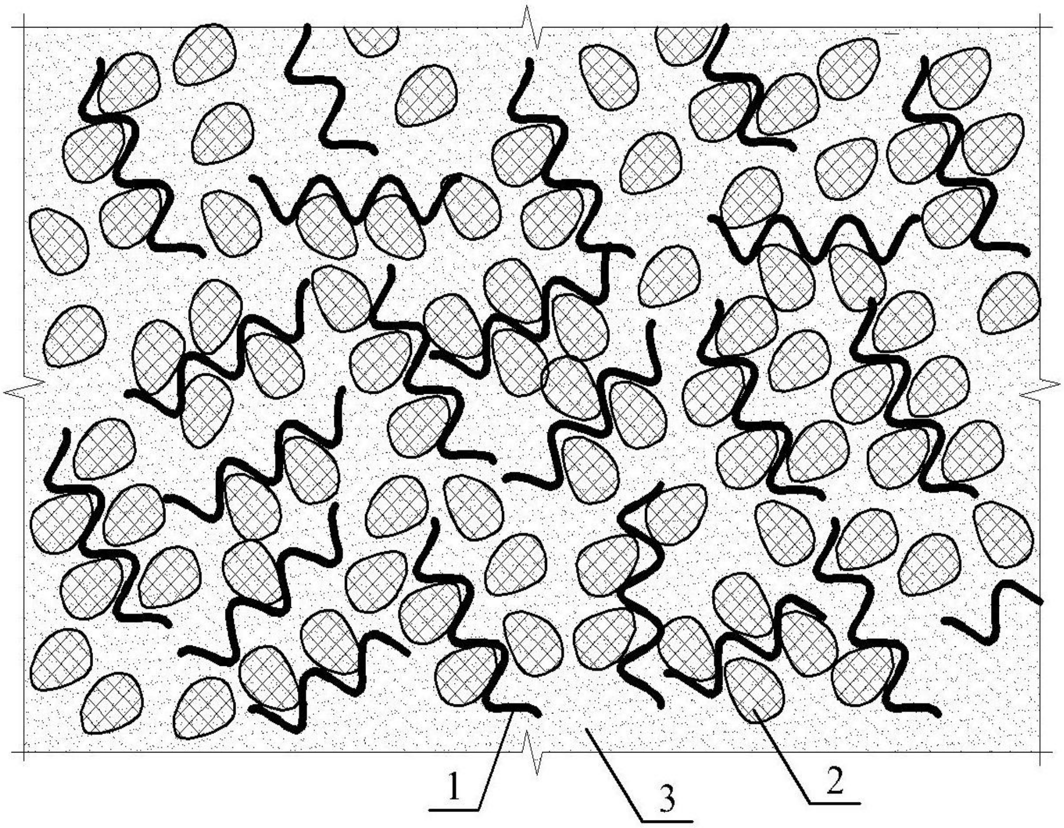


Figure.19. The location of cylindrical fiber in concrete with additional volume bonding of the aggregate

1. Fiber
2. Filling concrete
3. The cement slurry

Chapter 4 – TECHNOLOGICAL PROCESS OF PRODUCTION FOR FIBERCONCRETE PRODUCT

4.1. Manufacture concrete mixture and molding products

The composition of concrete is the quantitative ratio between all components of a concrete mix - cement, water, additives, fillers. It must provide, under specific conditions of preparation, transportation and packing, the obtaining of the characteristics of the concrete mixture and concrete given by the project with a minimum consumption of cement. The design of the concrete composition includes the assignment of the standard characteristics of concrete, the choice of raw materials for the preparation of concrete, the determination of the technological characteristics of the concrete mix, the selection of concrete according to specified regulatory and technological characteristics.

Out of many test applied to the concrete, this is the utmost important which gives an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not.

Compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, quality control during production of concrete etc.

Test for compressive strength is carried out either on cube or cylinder. Various standard codes recommends concrete cylinder or concrete cube as the standard specimen for the test.

For cube test two types of specimens either cubes of 15cm x 15cm x 15cm or 10cm x 10cm x 10cm depending upon the size of aggregate are used.

This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of these specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen. [13]

4.2 Materials for testing

Materials for testing fiber-reinforced concrete samples were as follows:

1. Portland cement (grade 500);
2. Granite crushed stone of fraction 10 mm;
3. Quartz sand of fine and medium size
4. Cylindrical fiber

4.2.1. Portland cement

Cement M-500 is intended for finishing and construction works inside and outside the premises. Mark cement 500 means that when hardened, the cement M-500 withstands a load of at least 500 kg / cm^2.

Cement M 500 is designed for the production of high-strength concrete, road and aerodrome coatings, reinforced concrete pressure and non-pressure pipes, ferro-concrete sleepers, bridge structures, poles of high voltage power lines, The network of railway transport and lighting, operated in the open air. It is used in the preparation of heavy and light concretes at enterprises producing prefabricated concrete and reinforced concrete products, pre-stressed reinforced concrete structures, elements of load-bearing structures (columns, beams, crossbars), paving slabs; When erecting monolithic structures of all types of construction. Used in the production of dry construction mixtures, facing and plastering works.

Used cement, packaged in paper bags, weighing 25 kg (Fig. 20)

Figure 20. Cement, which used in work

4.2.2. Granite crushed stone

Granite crushed stone of the fraction 10 mm was used for testing concrete samples for compression (Fig. 21)

Figure 21. Fractional screening of crushed stone

4.2.3. Granite crushed stone

In this work, river sand is extracted. The color of the sand is light yellow. River sand does not contain clay particles, and also has a low content of stones, so such sand is most often used for various concrete works. The size module is 1.8-2.2 mm. The coefficient of filtration of river sand is 5.7 m / day, which indicates its high ability to pass water.

Its characteristics correspond to class I with a high coefficient of filtration and a low content of clay particles. This type of sand is widely used in construction, as it is universal for various types of work and meets the basic requirements of construction organizations, ensures high quality and reliability of the materials produced.

4.2.4. Cylindrical fiber

To compare the variants, concrete cubes were made of concrete without fiber, with the content of fiber with flattened ends (Figure 22) and helical cylindrical fiber (Fig. 23).

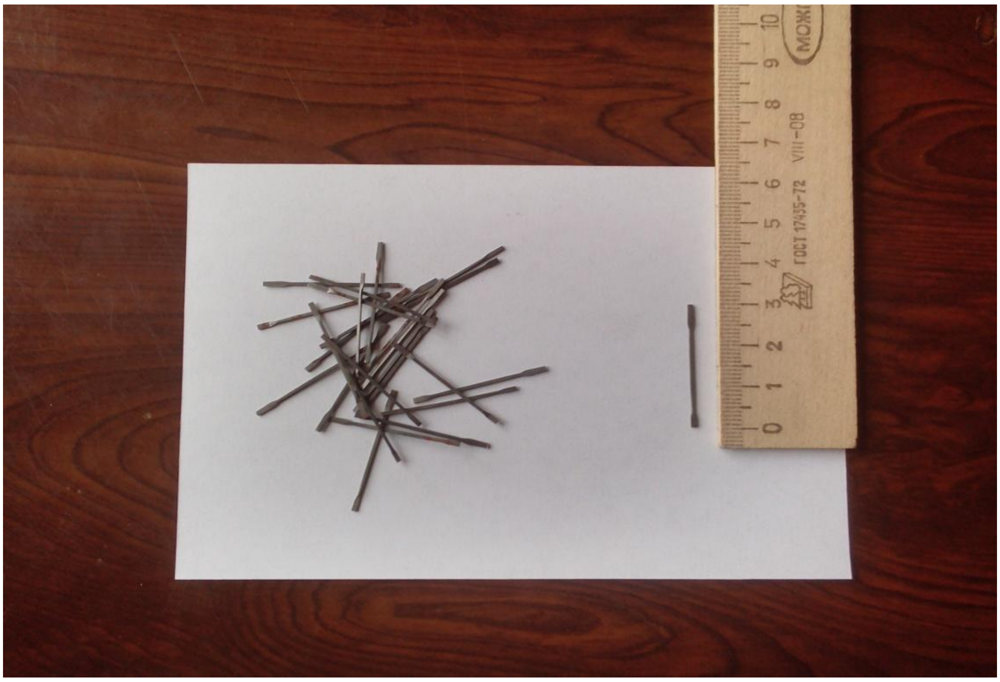


Figure 22. Fiber with flattened ends

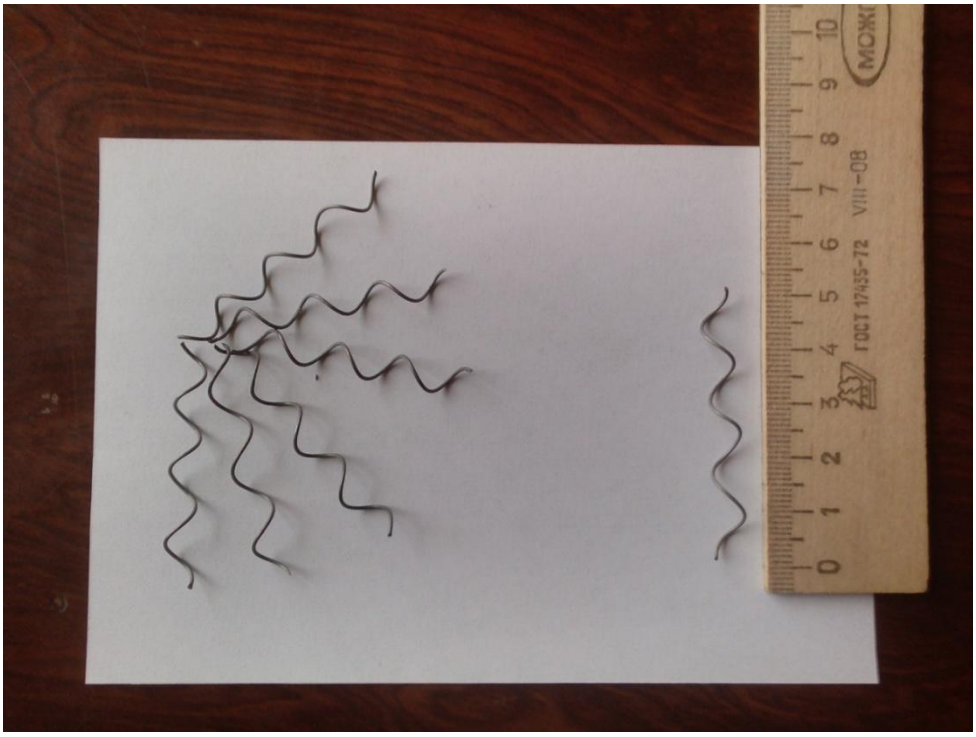


Figure 23. Cylindrical fiber

4.2.5. Compositions of concrete

The number of constituents of the fiber-reinforced concrete mixture is given in table 3.

Table 3. The number of constituents of the fiber-reinforced concrete mixture

Composition		Mass ratio of composition				Fiber, %*
		Cement, kg	Sand, kg	Granite, kg	water–cement ratio	
1	Concrete without fiber	1	1.4	2.9	0.45	-
2	Concrete fiber with flattened ends	1	1.4	2.9	0.45	1.5
3	Concrete with cylindrical fiber	1	1.4	2.9	0.45	1.5

* The content of fiber in the concrete mixture is taken as 1.5% of the volume, as the most optimal ratio [14].

4.3 Use additives for improvement property and hardness characteristics of concrete

Superplasticizers, also known as high range water reducers, are chemical admixtures used where well-dispersed particle suspension is required. These polymers are used as dispersants to avoid particle segregation (gravel, coarse and fine sands), and to improve the flow characteristics (rheology) of suspensions such as in concrete applications. Their addition to concrete or mortar allows the reduction of the water to cement ratio, not affecting the workability of the mixture, and enables the production of self-consolidating concrete and high performance concrete. This effect drastically improves the performance of the hardening fresh paste. The strength of concrete increases when the water to cement ratio decreases. However, their working mechanisms lack a full understanding, revealing in certain cases cement-superplasticizer incompatibilities.[15]

4.3.1 Application of the supereplasticizer S-3 to improve the properties of the fiber-reinforced concrete mixture

Superplasticizer S-3 - development of Russian specialists. Superplasticizer S-3 is an analogue of foreign plasticizers such as "Maiti 100" Japan, shikament, mill (Germany), not inferior to them in quality. The addition of plasticizer S-3 in the amount of 0.2-0.7% of the mass of cement makes it possible to obtain cast self-compacting, practically vibration-free concrete mixes, and with decreasing water consumption, higher strength concrete with constant mobility of the mixture. You can use both of these effects in part, i.e. To obtain mixtures of increased mobility in comparison with the initial one and at the same time to slightly increase the strength of concrete by reducing the water flow. The most effective applications of the additive in concrete plasticizer S-3 - the production of reinforced concrete products (paving slabs, slabs, panels, pressure pipes, etc.) and massive thick-reinforced structures, the erection of monolithic reinforced concrete structures, the production of concrete floors and coatings with high performance properties And an excellent appearance.

Increasing the fluidity of concrete and mortar mixes is 6-7 times, which makes it possible to concreate thick-reinforced and conventional structures practically without the use of vibrators. Additive in concrete plasticizer, Superplasticizer S-3 helps reduce the water requirement of the concrete mix by 15% to obtain an equiprobable concrete.

Superplasticizer contributes to the increase in strength of 10-15Mpa (30%), the density and uniformity of concrete, improving its structure. Additive for concrete plasticizer helps increase the adhesion of new concrete to the old one. The addition of plasticizer to concrete increases the water resistance, frost resistance and corrosion resistance of concrete by 2-4 times. Additives for concrete super plasticizer helps reduce labor costs when laying concrete. Additive to concrete superplasticizer S-3 - light brown powder, easily soluble in water. In dry form it is packed in bags of 25 kg.[16]

4.3.1.1. Application area

Superplasticizer, plasticizer C-3 is recommended to be used when erecting all types of structures from monolithic heavy concrete classes for compressive strengths of B15 and higher; In the manufacture of all types of prefabricated reinforced concrete structures and concrete products made of heavy concrete; When erecting all types of structures from monolithic fine-grained concrete classes for strength C10 and higher; When manufacturing all types of prefabricated reinforced concrete structures and concrete products on porous aggregates of classes for compressive strength C 7.5 and higher; If it is necessary to manufacture concrete mixtures using non-standard aggregates, including fine sands; When erecting monolithic structures using tensile cement or using mineral expansion additives; When erecting monolithic structures, manufacturing prefabricated reinforced concrete products from heat-resistant concrete on portland cement, slagportland cement and aluminous cement. [16]

4.3.1.2 Advantages and possibilities of superplasticizer S-3

The use of a highly effective Superplasticizer S-3 in the technology of making concrete mixtures provides for rheological properties:

- production of high-mobility and cast concrete mixtures (P4, P5), laid without vibration;
- improvement of workability, cohesion and homogeneity of concrete mixes;
- obtaining a water-reducing effect in concrete mixtures (up to 25% reduction in water consumption), increasing the survivability (viability) of concrete mixtures by 1 to 1.5 hours.

On physical and mechanical parameters:

- Increase strength characteristics of concrete on ordinary materials by 15% or more;
- due to the water-reducing effect, the increase in strength parameters of concrete by 30-40%;
- obtaining concrete with high water resistance rating W = 10 and more, frost resistance F = 300 and more, and corrosion resistance;
- Improvement in 1,5 - 1,6 times of adhesion of concrete with embedded fittings;

On technical and economic indicators:

- saving of binder (cement) in concrete mixtures by 15 - 20% without reducing the strength of concrete;
- replacement of PCs - 500 with PCs -400;
- reduction of energy costs for heat and moisture treatment of concrete;
- Reduction of labor costs by 2 - 3 times (at W / C = const) when laying concrete mixes;
- a decrease in the temperature of isothermal heating by 10-15 ° C (at W / C = const)
- improvement of the quality of the surface of products, as well as prevention of vysokoobrazovaniya. [16]

4.3.1.3 Recommendations for the use of additives for concrete superplasticizer S-3

For the preparation of concrete with plasticizer of concrete S-3, materials corresponding to noratives should be used.

Selection of the composition of concrete with additive is to adjust the working composition of concrete without additives. Superplasticizer S-3 is introduced into the concrete mixture together with the water for mixing in the form of an aqueous solution of the working concentration. The working concentration of the solution used is selected by the customer based on the requirements of the technology, the conditions of use and ease of use. The greatest dilution effect of a concrete mixture is observed when a plasticizer of concrete is introduced with a second part of the water for mixing. The time and conditions for mixing are also chosen by the consumer based on the conditions of the technology. The effectiveness of the Superplasticizer S-3 depends directly

From the mineral composition of cement and aggregates. [16]

4.3.1.4 Dosage additives for concrete Superplasticizer S-3

The dosage of the plasticizer of concrete S-3 depends on the purpose of the concrete mix, the content of the tricalcium aluminate in the cement, the active mineral additives and the dispersion of the cement. The recommended dosage is 0.4 - 1% of the binder mass in

terms of dry matter. The optimum dosage is determined experimentally on the materials used. [16]

4.3.1.5 Compatibility of additives for concrete Superplasticizer S-3

Superplasticizer S-3 is compatible with all types of additives produced by component. Combination with other types of additives, which have a distinctive basis, must be agreed with the manufacturer. [16]

4.3.1.6 Packing of additives for concrete Superplasticizer S-3

The plasticizer C-3 is available in the form of an aqueous solution and a dry powder. In the form of an aqueous solution is poured into railway tanks, tank trucks, plastic containers or released into the packaging of the buyer. In the form of a dry powder is packed in polypropylene fabric bags with a polyethylene liner. [16]

In the master's work, the superplasticizer was applied in the form of a powder.

4.4 Manufacture of experimental fiberconcrete product

The sampling and testing of concrete is a common step in the production process. Samples are taken during production and required tests are then carried out on the samples. The product being manufactured during the testing will then be accepted or rejected based on the test results from the samples. Because every rejected product costs the company a considerable amount of money in materials and labor, it is important that samples are taken by a trained technician who fully understands the importance of the final decisions that are based on the test results complied from each sample.

The technological process of production of concrete cubes for testing consisted of the following processes:

1. Mixing of concrete mixture
2. Laying the concrete mixture in metal molds
3. Vibrating the mix on a vibrating table

4. Concreting of concrete samples 28 days

All components of the concrete mix were pre-dosed in accordance with the specified composition of the mixture.

Mixing of the mixture was carried out in a concrete mixer of gravitational action (fig.24)

Figure 24. A concrete mixer of gravitational action

The addition of fiber to the mixture was performed at intervals of 3 minutes.

Vibration table (fig. 25) was used to compact the concrete mix. Vibrations were carried out for 10 minutes.

Figure. 25 Vibration table

Hardening of concrete samples took place at a temperature of 20 degrees Celsius. A total of 27 samples were produced.

Chaper 5 – EXPERIMENTAL VERIFICATION OF THE RESULTS OF MANUFACTURE

5.1 Laboratory tests of hardness characteristics of fiberconcrete product

Testing of concrete samples for strength was carried out in accordance with the normative documents [17, 18, 19].

Concrete samples gained strength at a temperature of 20 degrees Celsius and a relative humidity of at least 90%. For the tests, 3 samples (Fig.26) were taken for each series of tests. In total, 27 samples of different compositions of concrete were tested. Samples were tested on a hydraulic press (Fig. 27).

The size of the edge of the concrete cubes was 100 mm.

Figure 26. Concrete test cubes

Figure 27. Hydraulic press for testing of concrete

The test data are listed in tables 4,5, 6

Table 4. Test results of samples without fiber (Composition 1)

Composition	Sizes of the samples, cm	Age of samples,days	Cross-sectional area, cm^2	Compressive strength, MPa	
				Individual samples	Average for three samples
1	100×100×100	7	100	14.38	14.50
	100×100×100	7	100	14.65	
	100×100×100	7	100	14.46	
1	100×100×100	14	100	24.91	25.20
	100×100×100	14	100	25.36	
	100×100×100	14	100	25.28	
1	100×100×100	28	100	32.72	32.60
	100×100×100	28	100	32.47	
	100×100×100	28	100	32.63	

Table 5. Test results of samples with fiber with flattened ends (Composition 2)

Composition	Sizes of the samples, cm	Age of samples,days	Cross-sectional area, cm^2	Compressive strength, MPa	
				Individual samples	Average for three samples
2	100×100×100	7	100	22.75	22.50
	100×100×100	7	100	22.21	
	100×100×100	7	100	22.53	
2	100×100×100	14	100	35,98	36,50
	100×100×100	14	100	36,95	
	100×100×100	14	100	36,51	
2	100×100×100	28	100	43,11	42,50
	100×100×100	28	100	43,21	
	100×100×100	28	100	41,12	

Table 6.Test results of samples with cylindrical fiber (Composition 3)

Composition	Sizes of the samples, cm	Age of samples,days	Cross-sectional area, cm^2	Compressive strength, MPa	
				Individual samples	Average for three samples
3	100×100×100	7	100	32,11	31.80
	100×100×100	7	100	31,12	
	100×100×100	7	100	32,22	
3	100×100×100	14	100	45,41	43.50
	100×100×100	14	100	43,72	
	100×100×100	14	100	41,42	
3	100×100×100	28	100	49,21	49.70
	100×100×100	28	100	48,52	
	100×100×100	28	100	51,32	

Based on the test results, a timetable was set for the strength of concrete cubes (Fig. 28)

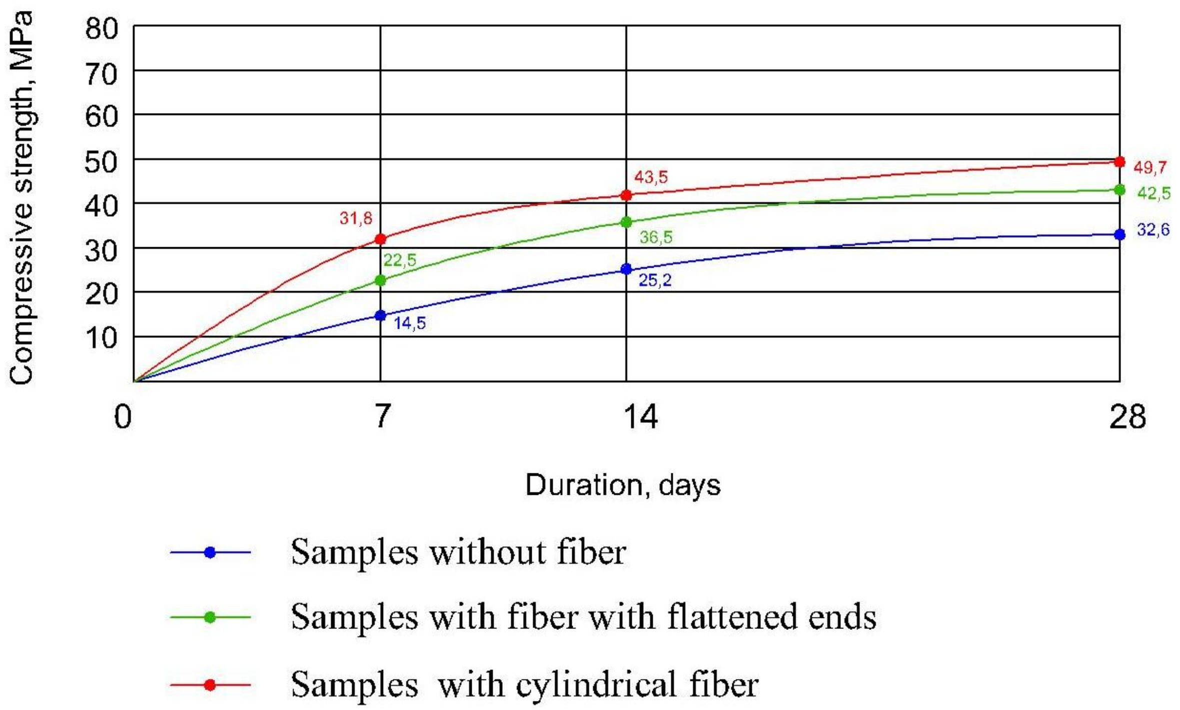


Figure 28. Graph of strength of concrete samples

As a result of tests of concrete samples, it was found that samples with spiral fiber have higher increased strength characteristics of concrete by 52% compared to samples without fiber and by 17% compared to samples with fiber in the form of straight segments.

Table 5.4 shows the effect of the "Plasticizer C-3" additive on the mobility of the concrete mix and the strength of the concrete.

Table 7. Effect of the "Plasticizer S-3" additive on the mobility of the concrete mix and the strength of concrete

Additive		Concrete mixture		Concrete strength for compression MPa at the age, days		
composition	dosage , %	Water/Cement	Cone draft , cm	7	14	28
Control without fiber	---	0,5	2,1	14,50	25,20	32,60
With cylindrical fiber	1,0	0,4	4,6	35,14	48,07	52,93

As a result of tests of concrete samples with superplasticizer, it was found that samples using Superplasticizer in an amount of 1% of the binder weight have increased tensile strength by compression by 10% and increased mobility of the concrete mix without reducing strength.

The results of testing the samples using a plasticizer are shown in Fig. 29.

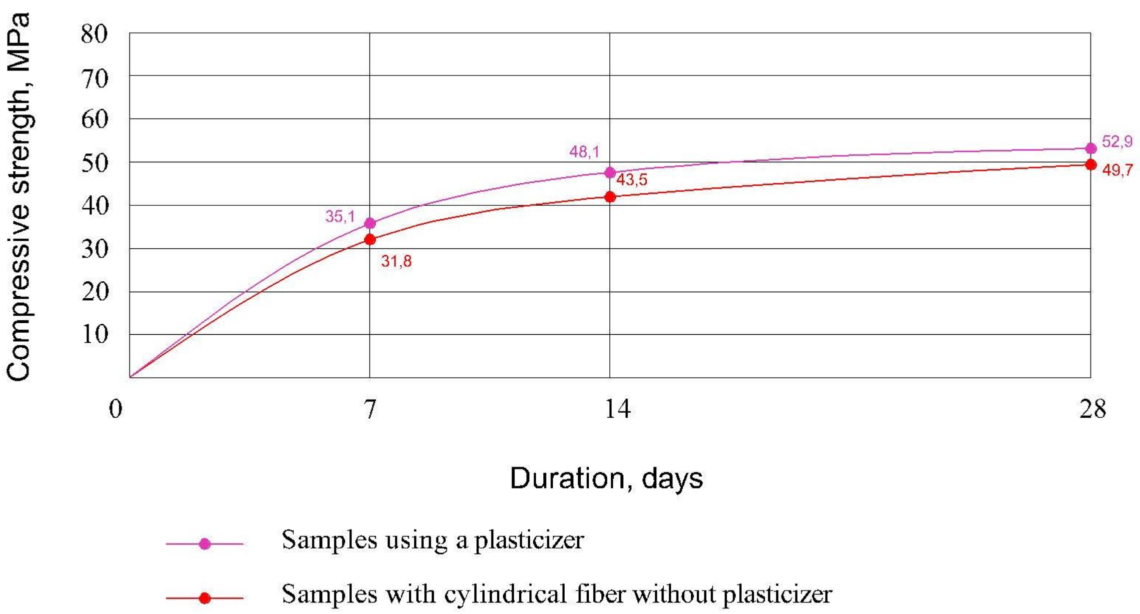


Figure 29. Results of testing the samples using a plasticizer

When tests of concrete samples with superplasticizer were carried out, it was found that samples using Superplasticizer in the amount of 1% of the binder weight have increased strength characteristics for compression by 10% and increased mobility indices of the concrete mix without reducing strength;

6. CONCLUSION

The domestic and foreign experience of using steel-fiber-reinforced concrete has been studied and it is established that:

- fibreconcrete mixes - a modern, effective building material for production of multi-purpose steelfibre concrete;

- for the production of steel-fiber-concrete mixtures, fine-grained materials containing coarse aggregate and dry mixtures with a content of dispersed reinforcement from 1 to 2% by volume can be used;

- As a result of tests of concrete samples, it was found that samples with spiral fiber have increased strength characteristics of concrete by 52% compared to samples without fiber and by 17% compared to samples with fiber in the form of straight segments;

- when tests of concrete samples with superplasticizer were carried out, it was found that samples using superplasticizer in the amount of 1% of the binder weight have increased strength characteristics for compression by 10% and increased mobility indices of the concrete mix without reducing strength;

- The developed composition of fiber-reinforced concrete can be used for constructing floor structures, covering roads, slabs, beams and low-reinforced structures.

Further research work:

- Determination of the influence of the diameter and pitch of the fiber wire on the strength characteristics of concrete;

- Tensile tests of fiber-concrete with fiber;

- Development of methods for the supply of fiber to the concrete mix.

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