Increasing bending strength and flexibility of fiber concrete matrix by laboratory method
(with volume changes of all kinds of fibers)

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ABSTRACT

By adding fibers as well as additional materials in concrete, the properties of concrete can be increased in terms of durability, flexibility and tensile strength. Another use of artificial fibers to improve mechanical properties and reduce shrinkage of fresh and hardened concrete, increase energy absorption and resistance to impact and explosion can be mentioned. The use of fiber concrete has many advantages compared to the use of reinforced concrete, while it also has disadvantages, such as the lack of uniform distribution of fibers in the concrete matrix and the lack of proper adhesion between polymer fibers in cement mortar. Generally, fiber concrete is used in concrete parts due to smaller cracks and less width and more durability in case of uniform distribution of fibers. Research shows that fibers significantly increase the tensile strength, plasticity of mortar and concrete. In fact, after cracking, the fibers bridge between the crack plates and cause a significant increase in toughness and energy absorption capacity. Adding artificial fibers to concrete brings advantages such as reducing plastic grip cracks, reducing plastic drop cracks, increasing impact resistance and increasing resistance to crushing. In this research, the effect of different types of fibers with different volume percentages on the compressive, bending and tensile strength of the samples at different ages compared to the control sample has been measured by laboratory method. All kinds of samples have been tested to determine the resistance against surface explosions..

KEYWORDS

Fiber concrete, polymer fibers, increasing the tensile strength of concrete, steel fibers, laboratory method

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1. Introduction

Concrete is a brittle material that has high resistance under pressure; But its resistance is relatively weak in stretching. Steel rebars are used in concrete structures to withstand tensile forces (after cracking in concrete). In reinforced concrete, the tensile stress of the concrete at the crack is much lower than the yield stress of the steel rebar, so concrete cracking occurs before a significant load is transferred to the steel rebar. Also, steel rebar is used to limit the width of cracks based on design requirements in service loads. In fiber concrete, unlike steel rebars, the fibers are spread uniformly in the concrete mixture, therefore, the distance between the fibers is much less than the distance between the rebars; Therefore, fibers can be more effective in controlling concrete crack width than rebar network. As a result, the tensile stresses are borne by the fibers in the initial stages of cracking, so the crack propagation and patterns change depending on whether the concrete is unreinforced or reinforced. Figure 1 also schematically shows the crack control mechanism by fibers. In addition, it can provide bending and tensile strength after cracking. More than 3000 years ago, natural fibers were used for brittle materials such as clay. In modern times, there have been many scientific studies on the use of steel fibers in concrete. Since then, thousands of fiber reinforced concrete projects have been implemented, including floor slabs, steel deck roofs, piled slabs, precast components, and shotcrete using fiber reinforced concrete. Fibers in general can be used as a supplement and to reduce the steel bars in the members of various devices. Fibers reliably control cracks in concrete and increase the resistance of materials against fatigue, impact and shrinkage or thermal stresses. Fibers can be effective in improving the performance of concrete members in two ways, one by increasing the tensile strength of concrete and the possibility of considering it in structural calculations, and the other by controlling cracks and thus improving the durability of concrete. With the increasing expansion of concrete structures, properties such as the strength and durability of concrete have gained special importance. Therefore, it is necessary to use special concretes and obtain new compounds from them, which can be mentioned by adding fibers as well as additional materials to improve the properties of concrete. In recent years, the use of synthetic fibers has been greatly expanded in order to improve mechanical properties and reduce shrinkage of fresh and hardened concrete, increase energy absorption and impact resistance of concrete, and replace thermal reinforcements with fibers. Fibers significantly increase tensile strength, ductility of mortar and concrete. Fiber concrete is very important in civil engineering as an alternative to reinforced concrete with reinforcement and due to the improvement of the proper performance of fibers in concrete and economic efficiency and increase in speed without loss of quality. Adding artificial fibers to concrete has advantages such as reducing plastic grip cracks, reducing plastic drop cracks, reducing concrete permeability, increasing impact resistance and wear resistance, increasing resistance to crushing. The choice of type, material, size, geometry and amount of fibers depends on the application and environmental conditions and climate of the structure. In a general classification, fibers are natural and synthetic according to the type of constituent material. In this research, the effect of fibers in different volume percentages on the compressive, bending and tensile strength of the samples at different ages compared to the control sample has been measured.

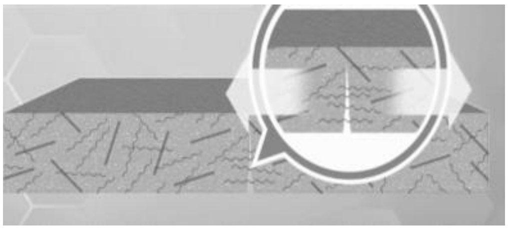

Figure 1. Crack control mechanism by fibers

2. Methodology

In this research, by examining different mixing plans, the best concrete mixing plan that provides good adhesion with the three available fibers was reached. Different percentages of these fibers were used in order to achieve the optimal percentage of three fibers: steel, plastic and bar chip. In the following, a brief description of the materials used in this research is given.

According to ASTM-C 1116 standard[1], the type of fibers that can be used in concrete is divided into four general categories, which include steel fibers, glass fibers, polymer fibers, and natural fibers. Steel fibers include stainless steel fibers, alloy steel and carbon steel, which must be in accordance with the ASTM-A820 standard. ASTM-A820/A820M standard[2] is related to the specification of steel fibers that can be used in concrete. The steel fibers used for concrete reinforcement are short in length and small enough to be easily dispersed in concrete using conventional mixing methods. This type of fiber is the most used in fiber concrete. According to the investigations and using the previous researches, it was observed that the use of steel fibers in fiber concretes of 2 to 4% by volume is suggested. Barchip fibers are one of the newest types of fibers used in concrete, and these fibers can be considered as a substitute for steel fibers. These fibers have a specific weight of 910 kg/cm3 and the base of these fibers is made of polypropylene. Synthetic fibers are also the same as the Barchip; But it has a different appearance, and the specific weight of these fibers is the same as the Barchip, and in this design, similar to other types of fibers, 1 to 2 percent have been used. In this research, neutral polycarboxylate superplasticizer type 102NPC has been used among the ten common additives in the market, which has been used to increase efficiency and slump, as well as reduce the ratio of water to cement. In the design method of mixing reinforced concrete with fibers, it is basically similar to plain concrete design. In spite of this, some considerations must be observed to spread the fibers uniformly and prevent separation or the phenomenon of becoming pellets and create an effective mixture for pouring, compacting and paying concrete. Due to the ease of spreading, fibers are usually added to the mixture in a dry form. The problem of becoming pellets is often due to the use of high amounts of fiber more than 0.5 percent by volume with a high length-to-diameter ratio, or adding too much fiber too quickly to a mixture that does not have enough water or sufficient efficiency. It is being created. In this phenomenon, the fibers are gathered close to each other, causing a reduction in the effectiveness of the concrete mixture, and as a result, a reduction in the resistance and softness of the hardened concrete. In order to investigate the effect of fibers, a base concrete sample is made and then the compressive, bending and tensile strength of all fiber concretes is compared with it. In order to achieve the optimal design of the volume percentage of fibers in concrete to obtain the maximum tensile strength and bending strength in the concrete matrix, it is necessary to perform various tests.

3. Results and Discussion

According to the obtained results, the highest amount of compressive, tensile and bending strength is related to the samples made with two volume percent of steel fibers and also the highest strain in 28 days resistance is related to the samples made with two volume percent of barchip fibers. Also, two percent of steel fibers increased the compressive strength by 3.5%, the bending strength by 36.06% and the tensile strength by 80.83% compared to the control sample. Also, the results obtained from density, modulus of elasticity and Poisson's ratio tests, fiber concrete with two volume percent of steel fibers has the highest results; But in the electrical resistance test, this percentage of fibers has the lowest result, and the highest result is related to fiber concrete with two percent of barchip fibers by volume. The results show that two percent of steel fibers increases Poisson's ratio 93.3% and mortar density by It has increased up to 2430 kg/m3. Two percent of plastic fibers also increased electrical resistance by 28.57%.

4. Conclusions

In this article, three types of synthetic fibers, barchib and steel with percentages of 1, 1.5 and 2 and a combination of these fibers were evaluated. The mechanical properties of fiber concrete such as compressive strength, bending strength, tensile strength, modulus of elasticity, Poisson's ratio, electrical resistance were investigated and the results of this research are as follows:

• The larger the dimensions of the real sample of hardened concrete and the ratio of the volume to the side surface increases, the shrinkage ratio of the fibers in the surfaces decreases and moves towards uniformity; Therefore, additional tests on macroscopic and real samples are recommended.

• The grip of fiber elements increases if the strength of concrete increases and the separation of fiber elements from the core of concrete becomes more difficult.

• The use of micro fibers along with macroscopic fibers can control the cracks resulting from the shrinkage of concrete and the dynamic loads that create plastic strains and cause concrete fatigue and inactivation of microscopic cracks.

• Due to the fact that steel fibers have provided better results in most of the conducted tests, special precautions should be taken to prevent corrosion when using this type of fibers in areas with a high percentage of chlorine ions.

• In the mixing design, 1% steel fibers have the highest compressive strength, and the lowest compressive strength is related to 1% polypropylene fibers.

• 1% of polypropylene fibers reduces the compressive strength by about 15%. Therefore, polypropylene fibers will have a better effect in concrete with high cement grade and finer aggregates. Also, the nature of these fibers is not structural and it will have better results if combined with other fibers.

5. References

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[2] A. Standard, Standard specification for steel fibers for fiber reinforced concrete, United States: ASTM International, (2011). DOI: 10.1520/A0820_A0820M-22