Open Journal of Civil Engineering, 2023, 13, 192-197
https://www.scirp.org/journal/ojce
ISSN Online: 2164-3172
ISSN Print: 2164-3164

Effect of Steel Fiber on Concrete's Compressive Strength

Mohammed Saed Yusuf, Abdirisak Bashir Isak, Guled Ali Mohamud, Abdullahi Hashi Warsame, Yahye Ibrahim Osman, Abdullahi Husein Ibrahim, Liban Abdi Aziz Elmi

Department of Civil Engineering, Hormuud University, Mogadishu, Somalia
Email: Fe@hu.edu.so

How to cite this paper: Yusuf, M.S., Isak, A.B., Mohamud, G.A., Warsame, A.H., Osman, Y.I., Ibrahim, A.H. and Elmi, L.A.A. (2023) Effect of Steel Fiber on Concrete's Compressive Strength. *Open Journal of Civil Engineering*, **13**, 192-197.
https://doi.org/10.4236/ojce.2023.131014

Received: February 16, 2023
Accepted: March 28, 2023
Published: March 31, 2023

Abstract

The general goal of this research is to investigate whether steel fiber has a significant "positive" or "negative" influence on concrete compressive strength, as well as the optimal steel fiber ratio that delivers best result. Manually, cement, fine aggregates, coarse aggregates, steel fibers, and water were mixed together properly. A slump test was carried on the mixed concrete. After determining the workability, the mixed concrete was poured into cubes dimension 150 mm × 150 mm × 150 mm and left for 24 hours. After 24 hours, the samples were removed from the mold and placed in a water tank to cure for 7 to 28 days. The cube was tested for compressive and flexural strength in a universal testing machine after the samples had cured for the required 7 - 28 days. This study focuses on how to obtain high strength concrete using with steel fiber in the Conventional mix ratio to enhance concrete strength. Concrete reinforcement using steel fibers alters the characteristics of the concrete, allowing it to withstand fracture and hence improve its mechanical qualities. This study reports on an experimental study that reveals the effect of steel fiber on concrete compressive strength and the optimal steel fiber ratio that produces the best results. Steel fiber reinforcing improved the compressive strength of concrete. The average compressive strength of normal M25 concrete with 0% steel fibers and curing ages of 7 and 28 days was determined to be 22.97 N/mm^2 and 25.78 N/mm^2, respectively. The steel fibers are then added in various concentrations, such as 1%, 2%, and 3%, with aspect ratios of 70. The compressive strength of concrete with 1%, 2%, and 3% steel fiber with an aspect ratio of 70 was examined at 7 days and found to be 23.96, 24.80, and 26.14 N/mm^2 correspondingly.

Keywords

Steel Fiber Reinforced Concrete, Fiber Reinforcement, Compression Strength of Concrete, Improvement Compression Strength

1. Introduction

Conventional concrete, or normal strength concrete, is a structural material that consists of a mixture of cement, fine aggregate, coarse aggregate, and water. On some occasions, admixtures are used to improve specific properties or characteristics [1]. In general, concrete is very good in compression stress and durability. Unfortunately, concrete is brittle and can't tolerate tensile stress more than 10% of its compression strength [2]. To solve this weakness, many ideas have been proposed, such as steel reinforcement to improve the overall flexural ability of concrete and fiber reinforcement to improve the ductility of concrete and crack control [3]. Fiber reinforcement has made significant improvements in recent years. There are various types of fiber reinforcements, such as natural fiber, glass fiber, synthetic fiber, and steel fiber, which are the one we are using [4]. Steel fiber is a small, discrete carbon or stainless steel used for structural enhancement purposes. Steel fiber reinforced concrete (SFRC) is a mixture of conventional concrete and steel fiber (cement, fine aggregate, coarse aggregate, water, and small discrete discontinuous steel fibers) [5]. This study is focused on the improvement of using steel fiber in conventional concrete in its compressive and tensile strength. During this experiment, different tests will be carried out, such as a sieve analysis test for identifying aggregate size. The Slump test is used to determine the work-ability of concrete. Finally, test the cubic samples for compression. This study is focused on finding the optimum volume friction of steel fiber that results in the highest percentage of improvement in compression strength.

2. Literature Review

The current rush of migration from rural to urban regions in quest of economic benefits has prompted the construction of infrastructure utilizing concrete at an unparalleled rate since the creation of concrete, owing mostly to its great compressive strength. However, the brittleness of concrete has long been it fundamental disadvantage, resulting in poor tensile strength [6].

The necessity to ensure a structure's quality forces designers to think about different loading scenarios more and more. When a structure must survive impact loads, it is critical to understand the behavior of concrete that has been subjected to this sort of loading, as well as the properties of a suitable material capable of withstanding short-term dynamic stresses [7]. Some birds use tiny sticks and grasses as fibrous filaments to mix with clay and build their nests. Therefore, the use of fibrous elements to increase the mechanical characteristics of contentious materials was not invented by man, but rather adopted [8].

2.1. Research Gap Analyze

Many studies have been conducted to investigate the use of steel fiber reinforcement to improve concrete ductility and crack control. [9] researched just and compared percentages of steel fiber of 1 percent, 2 percent, and 3 percent to find the optimal volume fraction with the greatest compression and flexural strength. Also, further studied their studies with percentages of 1%, 2%, 3%, 4%, and 5% with aspect ratios of 50, 60, and 67 to identify the best volume fraction with the maximum compression and flexural strength [10]. These studies have typically focused on the highest volume friction and the finest aspect ratio of reformed steel fiber. They have not conducted tests on the effect of straight steel fiber on concrete compressive strength. Therefore, to address this gap, this study investigates the effect of straight steel fiber with different aspect ratios and volume fractions on concrete compressive strength.

2.2. Bond Behavior of Steel Fiber

As previously stated, the use of fibers to improve the properties of brittle materials is a fairly old practice. Steel fiber was introduced as a new type of fiber in the early 1960s. The earliest type of that fiber was straight fiber. The friction between the concrete and the fiber determines the fiber's bond. As a result, a rectangular piece with a larger aspect ratio performed better form of strength [11]. Steel fibers play an important role in the propagation of micro cracks. There are two scenarios in which fibers may fail, the first is fiber fracture, and the second is fiber pull-out from the concrete. Because it is more ductile and functions as an energy absorbable, the second scenario is preferred to put it another way, hooked-end fiber and crimped-fiber should bend and yield greatly in order for the fiber to be drawn out. As a result, this procedure will consume a significant quantity of energy.

3. Methodology

Cement, in a broad sense, refers to all binding elements, however in a more specific meaning, it refers to the binding materials used in building and civil engineering projects. It is a dry powder that is used to adhere structural elements together when water is added, and plays an important role to the hardness, strength, and durability of concrete, specially takes a role of keeping structures together. Nevertheless, Ordinary Portland Cement is used to complete all of the activities necessary throughout this experiment.

In general, aggregate accounts for 70 - 80 percent of the total volume of concrete, serves as the main body. Aggregate is one of the most fundamental and necessary components of concrete that gives concrete its body, decreases shrinkage, and has an economic impact. The size of the aggregate used in a concrete is influenced by the structure, whether plain cement concrete or reinforced cement concrete is applied. In construction, the most typical aggregate sizes are 20 mm, 40 mm, and 75 mm. RCC structures employ 20 mm of aggregate, 40 mm of aggregate in PCC structures or mass concreting, and 75 mm or larger aggregate in retaining wall construction [1]. The aggregates used in this study are as follows:

1) Fine aggregate or natural sand smaller than 4.75 mm.
2) Coarse aggregate or gravel is 20 mm.

3.1. Experimental Procedures

Concrete and steel fiber (cement, fine aggregate, coarse aggregate, water, and small discrete discontinuous steel fibers). Steel fibers are classified according to their length, diameter, configuration, tensile strength, and other criteria such as aspect ratio (Parashar & Parashar, Utility of wastage material as steel fibre in concrete mix m-20, 2012) Steel fibers with lengths of 35 mm, diameters of 0.5 mm, and aspect ratios of 70 were used in this experiment.

Experimental procedure manually, cement, fine aggregates, coarse aggregates, steel fibers, and water were mixed together properly. A slump test was carried on the mixed concrete. After determining the work-ability, the mixed concrete was poured into cubes dimension 150 mm × 150 mm × 150 mm and left for 24 hours. After 24 hours, the samples were removed from the mold and placed in a water tank to cure for 7 to 28 days. The cube will be tested for compressive and flexural strength in a universal testing machine after the samples had been cured for the required 7- 28 days.

3.2. Sieve Analysis

A sieve analysis is a technique for determining the particle size distribution of a granular material with macroscopic particle sizes. When analyzing materials, it's crucial to do a sieve analysis because particle size distribution can impact a variety of attributes, including concrete strength, mixture solubility, and so on. In this study a coarse aggregate has merely been sieved. On each sieve, the retained mass was measured. Then, for each sieve, a retained percentage was calculated to determine the percentage passed. This task was managed to complete using material that pass slump test d sieve 25 and had been retained by sieve 20 opening size as shown in **Figure 1**.

Slump cone test, is to verify a concrete mix's consistency or work-ability. The

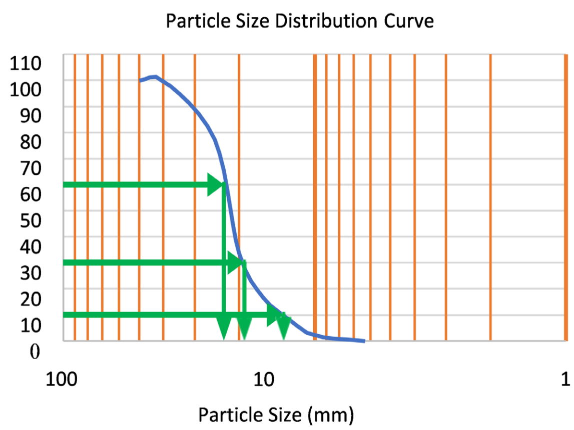

Figure 1. Particle size distribution curve.

consistency of concrete is determined by a concrete slump test, which assesses how well it holds together. The result may be seen by viewing the form of a finely compacted concrete cone after the mold has been removed. In this study slump test results shows that the height is 7 cm out of 30 cm which is true slump.

3.3. Compressive Test

Compression Strength concrete reinforcement using steel fibers changes the property of the concrete, allowing the concrete to endure fracture and enhance the mechanical properties of the concrete. The use of steel fibers as reinforcement increased the compressive strength of concrete. The average compressive strength of standard M25 concrete with 0% steel fibers and 7- and 28-day's age of curing was determined to be 22.97 and 25.78 N/mm^2 as shown in the charts below. The steel fibers are then added in different percentages, such as 1%, 2%, and 3%, with aspect ratios of 70. The average of 7 days age of curing the compressive strength of concrete with 1%, 2%, and 3% of steel fiber and an aspect ratio of 70 was studied to be 23.96, 24.80, and 26.14 N/mm^2 respectively. Whereas the average of 28 days age of curing the compressive strength of concrete with 1%, 2%, and 3% of steel fiber and an aspect ratio of 70 was studied d to be 27.76, 30.59 and 28.50 N/mm^2 as shown Figure 2, Figure 3.

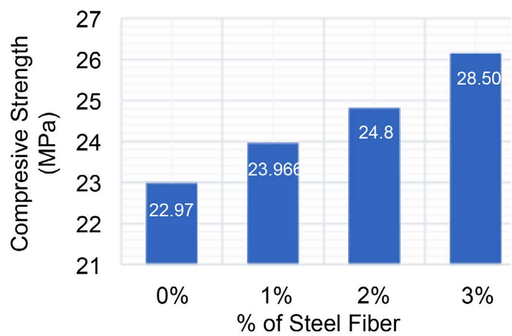

Figure 2. Effect of steel fiber on the average compressive strength of concrete at 7 days.

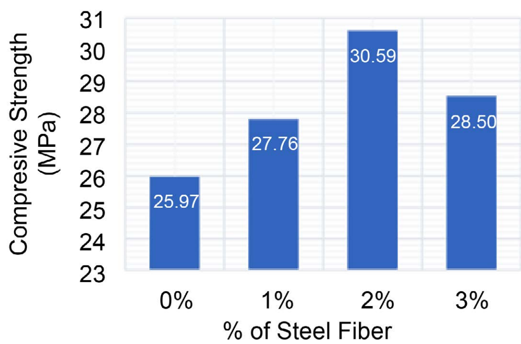

Figure 3. Effect of steel fiber on the average compressive strength of concrete at 28 days.

4. Conclusion

The reinforcement of concrete using steel fibers changes the compressive property of concrete. Based upon the results of the experiment, the following conclusions are drawn: The use of steel fiber as reinforcement has indeed positive impact on concrete's compressive strength. The use of steel fibers as reinforcement improved the compressive strength of concrete. The greatest compressive strength of 30.59 MPa was reached by the 2% steel fibre volume fraction reinforcement at 28 days age, which was 18.66% greater than the control sample at 7 days of age the highest compressive strength of 26.14.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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