

## Compressive Strength Performance of Modified Fiber-Reinforced Concrete Incorporating ViscoCrete Admixture

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**Abstract:** Thus, this study investigates compressive strength effects of a modified concrete mix comprising fiber and ViscoCrete-based superplasticizer. The aim was to investigate the mechanical performance of concrete as compared to a standard reference mix for the modified mix composition. In the experimental program, ordinary Portland cement, natural sand, gravel, potable water, ViscoCrete admixture, and fiber was used in the preparation. The modified mix selected was described as Mix D (New Tech D) with a ratio of 480 kg/m<sup>3</sup> cement, 144 L water, 700 kg/m<sup>3</sup> sand, 1050 kg/m<sup>3</sup> gravel, 4.8 kg/m<sup>3</sup> ViscoCrete and 0.9 kg/m<sup>3</sup> fiber. The concrete samples were formed in cube molds, cured in standard conditions and subjected to compressive strength determination. The compressive strength of the reference mix was reported to be 30 MPa while that of the modified mix was estimated to be 50 MPa. This equates to a compressive strength increase of approximately 66.7% compared to the reference concrete. The enhancement is expected resulting from a combination of optimized material proportions, improved workability induced by a superplasticizer, and fiber aiding the prevention of internal crack formation. Results show improved mechanical properties of the modified concrete when compared with the conventional mix, and in particular it can enhance performance with higher strength application.

**Keywords:** modified concrete, compressive strength, fiber-reinforced concrete, ViscoCrete, superplasticizer, mix design

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### 1. Introduction

Steel fiber reinforced concrete (SFRC) was considered highly promising as a construction material because of its enhanced mechanical performance, particularly in terms of tensile strength, ductility, and crack resistance. The application of steel fibers into concrete leads to a more ductile structure and, as a result, makes the concrete much better at withstanding post-cracking loads by a stronger and ductile bond and mechanical anchoring in cementitious material. Of these fibers, crimped (or corrugated) steel fibers are most widely used due to the excellent bond properties and mechanical anchorability.

Still, using steel fibers, especially at moderate to high volume fractions, is in some cases harmful to the workability of fresh concrete in a highway, which is a reason why the polycarboxylate ether (PCE)-based superplasticizers such as ViscoCrete are widely used to improve flowability and thus maintain a low water-cement ratio. In this section, we examine how crimped steel fibers and superplasticizers affect concrete properties.

The development of steel fibers enhances the mechanical functionality of concrete in the tension/flexure zone. Compared with typical concrete that doesn't crack easily due to the crack-bridging action of the steel fibers, SFRC provides more stability after a crack.

The steel fiber content has shown promising value increases in tensile strength, flexural strength, and impact resistance in previous studies [1]. The fibers serve as a reinforcement for microcracks, thus delaying the propagation of cracks and facilitating the absorption of energy. Despite a little improvement in the compressive strength, the overall structural performance is considerably increased.

Average fiber volume fraction ranges from 0.5% to 1.5% typically, although an ideal range can include some value in smaller fibers, such as 0.4% and 1.0%, below which workability problems become more noticeable [2]. Between 0.9% and around 0.9% volume fraction, there is a working balance in steel fibers between mechanical enhancement and working ability.

The design of the fiber is key to SFRC performance. Corrugated or crimped steel fibers with a wavy form can more easily interlock with cemented materials.

The enhanced bond strength of crimped fibers results in larger pull-out resistance, which subsequently improves the toughness and post-cracking properties [3]. Corrugated fibers have also been found to have a high fracture energy and ductility in high-performance concrete [2].

Compared with irregular or recycled fibers, crimped fibers offer:

- More uniform geometry
- Better dispersion
- More predictable mechanical performance

Hence, they can be used for structural and high-performance applications. Despite its mechanical benefits, steel fibers have negative effects on the rheological properties of fresh concrete. The presence of fibers increases internal friction and impedes the mobility of the mix, as a result, contributing to the loss of that: Slump. Flowability. Passing ability.

As the fiber volume fraction increases, the effect becomes more significant. Wang et al. (2022)[4] demonstrated that when the fiber content in self-compacting concrete increases, workability decreases significantly, especially for higher dosages.

Crimped fibers cause more fiber interlocking and clustering with their geometry as well. Consequently, compaction is poor, and distribution is not uniform.

It has been used to mitigate the disadvantages of steel fibers on workability by the use of polycarboxylate ether (PCE)-based superplasticizers. ViscoCrete, the first commercial PCE superplasticizer, is known to drastically decrease water demands but help in maintaining or enhancing the workability of steel fibers.

PCE superplasticizers have electrostatic repulsion and steric hindrance, which disperse cement particles to enhance the flow of the mixture.

- Lower water–cement ratios
- Improved workability
- Enhanced strength development

Research by [5], shows that the use of superplasticizers results in larger and stronger compressive and flexural strength in fiber-reinforced concrete due to more compact particle dispersion and reduced porosity. And PCE-based admixtures are especially useful in fiber-reinforced systems where they help ensure:

- Uniform fiber distribution
- Reduced risk of fiber balling.
- Greater compaction and homogeneity [2]

A crimped steel fiber and PCE superplasticizers result in a high-strength composite with improved mechanical and rheological properties. Steel fibers contribute to:

- Crack control
- Toughness. Load-carrying capacity

While superplasticizers compensate for:

- Reduced workability
- Increased internal friction

Without the use of superplasticizers, high fiber contents will lead to:

- Poor workability
- Segregation. Reduced mechanical performance

On the other hand, with sufficient superplasticizer dosage, the concrete mixture is:

- Uniform fiber dispersion
- Improved compaction
- Enhanced strength and durability

Such a complementary interaction is necessary for the successful implementation of SFRC in applications.

## 2. Materials and methods

### 2.1 Materials

For the concrete mixture used in this study, ordinary Portland cement was used as the main cementitious material. The coarse aggregate was crushed gravel, and the fine aggregate was natural sand. During the mixing, clean water suitable for concrete production was used.

A polycarboxylate-based superplasticizer commercially known as ViscoCrete was added into the mix to enhance mix fluidity and alleviate the water requirement.

Fibers were also inserted into the mix to enhance the performance of the hardened concrete and aid in cracking control. The steel fiber used in this study shown in fig1. That is, the chosen concrete mix for this work was Mix D (New Tech D). Its proportions were then calculated based on the required proportions for one cubic meter of concrete and converted into the quantity necessary for specimen casting.



Figure 1: Steel fibers.

## 2.2 Mix proportion

The proportions of the adopted concrete mixture for 1 m<sup>3</sup> are listed in Table 1.

To prepare six cube specimens, the material quantities were converted based on a concrete volume of 0.0233 m<sup>3</sup>, which included an additional allowance for material loss during mixing and casting. The required quantities are presented in Table 1 and table 2.

Table 1: Mix design in Kg/m<sup>3</sup>

Material	Quantity
Cement	480 kg
Water	144 L
Sand	700 kg
Gravel	1050 kg
ViscoCrete	4.8 kg
Fiber	0.9 kg/m <sup>3</sup>

Table 2: Quantities Used For Casting 6 Cubes

Material	Quantity
Cement	11.2 kg
Water	3.35 L
Sand	16.3 kg
Gravel	24.5 kg
ViscoCrete	0.112 kg (approximately 112 g)
Fiber	0.021 kg (approximately 21 g)

## 2.3 Mixing procedure

The cement, sand, and gravel were mixed in the dry state to a uniform appearance at the beginning of the mixing process. Subsequently, water and ViscoCrete were added gradually to the dry mix. Fibers were added slowly and carefully to ensure proper distribution within the concrete and to minimize clumping. The freshly mixed concrete was poured into cube molds in layers. Each layer was compacted properly to reduce entrapped

air and obtain dense specimens. For the first 24 hours, the molds were left undisturbed. Following demolding, specimens were subjected to water curing and maintained under this condition until the testing age.

## 2.4 Testing Procedure

The compressive strength was determined on concrete cube specimens using a compression testing machine. After curing at the specified age, the cubes were tested, and the maximum failure load was recorded for each specimen. From these applied loads, compressive strength was calculated following the adopted testing procedure.

A few important notes:

- Do not take the old introduction, discussion, or conclusions and modify them only slightly. That also leaves a high overlap.
- Preserve standards, material names, and numerical values as facts; rewrite the explanation around them.

## 3. Results and discussions

### 3.1 Results

The compressive strength test results reveal that at the time of testing the modified concrete mixture possesses more strength than the reference mixture. Compressive performance of the developed mix achieved definite improvement when optimum proportions of cement, aggregates, water, admixture, and fiber were selected, which is indicative of the efficiency of concrete performance. The results obtained at 7 days listed in table 3.

Table 3: Results of testing concrete.

Mix type	Compressive strength
Reference mix	30
Modified mix	50

The difference in compressive strength of the product from 30 MPa up to 50 MPa also represents an improvement of roughly 73.1 %. The result demonstrates that a more-dense and stronger concrete matrix was provided by the modified mixture than the reference mix.

### 3.2 Discussions

The improved compressive strength of the revised mix is due to the influence of the mix proportions, use of the ViscoCrete admixture, and fiber addition. The added superplasticizer probably aided with cement particle dispersion and increased the workability of the fresh concrete, which helped achieve better compaction without increasing the water content.

Consequently, it is probable that the hardened concrete formed a more compact interior structure with low void content. Moreover, the fiber showed a positive influence on concrete performance as fiber was in place. More generally than other materials, fibers will improve tensile and flexural properties but may have a secondary benefit for compressive behavior by reducing the number of microcracks and their propagation within the matrix. Improved crack management during the loading process can delay internal damage and enhance the load-carrying capacity of the specimen.

A further consideration is the overall composition of the mixtures. The percentages of cement, water, fine aggregate, coarse aggregate, admixture, and fiber appear to have made the concrete more uniform than the reference mixture. This uniformity helps to distribute stress within the specimen and minimizes the weak area that may promote premature failure. The obtained result verifies the capability of the modified mixture to be superior to the reference mixture to achieve compressive strength. This enhancement shows that the new mixture is appropriate for higher initial and medium-age applications, however, it must still be validated through further tests like flexural strength, splitting tensile strength, and durability evaluation.

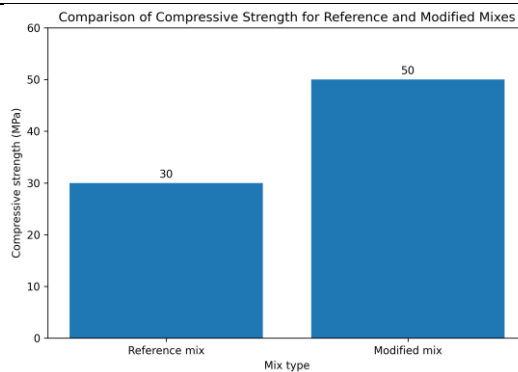


Figure 1: Comparative of compressive strength between the two mixes.

#### 4. Conclusions

1. The concrete mix modified showed a compressive strength of 50 MPa while the reference mix reached 30 MPa.
2. Compared to the reference concrete, the modified mix exhibits an increase of approximately 73.1% in compressive strength.
3. The strength improvement can be ascribed to the cumulative impact of the revised mix proportions, improved particle dispersion caused by ViscoCrete, and the fiber's crack-control role.

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