Evaluation on Strength Concrete Containing Micro Steel Fiber: A Review

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Abstract. Concrete has been used for a very long period in construction sites all over the globe. Concrete is very crucial in producing structural members in any building structure. It has to be strong enough to bear the loads of building so that it will not be failed. This article focused on a critical review of concrete containing micro steel fibres (MSF) in order to improve its ductility. In this study, the research is to determine whether the usage of micro steel fibre can improve the compressive and splitting tensile strength of concrete or not. In general, the strength of the concrete improves as the amount of MSF in the matrix increases. All the assessments conducted in all the paper that has been reviewed are following the standard test of British Standard. In a nutshell, the addition of micro steel fibre to concrete does have a huge impact on the tensile and compressive strength. The properties of concrete are expected to enhanced compared to normal concrete; however, the tensile strength does not show any improvement.

1. Introduction

Concrete is a very common composite that has been utilized for improving the civilization of humankind all over the globe. There is a lot of new type of concrete that has been implemented in building construction. Concrete is a composite that contain of cement, coarse aggregates, and fine aggregates which are strong in compression but weak in tensile strength [1]. So, it is essential to study more on the way to enhance the tensile strength.

Fresh concrete develops structural cracks as a result of drying shrinkage, resulting in structural failure. Concrete hardness and tensile strength can be improved by material with more durable mechanical properties. One of the methods to enhance the concrete properties efficiently is by adding the fibres [2]. Other research validates the paper's claim that steel fibres can improve both the strength and ductility of concrete. This is due to the randomly oriented interlocking mechanism and micro scratching mechanism will limit crack propagation which results in the improvement of strength and ductility [3]. Another research affirmed that by including the steel fibres in concrete can leave an effective result on flexural and compressive strength [4]. Steel fibre improves the tensile strength, flexural strength, impact strength, and toughness of concrete, in addition to increasing its compressive and ductility [3].

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In this study, it will mainly focus on reinforcing concrete with micro steel fibre with a specific percentage of micro steel fibre. The compressive strength test will be conducted on the concrete specimens consists of micro steel fibre, and the result obtain will be compared to the control specimens. The optimum percentage of micro steel fibre in concrete will be evaluated. Concrete is very crucial in the construction site. It is mostly used in making structure member such as slab, beam, column and foundation. It is a common knowledge that the concrete structure is very dependent on the compressive strength of each concrete elements [5].

Fibre-matrix interfacial properties provide a significant position in the global mechanical reaction of composite materials [6]. So, a higher volume fraction of fibres will improve the fibre interlocking instrument for composition of concrete. Thus, the mechanical properties of concrete are improved. Concrete struggles concerning tension criteria if the tensile stress meets the corresponding tensile pressure [7]. Besides, cement-based material has the brittle characteristic, and weak towards crack resistance, also the compressive strength is higher than flexural strength [8].

Concrete is usually exposed to weather and any extra load, which may cause failure to occur. Concrete structure needs to be strong to bear the axial load from the building to avoid any failure of the structure. One way to enhance the concrete strength is by applying additional material which is in this study by utilizing micro steel fibre. By doing so, the building stability and the service life of the building can be enhanced [9]. Moreover, the inclusion of micro steel fibre on the concrete mix design will improve the matrix bonding and mitigate cracking.

In this paper, the method of improving the mechanical strength of concrete by using micro steel fibre will be discussed. In order to achieve the purpose of this study, several previous studies on “the effect of micro steel fibre in concrete strength” and “the behaviour of concrete containing micro steel fibre in terms of splitting tensile and compressive strengths” have been studied and analyse to prove that the addition of MSF to concrete matrix would improve its properties in term of compressive and tensile strength.

2. Literature Review
Nowadays, there are a lot of research has been studied to make sure the increment of the strength of concrete in term of tensile and compressive strength by using additional material. This section will go through the material that may have the potential to improvise the compressive and tensile strength of concrete, which can benefit the industry in upgrading the quality of work.

Cement, in general, is an adhesive compound, also known as binder, that is commonly included in building projects. The cement of this kind is powders that will harden when contact with water. Hydration, which is also the chemical reaction of cement substances with water to obtain sub-microscopic minerals or a gel-like substance with a large surface area, causes setting and hardening. Cement is also referred as the hydraulic cement because of its hydrating properties, which allow it to set and harden even when submerged. Concrete is widely utilized in construction because of its durability and strength characteristic [10].

Many efforts have been made in order to enhance the strength of concrete by incorporating various types of additional materials. Table 1 below shows a list of previous research on concrete with different type of material which was conducted all of it in the year 2020.

| No | Author | Material | Outcomes |
|----|--------|----------|----------|
| 1  | [11]   | Micro-Silica | There is an improvement of 16%-25% in the average laboratory of compressive strength test compared to design |
| 2  | [12]   | Steel Fiber | All concrete specimen has declined in compressive strength. |
| 3  | [13]   | Steel Fiber | There is an increase on post-peak response, compressive strength, strain value, and energy absorption. The brittleness is reduced. |

Table 1: Previous research on concrete
2.1 Fibres
Primarily, fibres are discontinuous, short and also unarranged, spread throughout the mixture of concrete and lastly produce a composite construction material which also recognizes as fibre reinforced concrete (FRC). Usually, fibre is made of steel, glass, and polymer or derives chemical materials will be used in cement-based composite [14]. Based on Hong [6] the research stated that because of fibre have the tendencies to be more closely spaced than a conventional reinforcing bar, it can control cracking more effectively [15]. Tate [16] also states that fibres can never substitute a conventional steel bar because the steel bar has its own roles in advance concrete technology. With that being said, fibre and steel reinforcement should be utilized as much as possible.

Gholampour [17] claims that their research has demonstrated a huge potential of using ultra-high-strength MSF in the implementation of alternative on reinforced concrete elements, particularly in the design of seismic-resistant columns.

Table 2: Previous research on MSF

| No | Author | Percent of steel fiber | Type of concrete | Outcomes |
|----|--------|------------------------|------------------|----------|
| 1  | [18]   | 0%, 1%, 2% and 3%      | Geopolymer Concrete | With increasing fibre content and size, compressive and ultimate flexural strength increases. |
| 2  | [19]   | 0%, 0.5%, 1.0%, 1.5%, and 2.0% | Ultra-High-Performance Concrete | Pull-out behaviour and tensile performance did not have a negligible connection. |
| 3  | [20]   | 0.5%, 1%, 1.5% and 2% | Ternary Concrete | The tensile strength increases by 15.29%, 25.95 and 35.78% compared to the ordinary concrete mix |

3. Result and Discussion
The purpose of this article is always to discuss regarding efficiency of MSF in concrete composition. Several paper using concrete with micro steel fibre as additional material was reviewed. The splitting tensile and compressive strength of normal concrete was evaluated in order to compare with the strength of which contains MSF as additional material. Moreover, the percentage of micro steel fibre also needed to be evaluated so that conclusion on the relationship between concrete and micro steel fibre can be determined. Table 3 shows the various studies conducted on compressive strength.

Table 3: Previous research on compressive strength

| No | Author | Curing 7 Days | Curing 28 Days | Percent of MSF | Type of Concrete |
|----|--------|---------------|---------------|----------------|-----------------|
| 1  | [4]    | 24.33MPa      | 39.8MPa       | 1%             | Normal Concrete |
| 2  | [20]   | -             | 43.94MPa      | 0.5%           | Ternary Concrete |
| 3  | [21]   | -             | 43.0MPa       | 0.5%           | Self-Compacting Concrete |
| 4  | [22]   | 32.1MPa       | 51.7MPa       | 1%             | High-Strength Concrete |
| 5  | [23]   | 41.2MPa       | 43.7MPa       | 0.5%           | Normal Concrete  |
Figure 1. Comparison of compressive strength for normal concrete (NC) and concrete with MSF.

The compressive strength of normal concrete (NC) and concrete with MSF for specimens aged 7 and 28 days was portrayed in Figure 1. Based on the figure above, every researcher found out that there is a remarkable improvement for every type of concrete after incorporating micro steel fibre into the concrete. For Vijaya [20] and Abid [21], the compressive strength for 7 days is not tested; therefore, only 28 days' compressive strength is available. However, there is only a little improvement for Gholampour [22]. In his study, Gholampour et. al is using high strength concrete in his research about micro steel fibre. That is why the results for the normal concrete have a very high compressive strength compared to another researcher. From these five types of research, Eisa [4] and Abid [21] show a negative effect which shows the declining in numbers of compressive strength. For Eisa [4], there is diminishing of concrete strength from 44.2MPa to 39.8MPa, which after calculated to be 11% of reduction. Same goes to Abid [21], the result show 44.5MPa, which reduces to 43MPa and from that there is 3.5% of reduction. The three other researchers only show a positive impact. From all these five types of research, the best percent for micro steel fibre so that the concrete achieves the highest strength is 0.5% as stated by Kenneth [23]. Table 4 below shows the various studies which were conducted on splitting tensile strength test.

| No | Author | Curing Percent of MSF | Type of Concrete |
|----|--------|-----------------------|-----------------|
| 1  | [4]    | 2.55MPa 5%            | Normal Concrete |
| 2  | [20]   | 4.12MPa 0.5%          | Ternary Concrete |
| 3  | [21]   | 4.5 MPa 0.5%          | Self-Compacting Concrete |
| 4  | [23]   | 7.07MPa 7.23MPa 0.5% | Normal Concrete |
| 5  | [24]   | 16.6MPa 2%            | High Strength Concrete |
The comparison of splitting tensile strength between normal concrete (NC) and concrete with MSF for specimens aged 7 and 28 days is shown in Figure 2. Based on the Figure 2, there are a few studies that conduct splitting tensile strength test for 7 days curing duration. Most of the paper only conduct laboratory testing for only 28 days. There can be found out that most of the researcher does not agree that by using micro steel fiber as additional material in concrete can improve the splitting tensile strength of concrete. However, from those five papers that have been reviewed found out that there has been declining in the tensile strength such as Eisa [4] with reduction of 25%, Kenneth [23] with reduction of 3.7% and Yoo [24] with the reduction of 0.6%. However, for Gholampour [22] and Vijaya [20] show an improvement on the tensile strength of concrete. From figure 4.2 above, Abid [21] shows a very high value of splitting tensile strength because the research was about high-strength concrete. That is why the value is very different compared to another researcher.

4. Conclusion
In conclusion, based on the review on previous studies, there are few things that can be highlighted; i) It has been proven that MSF can increase the strength of the concrete. ii) The optimum percentage for micro steel fibre to be added into concrete by volume fraction is 0.5%. iii) The greatest improvement in compressive strength is 24% which is from 35.2Mpa to 43.7Mpa.

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