Physical behaviours of maximum loading and cracking for slurry infiltrated fibre reinforced concrete

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Abstract. Concrete prisms are being tested with flexural testing by different percentage volume of steel fibres. The total number of 24 prisms were made which contain 3 %, 6 % and 9 % of steel fibres respectively. This only consist experimental results. Specimens used in this study using a prism mold of 100 mm x 100 mm x 500 mm. Eighteen prisms will be added with a layer of 10 mm of steel fibre using slurry method. All of the samples were tested using flexural testing to determine the maximum loading. The highlight scope of this research is to evaluate the physical behavior of Slurry Infiltrated Fibre Reinforced Concrete in term of maximum load and cracking pattern. The results of the study were also compared with concrete without steel fibres. However, the workability of the concrete decreased as the number of steels fibre increase. The maximum load was obtained by the lowest percentage of steel fibre (3%).

1. Introduction

Slurry Infiltrated Fiber Concrete (SIFCON) is a special type of steel fiber reinforcement cement composite which has better mechanical properties such as shear strength, tensile strength, compressive strength and flexural strength [1]. In the form of discrete interlocking fibres that lend significant properties to the matrix, Slurry Infiltrated Fiber Concrete (SIFCON) is similar to Fiber Reinforced Concrete (FRC). However, there are some aspect that differentiate between FRC and SIFCON. In FRC, the fibre content usually varies from 1% to 3% but for SIFCON, the fibre content varies from 5% to 20% [2,3]. Experimental result based on previous researchers have shown that the different percentage volume of SIFCON give different result of performance of the concrete [4].

SIFCON is evolve in construction material because it possessed high strength and large ductility. From past investigation, it has been proven that the flexural behavior of SIFCON whereas the ductility and the energy absorption capacity of SIFCON specimens are always higher than those FRC specimens [5]. Another experiment result of SIFCON showing that the use of SIFCON has increased the efficiency and ductility of concrete [6].

SIFCON is a recent development in concrete technology where it is designed to optimized performance characteristics of given materials, exposure conditions and usage, costs, service life and durability. Researchers have found that the application of SIFCON in the areas of pavement repairs,
repair of bridges structures, safe vaults and defense structures due to excellent energy absorption capacities [7]. The aim of this research is to determine the maximum load of concrete for normal concrete and secondly is to strengthen concrete using Slurry Infiltrated Fiber Concrete method.

2. Materials and method
The concrete was produced with different percentage. A total of 24 prisms was cast produced with 6 without the addition of steel fiber and another 18 will be added with a layer of 20 mm steel fiber after 24 hours. During normal casting, the thickness of the concrete will be reducing to 20 mm. The percentage of steel fiber that will be use are 3 %, 6 % and 9 % respectively. Each sample was produced with three prisms and took the average of the result. Then, the sample will have curing process for 7 and 28 days. After completed the curing process, it will undergo flexural testing to determine the maximum loading and flexural strength as shown in Figure 1 and 2. Overall process was explained in Figure 3.

![Figure 1. Slurry Infiltrated process.](image1.png)

![Figure 2. Flexural Test.](image2.png)
3. Result and discussion

For cracking result, it is observed after the prism reaching maximum load during flexural testing. The purpose of observing the cracking pattern is to study the performance of steel fiber in minimizing the crack. The result of crack width is shown in Table 1. The width of the crack that happen at the middle of the concrete shows that the presence of steel fiber did not reduce cracks for concrete with 6% and 9% percentage volume of steel fiber. A1 and A2 shows largest crack width since it has no steel fiber. The steel fibers contribution in the concrete is to improve the strain capacity of the composite. Moreover, the improved strain in tension helps in reduces crack width but it is more conventional with the combination of reinforcement. The durability of the ordinary concrete structures improves with the addition of steel fiber due to the engagement and bonding from the steel fiber and concrete.

This may be because of the excessive amount of water in the mixture due to human error. The more water used was resulted in higher the cracking tendency because water increases shrinkage and reduces strength. During the experiment is done, the water might be added more than the actual volume that makes the permeability of concrete is higher. The free water that remains after the hydration process as well as cement and aggregates that are not fully compacted will creates pores which are not filled by the
hydration process. Thus, it makes the concrete has less workability and reduces the strength of the concrete as well as produces larger crack width (increasing water/cement ratio).

Table 1. Crack width of concrete.

| Sample | Percentage of Steel Fiber (%) | Crack Width (mm) |
|--------|------------------------------|------------------|
| A1     | 0                            | 0.5              |
| A2     | 3                            | 0.3              |
| B1     | 3                            | 0.03             |
| B2     | 6                            | 0.01             |
| C1     | 6                            | 0.06             |
| C2     | 9                            | 0.02             |
| D1     | 9                            | 0.15             |
| D2     | 9                            | 0.08             |

Figure 4. Maximum load vs Percentage of Steel Fiber (%) for 7 days Curing.

Figure 5. Maximum load vs Percentage of Steel Fiber (%) for 28 days Curing.
From Figure 4, it is shows that the maximum loading for samples without steel fiber has the lowest maximum loading compared to other samples. It is increased for sample with 3 % percentage volume of steel fiber. However, for samples with 6 % and 9 % percentage volume of steel fiber, the maximum loading decreases respectively. For Figure 5, the maximum loading of concrete for 9 % percentage volume of steel fiber was the lowest while the maximum loading of 3 % percentage volume of steel fiber was the highest followed by concrete with 6 % percentage volume of steel fiber.

The factor that effect the maximum loading and strength of concrete is coarse and fine aggregate ratio. For this research, the fine aggregates ratio is more than coarse aggregates ratio which is 2:1. From previous research, if the ratio of fine aggregates is higher than coarse aggregates, the aggregates surface area will increase. The addition of steel fiber also effects the strength of the concrete. However, from this research, the percentage volume that has been used are 3 %, 6 % and 9 %. But, the strength of the concrete only directly proportional with the percentage volume of steel fiber only for 3 %. This is due to the mixture of the cement slurry that might be hardened and make the voids between the steel fiber are not fully filled by the cement slurry thus reduces the strength and maximum loading.

4. Conclusion

Overall, the objectives that has been stated for this research was achieved. The aim of this research is to study the strength of concrete with and without Slurry Infiltrated Fiber Concrete. The result from experimental work was observed. The parameter that being considered in this research are maximum loading and cracking pattern in terms of crack width. In this research, the results that has been obtained was slightly different with the previous research. The results show the increasing in performance of maximum loading and flexural strength for 3 % percentage volume of steel fiber from concrete without steel fiber. But, the results of maximum loading and flexural strength for 6 % and 9 % percentage volume of steel fiber were decrease. After conducting the flexural testing, the cracking pattern in terms of crack width can be observed at the surface of the prism. The critical area of the prism can be identified by observing the crack that occur in particular area.

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