SUSTAINABILITY POTENTIAL OF SYNTHETIC FIBRE (ROPE) REINFORCED CONCRETE BEAM

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ABSTRACT

The use of synthetic fibers as reinforcement in concrete has been an innovative development in recent years. Synthetic fiber reinforced concrete can be used to make the concrete lighter and less covered. Synthetic fiber reinforced concrete (SFRC) is a cementation material with reinforcement made of noncorrosive, high-strength synthetic fibers. Cover needs can be kept to a minimum by using a noncorrosive reinforcement. Additionally, the material is well suited for thin shells or folded structures since it is simple to arrange the synthetic fiber fabrics in intricate formworks. Synthetic fiber reinforced concrete has been used to make the concrete lighter and less covering. Where the load is less, synthetic fiber reinforcement can be used instead of steel reinforcement to reduce cost. So, the reinforcement has been replaced with strongersynthetic fiber reinforcement. A total of 4 types of beams have been made by replacing 100% steel reinforcement with synthetic fiber reinforcement. Consider how much the beam deflection and load are reduced or increased when replaced with 100% steel-reinforced beams and consider where the present synthetic fiber reinforcement can be used. A comparison of flexural behavior is made between reinforcement concrete beams and synthetic fiber-reinforced concrete beams. Three different beams were constructed for comparison with reinforcement concrete beams. The research was to compare 100% reinforcement concrete beams and what present of steel can be replaced by synthetic fiber reinforced. Loads and deflections are compared with steel beams and beams replaced by synthetic fiber reinforced. Four separate beams are designed. Type 1, 100% steel with load capacity 38kN and deflection 12mm. Type 2 is 83% Steel and 17% Synthetic fiber Reinforced, Its load capacity is 35kN and its deflection is 14 mm. Type 3 66% Steel and 34% Synthetic fiber Reinforced Which has a load capacity of 20kN and a deflection of 12 mm. Type 4 is 50% Steel and 50% Synthetic fiber Reinforced Its load capacity is 10kN and its deflection is 14mm.

Keywords: *Synthetic fiber reinforcement, deflection, replaced, load capacity,*

1. INTRODUCTION

In recent years, synthetic fiber-reinforced concrete (SFRC) has emerged as an intriguing alternative to reinforced concrete for components as the demand for SFRC's lightweight design is increasing. Particularly, lightweight folded structures or shells have shown significant application potential. The fabric typically consists of a planar, bidirectional assembly. Bundles of filaments are made of raw materials that won't corrode or deteriorate in the presence of chlorides or ambient air (although degradation of the synthetic fibers owing to chemical reactions between the fabric and the cementations matrix may occur). Considering how the type of fabric affects the response, many studies have focused on carbon fibers because of their availability (Valeri et al., 2020)

SFRC applications have not yet been widely used. This is primarily due to SFRC's lack of design guidelines. Significant efforts have been undertaken in recent years, particularly within the framework of two German collaborative research institutes, to create models that describe the load-bearing behavior of SFRC and to offer the necessary design criteria. For more details on load-bearing characteristics and to provide clear design methods, experimental research on SFRC members is being carried out. (Hegger et al., 2006)

Synthetic fiber materials, such as synthetic fiber reinforcement (SFRC), can be a substitute for steel in lightweight concrete elements. The purpose of this study is to evaluate beam's synthetic fiber-based performance to investigate how fracture patterns evolve and how well-synthetic fiber-reinforced beams support loads.

Since the synthetic fiber material can corrode, it's not a great substitute for steel material that can also be helpful to make lightweight concrete elements. And it is also pretty strong to take tensile strength as much as 3000 N/mm^2. (Murayama et al., 2002)

The main purpose of the study was to determine the effectiveness of SFRC for strengthening the RC beams in both flexure and shear. It had a great result to tolerate load both flexure and shear. And the bond with the concrete was enough to safely transfer the load. However, there was a different scenario for some other fabrics which made them unsuitable for SFRC use. (Nguyen & Ngo, 2020)

This test was proof that not all synthetic fiber materials can be used for SFRC. This test was conducted on multifilament yarns. This test explains the behavior of the fiber on different loads and proved that it is not good to be used in concrete. (U. Häussler-Combe & F. Jesse & M. Curbach, 2000)

The synthetic fiber-reinforced concrete underwent testing to see if it could withstand a load and a shearing load. must be aware that they collected their data after doing several tests on various bonds. How to lose weight through achieving success. It is possible to employ concrete as a layer with synthetic fiberreinforcement. (Brückner et al., 2006)

The experimental investigation presented in this study provides useful information on the behavior of composite SFRC/concrete structural elements which can be used for the conduction of large-scale tests. For beam-type specimens, the use of polymer-coated synthetic fibers and higher synthetic fiber reinforcement ratios results in higher load-carrying and deformation capacities. The effect of the SFRC/concrete interface roughness (based on the limited experimental data presented herein) was found to be rather small. Synthetic fibers 4 in participating SFRC formwork elements may serve as the composite beams' primary reinforcement substituting discrete steel reinforcement bars and resulting in mass savings. The idealization of the strain profile across the cross-section of a fiber roving proposed in this work renders the fiber model-based section analysis a reliable tool for the prediction of the ultimate flexural capacities of composite SFRC/concrete beams. The use of SFRC shafts as formwork elements for columns is an interesting prospect provided that in-situ construction practices will inhibit local buckling of the shells. (Papanicolaou & Papantoniou, 2010)

The study's goal is to determine whether it is feasible to replace reinforcing beams with synthetic fiber reinforcement while maintaining beam durability. How much stress and deflection the beam can withstand, as well as whether it can support the weight of loads applied to synthetic fiberreinforcement in place of beam reinforcement. Due to this reason, the beam reinforcement has been replaced by the synthetic fiber reinforcement at a of rate 17% and 34%, and 50% to understand the behavior of SFRC beam.

2. METHODOLOGY

Three-point bending tests were performed on each sample of the four conditions to evaluate the flexural performance of SFRC beams in four distinct circumstances.

2.1 Reinforcement

Figure 2.6: Synthetic fiber Reinforcement

Selected Synthetic fiber Fabrics with a load of 10kN as a Synthetic fiber Reinforcement.

2.2 Materials:

As a fine aggregate, selected sand with an FM of 2.6. As a coarse aggregate, selected stone with a unit weight of 1600kg/m3. The coarse aggregate has an absorption of 0.5 percent and a bulk dry specific gravity of 2.68.The details of mixtures of conventional concrete of class M 20 used for all types of textile reinforced are described.We selected Textile Fabrics with a Tensile Stress of 57 pa as a Textile Reinforcement. concrete mix design ratio 1:1.43:2.20.

2.3 Comparison Variants

A total of four variants of concrete facade panels were compared:
Type-1. Use 100% Steel

Type-2. Use 83% Steel + 17% Synthetic fiber Fabrics
Type-3. Use 66% Steel + 34% Synthetic fiber Fabrics
Type-4. Use 50% Steel + 50% Synthetic fiber Fabrics

2.4 Flexural Tests

Three-point bending tests were performed on each sample of the four conditions to evaluate the flexural performance of SFRC beams in four distinct circumstances.
Wooden formwork with the necessary final dimensions was used to cast the beams. Before the beam was horizontally cast as illustrated, the constructed cage reinforcement was set into the formwork. After 48 hours, beams were taken out of the formwork and stored in a humid chamber until the test day, which was when they were 28 days old.
three-point bending tests in a UTM- universal testing machine hydraulic system with a 1000kN capacity were carried out to assess the structural strength of the carbon-synthetic fiber-reinforced concrete. Utilized to measure the mid-span deflection of the beams, the experiments were driven by displacement at a 1 mm/min rate. The beams were set over support rollers that were spaced 1524 mm apart. The load was applied 711.2mm apart from both sides. The rollers used for support and load application have free horizontal displacement.

Figure 2.11: Beam setup for test

The beam is set up for testing in UTM. Its load capacity is 1000kN. Point loads are applied to the beam.

3.RESULTS

Beams are prepared in 4 conditions. Each load and deflection have been governing. And discuss how much percent was replaced, what amount of load and cost has decreased. Measure deflection in the deflection dial gauge.

3.1 Type 1- 100% reinforcement

First condition: 100% reinforcement concrete beam. Its load capacity is 38kN and its deflection is 14mm. The graph demonstrates the correlation between load and displacement. Based on the provided information, the following is a breakdown of how displacement alters with changing load.
Thedisplacement increases from 0mm to 0mm with increasing load, resembling a step-in pattern, reaching 14mm as the load increases to 38kN.

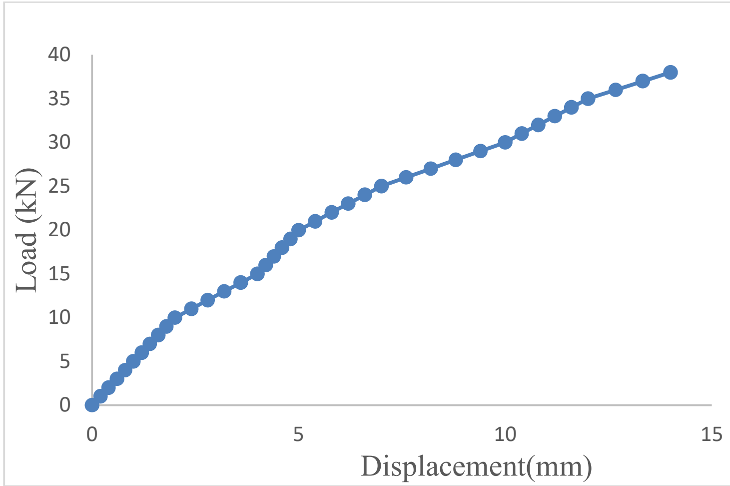

Figure 1 Load-displacement relation (for type 1 beam)

3.1.2 Type 2- 83% Steel and 17% Synthetic fiber Reinforced

2nd condition uses 83% Steel and 17% Synthetic fiber Reinforced. Its load capacity is 35kN and its deflection is 12mm. Which is close to 100% Steel.

The graph demonstrates the correlation between load and displacement. Based on the provided information, the following is a breakdown of how displacement alters with changing load:

- The displacement rises to 0.2mm with a rise in load to 1kN.
- The displacement grows in step with the load as it continues to rise. As the load increases to 35kN this pattern persists, leading to a displacement of 12mm.

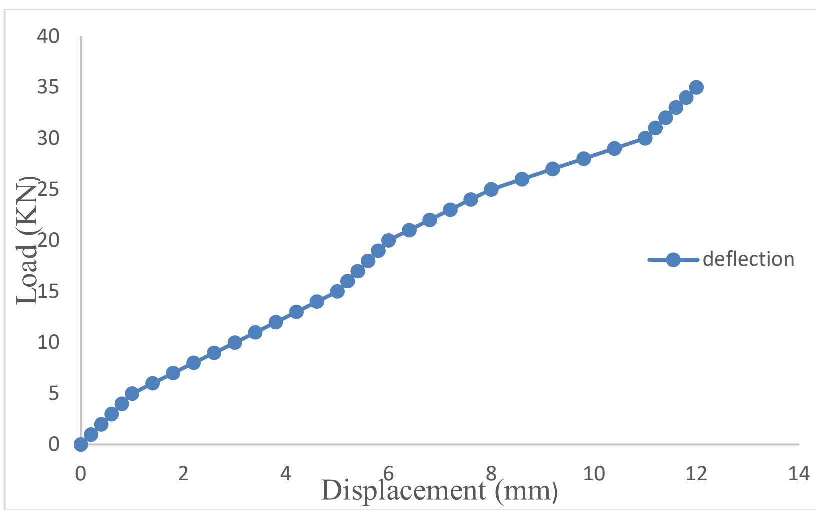

Figure 2 Load-displacement relation (for type 2 beam)

3.1.3 Type3- 66% steel and 34% synthetic fiber reinforced

3rd condition we have used 66% steel and 34% synthetic fiber reinforced. The load capacity was 19kN and the displacement was 12mm.

The graph demonstrates the correlation between load and displacement. Based on the provided information, the following is a breakdown of how displacement alters with changing load:

- When the load is increased to 1kN, the displacement increases to 0.20mm.
- As the load increases, the displacement increases in lockstep with it. The pattern continues when the pressure rises to 19kN, resulting in a displacement of 12mm.

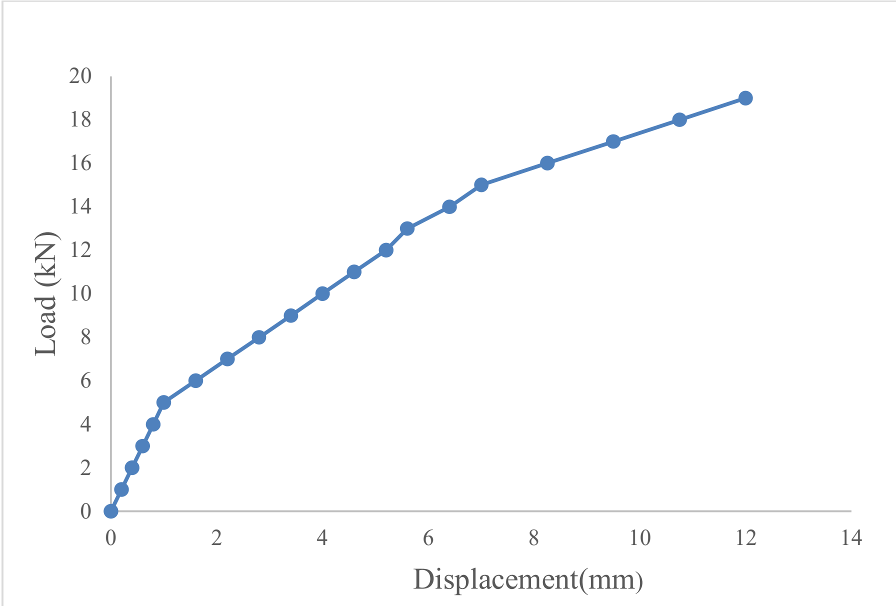

Figure 3 Load-displacement relation (for type 3 beam)

3.1.4 Type4- 50% steel and 50% synthetic fiber reinforced

4th condition we have used 50% steel and 50% synthetic fiber reinforced. The load capacity applied 10kN and the displacement was 14mm.

The graph demonstrates the correlation between load and displacement. Based on the provided information, the following is a breakdown of how displacement alters with changing load:

- The displacement rises to 1.2mm with a rise in load to 1kN
- The displacement grows in step with the load as it continues to rise. As the load increases to 10kN this pattern persists, leading to a displacement of 14mm.

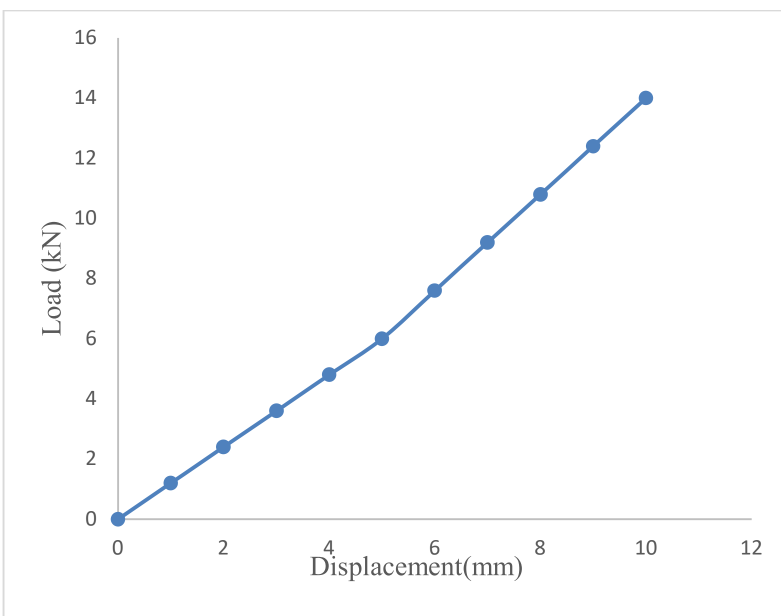

Figure 4 Load-displacement relation (for type 4beam)

3.5 Combined

Maximum load and maximum deflection are found in type-1 beam, Load 38kN, and deflection 14mm. The lowest load and deflection are found in type-4 beam, Load 10kN, and deflection of 12mm.

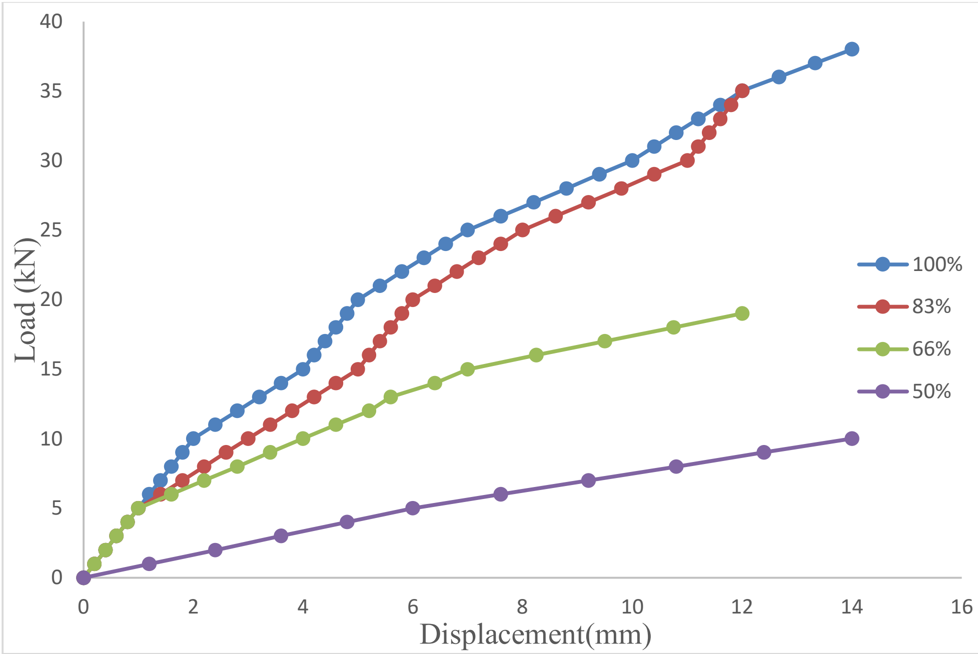

Figure 5:Load-displacement relation (for combined beam)

3.6 Failure pattern

Failure modes in reinforced concrete beams are classified into two major types: flexural failure and shear failure. The former occurs when the imposed load exceeds the flexural capacity of the materials of the beam, while the latter occurs due to a deficiency in shear resistance between different materials of the beam. All beams of this study occurred at flexural failure.

Figure 3.9: Failure pattern (for type 1 beam) Figure 3.10: Failure pattern (for type 2 beam)

Figure 3.11: Failure pattern (for type 3 beam)

Figure 3.12: Failure pattern (for type 4 beam)

3.1.6 Cost analysis

Beam Type	Cement (tk)	Stone(tk)	Sand(tk)	Rebar (tk)	Fiber (tk)
1	200	150	40	702	---
2	200	150	40	600	20
3	200	150	40	500	40
4	200	150	40	400	70

Four different types of beams have been constructed. It has 100% reinforcements for the first beam. 2nd bean is reinforced with 17% reinforced synthetic fiber and 83% steel. The third beam is made of 66% steel and 34% reinforced synthetic fiber, while the fourth beam is made of 50% steel and 50% reinforced synthetic fiber. Because there is less reinforcement in the second, third, and fourth beams, the price is likewise lower.

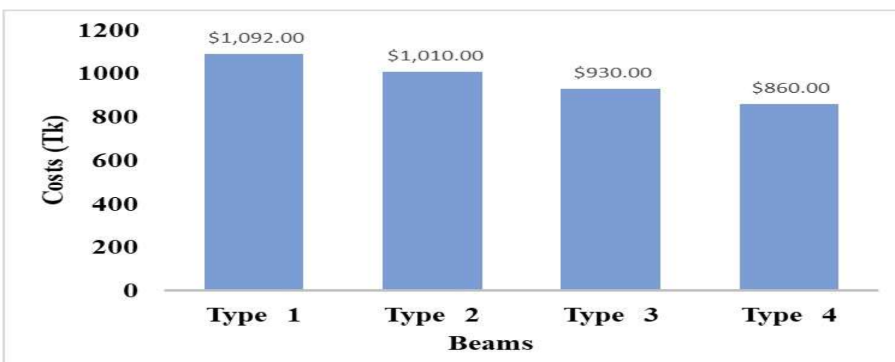

Figure 3.13: cost analysis

Cost savings for the second beam are 7.5%, the third beam is 14.83%, and the fourth beam is 21.52%. With the increase of synthetic fiber reinforcement, the amount of cost is reduced. Therefore, where the amount of load is very low, we can convert the reinforcement into synthetic fiber reinforcement and use it.

4.1 DISCUSSION

There are four distinct beams made in this investigation. The beam was designed to use synthetic fiber reinforcing in place of steel. Coarse aggregate, fine aggregate, cement reinforcement, and water are used as materials for making the beam. For fine aggregate, selected sand with an FM of 2.6 and for coarse aggregate, selected stone with a unit weight of 1600kg/m3.The coarse aggregate has absorption of 0.5 percent and a bulk dry specific gravity of 2.68. Reinforcement is replaced by synthetic fiber fabrics, selected Synthetic fiber Fabrics with a tensile load of 10kN Synthetic fiber Reinforcement.

So, four separate beams are designed. Type 1, 100% steel with load capacity 38kN and deflection 14mm. Type 2 is 83% Steel and 17% Synthetic fiber Reinforced, its load capacity is 35kN and its deflection is 12mm. Type 1 & 2 are close to each other and can be used. Type 3 is 66% Steel and 34% Synthetic fiber Reinforced which has a load capacity of 19kN and a deflection of 12mm.Type-3 beam can also be used where the amount of load is less. Type 4 is 50% Steel and 50% Synthetic fiber Reinforced which has a load capacity is 10kN and its deflection is 14mm. Type 4 beams can be used where there is no live load. Failure modes in reinforced concrete beams are classified into two major types: flexural failure and shear failure. The former happens when the applied load is greater than the flexural strength of the beam's materials, while the latter happens when there is insufficient shear resistance between the beam's various materials. This study's beams all experienced flexural failure.

4.2 CONCLUSIONS

The potential of synthetic fiber-reinforced concrete as a sustainable construction material is discussed. And how much load and deflection can be achieved by replacing steel with synthetic fiber reinforced, and where it can be used is discussed. Comparing the load and deflection of a 100% steel beam with what percentage of a replacement. Discussing where and how much replacement may be utilized There are four distinct beams constructed. Type 1, made entirely of steel, has a 38kN load capacity and a 14mm deflection. Type 2 Reinforced with 83% Steel and 17% Synthetic fiber, has a 35kN load capacity and a 12mm deflection. It is practically type 1 close. So, type-2 beams can be utilized wherever type-1 beams are required. Using 66% steel and 34% synthetic fiber reinforcement, Type 3 is It has a 19kN load capacity and a 12mm deflection. Where there is less load, type 3 beams can be employed. Type 4 is reinforced with 50% steel and 50% synthetic fiber. It has a 10kN load capacity and a 14mm deflection. Where there is less amount of load applied, Type 4 beams may be employed. There are two categories of failure mechanisms in reinforced concrete beams. It can be further improved through further research in the future.

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