International Journal on Applications in Civil and Enviornmetal Engineering
Volume 3: Issue2: May 2017, pp 5-9. www.aetsjournal.com ISSN (Online) : 2395-3837

BEHAVIOUR OF ULTRA-HIGH PERFORMANCE CONCRETE USING HYBRID STEEL FIBRE UNDER UNIAXIAL COMPRESSION

S K SHASHI KUMAR[1]
Lecturer, Civil Engg Department, Government Polytechnic Udupi (145), Udupi – 576104.
shashi9062@gmail.com

LOKESH G [2]
Lecturer, Civil Engg Department Government Polytechnic Kudligi (174) Kudligi, Bellary -583135.
2lokesh3@gmail.com

Abstract - A ground-breaking material with remarkable mechanical qualities and endurance, ultra-high performance concrete (UHPC) is a compelling choice for critical infrastructure applications. In this study, the behaviour of hybrid steel fiber-reinforced ultra-high performance concrete (HSF-UHPC) in uniaxial compression is the main objective. The purpose of the study is to shed light on the mechanical response and deformation properties of HSF-UHPC while taking into account the combined impact of steel fibres on its functionality.On prismatic samples of HSF-UHPC with different fibre contents and aspect ratios, experimental testing were carried out. To examine the stress-strain relationship, ultimate compressive strength, and post-peak behaviour of the material, uniaxial compression experiments were carried out. It was investigated how hybrid steel fibres affected the load-bearing ability, ductility, and energy absorption of HSF-UHPC.According to the findings, adding hybrid steel fibres considerably improved UHPC's ductility and compressive strength. With better crack resistance and increased load carrying capacity, the stress-strain response demonstrated a typical strain-hardening behaviour. The total mechanical performance of HSF-UHPC was enhanced by the interaction of various steel fibre types, allowing it to withstand greater loads and deformations without abrupt failure. The results of this study provide insight into how hybrid steel fibre reinforcement may improve the behaviour of ultra-high performance concrete under uniaxial compression. The design and construction of high-performance structures that require greater load-bearing capacity and durability may be affected by the increased mechanical properties and deformation characteristics of HSF-UHPC. Understanding how HSF-UHPC behaves under uniaxial compression offers useful information for enhancing its use in crucial infrastructure projects and demonstrates its potential to completely alter current construction methods.

I. Introduction

Due to its remarkable mechanical qualities and endurance, ultra-high performance concrete (UHPC) has become a ground-breaking material in the building industry. UHPC provides a game-changing solution for demanding structural applications, such as bridges, high-rise structures, and infrastructural components subject to severe loads and harsh environments, with compressive strengths exceeding 150 MPa and enhanced resistance to numerous environmental variables.

It is well known that adding steel fibres to concrete matrices has the ability to improve mechanical performance and lessen the inherent brittleness of conventional concrete. This study examines how ultra-high performance concrete responds to uniaxial compression while concentrating on the use of hybrid steel fibres. In order to take advantage of the synergistic effects that each fibre type brings to the composite material, hybridization entails blending different types of steel fibres, frequently with different geometries and qualities.

This study aims to thoroughly investigate the mechanical behaviour of hybrid steel fiber-reinforced ultra-high performance concrete (HSF-UHPC) under uniaxial compression. The study intends to clarify the combined impact of steel fibres on the stress-strain behaviour, ultimate strength, and deformation features of HSF-UHPC through a series of experimental testing and analysis.

By combining the benefits of several fibre types—such as hooked-end steel fibres for crack bridging and straight steel fibres for load distribution—the hybrid steel fibre reinforcing technique aims to increase ductility, tensile strength, and energy absorption capacity. To maximise the performance of the material and broaden its possible uses in contemporary building, it is essential to comprehend how hybrid steel fibres interact with UHPC during uniaxial compression.

By shedding light on the intricate interactions between hybrid steel fibres and ultra-high performance concrete, this study fills a knowledge gap in the field. The results of this study could revolutionise structural design and construction methods by providing a fresh way to improve vital infrastructure's load-bearing capability and all-around durability. This study advances our knowledge of the behaviour of HSF-UHPC under uniaxial compression, which advances the field of materials science and its useful applications in the building sector.

II. Materials and Techniques

1. UHPC Mix Design: Taking into account elements such cementitious materials, fine and coarse aggregates, water-cement ratio, and superplasticizer content, a suitable mix design for ultra-high performance concrete was created.

   Steel fibres that have undergone hybridization include two different kinds of steel fibres that have different mechanical characteristics and geometries. By volume of the UHPC mixture, the fibres were added at prescribed percentages.

2. Prepare the specimens:Casting: Using the created UHPC mixture with different fibre combinations and contents, prismatic examples were cast.

3. Specimen Geometry: To guarantee uniformity in testing settings, the prismatic specimens' dimensions were kept to a standard.

4. Testing with Uniaxial Compression: Setup: For uniaxial compression testing, a universal testing equipment with sufficient capacity was used. In compliance with international testing standards, specimens were compressed loaded at a consistent and controlled rate. oad-Displacement A helpful insight into the behaviour of the specimens was offered by the load-displacement curves acquired from the compression testing.

5. Ultimate Compressive Strength: To calculate the ultimate compressive strength, the highest load that each specimen could withstand was noted.

   Measurements of Strain: Axial strains at various loading levels were determined by placing strain gauges on certain specimens in a strategic manner.

   Observations and Discussion

6. Stress-Strain Behaviour: In order to investigate the typical behaviour of the specimens under uniaxial compression, the stress-strain curves were examined.

   Ultimate Strength and Deformation: For various fibre combinations, the ultimate compressive strength and related stresses were calculated and compared.

   Analytical Statistics:

   7. Limitations:Scope and Applicability:

   The materials and procedures described here offer a methodical way to look at the behaviour of hybrid steel fiber-reinforced ultra-high performance concrete under uniaxial compression. on-depth understanding of the role of hybrid steel fibres on the mechanical properties and deformation characteristics of the material is the goal of the experimental setup, data gathering, and analysis processes.

III. Preparation of Samples and Methods of Mixing

The dry powders were combined for three minutes at maximum speed. Then, we added water and SP and stirred slowly for about 6 minutes. Steel fibres were added gradually and thoroughly blended for another six minutes. After inoculating specimens with mould, they were stored for around 24 hours in a chamber maintained at 20°C with a relative humidity of 95% or higher. After being demolded, they spent 7 and 28 days curing in water saturated with limestone at 20 degrees Celsius.

IV. Testing and model validation

Prismatic Testing of Uniaxial Behaviour Specimens used measured 100100400 mm. A 3,000-kilogram-force compression testing machine was used for the evaluation.

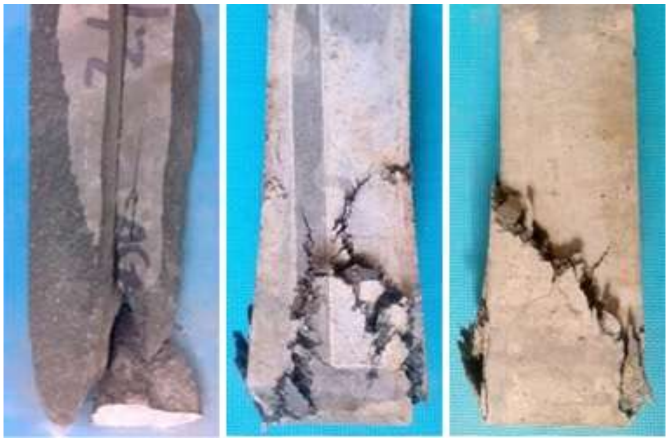

Fig 1: Effects of hybrid steel fiber on failure pattern of UHPC under compression

Two LVDTs with a gauge length of 300 mm were attached to the tested specimen in order to generate a stress-strain curve, as shown in Fig. 1. Simultaneously, the specimen's ability to move laterally was constrained. From the beginning of the test until the maximum load was reached, a steady load rate of 3 kN=s was applied.

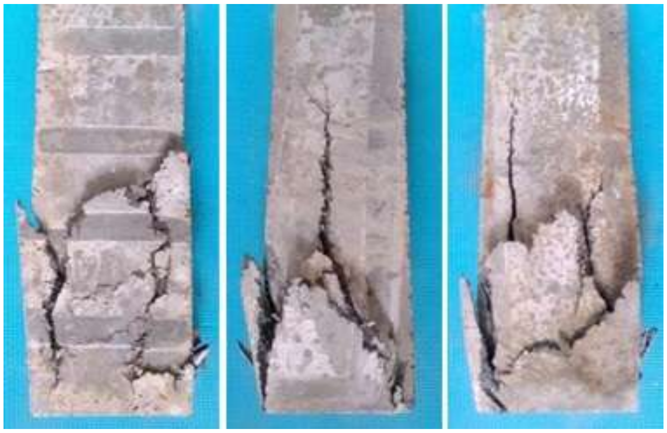

Fig 2: Effects of hybrid steel fiber on failure pattern of UHPC under uniaxial compression

The UHPC's postpeak behaviour was then captured by using a deformation rate of 0.5 mm=min. A data gathering system linked to the control system recorded the load and deformation [Fig. 1(b)]. Three sample means were provided.

V. Uniaxial compression failure in UHPCs and the role of hybrid steel fibre.

In Fig. 2, we see the failure pattern that occurs under uniaxial compression. The specimen split into two main pieces upon failure in the reference mixture devoid of steel fibre. Shearing failure occurred when more than 1% of long steel fibre was introduced.

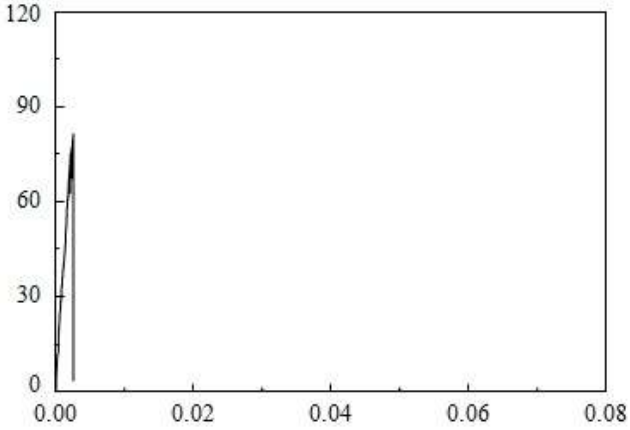

Fig 3: Strain Vs Stress

At an angle of 20° to 40° perpendicular to the vertical axis of the specimen, shear cracking was clearly visible. Once the UHPC matrix's ultimate compressive strength was reached under external force, cracking propagated across the whole section to create a succession of shear surfaces. There was still tensile stress between the steel fibre and matrix even though the UHPC specimen exhibited relative slippage along the shear surface.

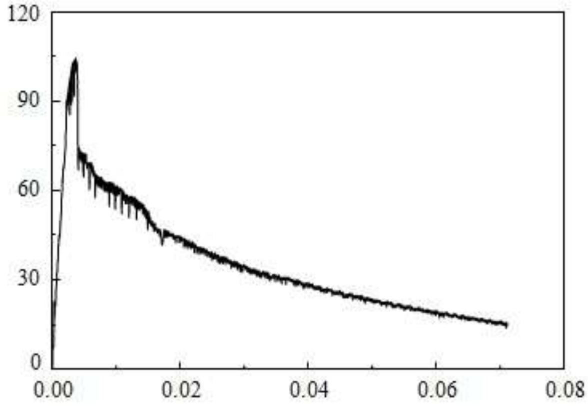

Fig 4: Strain Vs Stress

The steel fibres prevented instantaneous destruction by resisting slippage and absorbing shear force. The bearing capacity decreased as the load did so because more and more steel fibres were being pushed out.

V. Discussion

Modulus of Elasticity, Peak Stress, and Strain at Peak Stress as Affected by Hybrid Steel Fibre Figure 4 displays the changes in peak stress, strain at peak stress, and elastic modulus caused by the use of hybrid fibre.

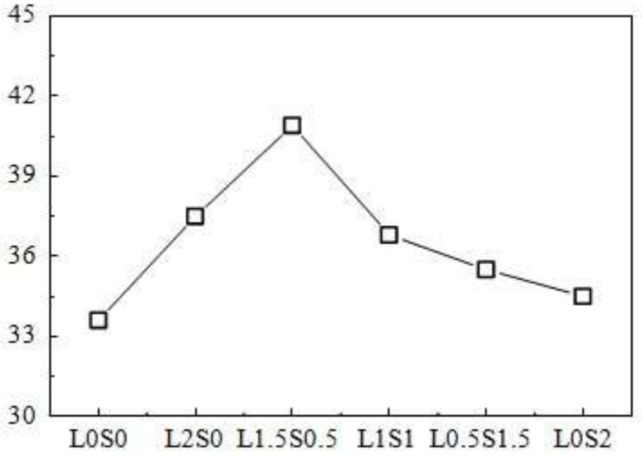

Fig 5 : Count Vs Elastic Modules

The elastic modulus, peak stress, and strain at peak stress of the fiber-free reference sample were 81.4 MPa, 0.0026, and 33.6 GPa, respectively. After 28 days, the standard compressive strength (100 100 400 mm prisms) of all six mixtures was greater than 100 MPa (Liu et al., 2011) when the sizes were converted using a coefficient of 1.24.With the addition of fibres, these numbers clearly rose. Peak stress, strain at peak stress, and elastic modulus were all maximised in the L1.5S0.5 mixture compared to the reference mixture without fibre by 34, , and 22%, respectively.

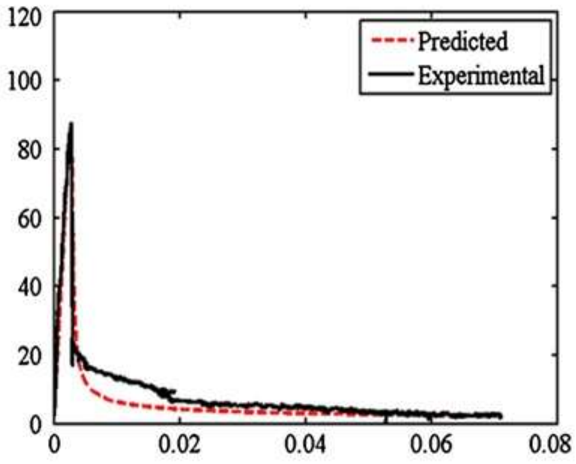

Fig 6: Stress Vs Strain

This was due to the fact that hybrid fibres, through their mutual effects, could limit the rotation of each other, allowing for orientation in the direction of flow or loading. However, hybrid fibres were able to have a multiplicative effect on compression behaviour at both the 6- and 13-mm length scales. But as the amount of short fibre consumed increased, the corresponding numbers declined.

Results for the L0S2 mixture were similar to those for the reference mixture. Compressive strength of ultra-high performance composites (UHPC) with total hybrid steel fibre of 2% was studied by Yu et al. (2014). Compressive strength was determined to be greatest for UHPC that consisted of 1.5% long fibre and 0.5% short fibre.

VI.Conclusion

Uniaxial compression properties were optimum for UHPC mixture with 1.5% long fibre and 0.5% short fibre. Compared to the reference combination without fibre, its peak stress, strain at peak stress, and elastic modulus rose by 34, 46, and 22%. The proportional limit of UHPC was 87–93% of peak load, and To predict the uniaxial compression qualities from measured quantities including the maximum stress, maximum strain, elastic modulus, and toughness index, an analytical model was presented. An analytical model was suggested to estimate uniaxial compression properties based on peak stress, strain at peak stress, elastic modulus, and toughness index.

REFERENCES

[1] Carreira, D. J., and Chu, K. H. (1985). “Stress-strain relationship for plain concrete in compression.” *Proc. Am. Concr. Inst.*, 83(6), 797–804.

[2] Ezeldin, A. S., and Balaguru, P. N. (1992). “Normal and high strength fiber reinforced concrete under compression.” *J. Mater. Civ. Eng.*, 10.1061/ (ASCE)0899-1561(1992)4:4(415), 415–429.

[3] Fanella, D. A., and Naaman, A. E. (1985). “Stress-strain properties of fiber reinforced mortar in compression.” *Proc. Am. Concr. Inst.*, 82(4), 475–483.

[4] Habel, K., Viviani, M., Denarié, E., and Brühwiler, E. (2006). “Develop- ment of the mechanical properties of an ultra-high performance fiber reinforced concrete (UHPFRC).” *Cem. Concr. Res.*, 36(7), 1362–1370.

[5] Harish, K. V., Dattatreya, J. K., and Neelamegam, M. (2013). “Experimen- tal investigation and analytical modeling of the σ-ε characteristics in compression of heat-treated ultra-high strength mortars produced from conventional materials.” *Constr. Build. Mater.*, 49, 781–796.

[6] .Hassan, A, Jones, S., and Mahmud, G. (2012). “Experimental test methods to determine the uniaxial tensile and compressive behaviour of ultra high performance fibre reinforced concrete (UHPFRC).” *Constr. Build. Mater.*, 37, 874–882.

[7] Liu, S., Li, L., and Feng, J. (2012). “Study on mechanical properties of reactive powder concrete.” *J. Civ. Eng.*, 1(1), 6–11.

[8] Liu, S., Yan, P., and Feng, J. (2011). “Size effect on strength of ultra-high strength concrete RPC.” *Highway*, 3, 123–127.

[9] Mansur, M. A., Chin, M. S., and Wee, T. H. (1999). “Stress-strain relation- ship of high-strength fiber concrete in compression.” *J. Mater. Civ. Eng.*, 10.1061/(ASCE)0899-1561(1999)11:1(21), 21–29.

[10] Markovic, I. (2006). “High-performance hybrid-fibre concrete: Develop- ment and utilisation.” Ph.D. thesis., Delft Univ. of Technology, Delft, Netherlands.