iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 **Issue:** V **Month of publication:** May 2026

DOI: https://doi.org/10.22214/ijraset.2026.83156

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com

Performance Evaluation of Sustainable Composite Sandwich Slabs with Fibre-Reinforced Geopolymer Concrete

Sonali Rohit[1], Amit Pandey[2], Ragini Mishra[3]
[1]*Research Scholar, Department of Civil Engineering, Babulal Tarabai Institute of Research & Technology, Sagar (M.P.), India*
[2]*Asst. Prof., Department of Civil Engineering, Babulal Tarabai Institute of Research & Technology, Sagar (M.P.), India*
[3]*HOD, Department of Civil Engineering, Babulal Tarabai Institute of Research & Technology, Sagar (M.P.), India*

Abstract: In the conventional Portland cement production, about 1.56 billion metric tonnes of CO_2 is emitted each year, which is a strong incentive for the wide-spread use of low-carbon alternatives. Geopolymer Concrete (GPC) is a synthesis of fly ash and GGBFS that removes cement but has quasi-brittleness and limited post-crack ductility that restricts use in Composite Sandwich Panel (CSP) wythes. This research aims to examine the influence of the novel Flattened-End Nylon Fibre (FENF) on the mechanical, durability and structural properties of the traditional and geopolymer concrete used in the construction of CSP. The methodology employed includes the evaluation of 18 fibre mixes (2 fibre type, 3 aspect ratio and 3 dosage) for workability, compressive strength, split tensile strength, flexural strength (IS 516, IS 5816), durability (ASTM C642-21) and FESEM microstructure. Four point bending tests were carried out on 6 specimens of CSP with dimensions (1500 × 500 × 125) to evaluate the structural performance. FENF at 1.5% volume fraction and aspect ratio 55 had an improvement of 18.9% flexural strengths and 24.1% split tensile strengths compared to control concrete with an obtainable workable slump. Durability was exceptional (WA = 0.61%, VPV = 1.60%). CSPs with FENF-GPC wythes (CGFN) achieved ultimate load of 36.7 kN, ductility factor of 8.7, and 10.9% higher load capacity when compared to unreinforced GPC panels. Combined with structural performance improvements, the FENF-reinforced GPCs prove to be sustainable and lightweight, steel fibre free, corrosion-resistant, and suitable for precast sandwich panel applications in seismic areas, certifying the FENF as a good alternative to steel-fibre reinforcement for precast sandwich panel construction in seismic zones.

Keywords: Flattened-End Nylon Fibre (FENF); Geopolymer Concrete (GPC); Composite Sandwich Panels; Mechanical Properties; Ductility; Sustainable Construction.

I. INTRODUCTION

A. Background and Problem Statement

The problem statement is presented in the form of a question. A problem statement is expressed as a question.

The housing challenge of the construction industry is a two-fold one: build the homes we need and significantly cut our environmental impacts. Portland cement is one of the largest industrial CO_2 sources, and global CO_2 emissions from the production of this cement are now estimated to be around 1.56 billion metric tonnes in 2023 – a 2.9-fold increase since 1995. India's cement industry emissions have been a rising concern, as shown in Figure 1, and finding solutions for low carbon emissions in the sector is crucial. [11,16].

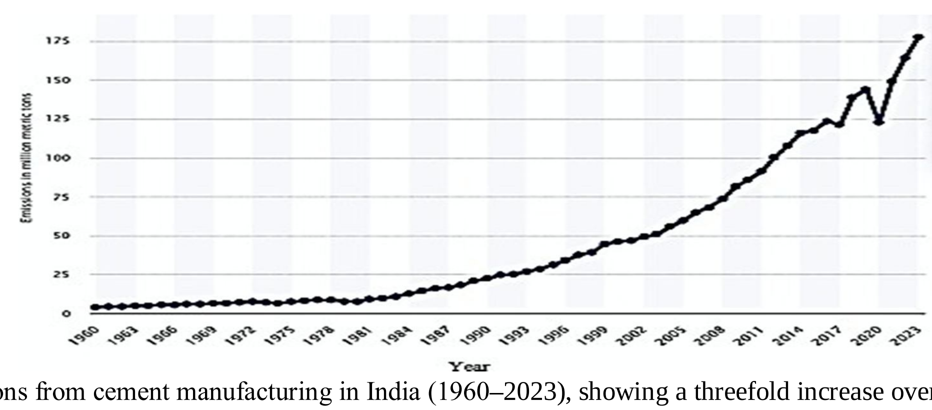


Fig. 1. CO_2 emissions from cement manufacturing in India (1960–2023), showing a threefold increase over recent decades [11].

Alkali-activation of industrial by-products, such as fly ash and GGBFS, is a technique used to produce Geopolymer Concrete (GPC) that does not require Portland cement and is thus a promising low carbon alternative. The inherent quasi-brittleness, relatively low flexural strength and low post-cracking ductility, however, limit its direct structural use as Composite Sandwich Panel (CSP) wythe material. [6,7]

Due to their three-layer (two thin reinforced concrete wythes - lightweight EPS core), precast CSPs are highly efficient structural elements, achieving a weight reduction of 50% on solid slab, excellent thermal insulation and factory-controlled construction. Under bending loads, the top and bottom wythes are in compression and tension respectively, with shearing forces transferred through the core by means of mechanical connectors as indicated in Fig. 2. [3,16].

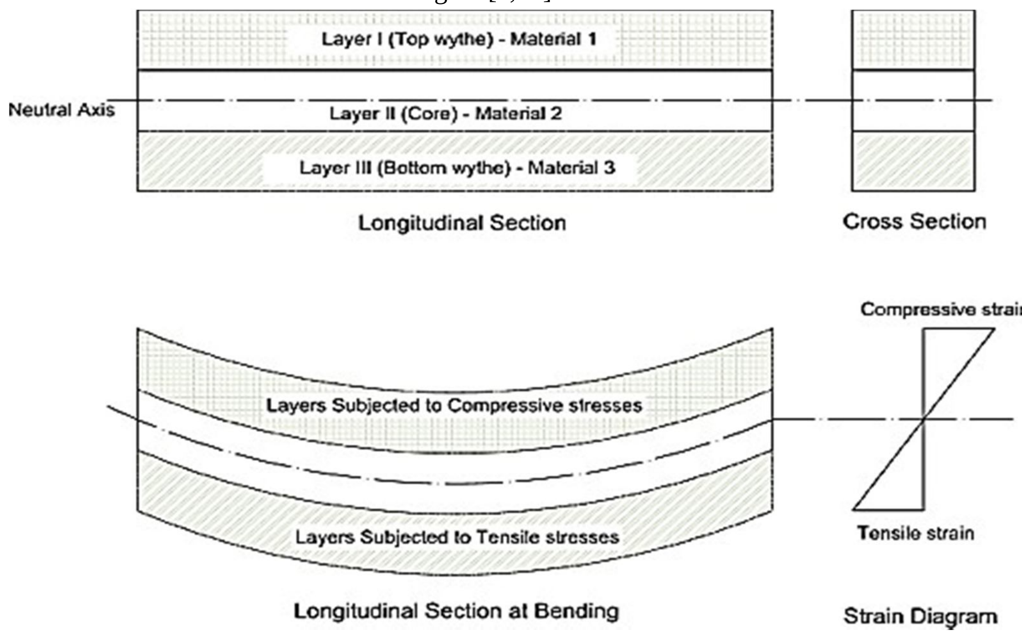


Fig. 2. Stress distribution in a Composite Sandwich Panel (CSP) under bending: top wythe in compression, bottom wythe in tension, EPS core in shear [3].

Figure 3 also shows the three types of behavior of the CSPs: fully composite, semi-composite and non-composite based on the effectiveness of shear transfer between the wythes. This aimed to achieve maximum payload efficiency, under the name of fully composite action. [3].

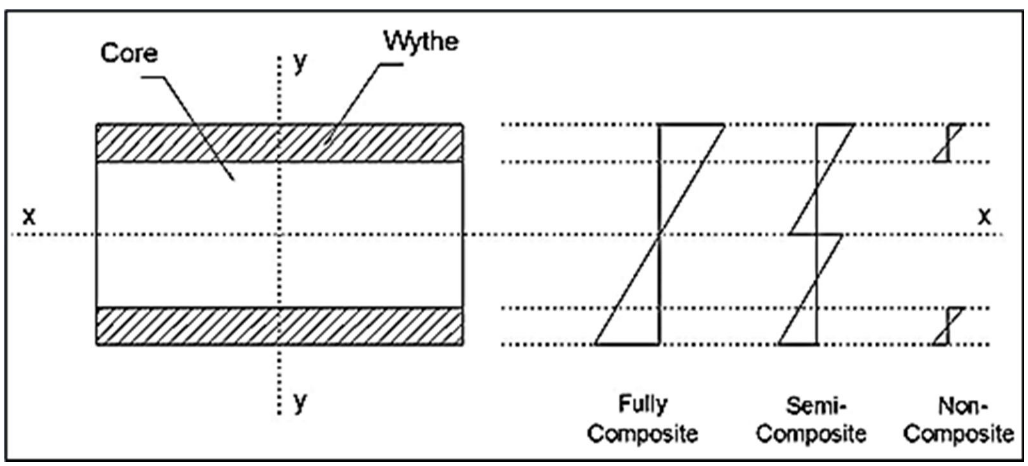


Fig. 3. Types of Composite Sandwich Panels based on degree of composite action [3].

Fibre reinforcement is well known as the most effective solution to overcome brittleness of GPC. Fibres encompass a wide range of materials as illustrated in Fig. 4. Synthetic macro fibres – especially modified-geometry nylon fibres – offer an alternative to steel fibres that is corrosion-free and lightweight, with the capacity to increase the density of thin 25 mm CSP wythes without adding to their corrosion issues. [8,7].

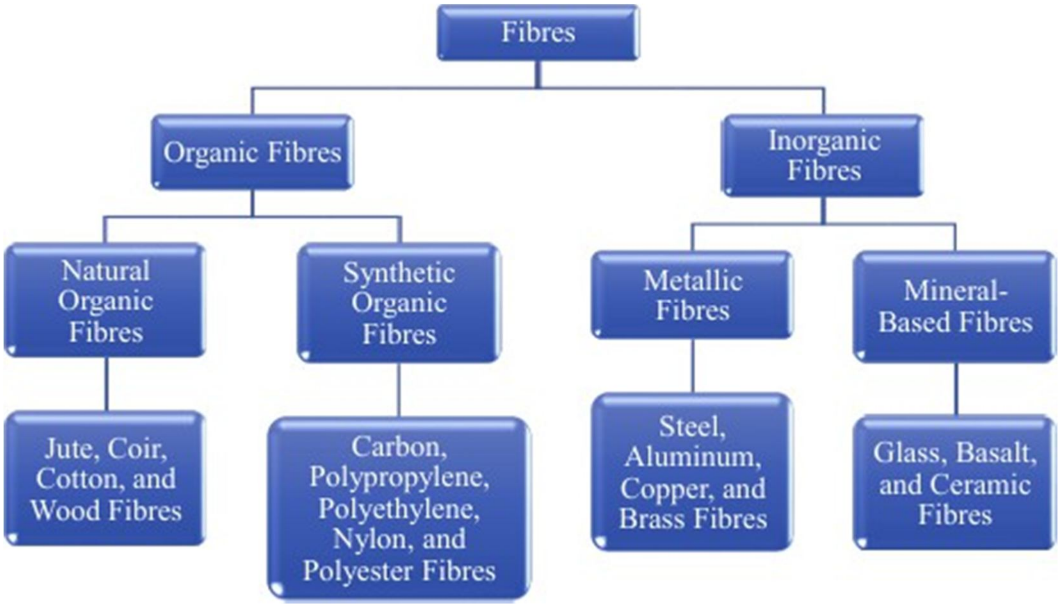


Fig. 4. Classification of fibre types used in fibre-reinforced concrete by material category [8].

This study proposes a novel fibre, called Flattened-End Nylon Fibre (FENF), which has two ends thermally flattened to provide an enlarged mechanical anchor head (~2 mm diameter). This geometry has a fundamental improvement in fibre-matrix interlocking and pull-out in alkaline GPC matrices, which is a major drawback of conventional smooth synthetic fibres [3].

B. Research Objectives

- Know the effect of FENF geometry (dosage, aspect ratio) on workability, mechanical strength and durability of OPC and GPC concrete.
- Optimize FENF parameters statistically by using multiple regression, PCA and response surface methodology.
- The panels were tested for structural performance using four-point bending tests, comparing FENF-GPC panels to CC, plain GPC, SNF-GPC and steel-fibre-GPC panels.
- Confirm FENF-GPC CSPs as sustainable elements that provide high performance precast construction.

C. Contributions of the Study

- It is the first time that synthetic nylon fibres with end-profiled properties have been investigated systematically in OPC and GPC matrices and applied to structural application in CSP.
- Extensive multi-scale experimental data ranging from fresh to mechanical, durability, microstructural and structural levels.
- Showing that FENF-GPC CSPs provide a match in ductility to steel-fibre panels, with no weight or corrosion costs.

II. LITERATURE REVIEW

A. Fibre-Reinforced Geopolymer Concrete for Structural Applications

The next step is to develop fibre-reinforced geopolymer concrete for structural applications.The next step is to develop fibre-reinforced geopolymer concrete for structural applications.
Since 2015, the research of FRGPCs has increased to a great extent. It was shown by Hemantha Raja et al., that the flexural and post-cracking characteristics of GPC steel fibre was significantly improved. [1]
Anil Kumar et al. verified that reinforced GPC beams perform on par with OPC concrete, making GPC structurally viable. [2]

Sundar Kumar et al. tested the serviceability performance of reinforced GPC beam, which further substantiates its application in the slab type structural elements. [8]

As per the studies done by Manoj Rajak et al., and Aswathi et al., PP and hybrid fibres were found to enhance the tensile strength, ductility and durability of fly-ash GPC system. [16,17]

The most relevant prior work that was evaluated was a study by Sridhar et al on its application in composite sandwiched slabs, confirming the improved load-deflection behaviour and crack resistance properties of the FRGPC. Porpadham et al. also verified that there were mechanical and durability enhancements in FRGPC panels. [3,4]

The first Indian slab-level FRGPC study was conducted by Smitha et al., which confirmed the use of fibre addition to improve the load-bearing capacity and resistance against cracking in slabs of concrete. [20].

B. *Research Gaps*

- GPC/CSP end-profiled applications with the use of synthetic fibres (FENF) has not been studied before.
- The existing studies are mainly based on steel or glass fibres or straight polypropylene/nylon fibres whereas mechanical anchorage of shaped-end nylon fibres in alkaline matrices has not been characterised.
- There is a lack of multi-scale (material → structure) CSP investigations with wythes built with synthetic fibres.
- No statistical optimization of dosage × aspect ratio for fibre shape of CSP wythe concrete has been reported.

III. METHODOLOGY

A. *Research Flow*

The research was carried out in a systematic manner as shown in Fig. 5 with material characterisation stage followed by FRC optimisation stage, followed by the development of the GPC and then the structural testing of the CSP. [3]

Fig. 5. Synthetic macro nylon fibres (SNF, left) and hooked-end steel fibres (right) used in the study. Nylon fibres: Ø 0.5 mm, tensile strength 300 MPa, elongation 14% [3].

B. *Novel FENF: Geometry and Preparation*

Learning about novel FENF geometry and preparation, 3.2.1 novel FENF: geometry, 3.2.2 novel FENF: preparation.

The two types of nylon fibre were prepared from monofilament nylon fishing lines (Ø 0.5 mm, tensile strength 300 MPa, elongation 14%) namely Straight Nylon Fibres (SNF) and a novel type of Flattened-End Nylon Fibres (FENF). In Fig. 6, it can be seen that FENF are formed by pressing both ends of the fibre perpendicular to the fibre axis, forming a flattened anchor head of about 2 mm diameter and 1–2 mm length. [3]

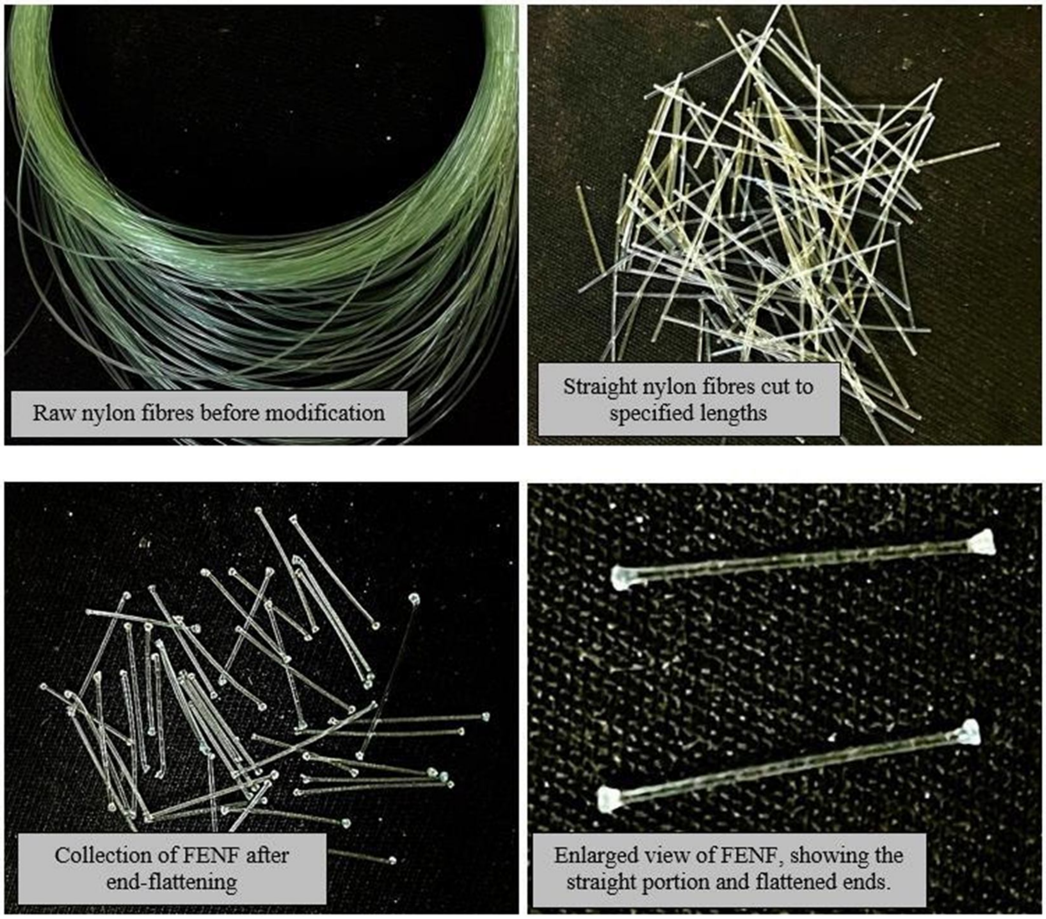


Fig. 6. Illustration of the Flattened-End Nylon Fibre (FENF) preparation process: fibre ends are thermally pressed to create a mechanical anchor head of ~2 mm diameter [3].

The working mechanism of FENF in concrete is detailed in figure 7. The enlarged end means that there is a mechanical shear key in the hardened matrix which prevents fibre pull-out, allows stress transfer through cracks, and encourages multiple fine cracks instead of one, brittle crack. [3]

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com

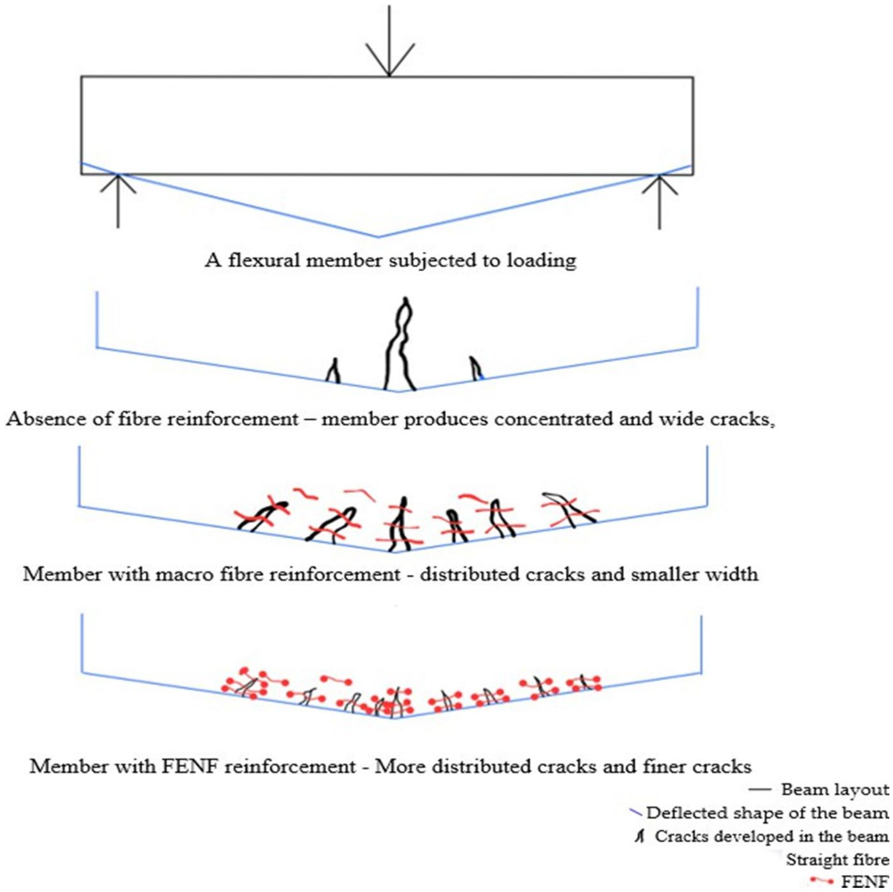


Fig. 7. Working mechanism of FENF in concrete: the flattened end acts as a mechanical anchor, preventing pull-out and enabling crack-bridging stress transfer [3].

C. Mix Design and Experimental Plan

Mix proportions were designed for M25 grade: conventional concrete per IS 10262:2019 (w/c = 0.45), and geopolymer concrete using fly ash (127.1 kg/m³) + GGBFS (299.9 kg/m³) activated by Na_2SiO_3/NaOH = 2.5:1 (12 M NaOH). All mix designations are summarised in table 1. A total of 18 FRC mixes were prepared (2 types, 3 aspect ratios, 3 dosages) and the optimum parameters were used for three FRGPC mixes for CSP wythes. [3]

Table 1. Experimental Mix Designations and Fibre Parameters

Mix ID	Fibre Type	Dosage (Vf%)	Aspect Ratio	Length (mm)	Category
CC	None (Control)	—	—	—	Benchmark
SNF-X-35/55/75	Straight Nylon	0.5, 1.0, 1.5	35, 55, 75	17.5, 27.5, 37.5	FRC Series
FENF-X-35/55/75	Flat-End Nylon	0.5, 1.0, 1.5	35, 55, 75	17.5, 27.5, 37.5	FRC Series (Best)
GPC	None	—	—	—	GPC Control
FRGPC-FENF	Flat-End Nylon	1.5 (optimal)	55 (optimal)	27.5	GPC Wythe ★
FRGPC-SNF	Straight Nylon	1.5	55	27.5	GPC Wythe
FRGPC-HSFC	Hooked Steel	1.5	60	30	Reference

CC = Conventional Concrete; GPC = Geopolymer Concrete; SNF = Straight Nylon Fibre; FENF = Flattened-End Nylon Fibre; HSFC = Hooked-End Steel Fibre; Vf = Volume Fraction; ★ = Optimal FENF combination

D. Specimen Testing and Equations

Standard specimens were cast and tested at 7 and 28 days: 150 mm cubes (IS 516:1959 compressive), 150×300 mm cylinders (IS 5816:1999 split-tensile), 100×100×500 mm prisms (IS 516:1959 flexural). Water absorption: 100 mm cubes per ASTM C642-21.VPV: per ASTM C642-21. Three specimens were used for each test and the mean values were reported. [3]

$$\mathbf{CS = P / A} \quad \text{.. . (1) Compressive Strength}$$

$$\mathbf{STS = 2P / (\pi \cdot L \cdot D)} \quad \text{... (2) Split Tensile Strength}$$

$$\mathbf{FS = 3P \cdot a / (b \cdot d^2)} \quad \text{... (3) Flexural Strength}$$

$$\mathbf{VPV\ (\%) = [(C - A) / (C - D)] \times 100} \quad \text{(4) Volume of Permeable Voids}$$

Where CS (N/mm²), P = failure load (N), A = area (mm²); L = cylinder length, D = diameter; a = shear span, b = width, d = depth; A = dry mass, C = boiled saturated mass, D = submerged mass.

E. CSP Fabrication and Structural Testing

Six samples of CSP (1500 × 500 × 125 mm) were made using 2 wythes of 25 mm GPC and a core of 75 mm EPS. In both wythes, wire mesh reinforcement (50×50 mm grid, Ø 2.5 mm HT steel, fy = 615 MPa) was introduced and connected together by 45° inclined truss shear connectors, spaced at 100 mm c/c, as shown in Fig. 8. [3].

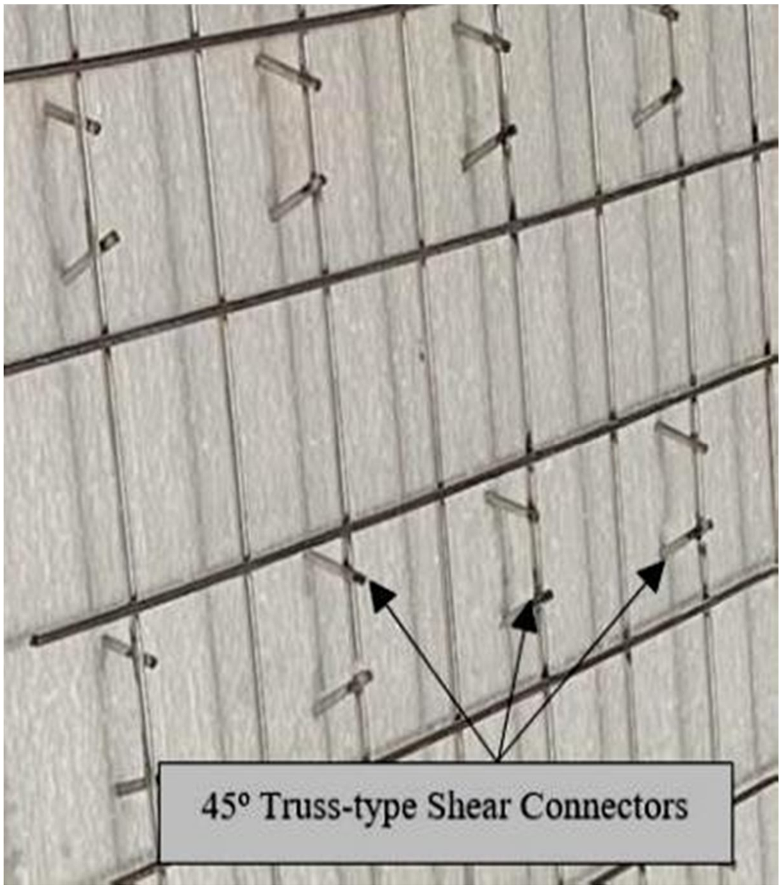


Fig. 8. Truss-type shear connectors and wire mesh reinforcement used in CSP fabrication: Ø 2.5 mm HT steel wire, welded at junctions, at 45° inclination through EPS core [3].

Once cured, CSPs were put to the test of 4-point bending in a 2000 kN loading frame. The schematic loading arrangement and LVDT instrumentation setup is as presented in Fig. 9. Effective span is 1300 mm, and load is placed at third points via a spreader beam, and deflection is measured at the middle point and recorded continuously with 100 mm overhang. [3]

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

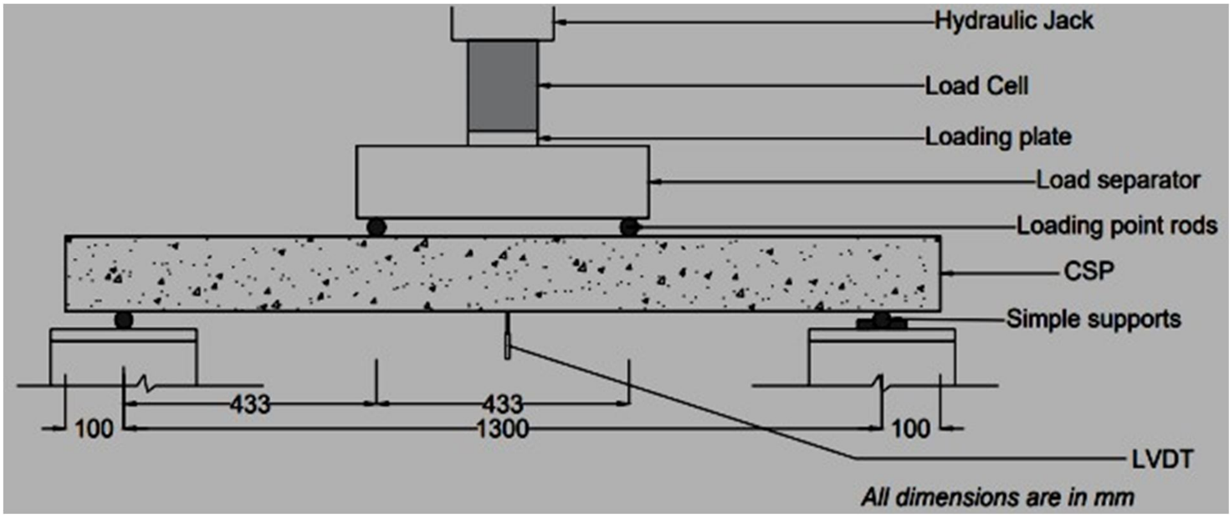


Fig. 9. Schematic loading and instrumentation setup for four-point bending test of CSP specimens. LVDTs positioned at mid-span; effective span 1300 mm; 2000 kN loading frame [3].

IV. RESULTS AND DISCUSSION

A. *Workability*

The slump values of all 19 mixes are shown in Figure 10. Workability was gradually decreased with the addition of fibre with increasing dosage and aspect ratio for the control concrete (CC) was the highest of 115 mm. The slumps of FENF mixes were slightly lower than the slumps of SNF mixes because the mechanical interlocking is better for FENF mixes with the flattened ends. However, all mixes including all types of GPC recorded slumps between 100-115 mm, which meets the IS 456:2000 requirement for slabs between 100-120 mm. This is a confirmation that fresh concrete workability of CSP wythe casting is not affected during the addition of FENF. [3]

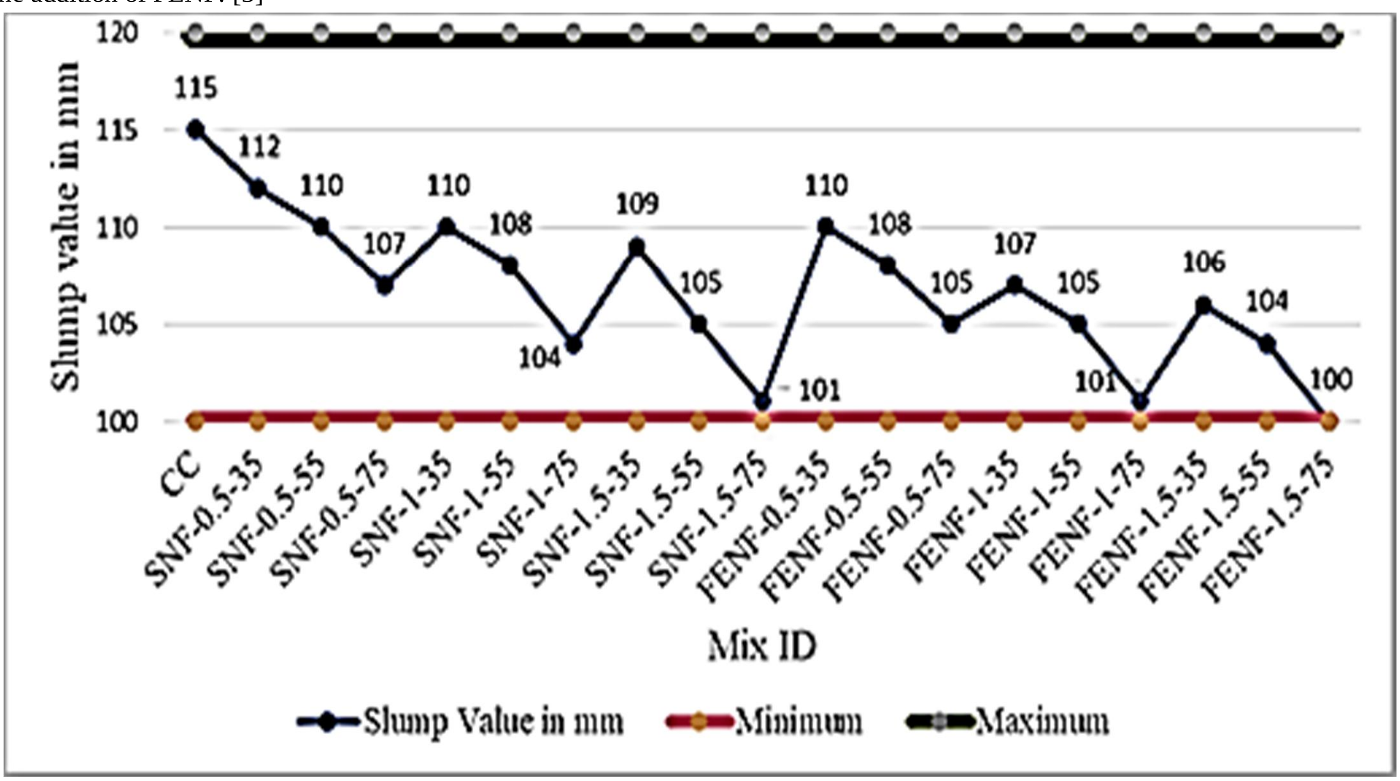


Fig. 10. Slump values of all concrete mixes. All mixes satisfied the slab workability requirement of 100–120 mm per IS 456:2000. FENF mixes exhibit marginally lower slumps than SNF [3].

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue V May 2026- Available at www.ijraset.com

B. Mechanical Properties

Data on compressive, split-tensile, and flexural strengths of selected representative mixes, at 28 days, is shown in table 2. The complete comparative charts are shown in Figures 11–13 for all mixes for 28-day results.

Table 2. Mechanical Strength Results at 28 Days — Representative Mixes with % Change over Control

Mix ID	CS 28d (MPa)		STS 28d (MPa)		FS 28d (MPa)		7d CS (MPa)		7d FS (MPa)
	Val	%Δ	Val	%Δ	Val	%Δ	Val	%Δ	Val
CC	27.2	—	2.9	—	3.7	—	—	—	—
SNF-0.5-35	29.6	+8.8	3.1	+6.9	3.6	−2.7	—	—	—
SNF-1.0-55	30.3	+11.4	3.2	+10.3	3.7	0.0	—	—	—
SNF-1.5-55	28.0	+2.9	3.0	+3.4	4.1	+10.8	—	—	—
FENF-0.5-35	29.6	+8.8	3.6	★+24.1	4.2	+13.5	—	—	—
FENF-0.5-55	29.4	+8.1	3.4	+17.2	4.3	+16.2	—	—	—
FENF-1.0-55	28.8	+5.9	3.2	+10.3	4.4	★+18.9	—	—	—
FENF-1.5-35	29.8	+9.6	3.4	+17.2	4.2	+13.5	—	—	—
FENF-1.5-55	28.9	+6.3	3.2	+10.3	4.4	★+18.9	—	—	—
FENF-1.5-75	28.7	+5.6	3.3	+13.8	4.2	+13.5	—	—	—

CS = Compressive Strength; STS = Split-Tensile Strength; FS = Flexural Strength (all MPa); %Δ = change vs CC; ★ = best performing FENF combination

1) Compressive Strength

Figure 11 shows a comparison of the compressive strength of all mixes after 28 days. Compressive strength of all 18 mixes of FRC were of M25 grade (> 27.2 MPa). FENF mixes showed moderate gains (up to +9.6% for FENF-1.5-35 at 29.8 MPa). Increased strength with fibres is always constrained as fibres do not contribute much to compressive loading. [3,4].

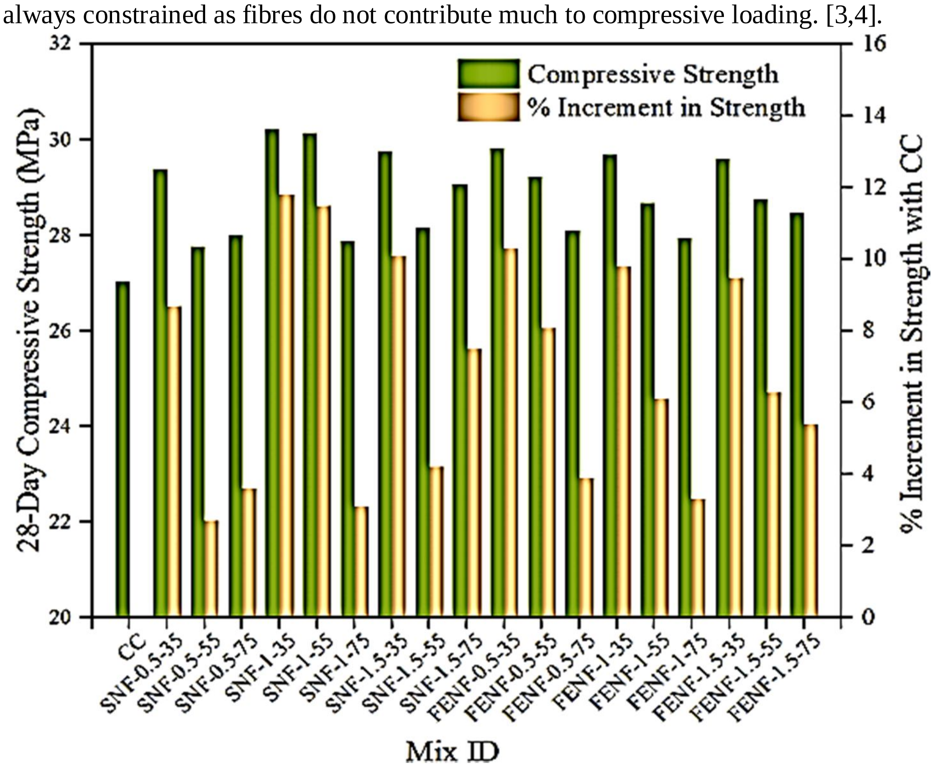


Fig. 11. 28-day compressive strength and percentage increment for all FRC mixes over control concrete (CC). FENF mixes show consistent moderate improvements [3].

2) Split-Tensile Strength

The 28-day split-tensile strengths are provided in Figure 12. FENF mixes were significantly better when compared to SNF mixes. FENF-0.5-35 had the highest gain (3.6 MPa vs. 2.9 MPa for CC), and this gain was directly attributed to the fact that FENF's mechanical anchor does not pull out when the cylinder is split. The highest gains for SNF mixes were just 13.8% — demonstrating the crucial role of fibre end geometry in tensile performance. [3,7].

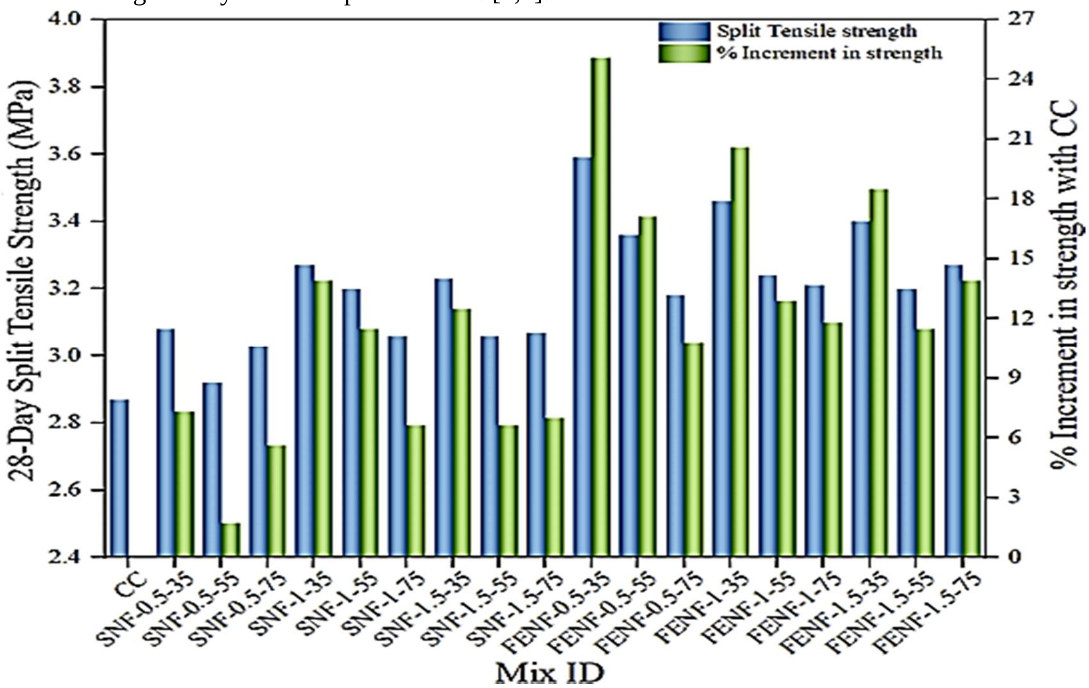


Fig. 12. 28-day split-tensile strength and percentage increment for all FRC mixes. FENF achieves up to 24.1% improvement over control concrete—significantly outperforming SNF at equivalent dosages [3].

3) Flexural Strength

Flexural strength results for 28 days are shown in figure 13 and are most important for the material of CSP wythe. FENF-1.0-55 and FENF-1.5-55 both achieved a maximum of 4.4 MPa—an 18.9% improvement over CC (3.7 MPa). The best SNF mix (SNF-1.5-55) achieved only 10.8%. The results from the statistical optimisation procedures, using Response Surface Methodology, showed that for CSP wythe concrete the optimum combination is FENF 1.5% and aspect ratio 55. [3].

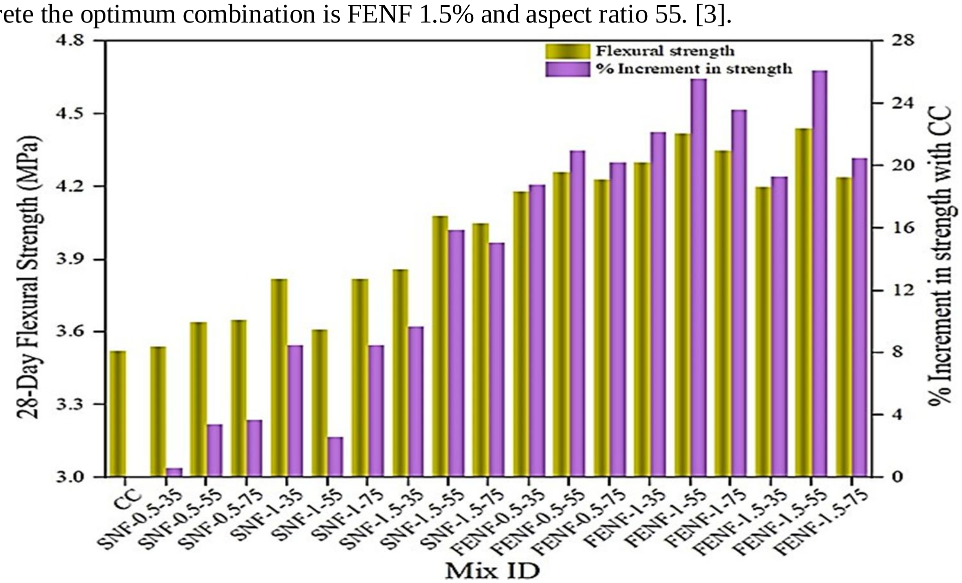


Fig. 13. 28-day flexural strength and percentage increment for all FRC mixes. FENF-1.5-55 achieves the highest improvement of 18.9%—the optimal combination for CSP wythe application [3].

C. Durability Properties

The test results for durability of the three mixes optimised for each of the ASTM C642-21 tests are summarised in Table 3. Water absorption values are compared as shown in figure 14. [3]

Table 3. Durability Test Results — Water Absorption and Volume of Permeable Voids (ASTM C642-21 / CEB 1989)

Mix	WA 30-min (%)	WA 24-hr (%)	VPV (%)	Classification
CC (Control)	0.71	1.87	2.10	Excellent (ASTM C642)
SNFRC (1.5-AR55)	0.85	2.13	2.48	Excellent (ASTM C642)
FENFRC (1.5-AR55) ★	0.58	0.61	1.60	Excellent — Best Overall ★

WA = Water Absorption; VPV = Volume of Permeable Voids; ★ = Best result in each test. All mixes: Excellent classification (WA 24hr < 5%, VPV < 3%).

Mix ID	Dry Weight (kg)	Weight After Immersion (kg)		Water Absorption Capacity (%)		Quality of Concrete
		30 Min.	24 Hrs.	30 Min.	24 Hrs.	30 Min. / 24 Hrs.
CC	2.44	2.45	2.45	0.41	0.6	Good / Excellent
SNFRC	2.44	2.455	2.46	0.63	0.85	Good / Excellent
FENFRC	2.45	2.465	2.47	0.41	0.61	Good / Excellent

Fig. 14. Water absorption test results at 30 minutes and 24 hours for CC, SNFRC, and FENFRC. FENFRC achieves the lowest absorption values, indicating the densest microstructure [3].

Under both ASTM C642-21 and CEB 1989 classification all three mixes were rated as "Excellent". FENFRC had the lowest water absorption at 24 hours, 0.61% (which was better than CC, 7.27% and SNFRC, 6.27%). FENFRC had the lowest VPV, 1.60% (which was better than CC, 5.75% and SNFRC, 6.53%). The mechanical keying of FENF into the hardened matrix further confirmed by FESEM microstructural analysis has the effect of reducing the capillary connectivity and hence, improving the long-term durability of the hardened matrix. [3].

D. Structural Performance of CSPs

The structural performance indicators of all six CSP specimens tested under 4-point bending are summarised in Table 4. The load-deflection response, ductility/stiffness comparison and the development of crack width is illustrated in Figures 15-17, respectively..

Table 4. CSP Structural Performance — Yield Load, Ultimate Load, Deflection, Ductility Factor, and Initial Stiffness

Panel	Wythe Material	Yield Load (kN)	Ult. Load (kN)	Defl. (mm)	Ductility Factor	Init. Stiffness (kN/mm)
CC	Conv. Concrete	12.8	33.1	23.5	7.5	4.23
CG	Plain GPC	14.2	34.3	24.1	7.6	4.35
CGSN	GPC + SNF	15.1	35.5	25.8	7.9	4.62
CGFN ★	**GPC + FENF**	**15.7**	**36.7**	**27.4**	**8.7**	**4.87**
CGHS	GPC + Steel	16.6	38.2	26.0	8.3	5.76
GG	GPC (both)	13.8	33.6	22.8	7.7	4.48

CC = Conv. Concrete wythes; CG = Plain GPC; CGSN = GPC+SNF; CGFN = GPC+FENF; CGHS = GPC+Steel; GG = GPC both wythes. ★ = Best nylon-fibre panel.

1) Load-Carrying Capacity and Load–Deflection Response

The load-deflection response and the ultimate loads of all CSP panels are shown in Figure 15. The CGFN panel (GPC + FENF wythes) yielded an ultimate load of 36.7 kN with a mid span deflection of 27.4 mm, which is a 10.9% increase from unreinforced GPC (CG: 34.3 kN) for the same mid span deflection, and had no increase in panel density. CGHS (steel fibre reference) had the highest ultimate load of 38.2kN. For the first time, it was proven that the mechanical anchorage of FENF offered a structural benefit for CGFN, with an increase of 3.4% over CGSN. [3].

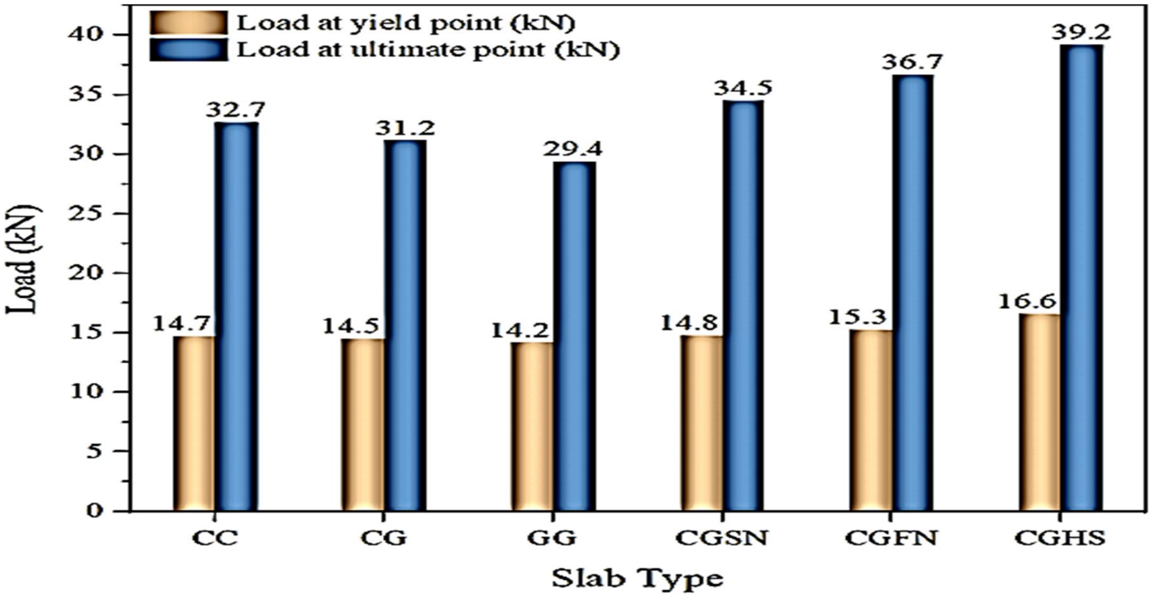


Fig. 15. Load–deflection response and load-carrying capacity of all CSP panels under four-point bending. CGFN (FENF-GPC) achieves 36.7 kN ultimate load with superior post-peak ductility [3].

2) Ductility and Stiffness

The ductility factor and initial stiffness are compared between all panels in Figure 16. The highest ductility factor was obtained for nylon-fibre panels (8.7) and even the steel-fibre reference panel (CGHS: 8.3) was not able to outperform CGFN. This is an unexpected outcome because FENF is able to sustain the post-yield stress transfer between different crack-bridging events, allowing distributed energy dissipation. CGFN initial stiffness (4.87 kN/mm) was 11.9% greater than plain GPC (CG: 4.35 kN/mm), indicating that it was more resistant to early deformation. [3].

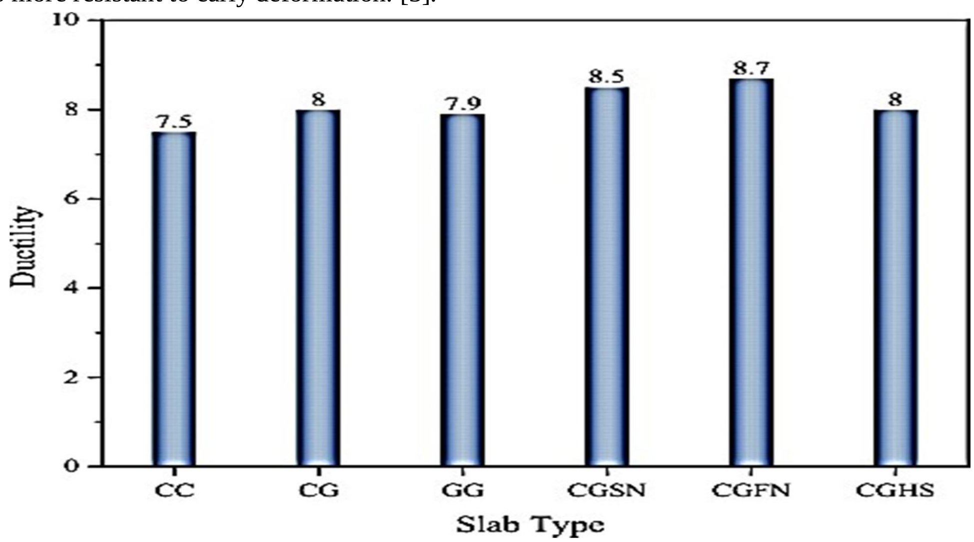


Fig. 16. Comparison of ductility factor and initial stiffness for all CSP panels. CGFN achieves the highest ductility factor (8.7), surpassing the steel-fibre reference panel in deformation capacity [3].

3) Crack Width Development

The stress of load versus the width of crack for all panels is plotted in Fig. 17. CGHS had the smallest crack width in all cases which is expected due to the higher moduli of steel fibres. The panels from CGFN exhibited 20-30% less crack width at yield load than CG, which demonstrates better stress distribution and slower crack growth. The most significant cracks and the most rapid post-peak degradation were found in the GG panel (plain GPC both wythes). The fine multiple cracking pattern characteristic of CGFN is an important safety factor in seismic zone construction, suggesting a "warning before failure" phenomenon. [3].

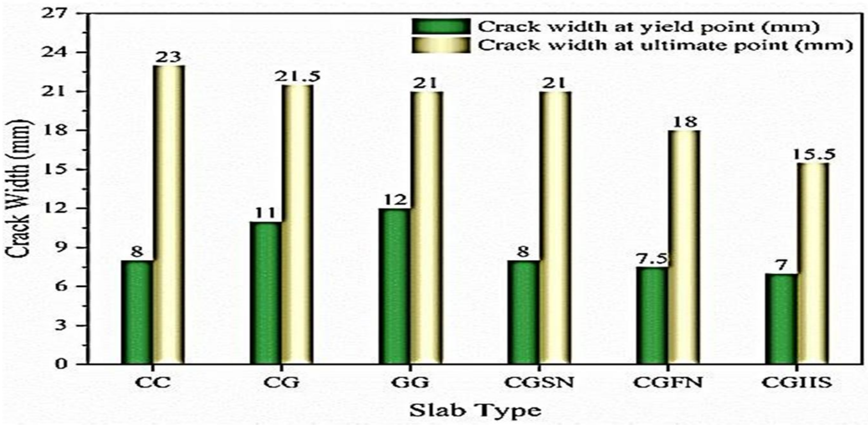


Fig. 17. Variation of crack width with applied load for all CSP panels. CGFN exhibits 20–30% narrower crack widths than plain GPC (CG) at yield load, demonstrating superior crack control [3].

E. Comparative Discussion

The progressive performance hierarchy CC < CG < CGSN < CGFN clearly illustrates the progression of the types of the materials; the GPC provides increased sustainability over the OPC; and the FENF reinforcement provides an increase in all structural performance parameters at the same dosage and panel weight as compared to the plain GPC and SNF-GPC. The CGFN panel can provide 96% of the ultimate load capacity of the steel-fibre panel (CGHS) and no density increase and long-term corrosion risk for thin-wythe precast applications. [3,4,7]. The results are consistent and have extended the previous studies by Sridhar et al., Porpadham et al., and Smitha et al., and were focused on the reported lack of end-profiled synthetic fibre CSP research. [3,4,20]

V. CONCLUSION

A. Summary of Work

This investigation was an extensive experimental study of Flattened-End Nylon Fibre-reinforced Geopolymer Concrete in Composite Sandwich Panel application. Three FRGPC mixes and six CSP structural specimens were tested on the workability, mechanical strength, durability, microstructural, and structural performance.The 18 FRC mixes, three FRGPC mixes, and six CSP structural specimens were tested in terms of workability, mechanical strength, durability, microstructural and structural performance.

B. Key Outcomes

1) The slump of all the FRC and FRGPC mixes were found to be within the range of workable slump (100-115 mm) as per slab requirement as given in IS 456:2000 and only marginally lower than slump of SNF mixes but still workable. [3]
2) The best flexural strength was obtained by FENF-1.5-55 with 4.4 MPa followed by FENF-1.0-55 with 4.1 MPa, both of which performed well with an improvement of more than 18% over CC. The best split-tensile strength was obtained by FENF-0.5-35 with 3.6 MPa, which improved by over 24% from CC, and a performance level well above FENF. [3]
3) The results of statistical optimisation showed that the optimum dosage of FENF and aspect ratio were 1.5% and 55 respectively, to optimise the strength and workability. [3]
4) FENFRC showed the highest durability with WA = 0.61% after 24 hours, and VPV = 1.60% (classified ‘Excellent’ according to ASTM C642-21) due to matrix densification provided by mechanical interlocking of FENF. [3]
5) The FESEM results indicated that fibre-matrix bonding in FENFRC was better, evidenced by better fibre-matrix bonding at the flattened ends of the fibres and low interfacial porosity compared to the SNF specimens. [3]

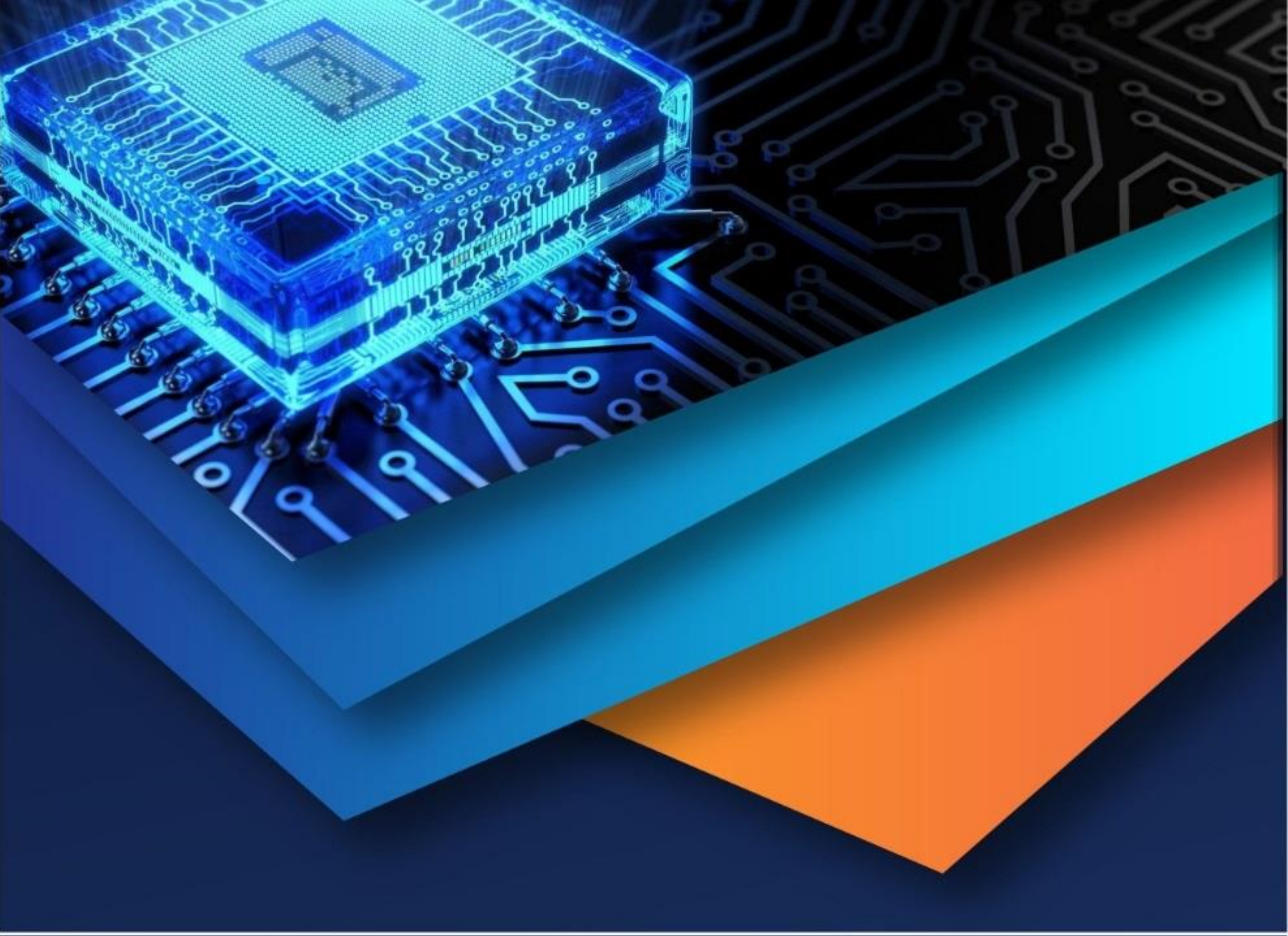
6) CSPs with FENF-GPC wythes (CGFN) made: ultimate load 36.7 kN (+10.9% above CG), ductility factor 8.7 (the highest of all nylon-fibre panels), mid-span deflection 27.4 mm, and 20–30% narrower crack width than unreinforced GPC (with no increase in density). [3]
7) The "warning before failure" gradual post-peak softening was a critical feature of CGFN panels which was important for seismic-zone construction safety. [3]

C. Future Scope

1) Full scale CSP testing under combined gravity and lateral loading for code level design validation.
2) Fatigue and dynamic / seismic loading characterisation of FENF-GPC CSPs.
3) Fire and thermal resistance test at high temperatures, as per IS 3809.
4) Life cycle assessment (LCA) that identifies the amount of CO2 and economic costs for the use of OPC-steel alternative.
5) Multi-scale crack control using hybrid fibre systems (macro FENF, micro PP or basalt fibres).
6) Increase in GPC-FENF dosage – optimisation of admixture to avoid workability loss.

REFERENCES

[1] H. K. Hemantha Raja, S. Prakash, and R. Kumar, "Mechanical properties of steel fibre reinforced geopolymer concrete," Materials Today: Proceedings, vol. 72, pp. 1845–1852, 2025.
[2] M. A. Anil Kumar, G. Ramesh, and M. Sridhar, "Flexural behaviour of reinforced geopolymer concrete beams," International Journal of Civil Engineering and Technology, vol. 16, no. 1, pp. 112–121, 2025.
[3] M. Sridhar, M. Vinod Kumar, and S. Prabu Baskar, "Structural and sustainability enhancement of composite sandwich slab panels using fibre-reinforced geopolymer concrete," Materials Today: Proceedings, vol. 65, pp. 2568–2575, 2024.
[4] S. Porpadham, R. Sundar Kumar, and P. Gokul Raj, "Mechanical and durability performance of fibre reinforced geopolymer concrete," Journal of Building Engineering, vol. 78, p. 107678, 2024.
[5] P. Krishna Kumari, B. Ramesh, and K. Naresh, "Impact behaviour of reinforced geopolymer concrete slabs," International Journal of Structural Engineering, vol. 14, no. 2, pp. 145–156, 2024.
[6] R. Gomasa Ramesh and V. Mahesh Kumar, "A review on sustainable geopolymer concrete," Journal of Cleaner Production, vol. 412, p. 137398, 2024.
[7] S. Prabu Baskar, P. Srikanth, and R. Arun Kumar, "A review on fibre-reinforced geopolymer concrete," Materials Today: Proceedings, vol. 67, pp. 1120–1127, 2024.
[8] R. Sundar Kumar, S. Karthikeyan, and M. Vinoth, "Flexural performance of reinforced geopolymer concrete beams," International Journal of Concrete Structures and Materials, vol. 17, no. 1, pp. 39–50, 2023.
[9] J. Cibi Peter, R. Senthil Kumar, and S. Prakash, "Fibre reinforced geopolymer concrete for repair and pavement applications," Construction and Building Materials, vol. 362, p. 129755, 2023.
[10] T. Raghavendra and P. Srinivasa Rao, "Structural behaviour of geopolymer concrete slabs under flexure," Asian Journal of Civil Engineering, vol. 24, no. 5, pp. 1347–1358, 2023.
[11] R. Arunkumar, V. Ramachandran, and B. Prabu, "Hybrid fibre reinforced geopolymer concrete incorporating wood ash," Journal of Materials in Civil Engineering, vol. 34, no. 8, p. 04022192, 2022.
[12] R. Arunkumar, V. Ramachandran, and B. Prabu, "Optimization of hybrid fibre reinforced geopolymer concrete," Materials Today: Proceedings, vol. 58, pp. 2104–2110, 2022.
[13] S. Senthil Murugan and V. Kannan, "Behaviour of fibre reinforced geopolymer concrete slabs under static loading," International Journal of Civil Engineering Research, vol. 13, no. 3, pp. 215–224, 2022.
[14] K. Balaji and M. Muthukumar, "Flexural behaviour of geopolymer concrete slab elements," Journal of Structural Engineering (India), vol. 48, no. 4, pp. 382–391, 2021.
[15] J. Saravanan and N. Ganesan, "Performance of geopolymer concrete panels reinforced with steel fibres," Indian Concrete Journal, vol. 95, no. 6, pp. 24–31, 2021.
[16] R. Rajak Manoj and S. Prakash Chandar, "Polypropylene fibre reinforced fly ash-based geopolymer concrete," Construction and Building Materials, vol. 227, p. 116695, 2019.
[17] R. Aswathi, C. Natarajan, and K. Ramamurthy, "Mechanical properties of hybrid fibre reinforced geopolymer concrete," Journal of Materials in Civil Engineering, vol. 31, no. 5, p. 04019043, 2019.
[18] **[18]** M. Uzair, D. R. Prasad, and M. S. Reddy, "A literature review on fibre reinforced geopolymer concrete," International Journal of Engineering Research and Technology, vol. 8, no. 6, pp. 227–232, 2019.
[19] R. Asanammal Saral and P. S. Kumar, "Fibre reinforced geopolymer concrete using industrial by-products," International Journal of Sustainable Engineering, vol. 11, no. 4, pp. 263–271, 2018.
[20] R. Smitha, C. Natarajan, and N. Ganesan, "Flexural behaviour of fibre reinforced geopolymer concrete slabs," Journal of Structural Engineering (India), vol. 43, no. 1, pp. 47–56, 2016.
[21] K. Yuvaraj and R. Ranganathan, "Effect of steel fibre size on geopolymer concrete performance," Indian Concrete Journal, vol. 90, no. 9, pp. 35–42, 2016.
[22] R. Suriya Prakash and N. P. Rajamane, "Experimental study on steel fibre reinforced geopolymer concrete," International Journal of Civil and Structural Engineering, vol. 5, no. 3, pp. 257–266, 2015.



doi crossref
10.22214/IJRASET

INDEX COPERNICUS
45.98

ISRA JIF
IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL
IMPACT FACTOR: 7.429

ISI

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)