

Is Basalt Fibre Reinforced Polymer (BFRP) a viable replacement for steel in reinforced concrete applications?

An Experimental evaluation of the mechanical behaviour of BFRP and steel reinforced concrete beams using three-point bending tests

Introduction & Statement

Background

Corrosion of steel reinforcement due to ingress and carbonation is a major cause of deterioration of reinforced concrete structures

Why BFRP?

BFRP offers high tensile strength, corrosion resistance, low density and reduced maintenance requirements, making it a promising alternative to steel



Research Question

Can BFRP provide a viable alternative to conventional steel reinforcement in concrete applications?



Aim & objectives

Aim: To evaluate and compare the mechanical performance of BFRP and steel reinforcement in concrete beams through experimental laboratory testing

Objectives



Compare flexural behaviour of steel and BFRP reinforced beams



Investigate cracking behaviour and failure mechanisms



Assess ultimate load capacity of each reinforcement material



Evaluate implications for durability and structural design



Determine whether BFRP is a viable reinforcement alternative to steel

Methodology

Specimens

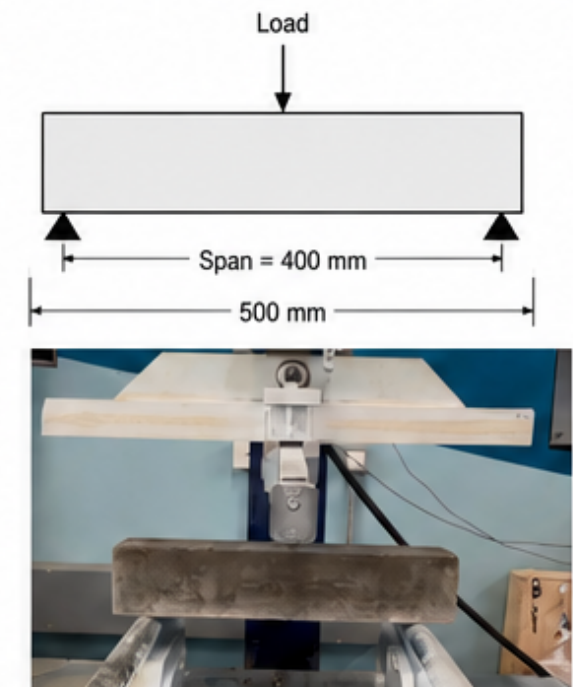
- 18 Specimens
- Steel: 10mm & 12mm
- BFRP: 8mm, 10mm & 12mm
- Plain concrete beams

Specimen details

- Beam size - 500mm x 500mm x 100mm
- Concrete Grade - C35
- Reinforcement placed at lower 1/3rd

Testing Procedure

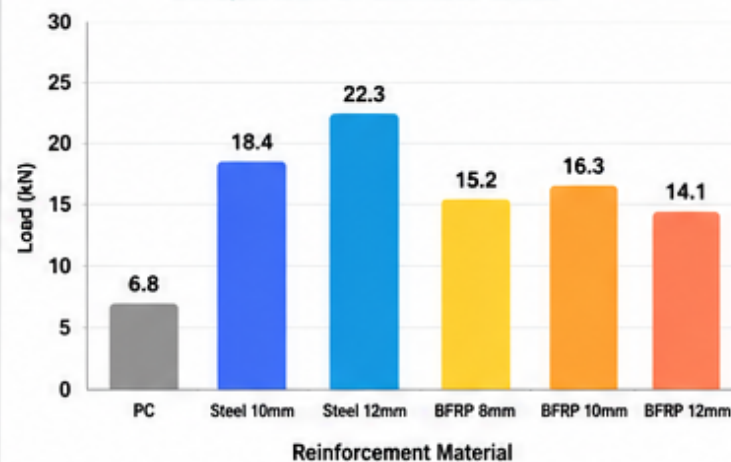
- 28 day curing
- Three point bending
- Compression test of PC cubes
- First crack load, ultimate load and failure mechanics



Results

Comparison of ultimate loads

Summary of results

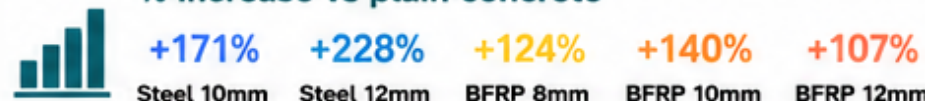


Steel reinforced beams achieved the highest ultimate loads.

BFRP reinforced beams showed intermediate capacity.

Plain concrete beams had the lowest capacity.

% increase vs plain concrete



Failure modes & Analysis

SR Beams - ductile behaviour

- Gradual crack propagation
- Steel yields prior to failure
- Stress redistribution occurs
- Noticeable deflection before failure



BFRP Beams - Brittle behaviour

- Linear elastic response
- Sudden brittle failure
- Limited deformation
- No yielding or warning



Evidence of bond deterioration

Clean separation and limited concrete adherence around the BFRP bar indicated partial debonding, contributing to the sudden loss of load capacity



Conclusion & Engineering Implications

Conclusion

BFRP cannot be considered a directly viable replacement due to its lower stiffness, brittle failure behaviour and dependence on bond performance.

However BFRP offers significant advantages in durability critical environments where corrosion resistance outweighs mechanical performance.

Best applications for BFRP

- Marine Environments
- Bridge Decks
- Water retaining structures
- Chemically aggressive environments

Engineering Implications

Steel Reinforcement

- ✓ High strength & stiffness
- ✓ Ductile with warning before failure
- ✓ Well established design methods
- ✓ Susceptible to corrosion

BFRP Reinforcement

- ✓ Corrosion resistant
- ✓ Lightweight & sustainable
- ✓ Brittle failure (No yielding)
- ✓ Lower stiffness & bond dependant

Future Research

- Full scale structural testing
- Long term durability studies
- Bond behaviour investigations
- Hybrid Steel & BFRP systems



KEY FINDING:

Steel reinforced beams achieved the highest ultimate loads and demonstrated ductile behaviour, whereas BFRP beams exhibited brittle failure despite improved corrosion resistance.