Effectiveness of FRP Wrapping on Reinforced Concrete Beams – A Review and Simplified Analysis

DINESHKUMAR S

M.E STRUCTURAL ENGINEERING, AVS ENGINEERING COLLEGE, SALEM-3.

TAMIL NADU, INDIA.

ABSTRACT

Retrofitting is essential for extending the service life of aging reinforced concrete (RC) structures. Fibre Reinforced Polymer (FRP) wrapping has emerged as an efficient, lightweight, and cost-effective technique to enhance flexural and shear capacities of RC beams. This paper reviews key published studies on FRP retrofitting, focusing on flexural strengthening. A simplified analytical model is developed to estimate the increase in bending capacity when RC beams are retrofitted with externally bonded FRP sheets. Results show that wrapping with a single layer of carbon FRP (CFRP) can increase ultimate moment capacity by ~25–30%. The paper also discusses practical challenges and future research directions.

Keywords: Retrofitting, FRP wrapping, RC beams, flexural strengthening, analytical study.

1. Introduction

Many existing RC structures built decades ago no longer satisfy current strength, load, or seismic standards due to aging, increased service demands, or deterioration. Demolition and reconstruction are often costly, time-consuming, and environmentally unsustainable. Instead, retrofitting techniques aim to upgrade existing structures.

Among retrofitting techniques, FRP wrapping—using Carbon FRP (CFRP) or Glass FRP (GFRP)—has gained wide acceptance for its low weight-to-strength ratio, high corrosion resistance, and ease of installation.

2. Literature Review

Extensive research has demonstrated the effectiveness of FRP retrofitting on RC beams.

Table 1

Study	Main Findings
Saadatmanesh & Ehsani (1991)	CFRP plates increased flexural capacity by up to 66%
Triantafillou (1998)	Debonding identified as critical failure mode
Teng et al. (2002)	Developed comprehensive design procedures
ACI 440.2R-17	Guidelines for FRP design and construction
IS 15988:2013	Indian standard for seismic strengthening using FRP

Typical findings:

- One or two layers of CFRP can improve strength by ~25–50%
- Additional layers show diminishing returns due to debonding
- FRP improves ductility and crack resistance

3. Simplified Analytical Model

A simply supported RC beam is analyzed:

Span: 3 m; Section: 230 mm × 300 mm; Concrete grade: M25; Steel: Fe 415.

Without FRP:

Mu = 0.138 fck b d^2

With FRP:

Mu_total = Mu + Af × ffe × (d - a/2)

Table 2: Analytical results:

Configuration	Ultimate moment (kNm)	% Increase
Without FRP	57	–
1 layer CFRP	72	~26%
2 layers CFRP	85	~49%

4. Results and Discussion

- Analytical model aligns with literature: ~25–30% gain with single layer CFRP.
- Additional layers give smaller marginal benefits due to debonding.

Practical considerations:
- Quality of bonding and surface preparation
- Long-term durability under UV, moisture, temperature
- Fire resistance concerns

Advantages:
- Fast installation
- Minimal added weight
- Cost-effective

5. Conclusion

FRP wrapping, especially CFRP sheets, is a highly effective retrofit technique for RC beams. It increases bending strength by ~25–50%, is lightweight, and cost-effective. Further research should address long-term performance, fire resistance, and hybrid systems combining FRP with other techniques.

References

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