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# Effect of FRP Strips Configuration, Beam Dimensions and Amount of Tensile Rebars on Shear Capacity of Reinforced Concrete Beams

Mehrdad Hejazi*[1] , Mitra Mohammadi[2]

[1]Associate Professor of Structural Engineering, Department of Civil Engineering, Faculty of Civil Engineering and Transportation, University of Isfahan, Isfahan, Iran

[2]M.Sc. in Structural Engineering, Isfahan, Iran

**ABSTRACT:** In this paper, the effect of the distance, number of layers and cross-sectional area of FRP strips, the amount of longitudinal rebars, dimensions of beam and compressive strength of concrete on shear capacity of reinforced concrete beams with rectangular cross-section stiffened by FRP strips under symmetrical concentrated loads using the finite element method has been studied. For this reason, the non-linear analysis of 101 reinforced beams has been performed for evaluation of the effect of the parameters on load capacity and mid-span deflection of the beams with and without strengthening. Obtained results indicate that for a constant concrete compressive strength, increasing the width and the number of layers of FRP strips increases the load capacity compared to the control beam. By changing the layout of reinforcing strips with irregular intervals along the beam, the load capacity increase is about 6% to 35%. Also, the increase of the amount of longitudinal rebars from Φ10 to Φ14 creasing the compressive strength of the concrete from 30 MPa to 50 MPa, and increasing the cross-sectional area of the beam from 150 × 300 mm to 150 × 400 mm in unstiffened beams, increase the load capacity by 31%, 23% and 55%, respectively.

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## 1-Introduction

Reinforced concrete beams are important elements for the performance and safety of the structures. The use of FRP strips is a suitable strengthening method for improving the performance. A number of researchers have studied the effects of FRP strips on structural behaviour of reinforce concrete beams [1-3].

The objective of this research is the study of the effect of the distance, number of layers and cross-sectional area of FRP strips, the amount of longitudinal rebars, dimensions of the beam and compressive strength of the concrete on the shear capacity of reinforced concrete beam with rectangular cross-section under symmetrical concentrated loads.

Analysis has been performed using the finite element code ABAQUS assuming non-linear behaviour for materials.

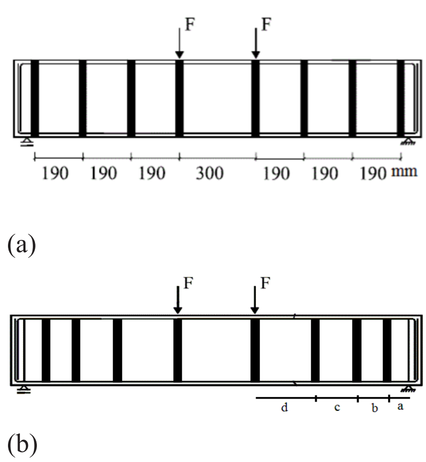
## 2-Methodology

Analysed models are divided into a number of groups. In all three groups D, E and F the amount of compressive steel rebar is 2Φ6. Yield stress and ultimate tensile stress of compressive rebars are fy=622 MPa and fu=702 MPa, respectively. Each FRP strip has a thickness of 0.167 mm, ultimate tensile strength of ffu=3000 MPa and modulus of elasticity of Ef=390000 MPa. Letters J, K and L relate respectively to the strip widths of 25 mm, 35 mm and 45 mm. M, N and O to strips with 1, 2 and 3 layers, and P, Q and R to 8, 10 and 14U-shaped strips along the beam.

As shown in Figure 1a, the beam is simply supported with two symmetrical concentrated loads, which are increased until the beam fails.

The distance between U-shaped strips is varying and represented by a, b, c and d as presented Figure 1b. For simplicity, models are put into two groups S and T. The amount of steel rebars and concrete compressive strength are represented by D and H.

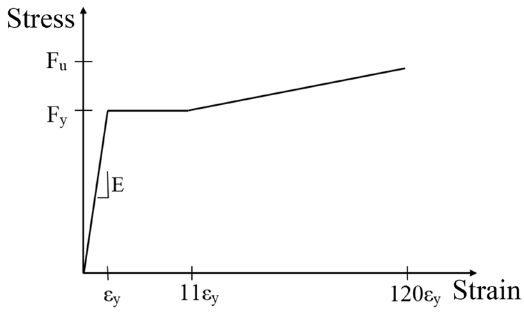
Figure 1. a) Studied beam, b) distance parameters for U-shaped strips



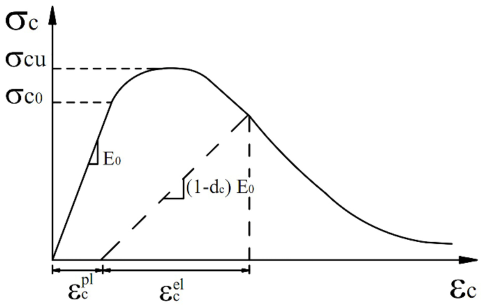

Corresponding Author Email: m.hejazi@pci.iaun.ac.iriaun.ac.ir

The von Mises yield criterion [4] and three-line curve stress-strain relationship (Figure 2a) [5] have been used for steel. The damaged plasticity model [6] has been considered for concrete (Figures 2b and c). For FRP strips the Tsai-Wu failure criterion [7] has been used. The effect of parameters has been evaluated on shear capacity and mid span deflection of the beam.

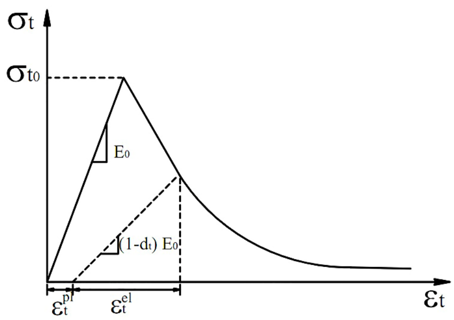
Figure 2. a) Stress-strain relationship: a) steel [4], b) compression for concrete damaged plasticity model [5], c) tension for concrete damaged plasticity model [6]




(a)

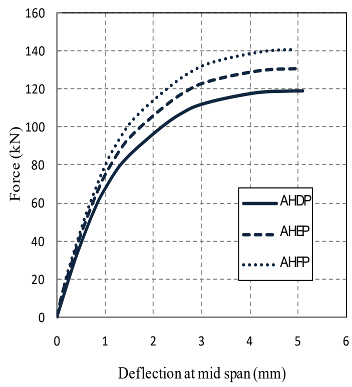



(b)

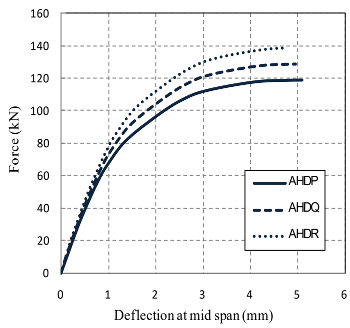



(c)

Figure 3. a) Load-defection diagram: a) with different steel types, b) with different number of FRP strips, c) stress contour in concrete, steel rebars and FRP strips




(a)

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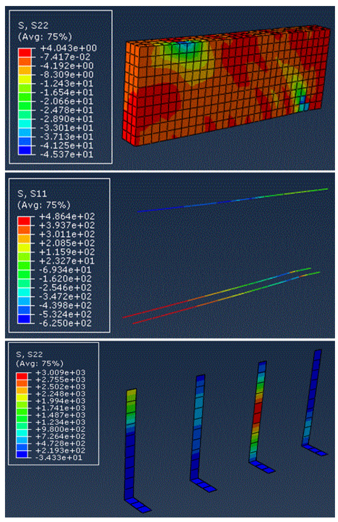


(c)

## 3-Parametric Study

Figure 3 shows the load-deflection diagrams at the mid span of the beams for group A and stress contour. Figure 3a is for steel types of D, E and F and Figure 3b is for FRP strip types of P, Q and R.

The maximum shear capacity is for beam AHFP with a final load of 140.66 kN and then for beams AHEP and AHDP with final loads of 130.83 kN and 118.83 kN, respectively. Similar results are obtained for beam groups B and C. Therefore, for beams with steel type F and constant concrete compressive strength type H, shear capacity is more than beam types of E and D, and the failure mode changes from shear (Figure 3a) to bending.

## 4-Conclusions

Main conclusions of the research are as follows.

1. Larger values of concrete compressive strength result in increasing the shear capacity up to 45% and decreasing the mid span deflection.

2. By increasing the width of FRP strips the shear capacity increases by 10%. Increasing the number of FRP strip layers increases the shear capacity by 18% and increases the mid span deflection.

3. It is possible to increase the shear capacity by 35% by changing the distance between the FRP strips.

4. The shear capacity increases by increasing the number of FRP strips.

## References

[1] R.Z. Al-Rousan, M.A. Issa, The effect of beam depth on the shear behavior of reinforced concrete beams externally strengthened with carbon fiber–reinforced polymer composites, Advances in Structural Engineering, 19(11) (2016) 1769-1779.

[2] K. ŞENGÜN, G. ARSLAN, INFLUENCE OF CFRP ON THE STRENGTH OF RETROFITTED RC BEAMS WITHOUT STIRRUPS, Sigma, 35(1) (2017) 77-85.

[3] H. Naderpour, S. Alavi, A proposed model to estimate shear contribution of FRP in strengthened RC beams in terms of Adaptive Neuro-Fuzzy Inference System, Composite Structures, 170 (2017) 215-227.

[4] W.-F. Chen, D.-J. Han, Plasticity for structural engineers, J. Ross Publishing, 2007.

[5] E.A. Sumner, Unified design of extended end-plate moment connections subject to cyclic loading, Virginia Tech, 2003.

[6] T. Jankowiak, T. Lodygowski, Identification of parameters of concrete damage plasticity constitutive model, Foundations of civil and environmental engineering, 6(1) (2005) 53-69.

[7] W. Van Paepegem, J. Degrieck, Calculation of damage-dependent directional failure indices from the Tsai–Wu static failure criterion, Composites science and technology, 63(2) (2003) 305-310.

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