AFRP Fabric Strengthening along Shear span in Shear deficient beams

Arya J [1], Dhanya Krishnan [2]

[1]M.Tech, Civil Engineering Department, Amal Jyothi College of Engineering, Kanjirappally
[2]Assistant Professor, Civil Engineering Department, Amal Jyothi College of Engineering, Kanjirappally

Abstract

In this study, AFRP (Aramid Fiber Reinforced Polymer) Fabric were utilized to externally strengthen the shear deficient beams in the shear span. Shear deficient beams externally strengthened with varying thickness of AFRP in Shear span and two layers of AFRP Strip of 50 mm width at the bottom of the beam are modeled and analysed. The overall length of the Chosen beam is 1800 mm and the cross section is 150 mm × 200 mm. The behaviour of control, shear deficient, and AFRP strengthened beams are investigated under two-point loading.The beam with one layer of AFRP along the Shear span and two layers of AFRP at the bottom of the beam have higher load carrying capacity as compared to two, three, four or five layers.

Keywords: AFRP, Shear Span, Shear Deficient, Externally strengthened

1. Introduction

A beam with less shear resistance than flexural strength is said to be shear deficient. This can cause the beam to fail suddenly when overloaded. Many civil structures, including buildings and bridges, use reinforced concrete because of its strength and durability. Like any building material, reinforced concrete (RC) can deteriorate over time owing to a variety of issues, including poor design, low-quality material, corrosion, and neglect, all of which shorten the structures' service life.

Traditional methods of strengthening and rehabilitation, like adding additional structural elements, enlarging sections, post-tensioning steel plates etc., have a number of drawbacks, such as being difficult to apply, time-consuming, and not very durable. It is difficult to combine mechanical qualities like strength, stiffness, hardness, and density with conventional materials. Composites are currently the most popular materials used to address these issues with the current demand for modern technology. Composites outperform the majority of conventional materials in terms of their mechanical and physical qualities.Externally Strengthened Aramid Fiber Reinforced Polymer (AFRP) sheets have become an increasing rehabilitation method to address some of these drawbacks.

When compared to other fiber-containing polymers, the main advantage of aramid fiber reinforced composites is their economical performance at lower weight. For instance, glass fibers are significantly less expensive but have a lower modulus and strength, which also adds weight. Of the three fiber kinds, carbon fibers are the strongest and have the highest modulus; nevertheless, they exhibit the least amount of elongation and are more costly than aramids. Because aramid fibers have a special blend of low density, high elongation, and high strength and modulus, the corresponding composites are more impact resistant. For demanding applications in the aerospace sector where exceptional mechanical qualities per unit weight are necessary, aramid fibers, in addition to various carbon fiber grades, are the predominant reinforcement in fiber-reinforced plastics (FRP).

2. Modelling and Validation of Control beam

ANSYS software is used for the analysis of control beam. The overall length of the beam,as shown in figure 1 is chosen as 1800 mm and the cross section is 150 mm × 200 mm.The dimension details[1] are given in Table 1.

Table 1: Dimension details of control beam

Details	Size in mm
Overall Length	1800
Net span	1500
Width	150
Depth	200
Stirrups spacing	160

The material properties of Concrete and Reinforcement [1] are given in the table 2 and 3 below.

Table 2: Properties of Concrete

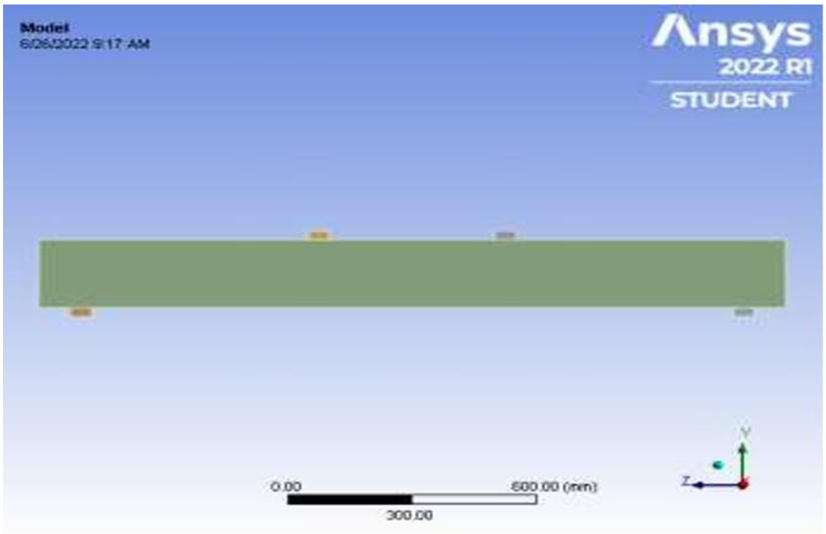
Property	Value
Grade of Concrete	40 Mpa
Modulus of elasticity	31500 N/mm^2
28 days compressive strength	44.7 N/mm^2
Uniaxial Tensile strength	3.2 N/mm^2
Poisson’s ratio	0.2

Table 3: Properties of reinforcing steel

Property	Value
Poisson’s ratio	0.3
Yield stress	500 N/mm^2
Modulus of elasticity	20,000 N/mm^2

Control beam modeling was completed with element type SOLID186 and reinforcement with REINF264, respectively. Following model modeling, the hexahedron mesh is created. Meshing is done using adaptive meshcontrolled size. On the basis of displacement convergence criterion, the load is applied as a 70 mm displacement. The support condition provided is simply supported.

Figure 1: Model of Control beam

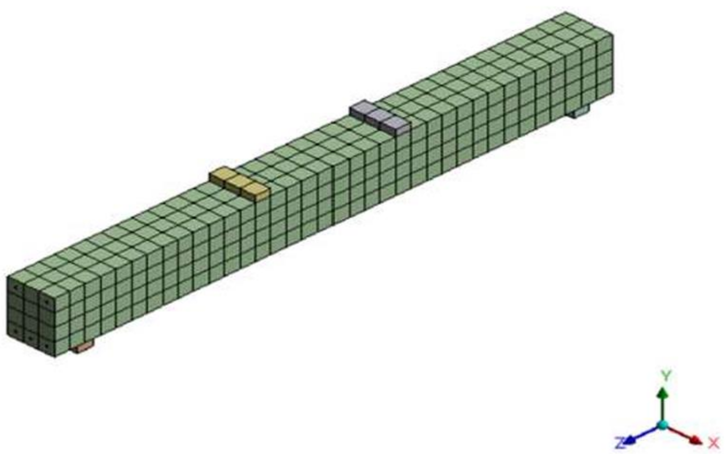


ANSYS software is used to do nonlinear static analysis in order to determine the maximum load carrying capacity. The Control beam's maximum load carrying capability of 94.612 kN and associated deformation of 7.66mm are determined by ANSYS.

3. Modelling and Validation of shear deficient beam

Three stirrups, one in the center and the other two at the ends of the reinforcement at 750 mm intervals, are present in the shear-deficient (SD) RC beam. The meshing is done using hexahedron mesh as shown in figure 2. The load is applied as 70 mm displacement according to displacement Convergence criteria. The Shear deficient beam's maximum load carrying capability 60.77kN and associated deformation of 4.33mm are determined by ANSYS.

Figure 2: Mesh model of shear deficient beam



4. Analysis of shear deficient beam externally strengthened with AFRP in the shear span of shear deficient beam

Shear-deficient beams that have been externally strengthened with two layers of 50 mm wide AFRP strip at the bottom and changing AFRP thickness in the shear span are modeled and examined. With ANSYS software, five models of shear-deficient beams are created. AFRP fabric impregnated with epoxy is used to reinforce the beams. The fabric is put in a fully wrapped strip form in the shear zone of the defective beams.The Material properties of AFRP and epoxyare given in table 4.

Table 4: Material properties of AFRP and epoxy

Material	Tensile Strength(Mpa)	Modulus of Elasticity (N/mm^2)	Layer thickness(mm)	Poisson's ratio
Epoxy	45	3800	1	0.21
AFRP	47.2	1310000	0.286	0.3

The thickness is varied as 0.286mm, 0.572.5mm, 0.858.0mm, 1.144.0mm, and 1.43.0mm. Half of the beam's effective depth, or 85 mm, is the assumed breadth of the AFRP layer. There is also a 50 mm AFRP strip at the bottom.

Figure 3: Modelling of Strengthened SD by varying the number of layers or thickness of AFRP along the shear span

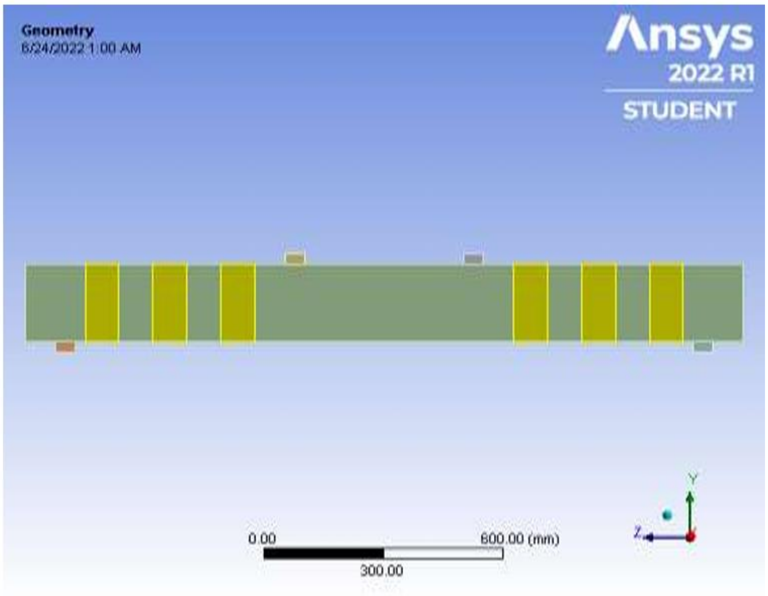


Figure 4 : Deformation Models of Strengthened SD using one layer of AFRP

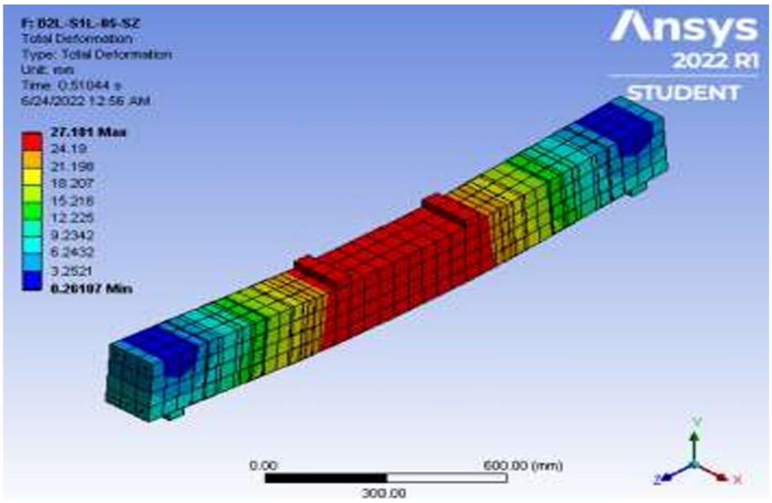


Figure 5: Deformation Models of Strengthened SD using twolayer of AFRP

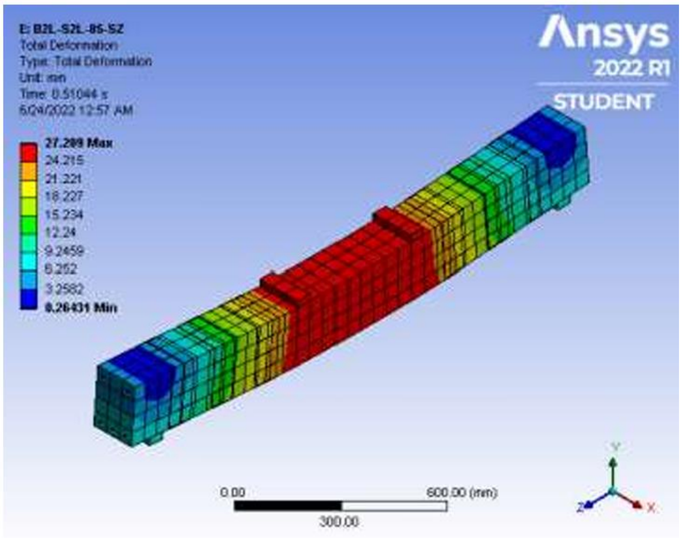


Figure 6: Deformation Models of Strengthened SD using three layer of AFRP

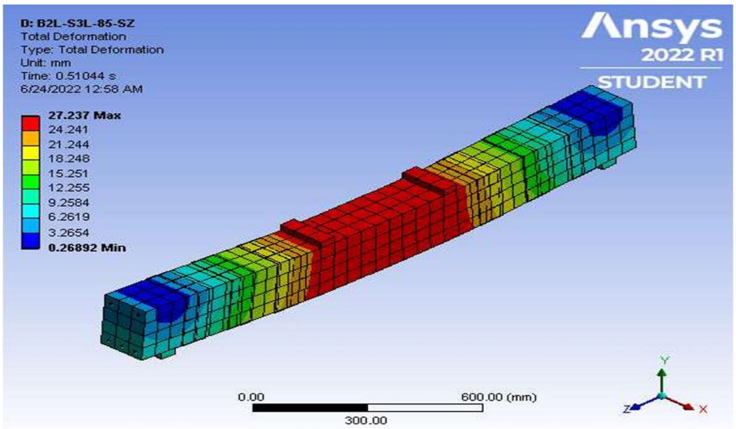


Figure 7: Deformation Models of Strengthened SD using four layerof AFRP

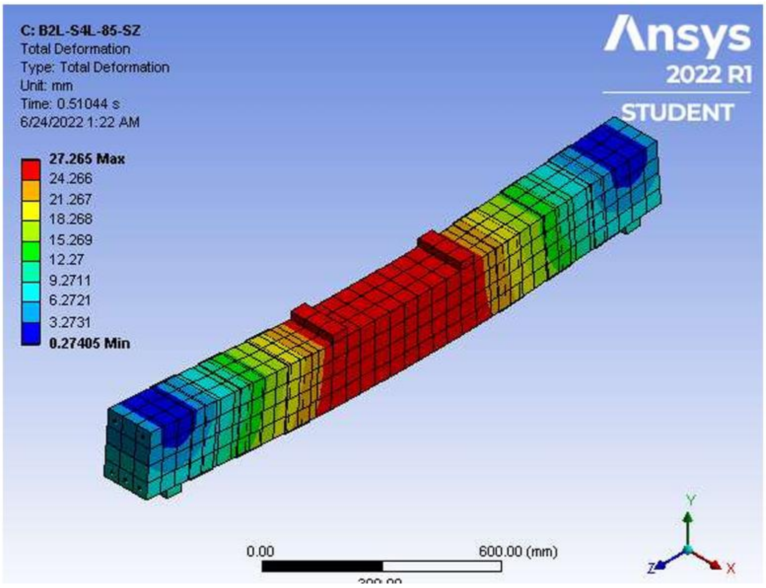
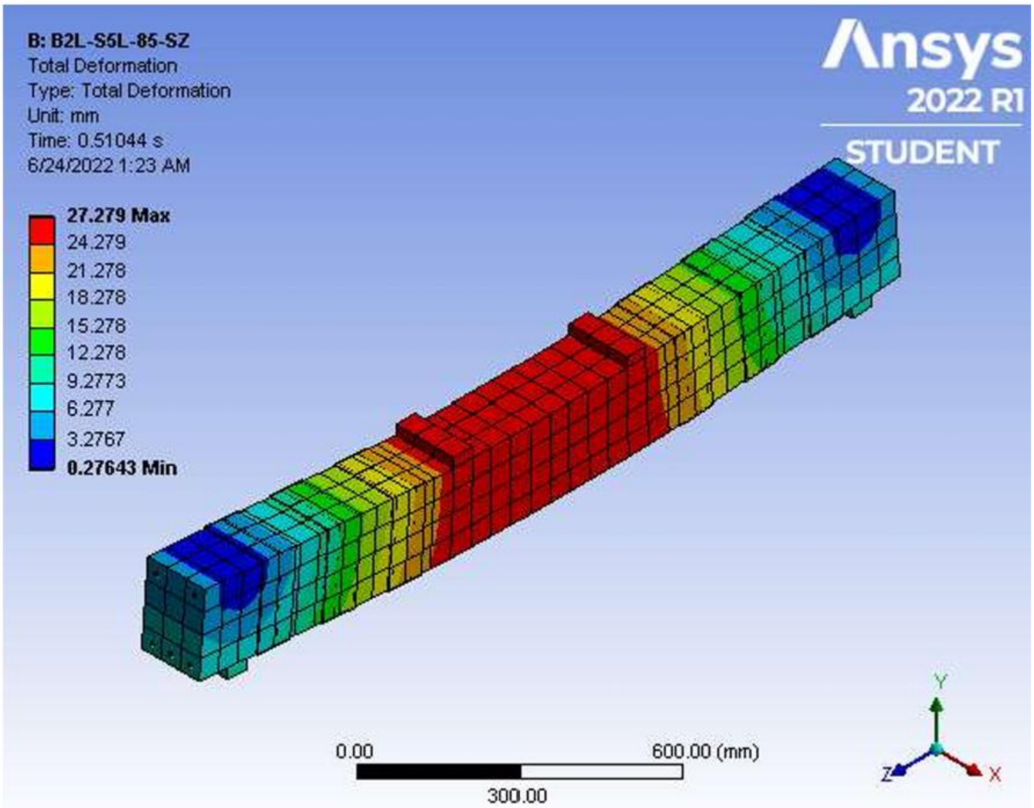


Figure 8: Deformation Models of Strengthened SD using five layer of AFRP



5. Results

For the beam with one layer thickness the maximum deformation was 34.64 mm at an ultimate load carrying capacity of 112.05 kN. For the beam with two layer thickness the maximum deformation was 34.69 mm at an ultimate load carrying capacity of 112.4 kN. For the beam with three layer thickness the maximum deformation was 31.16 mm at an ultimate load carrying capacity of 112.45 kN. For the beam with four layer thickness the maximum deformation was 35.01 mm at an ultimate load carrying capacity of 112.72 kN. For the beam with five layer thickness the maximum deformation was 32.75 mm at an ultimate load carrying capacity of 113.17 kN.

Therefore, the load carrying capacity of the slab increases slightly as the thickness increases. The load carrying capacity of the control beam is found to be 94.612 kN.

6. Conclusion

- The beam with one layer of AFRP along the Shear span and two layers of AFRP at the bottom of the beam have load carrying capacity (112.05 KN) and corresponding deformation (34.64mm) as compared to two, three, four or five layers.
- Thus for Strengthening a Shear deficient beam it is sufficient to provide AFRP at the shear span of the beam instead of applying full span.

7. References

1. Nawal Kishor Banjara , K. Ramanjaneyulu(2017) “Experimental and numerical investigations on the performance evaluation of shear deficient and GFRP strengthened reinforced concrete beams” http://dx.doi.org/10.1016/j.cdonbuilmat.2017.01.089
2. XiangqingKong , Xuejian Qi, Yihan Gu, Isah Abba Lawan, Yandong Qu (2018) “Numerical evaluation of blast resistance of RC slab strengthened with AFRP”https://doi.org/10.1016/j.conbuildmat.2018.05.081 SamuelJ., “Fine Particles, Thin Filmsand Exchange Anisotropy”, Magnetism, 1963, 3 (1), 271–350.
3. Arya J (2023) “External strengthening of shear deficient beams using AFRP and GFRP Fibers” International Journal of Engineering Research & Technology (IJERT),ISSN: 2278-0181 Vol. 12 Issue 06, June-2023
4. M A Ouda M AMashrei (2022) “Shear strength of steel fibrous concrete beams strengthened by CFRP using various techniques” https://doi.org/10.1016/j.istruc.2022.02.027