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Simulation of Exterior Wrapping for Flexural Study on Beams

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Abstract: *The need to retrofit existing reinforced concrete (RC) structures have increased over the decades due to corrosion of steel reinforcement inside the concrete, neglect and overuse, and increased loading. Experimental and numerical studies in this research field showed that using fibre-reinforced Polymer (FRP) materials to strengthen RC members in shear, flexure, and column confinement applications is an effective method to retrofit RC structures. This strengthening technology has numerous advantages over conventional steel plating, such as providing high strength-to-weight ratio, versatility, durability, and ease of use to strengthen RC members. The purpose of this paper is to study the effect of strengthening shear deficient RC beams with externally bonded (EB) carbon fibre-reinforced polymer (CFRP) sheets with and without U-wrap configuration.*

Keywords: Retrofit, Fibre-reinforced Polymer, Carbon fibre-reinforced polymer, Flexure, Strength-to-weight ratio, Versatility, Durability, Externally bonded, U-wrap.

I. INTRODUCTION

The use of fibre-reinforced compound (FRP) composite materials has gained its quality within the strengthening of RC structures applications throughout the last 3 decades. this can be thanks to its various blessings over the traditional retrofitting strategies like enlarging beam's sections or mistreatment steel plates. These blessings embrace high strength-to-weight magnitude relation, easy installation, corrosion resistance, skillfulness, and sturdiness of the FRP composites. numerous studies that are conducted to research strengthening of RC structures by the EBR technique verified that bonding FRP sheets to concrete substrate improved the flexural and shear capability of the structural components. However, the most downside of this technique is debonding of the FRP laminates from the concrete substrate before utilizing the FRP enduringness. to extend the effectiveness of the use of FRP enduringness, complete and partial wrapping were introduced. Ideally, completely wrapped RC beams have well-tried to be effective in terms of delaying FRP debonding failure. additionally, it utilizes the effective strain within the CFRP sheets. Studies verified that completely wrapped beams perform the simplest in terms of enhancing the shear capability and malleability of RC beams. This can be thanks to the upper earned effective strain on the fibre's vertical direction than that with side-bonded and U-wrap strengthening schemes. However, much it can't be enforced in several cases, wherever the beams square measure connected to the slabs. Hence, U-wrapped theme is that the most typically used technique to strengthen RC beam.

Fig 1. CFRP Wrapped Beam

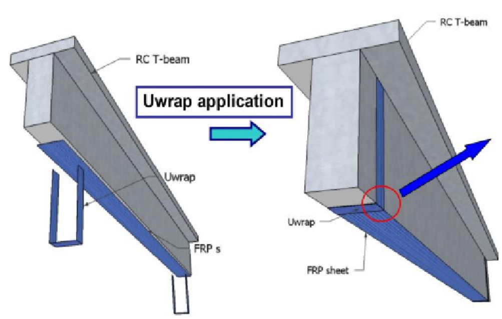

Fig 2. U Wrapped FRP Sheet

1.1 Objective

The main objective of this paper is as follows

- Numerous studies were carried out to investigate using FRP sheets in shear strengthening of RC structural members.
- Most of the experiments in the literature have proven that the scheme of complete wrapping is the best and ideal method for shear strengthening of the RC members.
- While it can be easily implemented in columns, it is very difficult to implement in beams, in most cases, due to the presence of slabs above the beams.
- Therefore, the aim of this study is to compare the most commonly used U-Wrap scheme to the non-wrap scheme of rectangular beams with varying thickness of CFRP sheets.
- The finite elemental analysis will be done by ANSYS software.
- Comparing the Analytical values and Experimental results to find the efficiency of each model.

II. METHODOLOGY

The process of the above research work is shown in Fig 3

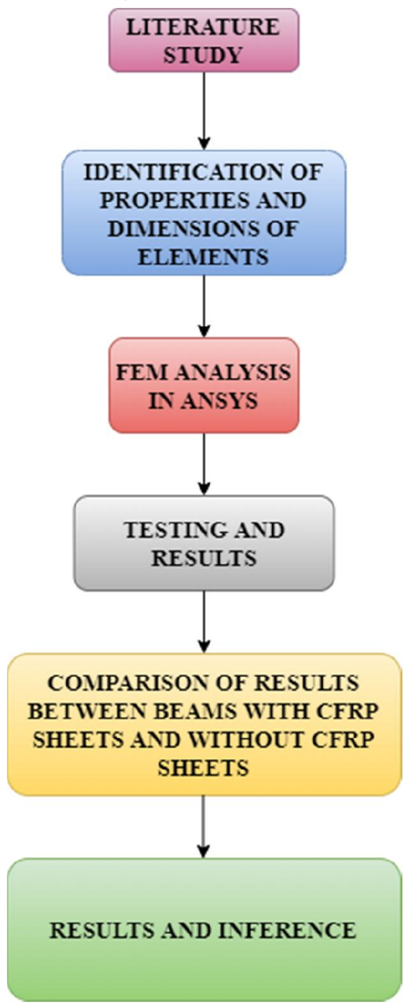

Fig 3. Methodology

III. DESIGN METHODOLOGY

The length, depth and width of the beam that is to be studied for flexural are 4m, 400mm, 250mm respectively. The finite element simulation of beam is done in ANSYS software. The beam is modelled with bottom bearing at the support and top bearing at the point of load applied, 4nos of rebar of 12mm diameter. Two beams were modelled based on the purpose of research (U-wrapped beam and Conventional beam). In U-wrapped beam, CFRP sheet is used. Fixed support condition was assigned and incremental loading upto 3.5kN has been applied. The following material parameters were assigned:

Concrete Beam:

- Young's Modulus = 3.044E+10 Pa
- Poisson's Ratio = 0.2
- Bulk Modulus = 1.6911E+10 Pa
- Shear Modulus = 1.2683E+10 Pa

Bearing:

- Young's Modulus = 6.8948E+07 Pa
- Poisson's Ratio = 0.5
- Bulk Modulus = 1.1491E+14 Pa
- Shear Modulus = 2.2983E+07 Pa

Rebar (At Compression Zone):

- Young's Modulus = 1.9995E+11 Pa
- Poisson's Ratio = 0.3
- Bulk Modulus = 1.6663E+11 Pa
- Shear Modulus = 7.6904E+10 Pa
- Yield Strength = 4.1369E+08 Pa

CFRP Sheet:

- Young's Modulus = 1.9995E+11 Pa
- Poisson's Ratio = 0.3
- Bulk Modulus = 1.6663E+11 Pa
- Shear Modulus = 7.6904E+10 Pa

IV. ANALYTICAL MODEL

4.1. Mesh Model

A mesh model has been created for both model of beams. A conventional beam with following dimensions as mentioned above, and a beam element with U-wrapped CFRP sheet of thickness varying between 10mm to 20mm. The created mesh model is as follows:

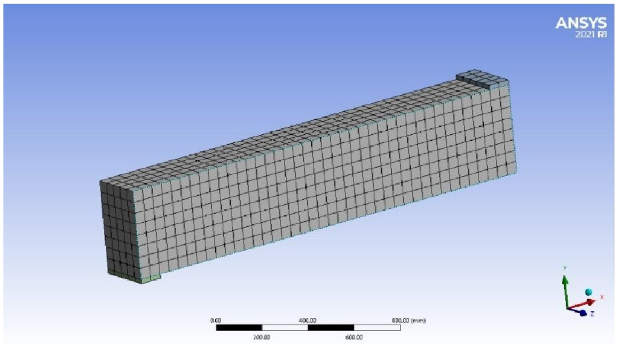

Fig 4. Beam without CFRP Wrap

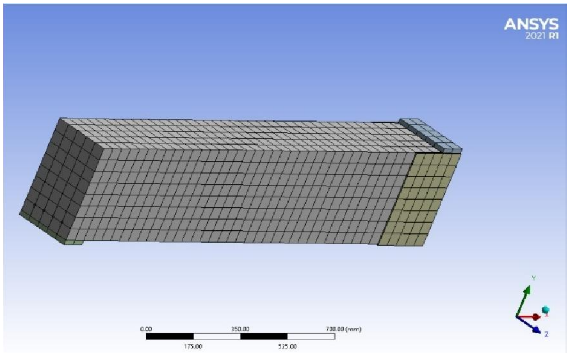

Fig 5. Beam with CFRP Wrap

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V. RESULTS

The mathematical model of the beam was analysed using ANSYS software. Based on the analysis, various results were extracted. They are as follows:

1. Directional Deformation
2. Maximum Principal Stress
3. Shear Stress
4. Stress-Strain Curve

5.1 Directional Deformation

The directional deformation result was taken along the Z axis of the Global Coordinate System. The directional deformation for the model beam as per analysis are as follows:

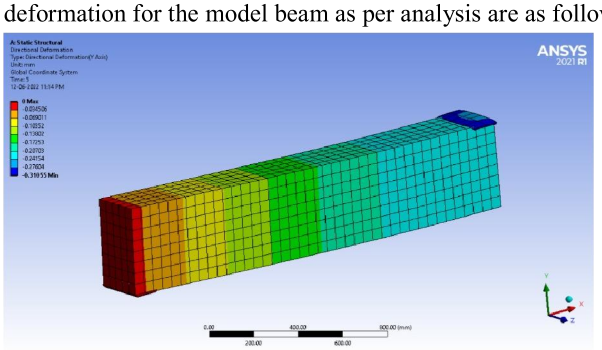

Fig 6. Deformation of Unwrapped Beam

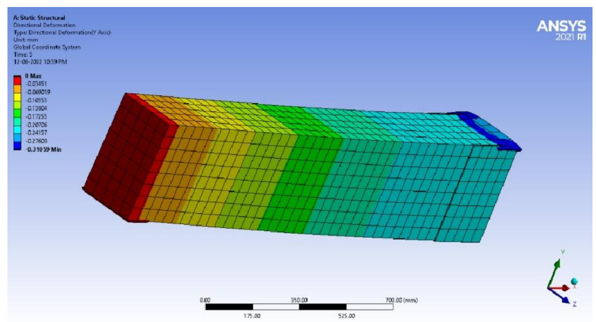

Fig 7. Deformation of Wrapped Beam

5.2 Maximum Principal Stress

The maximum principal stress is determined as per analysis of the analytical model. The maximum principal stress for both beams is given as below:

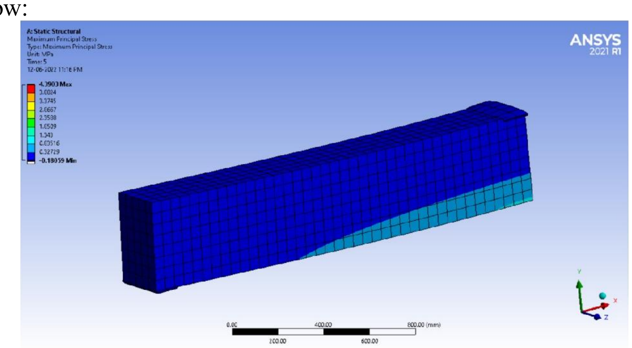

Fig 7. Max Principal Stress for Unwrapped Beam

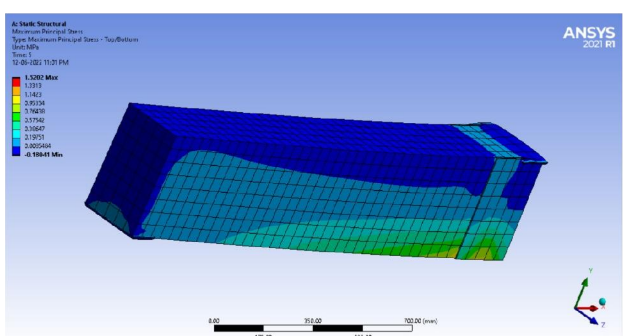

Fig 8. Max Principal Stress for Wrapped Beam

5.3 Shear Stress

The shear stress is determined as per analysis of the analytical model. The shear stress for both beams is given as below:

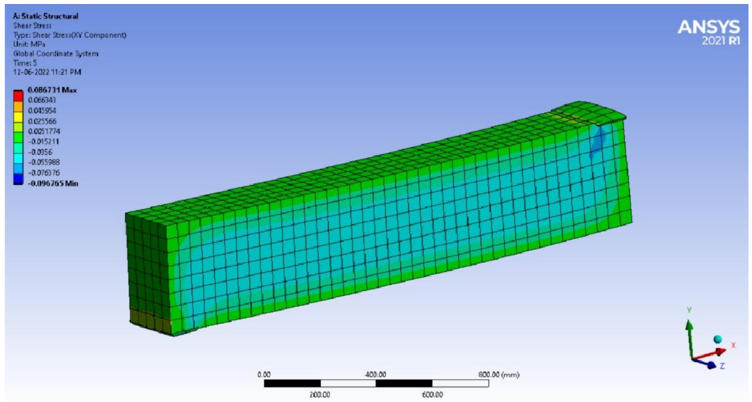

Fig 9. Shear Stress for Unwrapped Beam

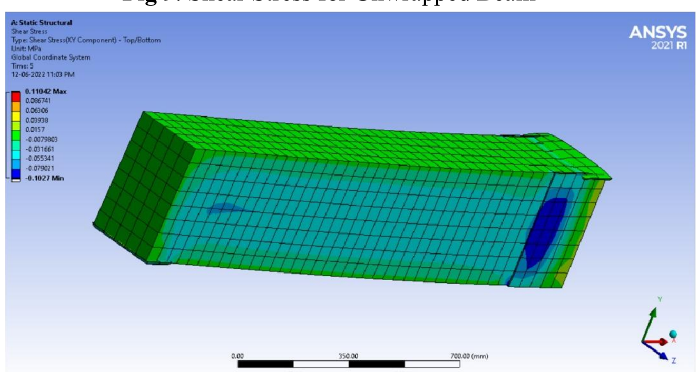

Fig 10. Shear Stress for Wrapped Beam

5.4 Stress – Strain Curve

The stress strain curve has been plotted as per analysis results. The stress strain curve is as follows:

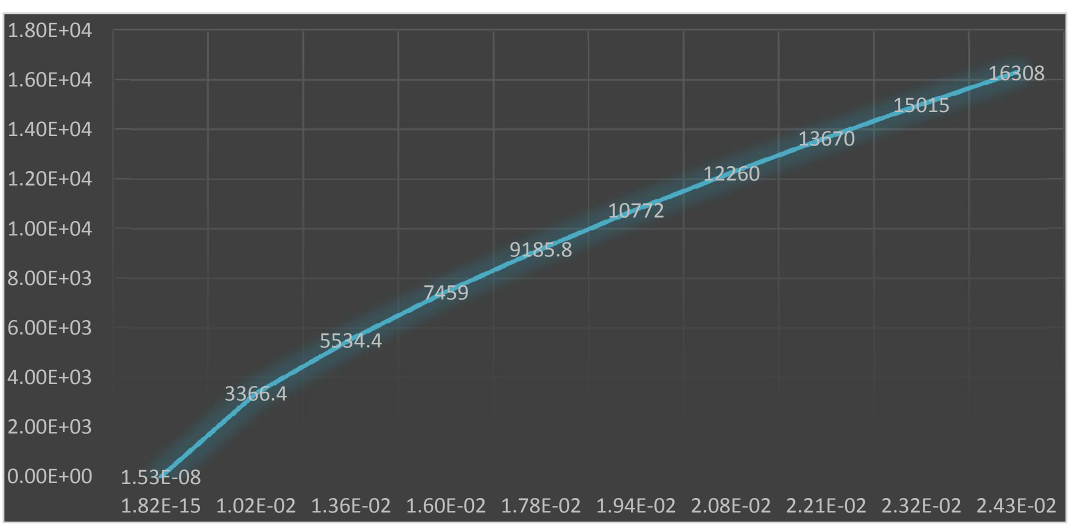

Fig 11. Stress-Strain Curve

VI. CONCLUSION

On literature study it is said that complete-wrapping scheme provides the best performance in terms of increasing the shear strength and significantly increasing the ductility of the strengthened RC beams, compared to U-Wrapped beams with the same depth. Completely wrapping the beams with CFRP laminates utilizes more of its strain capacity than that with the U-wrapped scheme. The failure mode of completely wrapped beams is FRP rupture, which is more favorable compared to the sudden debonding of the FRP laminates of the U-Wrapped beams. In the case where beams cannot be completely wrapped, the U-wrapping scheme is a feasible option. However, for the U-Wrapped beams to reach the same performance of the completely wrapped beams, CFRP laminates should be properly anchored to avoid the brittle debonding.

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