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GFRP Bars as a Substitution in Structure

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Abstract

Fiber Reinforced Polymer (FRP) is an advanced composite material that has been identified as a potential new construction material. Since it is a non-corrosive material it may be used as reinforcement in concrete member. However, there is limited experience with the design and construction of GFRP reinforced concrete structures. An analytical method is used to predict the deflection of the rectangular reinforced concrete beam strengthened by GFRP bars. To achieve the aim, finite element modelling has been carried out. All the work and modelling of beam is carried out in the software called ATENA 3D, a product of CERVENKA CONSULTING. During the study, experimental analysis of the beams were carried out and results from analytical and experimental works were compared. For such study, efficiency and effectiveness of different but very practical GFRP scheme for flexural and shear strengthening of RC beam has been analyzed. Here the beam reinforced with appropriate number of GFRP main bars and steel bars and combination of both were analyzed in the software and experimental work.
Keyword- GFRP bars, Strength, Flexibility, Replacement of steel bars

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I. INTRODUCTION

The traditional material used in the strengthening of concrete structures is Steel. Because of its drawbacks of low corrosion resistance and of handling problems involving excessive size and weight, there is a need for the engineering community to look for alternative. A Fiber Reinforced Polymer (FRP), also known as Fiber Reinforced Plastic, is a composite material that use natural or synthetic fibers to mechanically enhance the strength and stiffness of a polymer matrix.

A. Scope of Report

- To investigate and improve the understanding and the behaviour of reinforced concrete beam with GFRP bars, to compare the Analytical and Experimental results, to provide a safe, economic and durable structure.
- To understand behaviour of structural element using GFRP Bars instead of Traditional Steel Bars

B. Need of Study

- As steel bars gets corroded while in contact with water or any chemical agent, structure may be damaged due to corrosion and also some drawbacks as described in following table, the replacement for steel bars must be needed to give better strength to the structure.

Property	*Pultruded GFRP*	*Steel*
– *Corrosion resistance*	– *100-200 years*	– *20 years or less*
– *Thermal insulator*	– *Excellent*	– *Poor*
– *Electrical insulator*	– *Excellent*	– *Poor*
– *Long term bond*	– *Excellent*	– *Good*
– *Weight*	– *Less (0.25 * steel)*	– *Heavier*
– *Cut ability and ease to recycle*	– *Easy*	– *Difficult*
– *Transport Savings*	– *Yes*	– *No*
– *Injury Savings*	– *Yes*	– *No*
– *Tensile Strength*	– *High as compared to steel*	– *Low as compared to GFRP*

II. SOFTWARE INTRODUCTION

ATENA mainly used for the nonlinear analysis which is an advance tool for Engineering Nonlinear Analysis. It is software specially developed for analysis of concrete and reinforced concrete structure. ATENA is software developed by Cervenka consulting, a company from Czech Republic.

Some limitation is made in order to maintain a transparent and user friendly environment in all specific applications of ATENA.ATENA 3D program is designed for 3D nonlinear analysis of solids with special tools for reinforced concrete structures. However structures from other materials, such as soils, metals etc. can be treated as well. The program has three main functions…

– Pre-processing: Input of geometrical objects (concrete, reinforcements, interfaces, etc) loading and boundary conditions, meshing and solution parameters.
– Analysis: It makes possible a real time monitoring of results during calculations.
– Post-processing: Access to a wide range of graphical and numerical results ATENA 3D version 3.2.2 is limited to stress analysis.

III. PARAMETRIC STUDY

For better understanding of behaviour of beam model reinforced with STEEL, GFRP and combinations of both, total twelve beams were analyzed using ATENA 3D whose acronym are as follows:

1) S20*1500*200*200
2) 2. S25*1500*200*200
3) 3. S20*700*150*150
4) 4. S25*700*150*150
5) 5. SG20*1500*200*200
6) 6. SG25*1500*200*200
7) 7. SG20*700*150*150
8) 8. SG25*700*150*150
9) 9. G20*1500*200*200
10) 10. G25*1500*200*200
11) 11. G20*700*150*150
12) 12. G25*700*150*150

where,
S= Steel as Reinforcement
G= GFRP as Reinforcement
20= M20 Grade of Concrete
25= M25 Grade of Concrete

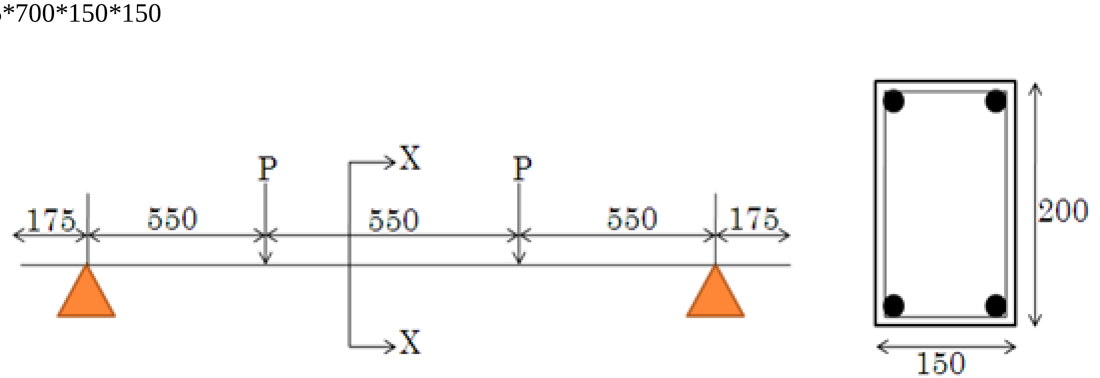


Fig. 1: Model Description

For the comparison purpose, experiment work was carried out and similar types of models were made which were without Shear Reinforcement, whose complete descriptions are as under:

1) G20*700*150*150*12mmB
2) G20*700*150*150*10mmB
3) SG20*700*150*150*12mmTB
4) SG20*700*150*150*10mmTB
5) GS20*700*150*150*10mmT*12mmB
6) SG20*700*150*150*10mmT*12mm
7) G20*700*150*150*10mmT*12mmB

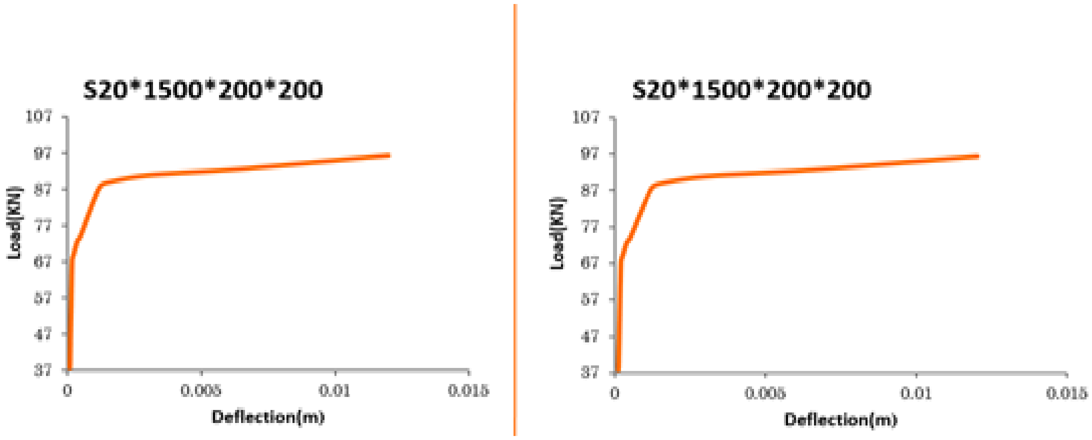
where,
S= Steel as Reinforcement
G= GFRP as Reinforcement
B= Only Bottom Reinforcement
TB=Top and Bottom Reinforcement

Few more models were analyzed using ATENA 3D which were without Shear Reinforcement, their description are as under:

1) G20*700*150*150*10mmTB
2) G20*700*150*150*12mmTB
3) G25*700*150*150*10mmTB
4) G25*700*150*150*12mmTB

IV. RESULTS AND DISCUSSION

From analysis function in software, following graphs were obtained for different models.



Graph 1: Load Vs Deflection

Models	Ultimate Load (KN)
S20*1500*200*200	96.5
S25*1500*200*200	104
SG20*1500*200*200	122
SG25*1500*200*200	130
G20*1500*200*200	138
G25*1500*200*200	148
S20*700*150*150	139
S25*700*150*150	150
SG20*700*150*150	172
SG25*700*150*150	187
G20*700*150*150	191
G25*700*150*150	211

Table 1: Software Results for Different Models

Models	Aggregated ultimate load from experimental work (KN)	Ultimate load from software analysis (KN)
G20*700*150*150*12mmB	131.8	129
G20*700*150*150*10mmB	130	127
SG20*700*150*150*12mmTB	182.52	179
SG20*700*150*150*1OmmTB	179.72	176
GS20*700*150*150*10mmT*12mmB	180	178
SG20*700*150*150*10mmT*12mmB	148.9	145
G20*700*150*150*10mmT*12mmB	183.10	180

Table 2: Experimental Results for Different Models

V. CONCLUSION

As we know that GFRP is the future of construction industry, it can be used as an alternative because of its advantages over steel reinforcement. Some of the advantages of GFRP over steel are its light weight resulting into lighter cross section, relatively low cost as compared to steel, less vulnerable to corrosion, and also it can be manufactured easily and does not require any special equipment.

- The ultimate strength of GFRP reinforced beam is much higher than that of beams reinforced with Steel.
- It has been observed from the graph of LOAD vs. DEFLECTION that the beam is susceptible to minimal deflection against higher load values.
- Also combination of steel with GFRP reinforcement proves efficient as far as Ultimate Strength is concerned.
- GFRP can prove a promising replacement of Steel and can serve economically with the essence of safety to the Society.
- Inspite of having low yield point GFRP can be used as a replacement of Steel as it has higher ultimate load value.
- Also GFRP gives lighter cross section as compared to steel.

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