Study, Analysis and Comparison of Mechanical Properties of GFRP Re-Bars with Steel Re-Bars Using Ansys Workbench for Bridge Application

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Abstract- In recent years the use of Glass reinforced polymer bars has increased due to its light weight, increased corrosion resistance of structures, greater service life. In this paper the comparison of steel re-bars and GFRP re-bars is performed by varying its diameter and applying boundary conditions in numerical method, ANSYS Workbench, according to the ASTM code.

The results of the ultimate Tensile Strength, Ultimate Tensile Strain, Transverse Shear strength, Bond Strength of both steel re-bar and GFRP re-bar are checked with the Literature review results. It is found that the GFRP re-bars is giving more strength compared to steel re-bar.

Key Points: GFRP re-bars, Steel re-bar, ANSYS Workbench, Bond Strength, ASTM code.

1. INTRODUCTION

A composite material can be defined as a combination of two or more materials that results in better properties than those of the individual components used alone. In contrast to metallic alloys, each material retains its separate chemical, physical, and mechanical properties. The two constituents are reinforcement and a matrix. The main advantages of composite materials are their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part. The reinforcing phase provides the strength and stiffness. In most cases, the reinforcement is harder, stronger, and stiffer than the matrix. The reinforcement is usually a fiber or a particulate. Particulate composites have dimensions that are approximately equal in all directions. They may be spherical, platelets, or any other regular or irregular geometry. Particulate composites tend to be much weaker and less stiff than continuous fiber composites, but they are usually much less expensive. There is a practical limit of about 70 volume percent reinforcement that can be added to form a composite. At higher percentages, there is too little matrix to support the fibers effectively.

Composites are high-performance composites, formulated using fiber or fabric reinforcement and shape memory polymer resin as the matrix. Since a shape memory polymer resin is used as the matrix, these composites have the ability to be easily manipulated into various configurations when they are heated above their activation temperatures and will exhibit high strength and stiffness at lower temperatures. High stain polymer are another type of high performance composites that are designed to perform in a high deformation setting and are often used in deployable systems where structural flexing is advantageous.

Characteristics of the GFRP:

1. High strength-to-weight ratio: GFRP is a lightweight material with high tensile strength and stiffness, which makes it useful in applications where weight is a concern.
2. Corrosion resistant: Unlike metals, GFRP is not susceptible to corrosion, making it ideal for use in harsh environments.
3. Dimensional stability: GFRP has a low coefficient of thermal expansion, which means it does not expand or contract significantly with changes in temperature.

4. Electrical insulation: GFRP is an excellent electrical insulator, which makes it ideal for use in electrical and electronic applications.
5. Design flexibility: GFRP can be molded into complex shapes and sizes, allowing for greater design flexibility and customization.
6. Durability: GFRP is resistant toimpact, fatigue, and creep, making it a durable material that can withstand harsh conditions.

Properties of GFRP :
1. Density (gm/cm^3): 1.25 - 2.50
2. Tensile Strength (GPA: 483 - 4580
3. Young Modulus (MPA: 35 - 86
4. Elongation (%): 1.2 – 5.0
5. Coefficient Linear Expansion: 6.0 - 10.0

Advantages of GFRP :
1. Corrosion Resistance
2. High Strength-to-Weight Ratio
3. Low Thermal Conductivity
4. Electrical Insulation
5. Design Flexibility
6. Non-Magnetic
7. Long Service Life

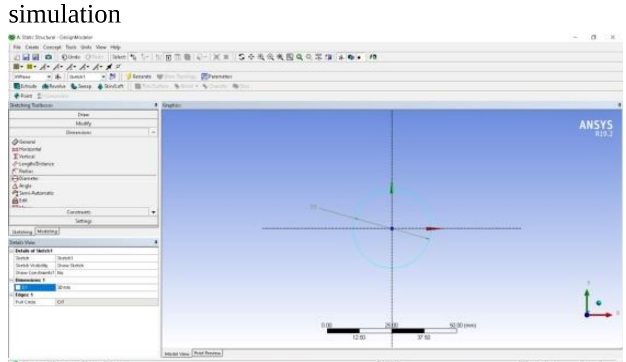
2. LITERATURE SURVEY

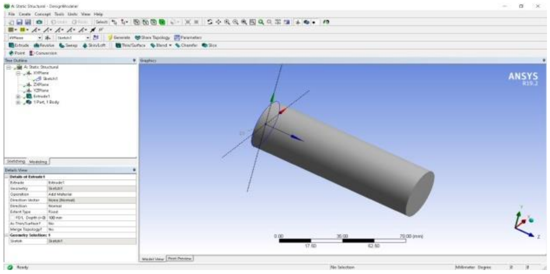
2.1Glass fibre reinforced plastic (GFRP) rebars for concrete structures
B. Benmokrane ∗, O. Chaallal †, R. Masmoudi ∗
The study described is a part of a large-scale experimental and theoretical programme on the application of fibre reinforced plastic (frp) reinforcement for concrete structures initiated at the Universiteide Sherbrooke (Sherbrooke, Canada). The programme is being carried out to gain an insight into the flexural behaviour of concrete beams reinforced with glass fibre reinforced plastic (gfrp) rebars. Results of experimental study on 3.3 m long beams reinforced with two different types of gfrp rebars are presented and compared to that of conventional steel reinforced concrete beams. Three series of reinforced concrete beams were tested in flexure. The beams were 200 mm wide and respectively 300, 450 and 550 mm high. The paper also attempts to present the properties of gfrp and its components and to give an oversight of relevant research activities involving gfrp rebars as reinforcement for concrete units.

2.2 Influence of corrosion on the experimental behaviour of R.C. ties
Stefania Imperatore a, Zila Rinaldi b, Simone Spagn uolo
Existing reinforced concrete elements are typically subjected to ageing and corrosion, leading to significant structural capacity decay. The variation in the steel-to-concrete interaction is one the first effects of corrosion, that consequently modify the bond-slip relationship. On a structural point of view, this implies a variation of the crack pattern, an increase of the element deformability, and an enlargement of the crack width. Several studies, available in the technical literature, analyse the corrosion influence on the bond properties by means of small specimens, in which only the local bond-slip behaviour can develop. In this paper, in order to investigate the problem at a full-scale level, three meters long tie rods were cast, artificially corroded and tested in the Laboratory of Materials and Structures of the University of Rome Tor Vergata. Each specimen was characterized by a 150 × 150 mm2 cross-section and reinforced with a Ø16 steel bar placed at the centerline of the element. The specimens were artificially corroded up to about 4% corrosion level (in terms of mass loss) and subjected to tensile test. The obtained results clearly highlight the influence of the corrosion of the bond transmission mechanism.

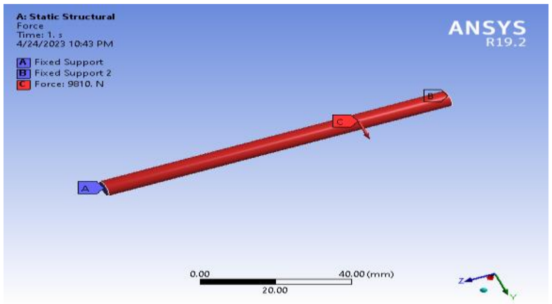
3. MODELLING AND SIMULATION

The Re-bar model is designed in Solid works and imported it to ANSYS workbench for performing CFD simulation

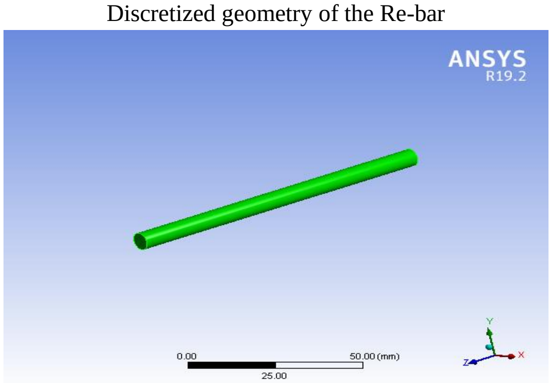


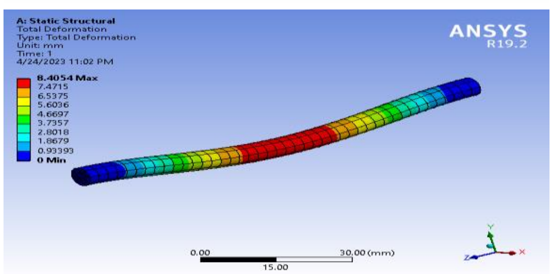


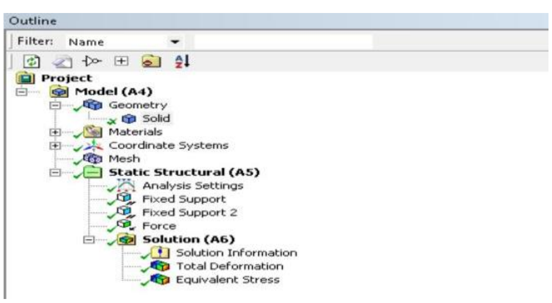
Geometry consideration for Re-bar Simulation



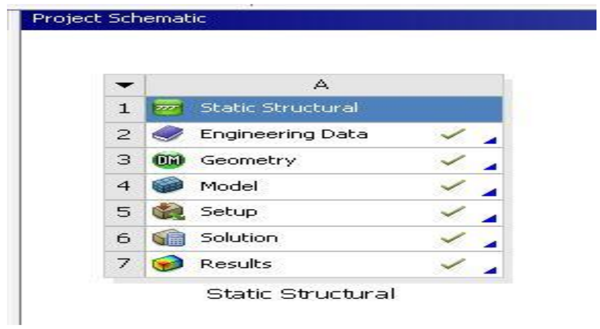
Discretized geometry of the Re-bar

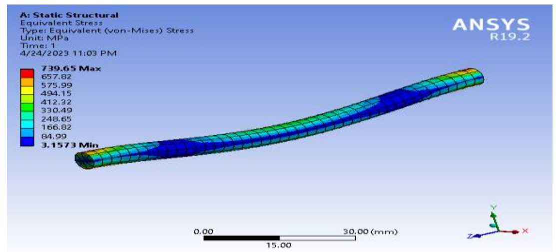






Shows named selections created in Ansys fluent





Simulation

- Draw a line at height of 60mm and length is 50 mm.
- Use a fillet command convert curve at radius of 10mm. The curve touch the bar on each bar .
- Than select the sweep command by circular path and its form a solid shape around bars. And make pattern block at 50mm distance of each other the block are arranged in linear path the blocks setup 10 blocks.

4.METHODOLOGY

The methodology of work is outlined below

Geometric modelling of a rebar in Ansys Design Modeller

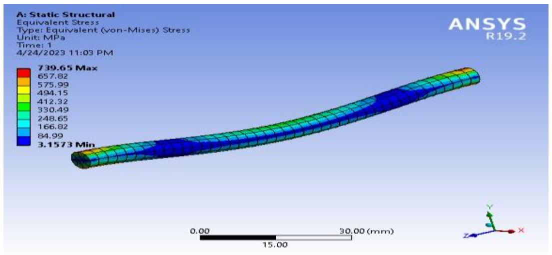
Static analysis for steel rebar model under loading conditions. In order to solve the problem of the project, a detailed finite element analysis is proposed to determine the total deformation and Equivalent stress in static condition using the analysis software ANSYS WORKBENCH.

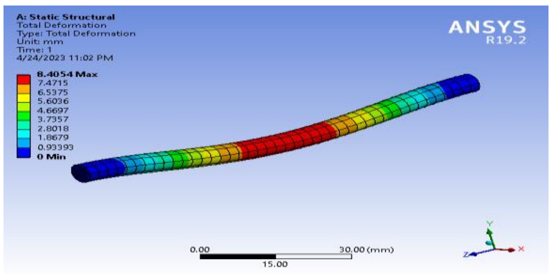
Modal analysis for steel rebar model under loading conditions. In order to solve the problem of the project, a detailed finite element analysis is proposed to determine the total deformation under frequencies at each modes using the analysis software ANSYS WORKBENCH.

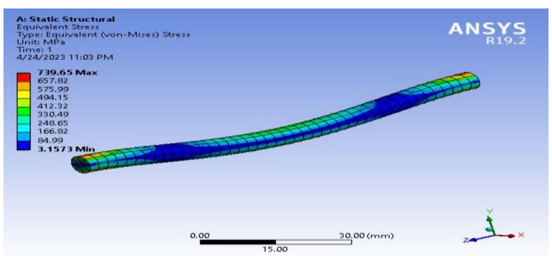
Fatigue analysis for steel rebar model under loading conditions. In order to solve the problem of the project, a detailed finite element analysis is proposed

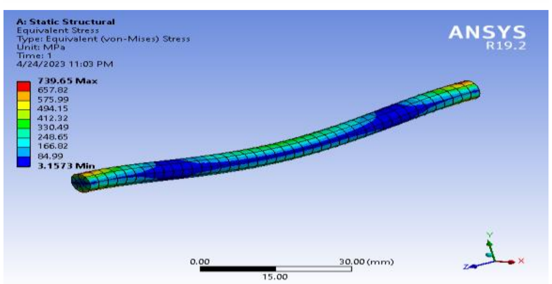
to determine equivalent alternative stress, factor of safety, fatigue life using the analysis software ANSYS WORKBENCH.
The above three analysis are repeated for GFRP rebar.
After analyzing, the two materials are compared.

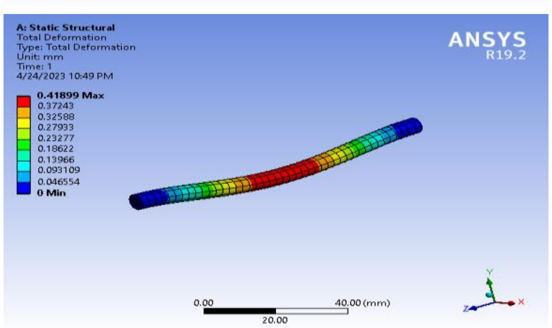
5.RESULTS

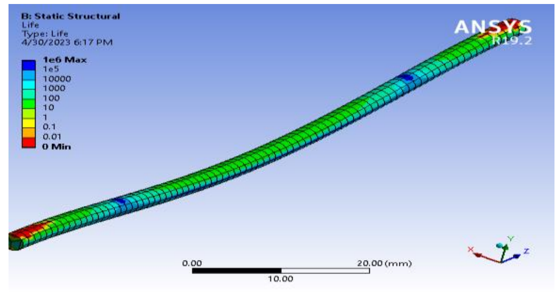


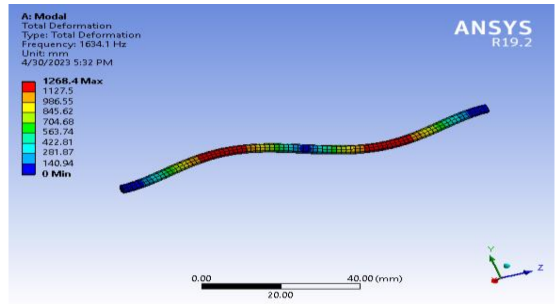


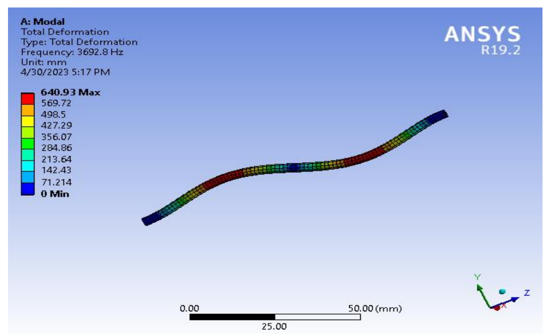


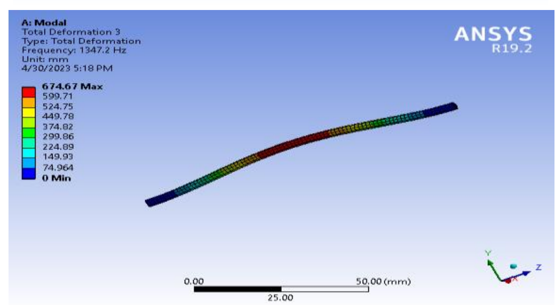












RESULT & Discussions

S.NO	Analysis	Steel Bar	GFPR Bar
1	Deformation (mm)	8.4054	0.14899
2	Stress (MPA)	742.9	739.65

Total Deformation Maximum (mm)	Equivalent Stress (MPa)		Stress Intensity (MPa)	
	Max	Min	Max	Min
8.4	742.9	4.1393	7457.1	6.5793

Static analysis Results for Steel Rebar

Total Deformation Maximum (mm)	Equivalent Stress(MPa)		Stress Intensity (MPa)	
	Max	Min	Max	Min
0.4	739.65	3.1573	7403.2	11.76

		STEEL	GFRP
MASS (Kgs)		0.0055	0.001375
TOTAL DEFORMATION MAXIMUM (MM)		8.4	0.4
EQUIVALENT STRESS (MPa)		742.9	739.65
STRESS INTENSITY (MPa)		7457.1	7403.2
LIFE IN CYCLES	MAX	1e6	1e8

Comparision of results of Steel and GFRP Rebars

6.CONCLUSION

- For construction, The construction should be solid and requires good material that fulfills the GFRP Rebar completely. This rebar went through so many processes and was tested at various levels, and then after, it will be used in construction.
- Physical, mechanical and durability properties of GFRP bars were evaluated and results compared with provisions of most recent guidelines.
- In conclusion, Glass Fiber Reinforced Polymer (GFRP) bars are a promising alternative to traditional steel reinforcement bars (rebars) in construction applications. GFRP bars offer several advantages over steel rebars, including corrosion resistance, high strength, lightweight, non-magnetic properties, and environmental sustainability.
- The use of GFRP bars can result in longer service life and lower maintenance costs for concrete structures, faster construction times, and lower labor costs due to their lightweight properties, and a reduced carbon footprint due to their recyclable materials.
- While there are still some challenges to overcome, such as higher upfront costs and potential durability concerns in some applications, the future scope of GFRP bars looks promising.

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