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Mechanical Characterization and Comparison of Glass Fibre (GFRP) and Glass Fibre Reinforced with Aluminium Alloy (GFRAA)

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***Abstract*:**
Fibre metal laminates (FML's) are good candidates for advanced aerospace structural applications and also in automotive applications due to their high specific mechanical properties especially fatigue resistance. The most crucial factor in manufacturing of these laminates is the adhesive bonding between aluminium and FRP layers. In this study, firstly the laminate specimens were designed in CATIA as per ASTM standards and analysed in ANSYS software. It was observed that glass fibre with aluminium alloy has less deformation strength compared to glass fibre reinforced polymer laminates. Then, after several glass-fibre reinforced aluminium laminates with different bonding adhesion were manufactured. Mechanical Tests like Tensile, Compression and Impact tests were carried out based on ASTM standard were then conducted to study the effects of interfacial adhesive bonding on impact behaviour of these laminates. It was observed that the damage size is greater in laminates with poor interfacial adhesion compared to that of laminates with strong adhesion between aluminium and glass layers. In addition, FMLs of with good adhesion bonding show better resistance under low velocity impact and their corresponding contact forces are about 25% higher than that of specimens with a weak bonding. Moreover, maximum central deflections in laminates with strong bonding are about 30% lower than that of FMLs with poor adhesion.

1. INTRODUCTION ABOUT COMPOSITE MATERIAL

Basic requirements for the better performance efficiency of an aircraft and in automotive applications are high strength, high stiffness and low weight. The conventional materials such as metals and alloys could satisfy these requirements only to a certain extent. This lead to the need for developing new materials that can whose properties were superior to conventional metals and alloys, were developed.

A composite is a structural material which consists of two or more constituents combined at a macroscopic level. The constituents of a composite material are a continuous phase called matrix and a discontinuous phase called reinforcement.

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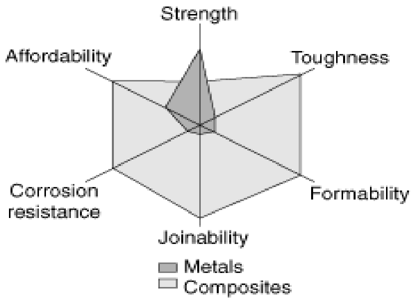

Figure 1. Primary Material Selection Parameter for A Hypothetical Situation for Metal and Composite

2. INTRODUCTION ABOUT REINFORCEMENT AND MATRIX

Reinforcement is a process or action of strengthening the materials. Reinforcement provides strength and stiffness and controls thermal expansion co-efficient. It also helps to achieve directional properties. Reinforcements may be in the form of fibres, particles or flakes. The fibre factors which contribute to the mechanical performance of a composite are length, orientation, shape and material.

3. LITERATURE SURVEY

The purpose of this literature review is to provide background information on the issues to be considered in this thesis and to emphasize the relevance of the present study. This literature survey is carried out as a part of the thesis work to have an overview of the production process, properties and behaviour of glass fiber composites.

Po-ChingYeh, The bearing properties of recently developed hybrid fiber/metal laminates, or Commingled Boron/glass fiber Reinforced Aluminium laminates (COBRA), are investigated in this study. Luca Caracogli, This study is conceived as the second part of an experimental analysis and focused on the performance of tapered highway light poles under dynamic excitation. Francesco Ascione, This paper deals with an experimental investigation on the bearing failure load of glass fibre/epoxy (GFRP) laminates. The effects of fibre-to-load inclination angle and laminate stacking sequence on the bearing load capacity have been determined experimentally on two different type of laminates: unidirectional and bi-directional (cross-ply). G.S. Langdon, Previous work on the blast response of aluminium/glass–fibre reinforced polypropylene fibre–metal laminates (FMLs) presented observations and quantitative analysis on panels of varying thickness and stacking configuration. Shengqing Zhu, In this contribution, the impact dynamic response and failure modes of fibre–metal laminated panels subjected to low velocity impact were investigated and presented. JoakimSchön, In bolted joints, a large part of the load is transferred by friction. The objective of this investigation is to measure the coefficient of friction for carbon fiber epoxy matrix composite, HTA-6376, in contact with aluminium, 3637-77, in reciprocal sliding. Thuc P. Vo, A parametric study has been undertaken to investigate the influence of the properties of the aluminium alloy on the blast response of fibre–metal laminates (FMLs).

4. METHODOLOGY

The specimens were designed in CATIA software according to the ASTM (American Society of Testing and Materials) standards. Then, after specimens were analysed in ANSYS software for checking the strengths of Tensile, Compression and Impact. In ANSYS, the material Glass fiber and Glass fiber with Aluminium is applied to the specimens before checking out the results. The results were compared with and without aluminium alloy. The results obtained by Design and Analysis were Engineering results.

This chapter describes the materials and methods used for the processing of the composites under this investigation. It presents the details of the characterization and tests which the composite samples are subjected to.

GFRP LAMINATE
In this laminate,
REINFORCEMENT - Glass Fiber Reinforcement Plastic (bi-directional type)
E-glass.
MATRIX- Epoxy.
Correct ratio of resin and hardener is 10:1
Resin: LY556 Hardener: HY951
GFRAA LAMINATE
In this laminate,
REINFORCEMENT - Glass Fiber Reinforcement Plastic (bi-directional type)& Aluminium Alloy
E-glass.
MATRIX- Epoxy.
ADDITIVE AGENT –Aluminium Powder
Correct ratio of resin and hardener is 10:1 and Aluminium powder is half of that of Hardener 0.5gms.
Resin: LY556 Hardener: HY951Additive agent: Aluminium Alloy


Figure2. GFRP MAT

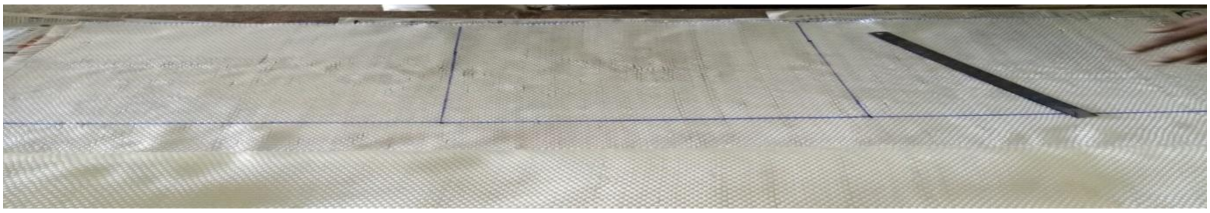
Figure 3.GFRP MAT IS MARKED ACCORDING TO REQUIRED DIMENSIONS 300x300MM

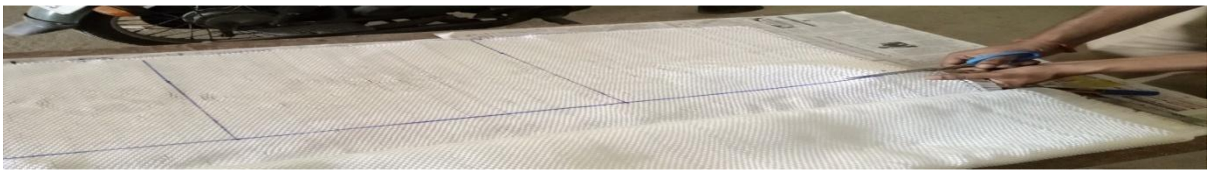
Figure 4.GFRP MAT IS CUTTED INTO LAYERS AS PER MARKED DIMENSION


Figure 5. GFRP LAYER AFTER CUTTING

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For proper mixing of Epoxy resin and Hardener, we have taken the ratio of 10:1 of Resin and Hardener of grades LY556 and HY957. The Epoxy resin grade LY556 and Hardener HY957 make the layers perfectly set after curing period. The ratio of 10 :1 is, if we use 10ml of epoxy resin we should use 1ml of hardener to mix it with because the hardener has more corrosive property and it will make the mixture in solid form within less mins. The ratio helps us in applying it to the layers for 20 mins without changing into solid form.

Figure 6. EPOXY RESIN LY556

Figure 7. HARDENER HY957

Firstly, we take a laminating wax cover, we should apply wax and then apply epoxy mixed with hardener solution on the wax cover and put the previously prepared GFRP layer on to the cover. Then, apply the solution on it and put the second layer on it. Repeat the steps for the seven layers. Then again cover it with the laminating cover applied with the solution. The laminate has been done under 22degree Centigrade room temperature. Apply dead weights on the laminated layers of GFRP and leave it for 48 hours for curing period i.e., for perfectly setting up of layers.

Figure 8. RELEASING AGENT-WAX

Do it the same process for GFRAA layers too. The small difference is for GFRP layers, we have just used epoxy resin and hardener but for GFRAA we add Aluminium powder also to the solution. The Aluminium powder ratio should be

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half of Hardener solution i.e., 5gms. Because more amount of Aluminium powder also De-laminate the layer and adding small amount also cannot give much strength to laminated layer.

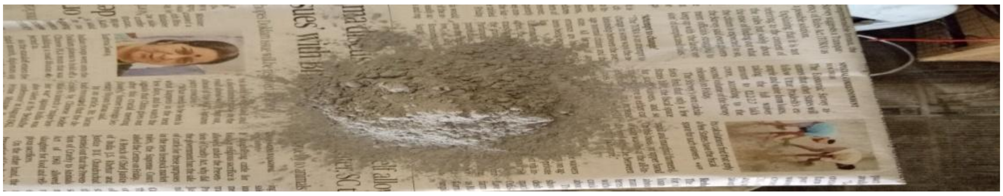


Figure 9. ALUMINIUM POWDER

And most important thing is we should continuously stir the solution, otherwise it gets tight and convert into solid form because of the hardener corrosive property. Then, put dead weights on the laminated layers of GFRAA and leave it for 48 hours for curing period.

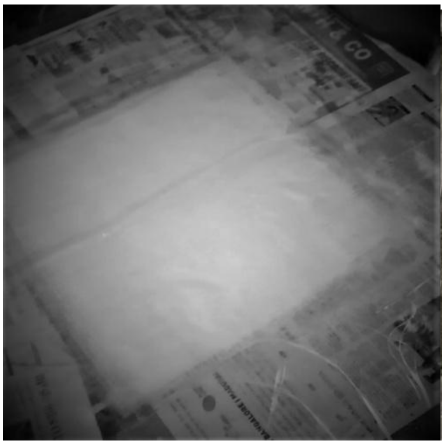


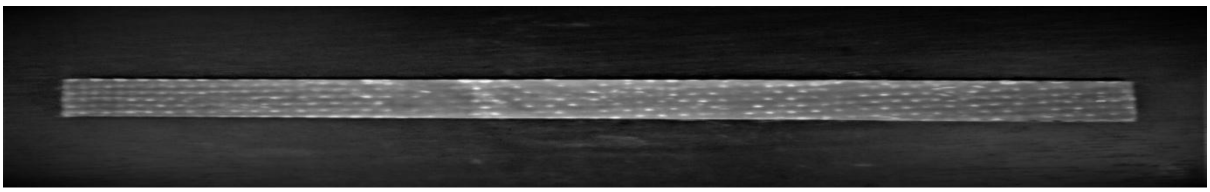
Figure 10.GFRP LAMINATE

Figure 11. GFRAA LAMINATE

After the curing period of 48 hrs, the specimens are prepared according to the dimensions by cutting the layers of GFRP and GFRAA.

3.5 LAMINATED SPECIMENS

LAMINATED SPECIMEN OF GFRP FOR TENSILE AND COMPRESSION TEST 250 X 25 MM



LAMINATED SPECIMEN OF GFRAA FOR TENSILE AND COMPRESSION TEST250 X 25 MM

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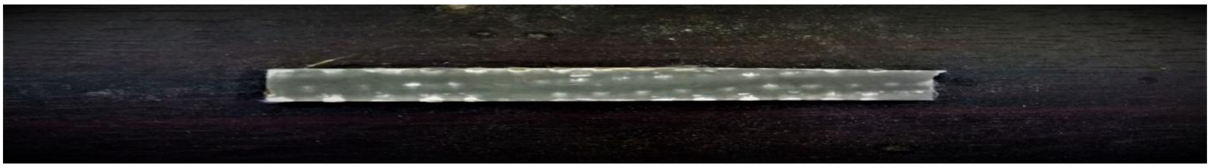
LAMINATED SPECIMEN OF GFRP FOR IMPACT TEST 80 X 10 MM



LAMINATED SPECIMEN OF GFRAA FOR IMPACT TEST 80 X 10 MM

5. MECHANICAL TESTING

5.1 TENSILE TEST

Tensile testing, also known as tension testing, is a fundamental materials science and engineering test in which a sample is subjected to a controlled tension until failure.Tensileload applied to a composite. The response of a composite to tensile loads is very dependent on the tensile stiffness and strength properties of the reinforcement fibres, since these are far higher than the resin system on its own.

Test was carried out with the help of UTM(Universal Testing Machine)

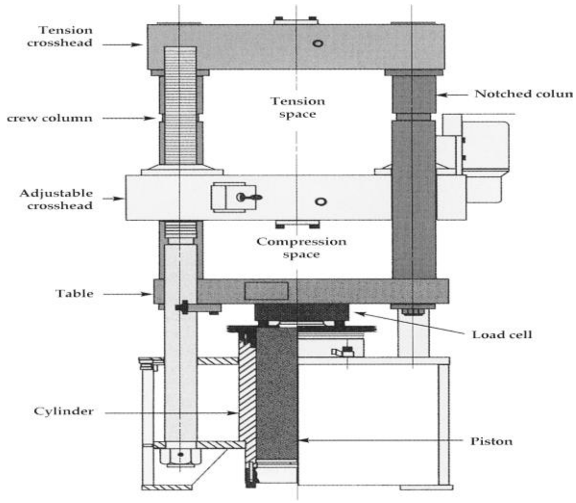


Figure12. Universal Testing Machine

This test is of static type i.e. the load is increased comparatively slowly from zero to a certain value. Standard specimens are used for the tension test. There are two types of standard specimen are which are generally used for this purpose, which have been shown below:

GFRP SPECIMEN BEFORE TESTING

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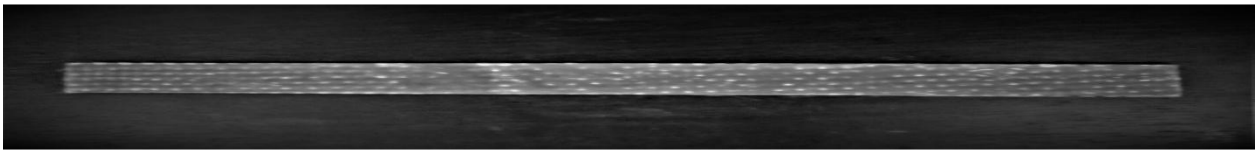
GFRP SPECIMEN AFTER TESTING



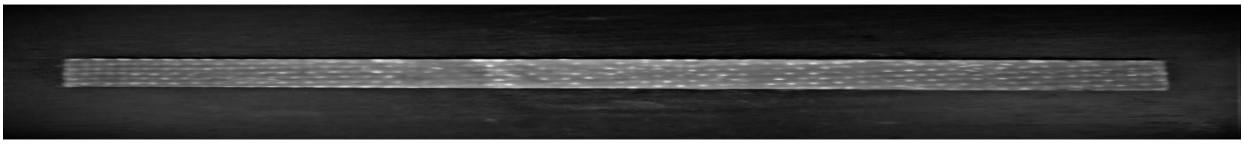
GFRAA SPECIMEN BESFORE TESTING

GFRAA SPECIMEN AFTER TESTING

5.2 COMPRESSION TEST (FLEXURE)

GFRP SPECIMEN BEFORE TESTING

GFRP SPECIMEN AFTER TESTING



GFRAA SPECIMEN BEFORE TESTING

GFRAA SPECIMEN AFTER TESTING

5.3 CHARPY IMACT TEST

The Charpy impact test, also known as the Charpy V-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. This

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absorbed energy is a measure of a given material's notch toughness and acts as a tool to study temperature-dependent ductile-brittle transition.


GFRP SPECIMEN BEFORE TESTING


GFRP SPECIMEN AFTER TESTING


GFRAA SPECIMEN BEFORE TESTING

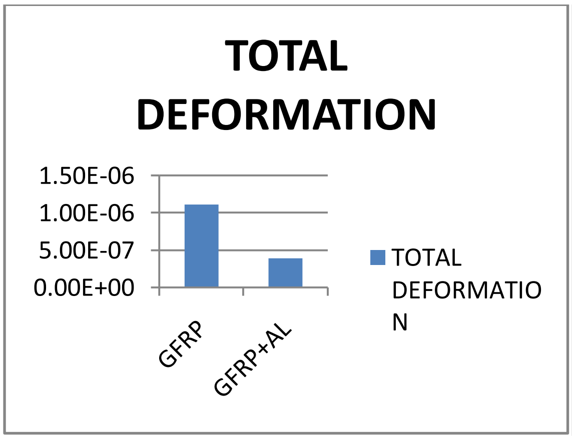

GFRAA SPECIMEN AFTER TESTING

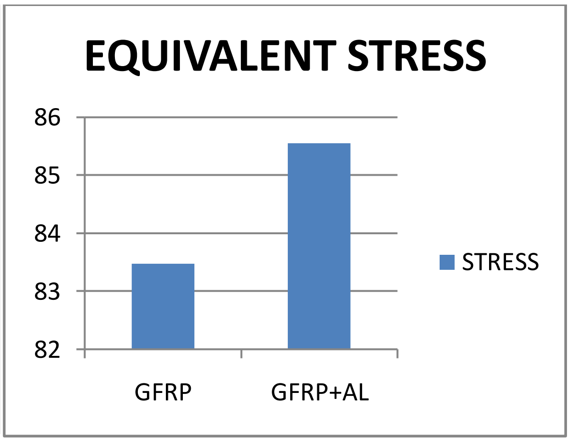
6. RESULTS AND DISCUSSIONS

6.1 COMPARISON OF RESULTS

6.1 Engineering Analysis Tensile Results

Composite Material	Total Deformation	Equivalent Stress	Equivalent Elastic Strain
GFRP	1.11E-6	83.472	5.56E-09
GFRP+AL	3.96E-7	85.547	2.04E-09





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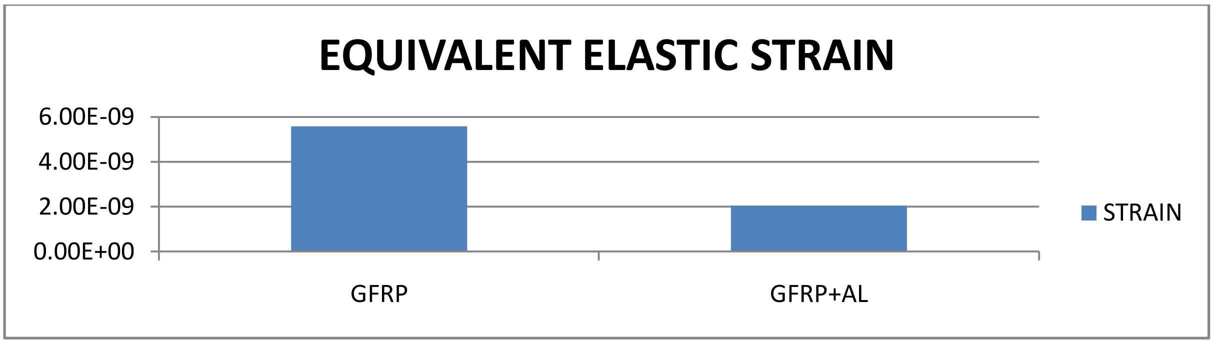
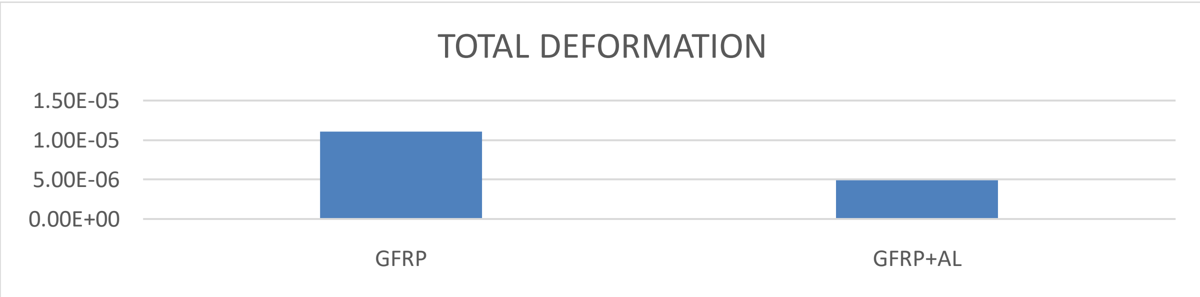
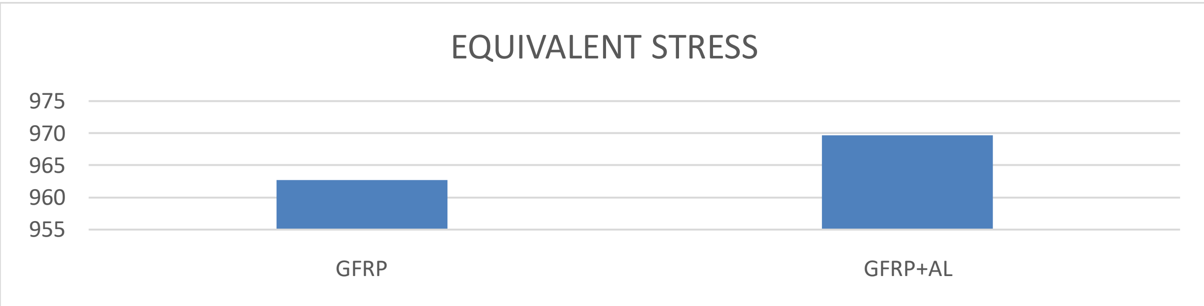
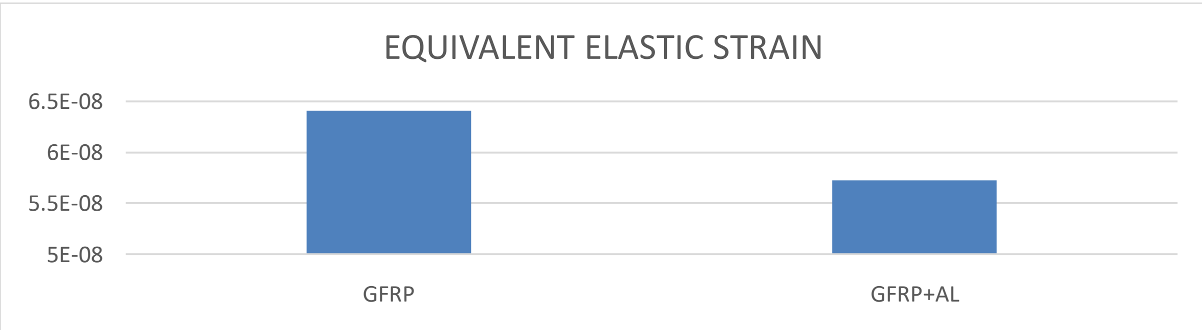


6.2 Engineering Analysis Compression Results

Composite Material	Total Deformation	Equivalent Stress	Equivalent Elastic Strain
GFRP	1.11E-5	962.67	6.41E-8
GFRP+AL	4.95E-6	969.7	5.73E-8

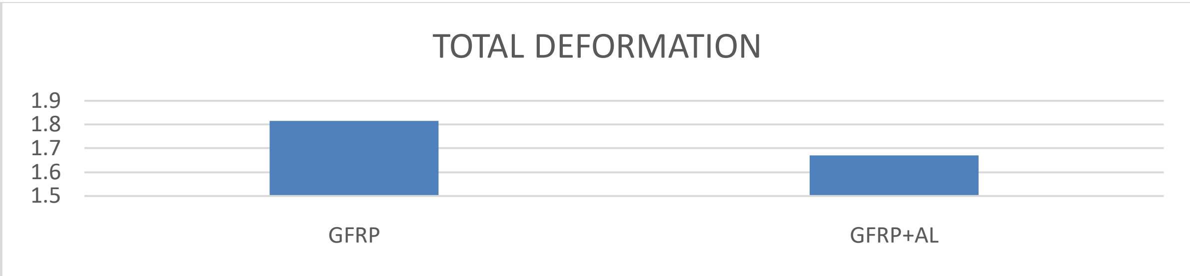


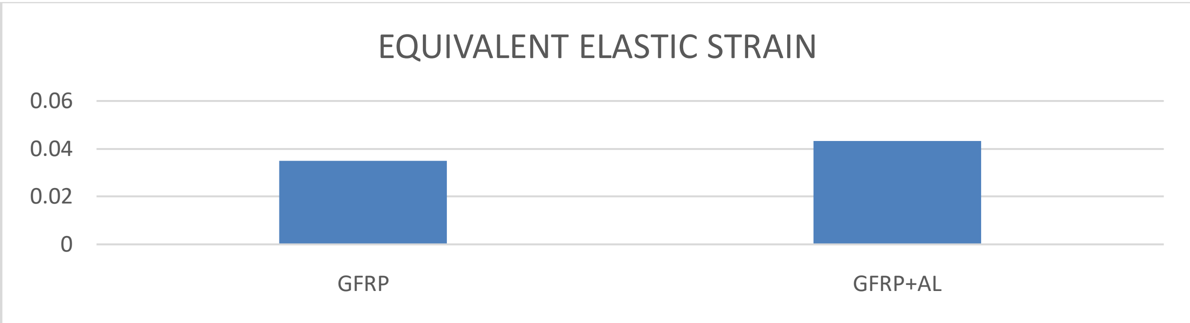




6.3 Engineering Analysis Impact Results

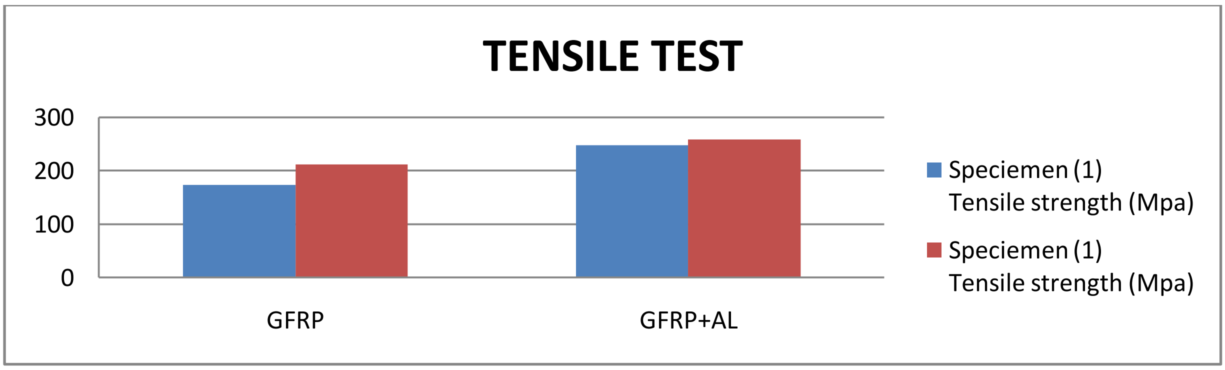
Composite Material	Total Deformation	Equivalent Stress	Equivalent Elastic Strain
GFRP	1.8171		0.03511
GFRP+AL	1.6706	1820.8	0.0433





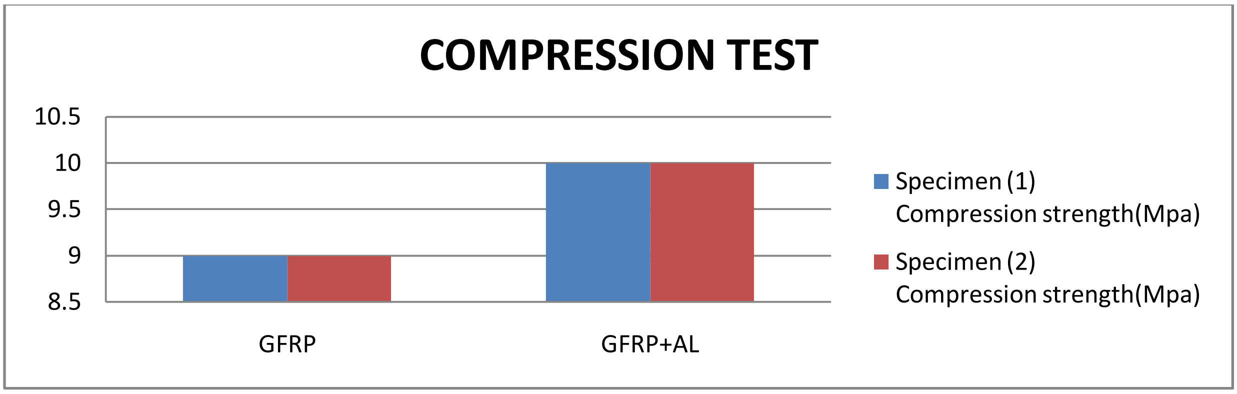
6.4 Experimental Tensile Results

TEST PARAMETERS	GFRP	GFRP + AL
Specimen (ID-1) Tensile Strength	173	248
Specimen (ID-2) Tensile Strength	212	258



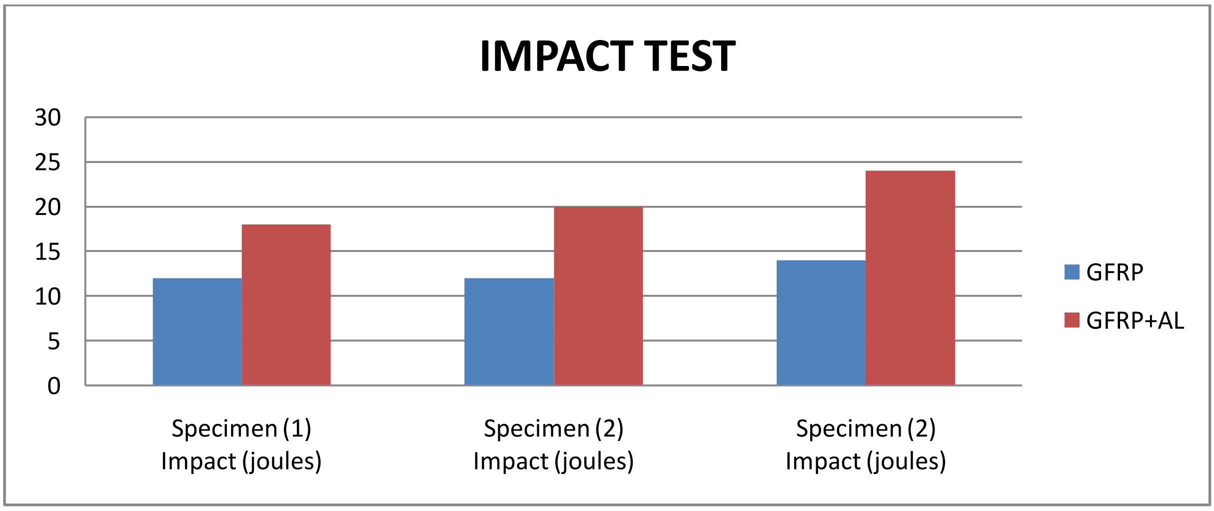
6.5 Experimental Compression Results

TEST PARAMETERS	GFRP	GFRP + AL
Specimen (1) Compression Strength	9	10
Specimen (2) Compression Strength	9	10



6.6 Experimental Impact Results

TEST PARAMETERS	GFRP	GFRP + AL
Specimen (1) Impact Strength (Joules)	12	18
Specimen (2) Impact Strength (Joules)	12	20
Specimen (3) Impact Strength (Joules)	14	24



7. FUTURE SCOPE

In this regard the laminate will prepare according to study the thermal characterization and mechanical characterization. FMLs consist of metallic alloy and fibre reinforced prepreg. Mostly commercially available GLARE, ARALL and CARALL consist various aluminium alloys. Many researches have been trying to use possible metallic alloys such as magnesium, titanium, etc. instead of aluminium alloys. It is expected that this diversity gives optimum mechanical properties. Same efforts have been examined for engineering polymeric materials to replace fibre reinforced prepreg.

8. CONCLUSION

- The Design and Analysis of a specimens GFRP and GFRAA shows that GFRAA has more strengths compared to GFRP.
- GFRAA has less deformation, less strain compared to GFRP.
- The analysis of specimens shows that, there will be more Ductility in GFRAA compared to GFRP i.e. it shows that Aluminium Alloy Decreases Brittleness of material.
- By comparing Laminated specimens results also, we find that the tensile and impact strength of the glass fiber with Al is higher than the glass fiber alone. This will affect in the application like automobile, aeronautical and marine structures.
- In the flexural strength of will not be increased during the reinforced the al with glass fiber, but during the testing the glass fiber with al specimen was not broken which cause the bending only. So that the elastic property (ductile nature) will be high when compared to that of glass fiber alone.
- Also conclude that, even when increases the strength also will not affect on the actual weight and cost of the laminate since that al is lighter and cheaper.

9. REFERENCES

1. H.S.Park,X.P.Dang, A.Roderburg, “Development of Plastic Front Panels ofGreen Cars” CIRPJournal of Manufacturing & Technologyvol 26 Pages 35-53.
2. Kuziak.R.Kawalla,R.waengler.s. “Advanced high strength materials for automotiveindustry A review” Journal of Archives of Civil & Mechanical engineeringvolume 8 issue2, 2008-12-30,Pages 103-117.
3. Falaichen, Bert Juttler,“Geometric Modelling& Processing”, Journal on CAD, volume 42 issue1 pages1-15.
4. David H. Allen “Structural Analysis, Aerospace” Journal on Encyclopaedia of Physical science and technology 3rd edition 2003.
5. Japan.s.Daniel.L. and Theodor.k.2005. “Finite Element Analysis of Beams”, Journal of Impact engg.Vol31, Pages 861-876., Pages155-173.
6. OLBISIolagoke (1997) “Hand book of ThermosPlastics”, MarcelDekker, New York.
7. Dominick v. rosato, “Plastics Engineering”, Manufacturing & Data Hand Book.
8. Donald v.Rosato, “Plastics Engineering”,Manufacturing& Data Hand Book.