

# Damping behaviour of Hybrid Aluminium-Glass Fiber Reinforced Microfiller Plastic Laminates

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**ABSTRACT:** Aluminium-Glass Fiber Reinforced Plastic laminates nowadays are being increasingly used in aerospace structures due to their high strength to weight ratio. In this research an attempt has been made to study the damping behavior of Aluminium-Glass Fiber Reinforced Plastic hybrid laminates at different impact velocities by introducing a small percentage of flyash as a micro filler material in the epoxy resin system. It is observed that the damping factor determined by drop weight method increases with the addition of micro filler for a constant impact velocity and that the damping property is higher at higher impact velocities. The damping factor increases at a faster rate upto 6% of fly ash loading and thereafter for higher additions it increases only marginally.

**KEYWORDS:** Microfiller, Flyash, Damping, Impact.

## I. INTRODUCTION

Aluminium-Glass Fiber Reinforced Plastic laminates consist of glass fiber reinforced plastic bonded to thin aluminium sheets on either side. These panels have the good properties of both the metal and fiber [1]. The good characteristics of aluminium such as ductility, specific stiffness and impact and damage tolerances together with the benefit of fiber reinforced plastic such as high specific strength, good corrosion and fatigue resistances are obtained. These hybrid laminates are used to partly substitute monolithic aluminium resulting in weight savings without much compromise to the strength to weight ratio. More specifically, such sandwich panels find application in tension dominated structural components where a small savings in weight results in a large savings in fuel cost as in aerospace and automobile structure [2]. One of the important safety issues concerned with these hybrid laminates is the impact performance/resistance. This is because, when such hybrid laminates are used in aerospace/automobile structures, they frequently experience damages due to impact sources like dropped tools during maintenance, runway debris, collisions between service cars or cargos and the structure, hails and bird hits, tyre shrapnel from tread separation and tyre ruptures [3]. Parameters that control the impact properties of this hybrid system are the thickness of layers, fiber volume fraction, constituent materials of FRP, fiber orientation, bonding material, and impact velocity/energy.

In the layup of Aluminium-Glass Fiber Reinforced Plastic laminates, there may be any number of aluminium and FRP layers, but the ratio between the number of aluminium and FRP layers should be  $(n+1)/n$  where  $n$  is the number of FRP layers [4] so that the outer most layer is aluminium on both sides.

## II. RELATED WORK

Many studies have been made on metal-FRP hybrid laminates with respect to parameters such as the thickness of metal layer, type of fiber in the FRP, orientation of fiber, thickness of FRP layers and fiber volume fraction in the FRP, that influence the mechanical properties of the hybrid laminates. A.Vlot [5] performed low and high velocity impact on aluminium – glass fiber epoxy laminates, aluminium- aramid fiber epoxy laminates and aluminium – carbon fiber epoxy laminates. He has shown that the energy required to create the first crack in the outer aluminium layer on the non impacted side was more in case of hybrid laminates with glass fiber than that of carbon and aramid fibers. The glass

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fiber hybrid laminate was found to exhibit a fiber or aluminium critical failure mode. The dent depth of the hybrid laminate was found to be more or less equal to that of monolithic aluminium alloy and the damage area after impact was found to be considerably lower than plain GFRP/CFRP laminates. The tensile strength of aluminium glass fiber hybrid laminates increased with increasing strain rate due to strain rate dependent behavior of glass fiber. The fiber matrix adhesion and its effects on the impact behavior of carbon fiber reinforced aluminium laminates was studied by G. D. Lawcock et al.[6]. They performed quasi static, low velocity and high velocity impact tests. They found that laminates with weaker fiber/matrix adhesion had larger damage zones even though the back face crack length and permanent indentation after impact were smaller for a given impact energy. Residual tensile strength after impact was found to be higher for the untreated fiber laminates due to increase in fiber/matrix splitting in the composite layer. S. H. Song et al.[7] investigated about the impact performance of carbon reinforced aluminium hybrid laminates, both experimentally and numerically. They observed that the specimen impacted by 2.35 J energy showed no critical damage and also absorbed 64% of the impact energy and that the specimen impacted by 9.40 J showed fiber and matrix failures in CFRP layers and a shear crack on the aluminium layer with absorption of 83% of the impact energy. Thus they found that the specimen impacted by 2.35 J showed less failure mechanism. F. Ashenai Ghasemi et al. [8] studied about the impact performance of Aluminium/Steel and Glass/Carbon fiber epoxy hybrid laminates under low velocity impact. They found that factors such as layer sequence of metal layers, material type of metal layers and composite medium, the  $E_{11}/E_{22}$  ratio of composite medium were very significant in affecting the dynamic behavior of the impacted laminates. G. S. Langdon and L. A. Rowe [9] carried out blast loading tests on Steel/Aluminium alloy-GFRP hybrid laminates. They showed that the blast loaded laminates exhibited large inelastic deformation and debonding failure of the steel-composite interface similar to that of Aluminium-GFRP panels. They also found that the non dimensional displacement of Steel-GFRP panels were lower than that of Aluminium-GFRP panels. S. Mckown et al. [10] investigated on the scaling effects of Aluminium alloy-polypropylene hybrid laminates. They found that the laminates had no significant scaling effects with respect to the tensile and flexural properties but the impact force and damage threshold energy obeyed scaling law. Although many studies have been carried out on hybrid metal fiber laminates, published information is very limited on the influence of adhesives used for bonding the fiber composite with the metal layer on the impact properties.

In this research an attempt has been made to increase the damping behavior of Aluminium-Glass Fiber Reinforced Plastic hybrid laminates by introducing a small percentage of fly ash material in the epoxy resin system.

### III. EXPERIMENTAL

The materials used in the fabrication of the test specimens were:

1. Aluminium alloy sheets – AA 1050 H 14;
2. E-glass fiber reinforced in epoxy resin
3. Epoxy resin as adhesive.(LY 556 and HY 951)
4. Fly ash of size 45 micro meter. ( $\text{SiO}_2$  – 42%,  $\text{Al}_2\text{O}_3$ -26%,  $\text{Fe}_2\text{O}_3$ -7%,  $\text{CaO}$ -12%)

Square specimens of size 300 × 300 mm were made. The thickness of aluminium sheet in the outer layers are 0.4mm and the thickness of GFRP layer is 1.7mm resulting in a metal thickness fraction of 0.32. The volume fraction of fiber in the GFRP layer is kept at 35%. The specimen was made by hand layup method. An acrylic mold, as per specimen shape was made. The surface of aluminium is cleaned by using acetone. The aluminium sheet was kept in the mold. Fly ash with resin is mixed by mechanical shear mixing for one hour in ambient temperature and this is followed by sonication for four hours. Then the hardener is mixed and stirred for 20 minutes. This mixture is applied over the aluminum surface. Unidirectional E-glass fibers were placed in the mixture. Finally outer aluminium sheet was placed and the mold cavity was closed by wax coated acrylic sheet. This setup was left curing for six hours at room temperature. Specimens with different weight percentage of fly ash in the resin were made by varying the percentage of fly ash in the epoxy resin system. The specimens were tested for their damping properties.

The number of specimens tested for each type of hybrid laminate is 3 and for each testing condition is also 3. All the specimens were tested in an instrumented drop weight impact testing machine under low velocity (< 11m/s). The

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specimens were clamped horizontally on all sides in a fixture. The steel indenter used to impact the specimens was of sharp nose shape. The total impactor mass was 4.91 kg. The velocity of impact was kept at 3.2 and 4.1 m/s. The pneumatic actuator in the machine prevents the indenter from multiple strikes due to rebounding after the first impact. An accelerometer is fixed underside of the specimen and connected to dynamic signal analyzer for measuring the amplitude- time response using labview. The damping factor of the laminate for a particular impact velocity is calculated by logarithmic decrement method. The damping factor  $\zeta$  by this method is given by the relation  $\zeta = \delta / (4\pi^2 + \delta^2)^{1/2}$  where  $\delta$ , the amplitude reduction factor is given by  $\delta = [1/n] [\ln (x/x_{n+1})]$ . For  $n=1$ ,  $\delta = \ln (x_1/x_2)$ .

## IV. RESULTS AND DISCUSSIONS

The damping behavior of the Aluminium-Glass Fiber Reinforced Plastic micro filler hybrid laminates for different weight percent flyash loading and different impact velocities is shown in Table I.

Table I Variation of damping factor for different flyash loading and impact velocities.

S.No	Fly ash loading %	Impact Velocity (3.20 m/s)	Impact Velocity (4.10 m/s)
1	0	0.03214	0.03863
2	2	0.04226	0.04726
3	4	0.05349	0.06046
4	6	0.06253	0.07221
5	8	0.06828	0.08042
6	10	0.07236	0.08741

For impact velocity 3.20 m/s and 0% flyash addition, the damping factor is 0.03214. For 10% addition, the damping factor increases to 0.07236 which is about 2.25 times than that of neat epoxy. This indicates that addition of flyash in the hybrid system reduces and controls the vibration. It is also observed that the damping factor for impact velocity 3.20 m/s is less than that of 4.10 m/s. This is because at low velocity of impact the contact time between the impactor and the specimen is more than that of higher velocity of impact and hence most of the energy at low velocity is converted into vibration resulting in low damping factor. For higher velocities, the amount of damping increases due to low contact time and dissipation of more energy for penetration with the remaining energy for vibration in the hybrid laminate.

It is observed that the damping factor increases with the addition of flyash (Figure-1) for both the impact velocities.

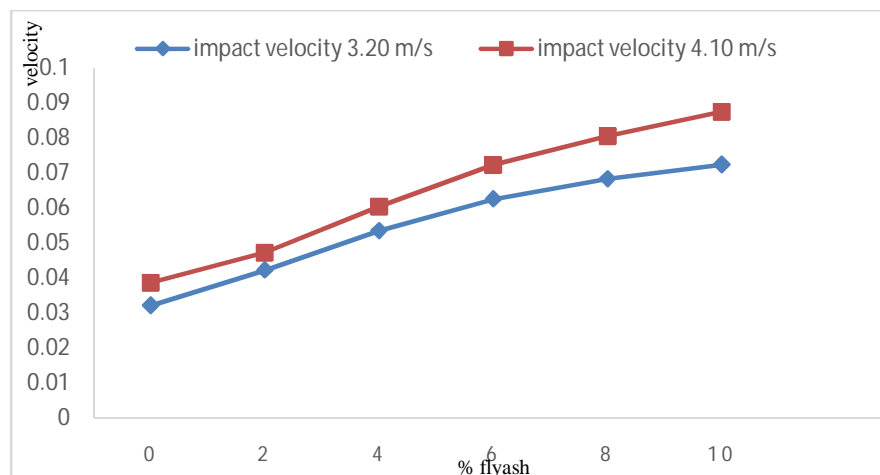


Fig. 1. Variation of damping factor for different flyash loading and impact velocities.

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Further, it is observed that the damping factor increases at a faster rate in the region of 2% to 6% of fly ash loading for both the impact velocities. For higher additions of flyash more than 6% to 10% the damping factor is observed to increase only marginally for the impact velocity 3.20 m/s as well as 4.10 m/s. Hence, it is better if the flyash percentage is limited to 10% by weight in the resin system.

## V. CONCLUSION

Aluminium-Glass Fiber Reinforced Plastic hybrid laminates with small amount of weight percentage of fly ash micro filler in the resin system were successfully prepared and the effect of addition of these particles in different weight percentage in the hybrid system on the damping behavior of the laminates at two different impact velocities was studied. It is observed that increasing the percentage of micro filler in the system increases the damping property of the hybrid laminates. The damping factor is found to be higher at higher impact velocities. It is also found that the damping factor increases drastically upto 6% clay loading and thereafter for higher additions it increases only marginally.

## REFERENCES

- [1] Vogelesang LB and Vlot A, "Development of fiber metal laminates for advanced aerospace structures", Journal of Material processing Technology, vol 103, pp.1-5,2000.
- [2] Asundi A. and Choi AYN, "Fiber Metal Laminates: An Advanced Material for Future Aircraft", Journal of Material Processing Technology, vol63, pp.384-394. 1997.
- [3] Wu G, "Mechanical behaviour of GLARE laminates for Aircraft Structures", JOM Journal of Minerals, Metals and Material Society, vol 57,pp.72-79, 2005.
- [4] Sinke J, "Manufacturing of GLARE parts and structures", Applied composite materials, vol 10, pp. 293-305,2003.
- [5] Vlot A, "Impact loading on Fiber Metal Laminates", International Journal of Impact Engineering, vol 18, pp. 291-307,1996.
- [6] Lawcock GD, Ye L, Mai Y-W and Sun C-T, "Effects of Fiber/ Matrix adhesion on carbon-fiber-reinforced metal laminates – II. Impact Behaviour" Composites Science and Technology ,vol 57, pp. 1621-1628, 1997.
- [7] Song SH, Byun YS, Ku TW, Song WJ, Kim J and Kang BS, "Experimental and Numerical Investigation on Impact performance of Carbon Reinforced Aluminium Laminates", Journal of Material Science and Technology, vol 26, pp. 327-332, 2010.
- [8] Ghasemi FA, Payeganeh G and Mlaekzadehfard K,"A Study on Modelling and Simulation of Dynamic behavior of Fiber Metal Laminates under Low Velocity Impact", Proceedings of the Modelling, Identification and Control, Innsbruck, Austria. IASTED, 2010.
- [9] Langdon GS and Rowe LA, "Blast loading of fibre-metal laminates: preliminary tests", Proceedings of the ICE. Engineering and Computational mechanics, vol164, pp. 139-146, 2011.
- [10] Mckown S, Cantwell WJ and Jones N,"Investigation of Scaling Effects in Fiber-Metal Laminates",Journal of Composite Materials, vol 42, pp. 865-888, 2008.