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Fabrication and Characterization of Steel Wire Embeded Gfrp Composites

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ABSTRACT

The aim of this study is to examine the effect of the impact performance on a bidirectional glass fibre/steel wire embedded laminates and to investigate the ability of the steel wire through thickness reinforcement to improve the delamination resistance of laminates. Laminates with lay-ups [90/0/0/90], of steel wire placing at ¼ th& ¾ th thickness with 3, 5& 7mm pitch distances have been fabricated and drop weight impact tests were conducted with different drop height (400 mm, 500 mm and 600 mm). From the experiment conducted, peak energy damage force, total energy and damage area were found for both plain GFRP and steel wire embedded GFRP specimens. From the obtained results it is found that the delamination and the damage area are reduced due to the inclusion of steel wire in the laminates at various thickness level.

KEY WORDS: Fabrication, embeded, steel.

1. INTRODUCTION

Amin Ajdari (2011), investigate the crushing behavior and energy absorption of honeycombs made of a linear elastic-perfectly plastic material with constant and functionally graded density were studied using finite element simulation, results provide new insight into the behavior of engineered and biological cellular materials, and could be used in development of a new class of energy absorbent cellular structures, Serge Abrate (2014), investigate the composite structures in contact with water are subjected to impacts by projectiles large and small, while the presence of water is known to affect the dynamics of immersed structures, its effects on the impact dynamics is unclear, Borrelli (2011),was conducted drop tests on water on semi-cylindrical composite structures, The objectives of such test campaign were to improve the knowledge about the water impact behavior of composite structures and to build an experimental database to support the validation of reliable simulation tools to be used during the design and certification process of aircrafts, Florian Pascal (2013), investigate the study of oblique medium velocity impacts (~70m/s) on the lower surface of helicopter blades is assimilated to a composite sandwich panel with a thin woven composite skin stabilized with a foam core, This modelling is accurate enough to be used to analyze the damage mechanisms of woven composite laminates during medium velocity impacts, Saghafi (2013), study the influence of the curvature type (convex or concave) and preloading on impact response of curved laminates is considered results show that the effect of preloading on damaged area of concave laminates is lower than for convex ones, Pietro Russo (2014), analyses the response of film-stacked composite laminate plates subjected to falling weight impact tests, recycled polyolefin show lower impact parameters with respect to the latter ones even if a partial improvement of the performances can be obtained by modification of the matrix by an adequate coupling agent, Lukasz Pieczonka (2014), study on impact damage detection in light composite sandwich panels in three different nondestructive testing methods, the c-scan was the most time consuming and required the immersion of the panel in water during testing, Antonucci (2014), was to investigate the response of laminates fabricated by a new vacuum assisted technology, labelled as "pulse infusion", under dynamic loads and the residual strength was evaluated, Rajesh (2014), involves the fabrication of epoxy and polyester resin composites using aluminum oxide, silicon carbide with different proportion of Al_2O_3 and SiC along with GFRP the epoxy resin shows higher strength as compared to composites with polyester resin.

Figure.1. Falling Weight

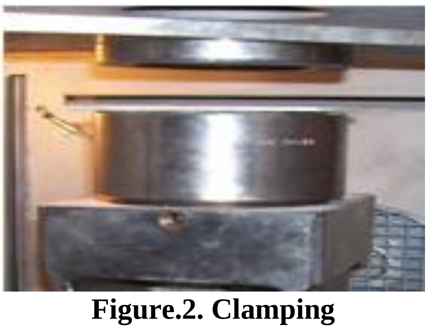

Figure.2. Clamping

Material: Specimens were manufactured from four layers of E-glass woven roving of weight 600 gsm Laminates with lay-ups [90/0/0/90], of steel wire placing at ¼ th& ¾ th thickness with 3, 5& 7mm pitch distances have been fabricated using hand layup process. An epoxy resin LY556 with hardener HY 591was used 1:10 ratio, the panels were cut into specimens of 300 x 300 mm with an average thickness of 3mm.

2. EXPERIMENTAL

The impact test was conducted in a FRACTOVIS PLUS drop weight impact testing machine in aerospace lab, MIT Anna University, Chennai. Fig.1. Shows the constructional details of the drop weight impact testing machine in such a way that the drop tower guides a falling weight towards the center of the specimen, the impactor having hemispherical of 12.7 mm diameter and mass of 10 kg. The clamping fixture of the testing device is designed to permit a pneumatic clamp on the specimen at a pressure of 8 bars. The clamp area is circular. The most common impactor shape used by investigators has been hemispherical. However, a dropped tool on a composite structure during maintenance or the drop of an object from a storey building or bridge on a composite may not always hit the structure with a blunt face of a specific size. Drop weight impact tests were conducted with different drop heights (400 mm, 500 mm and 600 mm).

Figure.3. Drop weight impact test setup

3. RESULTS

Bi directional GFRP having 600gsm four layers [90/0/0/90], of steel wire placing 1/4th& 3/4th of thickness, 3, 5,& 7mm pitch composite plates are impacted by low velocity drop weight impactor of various energy levels and compared with the experimental results.

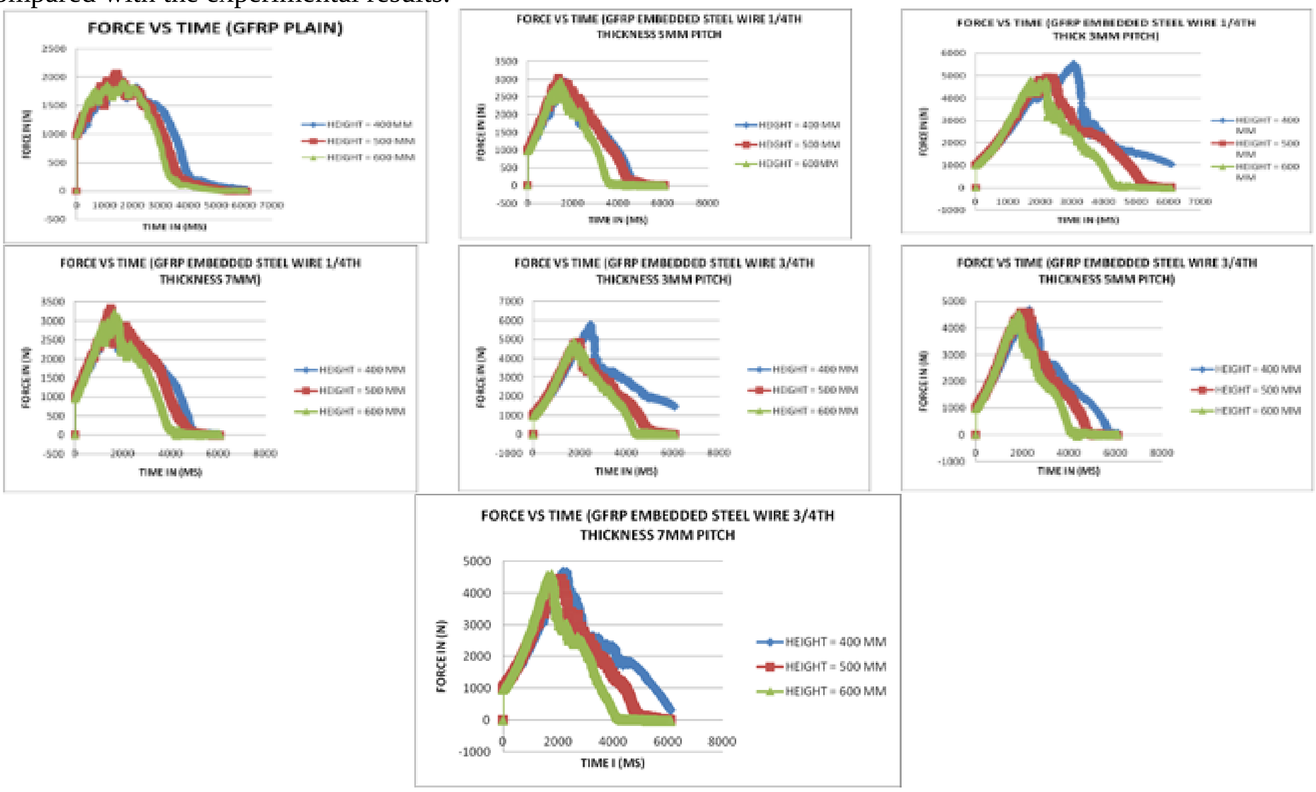

Figure.4. Force vs Time histories for the specimens impacted at various energies

Force vs Time history: The force-time histories obtained by the force transducer for the various energy levels of the impactor. The specimens impacted with the hemispherical impactor at an various heights of 400, 500, and 600mm the visible differences in force time histories, The ¼ th thick 3mm and ¾ th thick 3mm produces a more peak force and contact duration, The ¾ thick 5mm laminate also produces the peak force and contact duration slightly lesser than the above. The laminates of plain GFRP, ¼ th thick 5mm and 7mm, ¾ th thick 7mm having large drops in loads and progressive oscillations were observed. The peak force and contact duration increases based on the pitch density of steel wire and layer thickness above the steel wire, for the steel wire embedded and thickness of the GFRP layer which resulted in the increased the stiffening of the specimen.

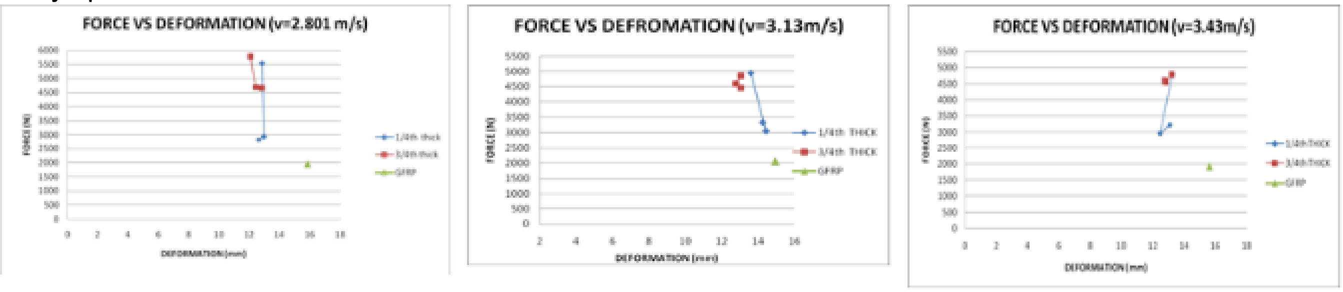

Figure.5. Force vs Deformation curves of GFRP, 1/4th& 3/4th thick steel wire embedded GFRP Laminates to different velocities

Force Vs Deformation: From fig.3.it can be seen that the deformation for without wire GFRP Laminate at any given impact force is lower than Steel wire embedded GFRP laminates. As the impact force the deformation size ,depth of penetration more for without wire GFRP compare with ¼th thick,3mm,5mm,7mm & ¾th thick 3mm,5mm,7mm pitch Steel wire embedded GFRP laminates . For without wire GFRP laminates, damage spread is conical, with the maximum damage on the back surface transverse crack and layer deformation to be found in bottom layer. However, for the ¼th thick 3mm & ¾th thick 3mm & 5mm pitch Steel wire embedded GFRP laminates, the absorbed energy of the laminates to be equal to the absorbed energy propagation of delamination front is arrested at the pitch location and the damage spread through the thickness in cylindrical fashion. The 3/4th thick 3mm,5mm & 7mm pitch Steel wire embedded GFRP laminates can withstand the more force and deformation also lower than comparing ¼th thick 3mm ,5mm & 7mm pitch Steel wire embedded GFRP laminates. The ¼th thick 3mm laminates absorb the more energy and deformation will be low because of more than 4 steel wires are placed inside the laminates it absorbs the energy and withstand the applied force. The ¾th thick 3mm and 4mm laminates absorbs the energy and deformation will be lesser than comparing ¼th thick 3mm pitch because of the two additional GFRP layers can placed over the steel wire , GFRP having strength to resist the applied force.

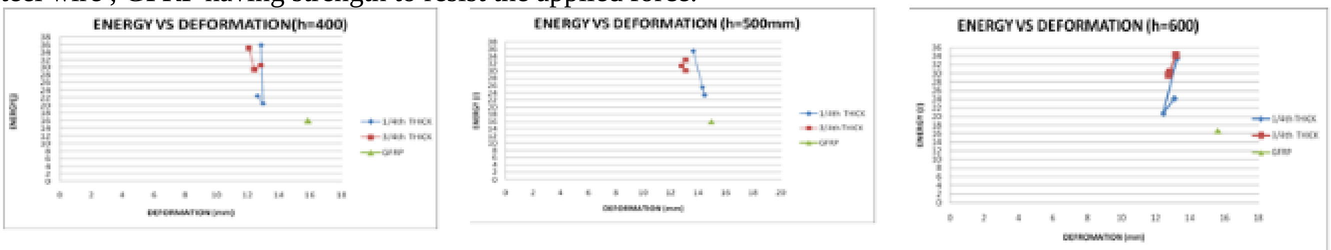

Figure.6. Energy vsDefromation curves of GFRP, ¼ th& ¾ th thick steel wire embedded GFRP laminates to various velocities

The total energy absorbed by the GFRP laminate will be lower than comparing Steel wire embedded GFRP laminates and also applied energy not equal to the absorbed energy. The ¾th thick laminates absorb the energy more than comparing with ¼th pitch laminates and also the deformation value of ¾th thick laminate will be lower than ¼th thick laminate. The without wire GFRP laminate damage completely by a conical impactor, depth of penetration will be more and transverse crack to be in bottom the layer. The ¼th thick 3mm and 3/4 3mm &5 mm are propagation of delamination front is arrested at the pitch location and the damage spread through the thickness in cylindrical fashion. The ¼th, thick 3mm laminates absorb the more energy and deformation will be low because of more than 4 steel wires are placed inside the laminates it absorbs the energy and withstand the applied force. The ¾th 3mm and 5mm laminates absorbs the energy and deformation will be lesser than comparing ¼th thick 3mm pitch because of the two additional GFRP layers can placed over the steel wire, GFRP having strength to resist the applied force.

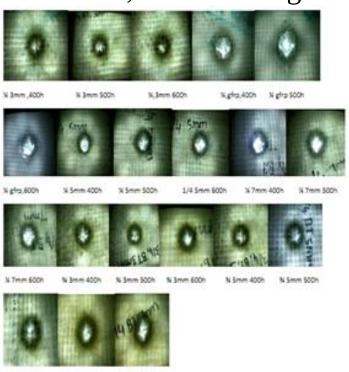

Figure.7. Damage analysis using back light technique

Damage Analysis: The damage patterns of GFRP embedded steel wire specimen having 1/4th& 3/4th thick layer GFRP with 3mm, 5mm & 7mm pitches of steel wire. The ¼th thick layers GFRP 3mm pitch and ¾th thick layers GFRP 3mm and 5mm pitch laminates does not damage completely the propagation of delamination front is arrested at the pitch location and the damage spread through the thickness in cylindrical fashion. The applied energy of the laminate is equal to the absorbed energy. The Depth of penetration will be lower than comparing with other laminates the crack and layer deformation will be lower. The ¼th thick layer GFRP 5mm &7mm pitch and ¾th thick layer GFRP 7mm pitch laminates will deform completely and depth of penetration will be more. The applied energy of the laminate does not equal to absorbed energy. The layer deformation also higher, transverse cracks to be found in bottom layer of the laminate.

4. CONCLUSION

Drop weight impact tests were carried out on GFRP [90/0/0/90], of steel wire placing 1/4th& 3/4th thickness, 3, 5, & 7mm pitches glass/epoxy laminates. The specimens were tested at different drop heights such as 400mm, 500mm, and 600mm. The impact damage area was evaluated by using back lighting technique. The flexural, tensile and izod test also have been reported. The following conclusions were drawn on the impact response of the GFRP without steel wire and steel wire embedded GFRP laminates.

For the above said cases impact force have been evaluated experimentally by drawing a graph between Force vs. Deformation for both GFRP without steel wire and GFRP steel wire embedded laminates from the graph it is found that the peak force of steel wire embedded GFRP is more than that of GFRP without steel wire laminates.
Damage area of GFRP without steel wire laminate is higher when compared to the steel wire embedded GFRP laminates which was observed for the damage plate of 400mm, 500mm and 600 mm height.
Steel wire embedded of the laminate will further improve the delamination resistance, as the steel wire embedded helps in containing the damage within the grid location.

Spread of damage is cylindrical in the case of steel wire embedded laminates whereas it is more likely to be conical in without steel wire laminates.

The Strength, tensile stress of the plain laminate is lower when compared to the steel wire embedded GFRP laminates.

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