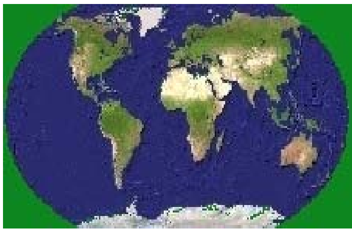

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Impact behavior on fiberglass reinforced laminates with the variation of composite core structure

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Abstract

Fiber reinforced composites have become increasingly important over the past few years and are now the first choice for fabricating structures where low weight in combination with high strength and stiffness are required. Fiber Reinforced Plastics (FRP) composites are in greatest commercial use. They have been extensively used in aerospace, automotive, marine and construction industries due to their inherent advantages over conventional metals. Failure modes of such laminated structures are also different than those of conventional metallic materials. Impact is one such great design limitation criteria involved in designing new composite products.
The objective of this paper, impact behavior on fiberglass reinforced laminates with the variation of composite core structure. The investigation is carried on the effect of adding a protective layer of rubber to the laminates. Impact test will be conducted on various models with the variation of core structure/layer orientation to find impact behavior on fiberglass reinforced laminates. This paper also involves optimum core structure in which impact test will be conducted by adding rubber layer.

Keywords Impact Behavior; Fiber Reinforced Laminates; Composite Core Structure

1. Introduction

R.C. Batra *et al* (2011) We analyze the damage initiation, damage progression, and failure during 3- dimensional (3-D) elastoplastic deformations of a fiber reinforced polymeric laminated composite impacted by a low speed rigid sphere, and compare computed results with experimental findings available in the literature. Damage is assumed to initiate when one of Hashin’s failure criteria is satisfied, and its volution is modeled by an empirical relation proposed by Matzenmiller, Lubliner and Taylor. The transient nonlinear problem is solved by the finite element method (FEM). Contributions of the work include considering damage in 3-D rather than plane stress deformations of a laminated structure and elasto-plastic deformations of the composite. This has been accomplished by developing a user defined subroutine and implementing it in the FE software ABAQUS. From strains supplied by ABAQUS the material subroutine uses a micromechanics approach based on the method of cells and values of material parameters of constituents to calculate average stresses in an FE, and checks for Hashin’s failure criteria. If damage has initiated in the material, the subroutine evaluates the damage developed, computes resulting stresses, and provides them to ABAQUS. The damage evolved at a material point is not allowed to decrease during unloading. The delamination failure mode is simulated by using the cohesive zone model available in ABAQUS. The computed time histories of the axial load acting on the impactor are found to agree well with the experimental ones available in the literature, and various damage and failure modes agree qualitatively with those observed in tests.

Debabrata Chakraborty (2006) he studied about delamination of laminated fiber reinforced plastic composites under multiple cylindrical impact. In the present paper a 3D finite element analysis has been performed for assessing delamination at the interfaces of graphite/epoxy laminated fiber reinforced plastic composites subjected to low velocity impact of multiple cylindrical impactors. Eight nodded layered solid elements have been used for the finite element analysis of fiber reinforced plastic laminates. Newmark-b method along with Hertzian contact law has been used for transient dynamic finite element analysis and an algorithm has been developed for determining the response of the laminated plate under the multiple impacts at different time. Appropriate delamination criterion has been used to assess the location and extent of delamination due to multiple impacts.

A study has been carried out to observe the effects of important parameters on the impact response of the laminate and the delamination induced at the interfaces. It has been observed that the contact force magnitude as well as delamination at the interface are greatly influenced by the time interval between successive multiple impacts.

A 3D finite element code for analysis of multiple cylindrical impacts on FRP laminated plate has been developed. The code is quite general in terms of number of impactors, time of impacts and location of impacts. Contact force histories, plate and impactor displacement, plate and impactor velocities have been studied for two successive cylindrical impacts and the subsequent delaminations at the interfaces due to such impacts have been assessed. Present work lead to the following important conclusions: 1. In case of multiple impacts, magnitude of contact force at various impact points depend upon the time interval between successive impacts in addition to mass and velocity of the impactors. Depending upon the relative velocities of the plate and the impactor at the time of contact magnitude of contact force will be different. 2. In case of multiple impacts, delaminations start from two distinct zones surrounding the impact points. However whether two delaminations will coalesce into one single delamination or remain two distinct delaminations depend upon the time interval of successive impacts in addition to the impactor velocity and the distance between the two impact points.

3. Delaminations at an interface near the impact points remain distinct for increasing time interval between the successive impacts. For quicker successive impacts, they coalesce into one big delamination.

Natural fibres have recently become attractive to researchers, engineers and scientists as an alternative reinforcement for fibre reinforced polymer (FRP) composites. Due to their low cost, fairly good mechanical properties, high specific strength, non-abrasive, eco-friendly and bio-degradability characteristics, they are exploited as a replacement for the conventional fibre, such as glass, aramid and carbon. The tensile properties of natural fibre reinforce polymers (both thermoplastics and thermosets) are mainly influenced by the interfacial adhesion between the matrix and the fibres. Several chemical modifications are employed to improve the interfacial matrix-fibre bonding resulting in the enhacement of tensile properties of the composites. In general, the tensile strengths of the natural fibre reinforced polymer composites increase with fibre content, up to a maximum or optimum value, the value will then drop. However, the Young's modulus of the natural fibre reinforced polymer composites increase with increasing fibre loadingFiber reinforced composites have become increasingly important over the past few years and are now the first choice for fabricating structures where low weight in combination with high strength and stiffness are required. Fiber Reinforced Plastics (FRP) composites are in greatest commercial use. They have been extensively used in aerospace, automotive, marine and construction industries due to their inherent advantages over conventional metals. Failure modes of such laminated structures are also different than those of conventional metallic materials. Impact is one such great design limitation criteria involved in designing new composite products.

Since technical grade carbon fibres were developed in the mid1960s, they have been gradually introduced in technical products. The application is connected with material questions such as matrix materials, fibre/matrix adhesion promoters and long term behavior, component production techniques or textile semi-finished materials. Precursors for carbon fibres can be rayon, polyacrylnitril or pitch. Depending on applications carbon fibers can even be graphitized.

Resistance to high temperatures and weathering, low flammability, low smoke density, low toxicity of decomposition products. Temperature resistance of course depends on choice of resin.

- •High chemical stability
- •Large variety of possible component shapes and sizes
- •High durability due to long prepreg storage life.
- •Prepregs comprise the range of reinforcements and resin matrix combinations. They are manufactured on a state-of-the-art fusible resin plant. Fusible resins have fewer volatile constituents and increase the composite materials' mechanical strength

2.0 IMPACT ANALYSIS OF COMPOSITE LAMINATES WITH FRP 0-90-0

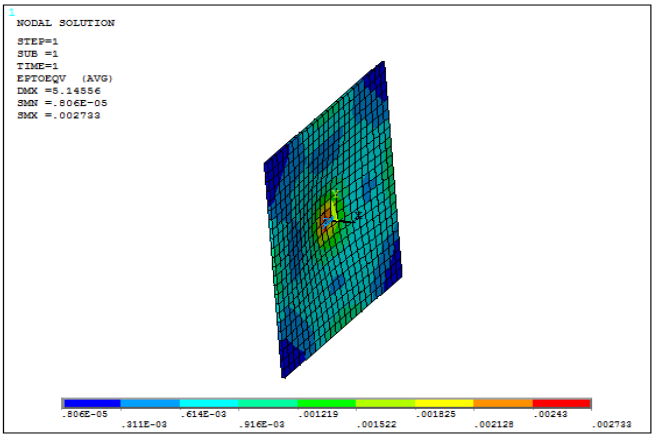

Fig1: von misses strain value with the help of color bar. Color bar is used to determine the value ranges on object. Von misses strain considers all directional and principal strain. Max strain=0.002733

2.1 IMPACT ANALYSIS OF COMPOSITE LAMINATES WITH FRP 0-45-0

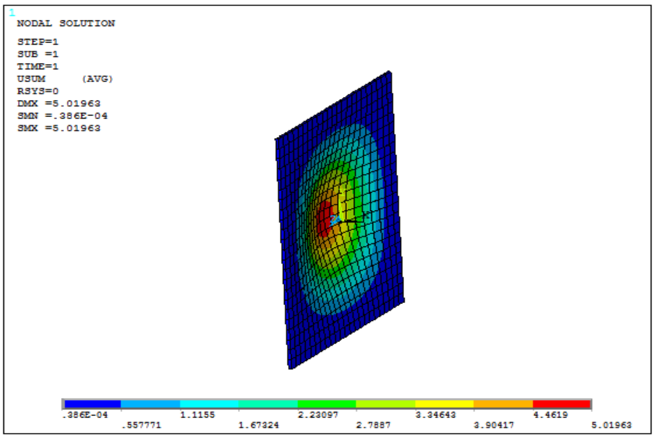

Fig 2: Displacement values due to impact loads Max displacement= 5.01963

2.2 IMPACT ANALYSIS OF COMPOSITE LAMINATES WITH FRP 45-90-45

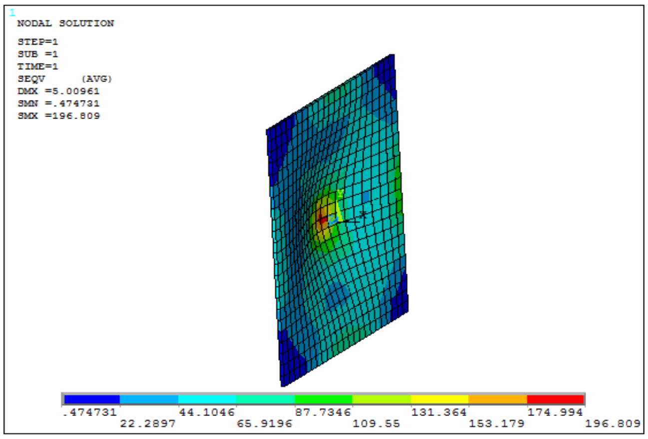

Fig 3: von misses stress value with the help of color bar. Color bar is used to determine the value ranges on object. Von misses stress considers all directional and principal stresses. Max stress=196.809

2.3 IMPACT ANALYSIS OF COMPOSITE LAMINATES WITH FRP 90-45-90

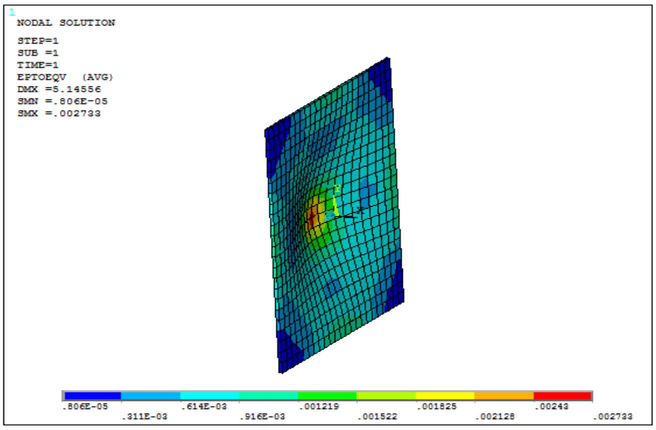

Fig 4: von misses strain value with the help of color bar. Color bar is used to determine the value ranges on object. Von misses strain considers all directional and principal strain. Max strain=0.002733

2.4 IMPACT ANALYSIS OF COMPOSITE LAMINATES WITH FRP 0-90-45-90-0

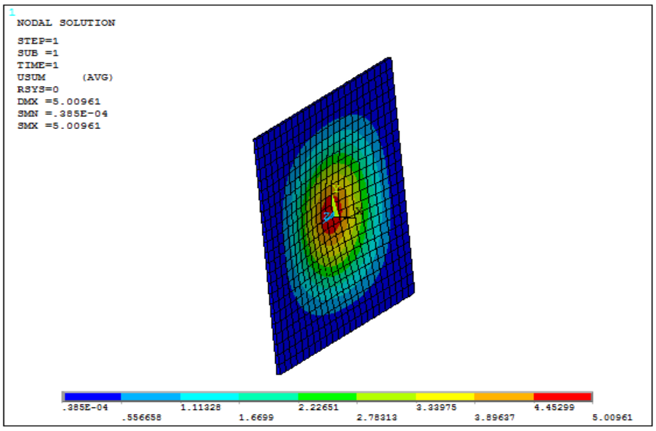

Fig 5: Displacement values due to impact loads Max displacement = 5.00961

3.0 Results and Discussions

3 layers

	0-90-0 layer Orientation	0-45-0 layer Orientation	45-90-45 layer Orientation	90-45-90 layer Orientation
Stress	197.885	197.203	196.809	197.885
Displacement	5.145	5.01963	5.00961	5.145
Strain	0.002733	0.002724	0.002718	0.002733

5 layers

	0-90-45-90-0 layer Orientation	0-45-90-45-0 layer Orientation	0-90-0-90-0 layer Orientation	0-90-45-90-0 with rubber
Stress	196.809	198.609	197.489	185.925
Displacement	5.00961	5.155	5.13	4.820
Strain	0.002733	0.002739	0.002728	0.00256

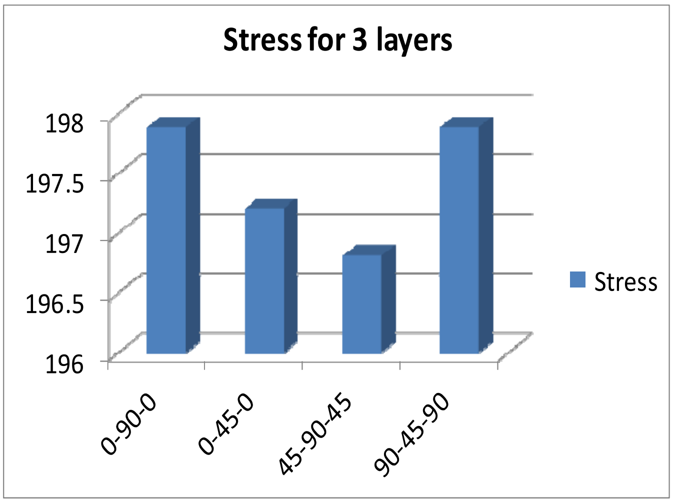

Fig 6:

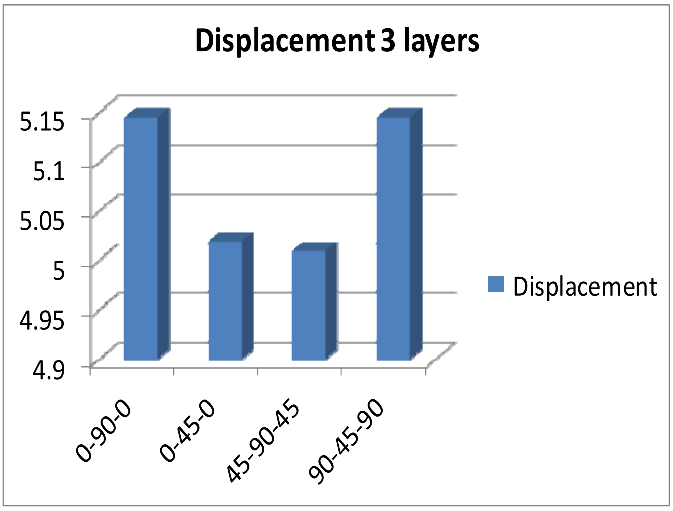

Fig 7:

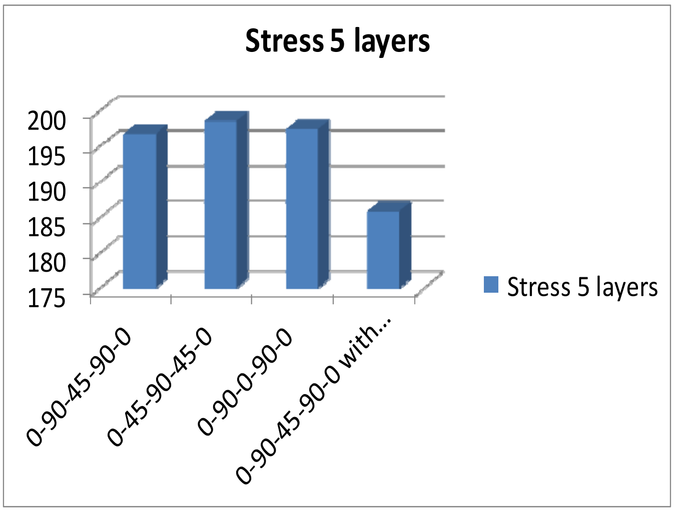

Fig 9:

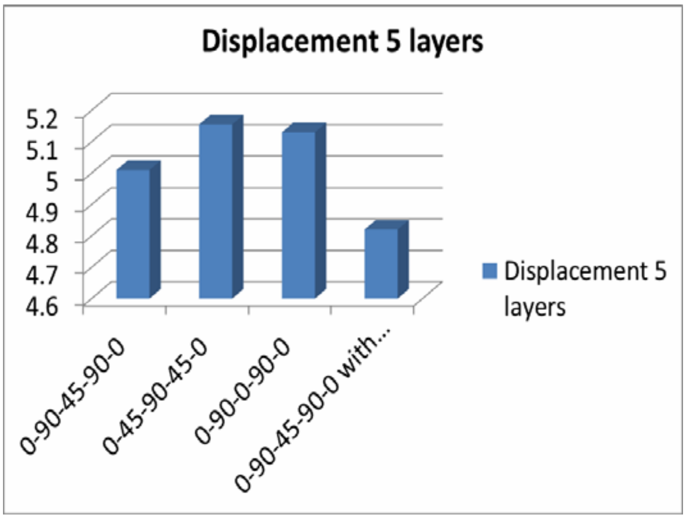

Fig 10:

4. Conclusion

In this paper impact analysis on FRP Laminates is done to determine the effect of layer orientation and rubber layer combination. Analysis is done on FRP Laminates by varying layer orientations on FRP (E-glass) layered matrix. Analysis is done on FRP Laminates using rubber layer in middle. As per the above results FRP Laminates with 0-90-45-90-0 with rubber as middle layer is giving maximum impact loading capacity.If rubber layer is used as middle layer impact loading capacity will be increased by 6%.

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