DISPLACEMENT STUDY OF GLASS FILLED UNSATURATED POLYESTER COMPOSITE PLATE UNDER TRANSVERSE IMPACT FORCE

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Abstract: A finite element analysis is offered for analyzing the response of glass fiber filled reinforced unsaturated polyester composite plate due to transverse drop weight impact. The analysis could be used to estimate the displacements of the composite plate during impact and the stress distribution throughout the plate thickness. A thin SHELL 163 ANSYS-LS DYNA explicit element has been used for modeling the composite plate and SOLID 168 ANSYS-LS DYNA explicit element has been used for modeling the drop weight impactor.

Keywords: Modeling, Explicit Element, Drop Weight Impact

1. INTRODUCTION

Impact resistance of composite materials, especially fiber reinforced plastics (FRP) is a very important area in modern day research. Fiber reinforced plastics structures usually react very poorly to transverse impact trials. In spite of the reservations about the mechanisms that lead to damage, it is difficult to establish the effect of an impact event on the performance of a composite structure after impact. In certain cases, the damage won’t be visible which could lead the materials with significant damage being allowed to continue in service.

Fiber Reinforced Plastics composites are one of the most preferred materials of choice over the past couple of decades for use in areas like automobiles, aerospace, piping, sports and construction. These preferences are attributed mainly due to their strength-to-weight ratio, superior mechanical properties and their environmental resistance. As most of the applications are subjected to impacts of some nature, ranging from dropping of tools to bomb blasts, it is imperative to study the impact behavior of these materials in order to design them comprehensively. We should also remember that conventional composite materials perform very poorly when subjected to transverse impacts.

S.N.A.Safri et al. experimented impact tests using drop weights of less intensity and observed the damages that occurred on various materials with different specimen thickness due to these impact loads. Eventually, they came out with a finding that E-800 had more strength in comparison with other types of similar materials. [1]

Rakesh Reghunath et al. conducted an investigation to evaluate the behavior of bidirectionally oriented glass filled composite material. They prepared specimens and carried out failure mode analysis and found out certain key factors that could affect the potency and firmness in the constitution of the materials. [2]
Muhammed Tijani ISA et al. carried out experiments with lesser intensity impacts on dissimilar composite materials. The outcome showed that strength of materials were largely influenced by the factors such as fracture in substances and rupture in glass fibers. They also examined alternate options which could render better results and concluded that using hybrid glass strands for reinforcing would lead to curtailing the above mentioned harms in materials. [3]

Sunith Babu.L and H. K. Shivanand investigated the properties of laminates that were filled with both glass strands and carbon. The test was conducted based on ASTM standards D3029 and D7137. They analyzed the performance of specimen with 2 mm thickness with a centrally acting impact load. [4]

In this research endeavor, we are examining the drop weight impact of glass fiber reinforced unsaturated polyester composite plate by finite element analysis.

2. EXPERIMENTAL SET UP

2.1 Analysis by Finite Element Method

Finite element method is perhaps the most popular numerical technique to resolve complex engineering problems. The concept of FEA is the discretization of a given model into finite elements, applying boundary conditions and loads as per the problem to solve it numerically.

In our work, we have adopted iterative methods to analyze the performance of the glass filled unsaturated polyester plate under a transverse impact load.

2.2 Modeling of Composite Plate

Orientation of [0°/90°] was considered for the composite plate. Thin SHELL 163 element was used for meshing the composite plate. It was a 4-noded element with twelve degrees of freedom at each node. SHELL 163 is an element with four nodes with the capabilities of membrane as well as bending. We made sure that both normal loads and in-plane loads are allowed to be used. The dimension of composite plate was 200 X 200 X 2.75 mm and properties for the glass filled unsaturated composite plate were supposed as given in table 2.1 and the boundary conditions were kept fixed on all sides of the plate.

|        |        |        |
|--------|--------|--------|
|        | 122 GPa|        |
|        | 7.95 GPa|        |
|        | 0.32   |        |
|        | 5.52 GPa|        |
|        | 1584 kg/mm³|        |

Table 2.1 Material properties of composite plate

2.3 Modeling of Drop Weight Impactor

Solid 168 element was used for meshing the impactor. It is a 10-Node Tetrahedral Structural Solid component with each node having three degrees of freedom. The impactor was
modeled as a sphere ball with radius of 12.5 mm. The Linear-Elastic model with material properties are given in table 2.2.

|   |   |
|---|---|
| E | 215 GPs |
| N | 0.30    |
| P | 7860 kg/mm³ |

Table 2.2 Material properties of drop weight impactor

3. RESULTS AND DISCUSSION

The impact analysis by numerical method using the commercially available analysis software is presented here. The assembly of the model is given in figure 3.1. And the deflection of the centre of the plate Vs time is given in figure 3.2.

In figure 3.2, Y axis represents deflection of the plate and X axis represents time. It is obvious from the above graph that the magnitude of the deflection reaches its maximum in 0.02 seconds from the start of impact and the maximum deflection is about 3.8 mm. It was programmed so as to avoid the repeated impact on the plate. The plate deflects to a maximum value and due to its elastic property the impactor rebounds. The plate deflects back to a value of
1.6 mm and after some small vibrations the plate regains its original position as the kinetic energy disappears.

The corresponding stress distribution at the centre of the plate along the fiber direction with respect to time is given in figure 3.3.

![Stress Vs Time](image)

Fig. 3.3. Stress Vs Time

The stress in Pascal is plotted in Y axis of the graph and time in X axis. The value of the maximum stress is about 38 MPa.

4. CONCLUSION

Numerical analysis was conducted to learn the impact behavior of the glass filled unsaturated polyester composite plate due to dropping of an impactor from the given altitude. During the examination, a finite element procedure was developed to study the response of the composite plate to a foreign object impact.

The plate was modeled using a thin SHELL 163 ANSYS-LS DYNA explicit element and the drop weight impactor was modeled using SOLID 168 ANSYS-LS DYNA explicit element.

It was observed that the maximum deflection of the plate was 3.8 mm and it occurred in 0.02 seconds. The total impact duration was about 0.16 seconds. Part of the kinetic energy was used in deflecting the plate to a maximum and because of the kinetic energy the impactor bounced back.

REFERENCES
1. S. N. A. Safri, M. T. H. Sultan and F. Cardona, “Impact damage evaluation of glass-fiber reinforced Polymer (GFRP) using the drop test rig – an experimental Based approach”, ARPN Journal of Engineering and Applied Sciences, vol. 10, no. 20, November 2015.

2. Rakesh Reghunath, Mahadevan Lakshmanan, and K M Mini , “Low velocity impact analysis on glass fiber reinforced composites with varied volume fractions”, International Conference on Materials Science and Technology (ICMST 2012) IOP Publishing IOP Conf. Series: Materials Science and Engineering 73 (2015)

3. 
Muhammed Tijani ISA, Abdulkarim Salaw AHMED, Benjamine Olufemi ADEREMI, Razaina Mat TAIB, Hazizan Md AKIL, Ibrahim Ali MOHAMMED-DABO, “Drop Weight Impact Studies of Woven Fibers Reinforced Modified Polyester Composites”, *Leonardo Electronic Journal of Practices and Technologies, Issue 24, January-June 2014*, p. 97-112.

4. Sunith Babu L, H. K. Shivanand, “Impact Analysis of Laminated Composite on Glass Fiber and Carbon Fiber”, *International Journal of Emerging Technology and Advanced Engineering, Volume 4, Issue 6, June 2014*.

5. N Rajesh Mathivan, J Jerald, “Experimental Investigation of low velocity impact Characteristics of woven glass fiber epoxy matrix composite laminate”, *Journal of materials and design, Vol 31, 2010, pp.4553-4560.*