Failure Analysis of Composite Windshield

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Abstract- The windshield is one of the major components in a vehicle that determines the injury to a pedestrians head. Therefore it is critical to study the damage to windshield glazing so as to promote the protection structure for pedestrians. The three dimensional model is created using the solid edge ST8 and velocity of impact is considered as 27.77m/s .In this paper pvb interlayer is used between the two glass layers. In this paper the pedestrians head is assumed as sphere of 100 gram .a three dimensional finite element model describing the impact between the spherical mass of 100 gram and the windshield is constructed to investigate the mechanism underlying damage to windshield. This paper studies the effect of different angle of pvb interlayer and glass is done. Analysis is done using abacus software and stress, total deformation, total energy and internal energy is obtained in all the cases.

Keywords— windshield,impact analysis;solid edge ST8; ABAQUS explicitly.

1. INTRODUCTION

Windshield the vehicle's inhabitants from wind and flying flotsam and jetsam, for example, dust, insects, and rocks, and give an efficiently framed window towards the front. UV covering might be applied to screen out destructive ultraviolet radiation. Be that as it may, this is typically pointless since most auto windshields are produced using laminated windshield glass. The larger part of UV-B is consumed by the glass itself, and any residual UV-B together with the majority of the UV-A is consumed by the PVB holding layer.

On motorbikes their fundamental capacity is to shield the rider from wind, however not as totally as in an car, while on games and racing motorcycles the primary capacity is lessening drag when the rider accept the ideal streamlined arrangement with his or her body as one with the machine, and does not shield the rider from wind when sitting upright.

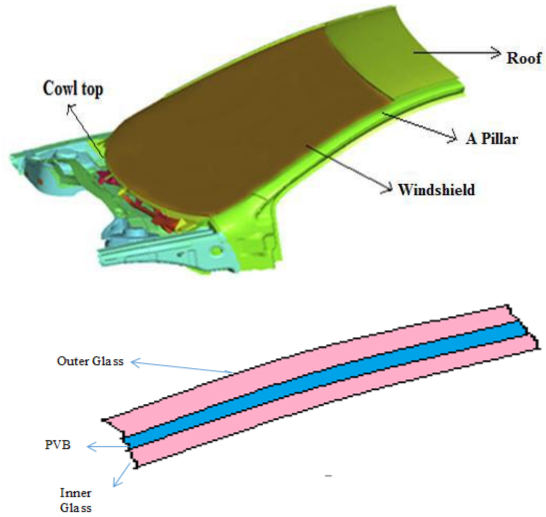

Fig 1: a) Windshield Structure b) Assembly of the Laminated Windshield

In 1927, the Canadian chemists Howard W. Matheson and Frederick W. Skirrow invented the plastic polyvinyl butyral. PVB has been the prevailing interlayer material since the late 1930s. It is at present fabricated and marketed by various organizations around the world, including Eastman (Kingsport, Tennessee, USA) (Saflex-mark PVB), Sekisui[5] (Kyoto, Japan)(Winchester, Kentucky) (Cuernavaca, Mexico)("S-Lec" mark PVB film and powdered PVB gums), Kuraray Europe GmbH [6](Frankfurt, Germany) ("Trosifol"-mark PVB and "Mowital/Pioloform" for powdered PVB saps), Chang Chung Petrochemicals Co. Ltd, Taiwan ("WINLITE"- mark PVB) and EVERLAM (Hamm-Uentrop, Germany) ("Everlam" mark).

Material

Polyvinyl butyral

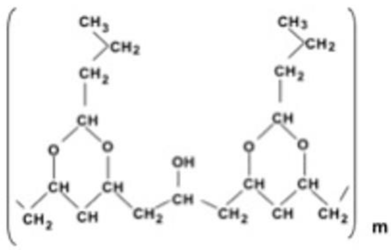

Fig 2: Pvb chemical structure

The market for overlaid glass items is mature. With just minor alterations, the PVB interlayer sold today is basically indistinguishable to the PVB sold 30 years back. Therefore, creative efforts have tended toward strategies for making the interlayer itself less expensive to produce, or making the interlayer easier to deal with and less prone to material deformities amid the way toward manufacturing laminated glass.

Problem Definition

The static/explicit dynamic analysis of different layer orientation in windshield model is analysed using appropriate finite elements in SIMULIA\ABAQUS software. The stresses induced in laminate layers are studied.

Methodology

As appeared in the stream outline underneath the essential step is to make a geometric model of windshield. The windshield model is finished utilizing Solid Edge ST8 modelling tool. The composite lay ups with 30^0,$60^0$and 90^0 inter laminar plies might be modelled. It is transported in into ABAQUS for meshing. The FE model is set up by meshing it with suitable elements then constraining the model by applying material properties, boundary conditions. This FE model is imported to ABAQUS/EXPLICIT to see the result of inter laminar stresses for the 30^0,$60^0$and 90^0 and results are plotted.

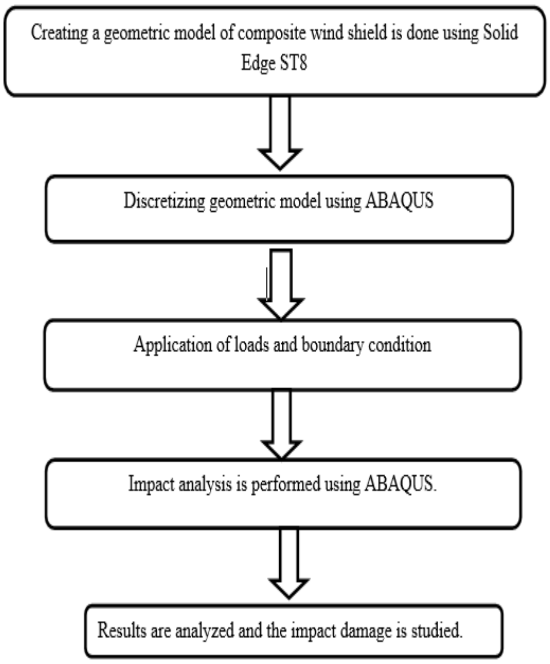

Fig 3: Flow chart of methodology.

Geometric Modeling

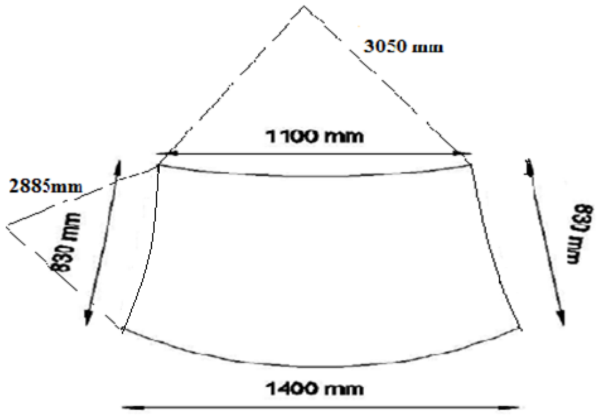

Fig 4: Actual Shell Panel

Meshing

During meshing of the composite wind shield linear quadrilateral elements are selected for meshing ,because these elements gives very accurate results.

Table 1. Elements and nodes count

TYPE OF ELEMENT	linear quadrilateral elements (S4R)
TOTAL NUMBER OF NODES	10201
TOTAL NUMBER OF ELEMENTS	10000

Table 2. Physical and Mechanical Properties of Glass and PVB and Equivalent Shell Structure

Properties	**Glass**	**PVB**	**Equivalent Shell Structure**
Density (ρ)	2500 kg/m3	1100 kg/m3	1493 kg/m3
Elastic Modulus (E)	74 GPa	2.6 GPa	67 GPa
Poisson"s Ratio (ϑ)	0.23	0.435	0.248

Loads and Boundary Conditions

The spherical is considered as the object of impact which has a mass of 100g and the velocity of the object is of 27.77m/s.The object has been constrained in X and Z directions. And the velocity boundary conditions are given in Y direction.

RESULTS & DISCUSSION

Impact analysis on glass

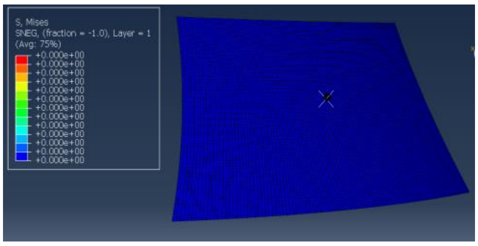

Fig 5: stress concentration on windshield before impact of the object.

The above fig shows the stress concentration on windshield before impact of the object.

Stresses on Glass after Impact

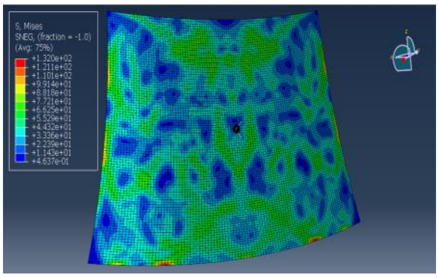

Fig 6: Stresses on Glass after Impact

The fig above shows stress impact of the object on the glass, as we compare (glass before impact of the object) can see the stress distribution through the glass. So the maximum stress is of 132.0 MPa and it is found at the edges of the glass. The minimum stress obtained in the glass after impact is 0.4637 MPa.

Deformation in Glass

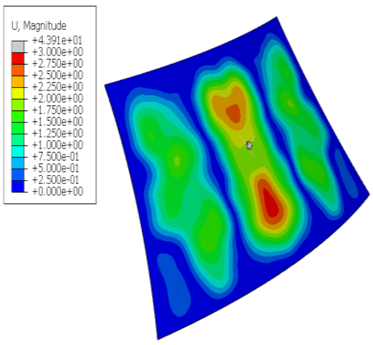

Fig 7: Deformation in Glass

The above figure shows that the total displacement of windshield after the impact of the object, as we observe in the figure that the total displacement taken at 4miliseconds is 3 mm

Internal Energy for glass

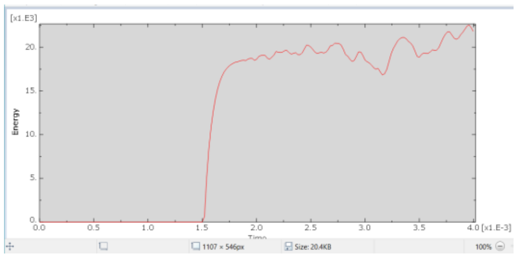

Fig 8: Internal Energy Graph for glass

Total Energy for glass

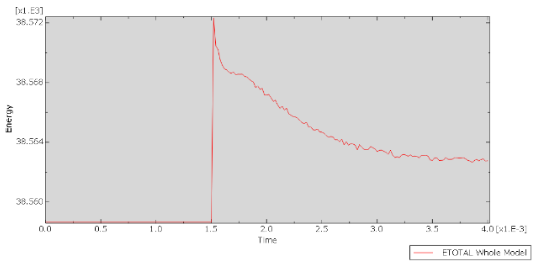

Fig 9: Total Energy Graph for 30^0 orientation

Impact Analysis on Composite Layup

In this study we have made The impact analysis on composite layup by changing different angles of impact force and also by changing the angle of orientation of the pvb layer .in both the cases we can observe how the von mises stress, displacement and internal energy changes through the graphs.

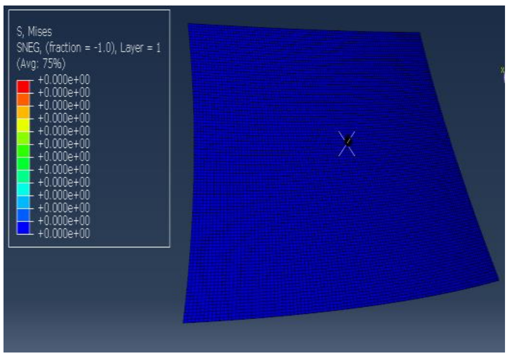

Fig 10: windshield before impact of the object

The above figure shows the stress concentration on windshield before impact of the object, here no stress distribution and no deformation occurs.

Case (1) for different angle of orientations

For 0⁰ Angle Orientation

Stress in Windshield

The fig below shows stress impact of the object on the windshield, as we compare (windshield before impact of the object) can see the stress distribution through the windshield. So the maximum stress is of 126.5 MPa and it is found at the edges of the windshield. The minimum stress obtained in the windshield after impact is 0.09MPa.

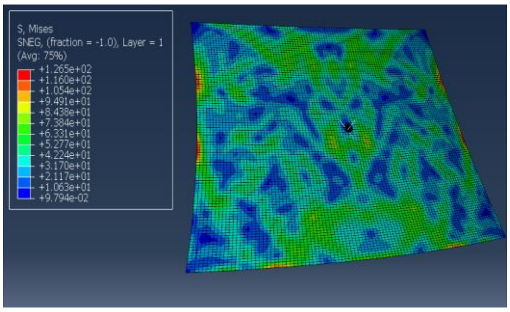

Fig 11: Stress in Windshield for 0^0 Orientations

Total Displacement in Windshield

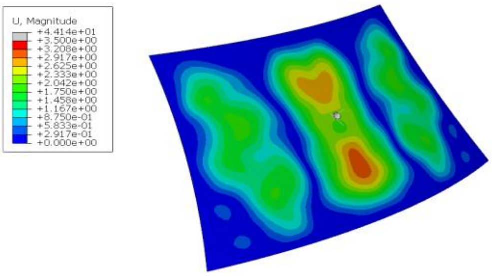

Fig 12: Total Displacement in Windshield for 0^0 Orientations

The above fig shows that the total displacement of windshield after the impact of the object, as we observe in the figure that the total displacement taken at 4miliseconds is 3.5 mm

Internal Energy

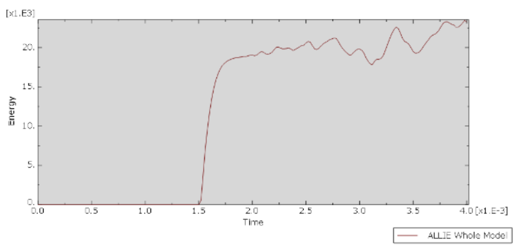

Fig 13: Internal Energy Graph for 30^0 Orientation

Total Energy

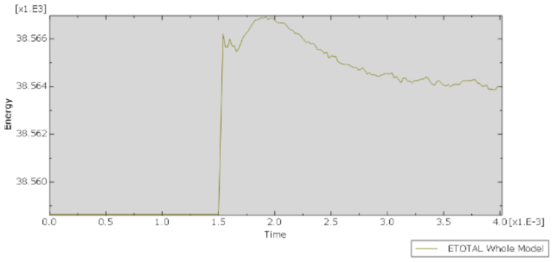

Fig 14: Internal Energy Graph for 30^0 Orientation

For 30^0 Angle Orientations

Stress in Windshield

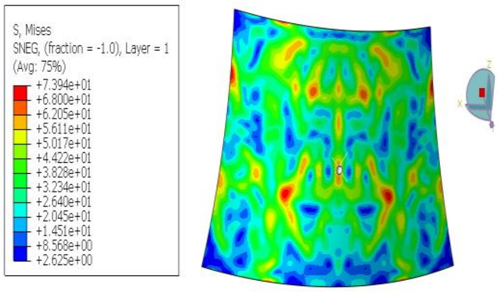

Fig 15: Stress in Windshield for 30^0 Orientations

The fig above shows Von Misses stresses in the PVB sandwich windshield, when windshield is subjected to a 30^0 angle orientation. In 30^0 angle orientation we can see the maximum stress is of 739.4 Pa and it is found at the edges as well as different places of the windshield.

Total Displacement in Windshield

The below fig shows that the total displacement of PVB sandwich composite windshield for 30^0 impact angle orientation. It can be observed from the figure that the total displacement taken at 4miliseconds is 3.95 mm.

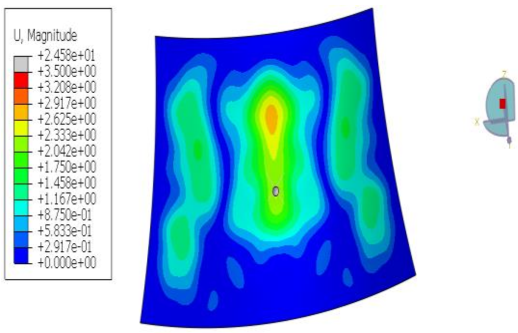

Fig 16: Displacement of Composite Windshield for 30^0 Orientation

Internal Energy

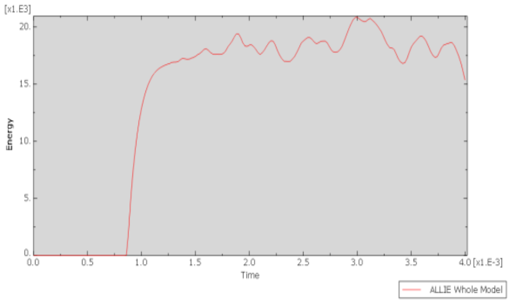

Fig 17: Internal Energy Graph for 30^0 orientation

From the above graph it can be seen that the distribution of internal energy when an impact is made with an angle of 30^0. Energy vs time graph gives information regarding the internal energy.

Total Energy

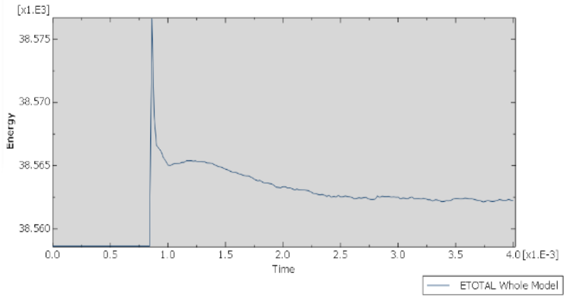

Fig 18: Total Energy Graph for 30^0 orientation

For 60^0 Orientations

Stress in Windshield

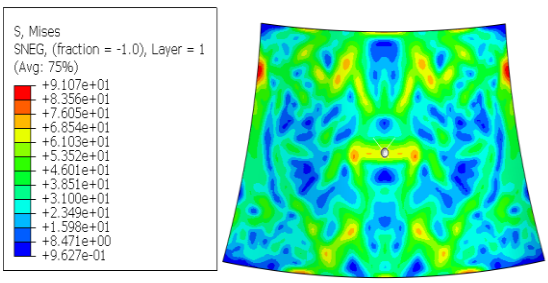

Fig 19: Stress in Windshield for 60^0 Orientations

The fig above shows Von Misses stresses in the glass windshield, when windshield is subjected to a 60 angle orientation. In 60 angle orientation we can see the maximum stress is of 910.7 MPa and it is found at the edges as well as different places of the windshield.

Total Displacement in Windshield

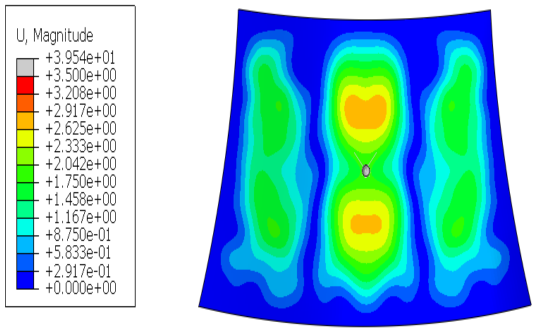

Fig 20: displacement of composite windshield for 60^0 impact angle orientation

The above fig shows that the total displacement of PVB sandwich composite windshield for 60^0 impact angle orientation. It can be observed from the figure that the total displacement taken at 4miliseconds is 3.95 mm.

Internal Energy

From the below graph it can be seen that the distribution of internal energy when an impact is made with an angle of 60^0. Energy vs time graph gives information regarding the internal energy.

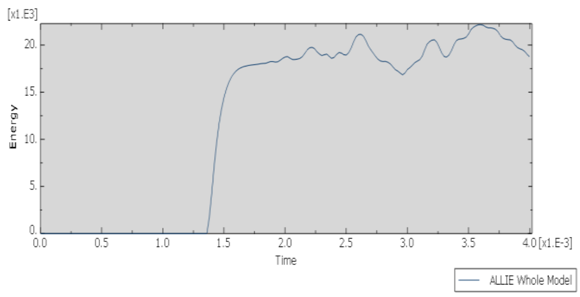

Fig 21: Internal Energy Graph for 60^0 orientation

Total Energy

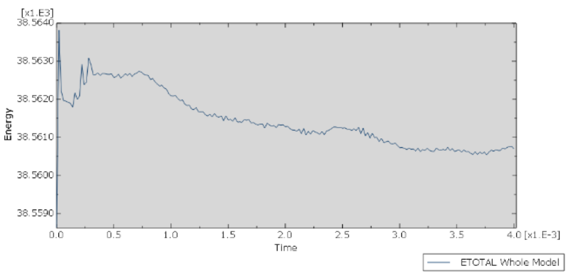

Fig 22: Total Energy Graph for 60^0 orientation

CONCLUSION

The analysis on the wind shield is done on glass only and PVB sandwiched between glasses. Stress of 139MPa, 3mm deflection is seen in glass only analysis. Stress of 126Mpa, 3.5mm deflection is seen in composite layer with PVB. The results show that an improvement in stress levels when PVB is used. However the analysis is done at 0^0 , 30^0 , 60^0 orientation of PVB.

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