Experimental and Numerical Model for Impact Loading on Multi-layered Laminated Safety Glass

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Abstract

Laminated safety glass (LSG) is widely recognized for its superior impact energy absorption, retention of structure, and minimization of injury due to shard fragments. This makes it an essential material in automotive and construction. This paper reports on an experimental-numerical investigation of LSG under impact loadings by systematically varying the layer configurations while keeping the same total thickness of the laminate. We have studied three specific configurations: 2-layer glass configuration with each layer having a thickness of 6 mm, 3-layer glass configuration with each layer having a thickness of 4 mm, and 5-layer glass configuration with four outer layers with a thickness of 2 mm and a central layer with a thickness of 4 mm. The total glass thickness is kept the same in all these configurations (12 mm), with an overall interlayer thickness of PVB of 3.04 mm. Ball drop tests have been numerically simulated using ABAQUS/Explicit, where glass is modeled with brittle cracking behavior. In a user-defined material subroutine VUMAT, crack propagation was simulated by element deletion based on the fracture energy threshold of elements. The fracture pattern in the numerical simulations was compared to experimental results conducted on the 2-layer glass configuration to validate the simulation. This paper underlines the modeling techniques used in the simulation and discusses the influence of some simulation parameters. The results provide valuable insights into the behavior of LSG under impact conditions, aiding the development of optimized configurations that enhance safety and post-impact structural integrity. The results reveal that an increase in the number of layers results in a more expanded central fracture zone following impact and a reduced duration for energy absorption. This indicates that multi-layered laminated configurations facilitate a more effective energy dissipation process, enhancing their impact resistance without significantly increasing weight.

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Keywords

Laminated Safety Glass, Impact loading, Multilayer Structures and ABAQUS/Explicit

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