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Optimum Design of Impact Resistance of Laminated Glass Plate

Shinobu Sakai[1], Kensuke Maenaka[2], Hirotoshi Kakuda[3] and Koetsu Yamazaki[4]

[1] Kanazawa University, Kanazawa,Japan, sakai@t.kanazawa-u.ac.jp
[2] Graduate School of Kanazawa University, Kanazawa, Japan, km061@stu.kanazawa-u.ac.jp
[3] PFU Co., Ltd., Kahoku, Japan, kakuda.hiro@pfu.fujitsu.com
[4] Kanazawa University, Kanazawa, Japan, yamazaki@se.kanazawa-u.ac.jp

Abstract

Laminated glass is widely used to enhance the structural functions such as safety, security and automobile applications. Generally, the laminated glass plate consists of two or more layers of float glass sheets combined by adhesive interlayer of tough Polyvinyl Butyral (PVB) under heat treatment. The impact resistance of this laminated glass plate is higher than that of a single glass plate of same thickness in total. After the glass plies are broken, the fragments of the glass are kept together by the PVB interlayer. The impact fracture behavior of the laminated glass is more complicated than that of the single glass, because of the combined influence of the large deformation and delamination strength so that two float glasses and the interlayer constitute the brittleness and hyper-elasticity, simultaneously. By using a finite element analysis code for the continuum, it is difficult to simulate the impact fracture behavior from a crack growth of the glass to the failure of the interlayer for the laminated plate.

In this study, the impact fracture behavior of a laminated glass plate for the outside surface of modern buildings has been studied by the numerical simulations and the experiments. The 3-D Discrete Element Method (DEM) was adopted in this numerical simulation. From the results of the simulation, the entire failure processes are predicted in detail. The impact loads and deformations of laminated plates were observed to be in good agreement between the experiments and the DEM simulations. Additionally, the laminated glass structures have been optimized for attaining the maximum durability against the impact fracture based on the response surface approach. The tensile strength of the interlayer and the adhesive strength between glasses and interlayer are taken as the design variables. From the results of optimization it has been observed that the laminated glass was hard to be broken in the case that the tensile strength was tough and that the adhesive strength was a little light. The optimum structure in high resistance of the impact fracture has been obtained for the PVB interlayer. The validity of the optimum design was confirmed by the verification analysis.

Keywords: Optimum design, Laminated glass, Impact fracture behavior, Discrete element method, Response surface methodology