SIMULATION OF LOW VELOCITY IMPACT OF SANDWICH PANELS APPLIED TO KOREAN LOW FLOOR BUS USING LS-DYNA

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1 Introduction

The continuing need for increased structural performance in the transportation industry has lead to an increase in the use of innovative fiber reinforced composites and sandwich materials technology. Due to their excellent mechanical properties combined with a high strength to weight ratio, sandwich constructions are particularly suited to transit applications. The problem of low velocity impact of monolithic composite panels has received much attention in recent years [1]. The transit car-body composite panel structures, in particular glass fabric/epoxy resin composites, are brittle in nature and absorb energy by damage rather than yielding. Damage may consist of fibre breake, matrix cracking and delamination. Damage may occur visibly under the impacter, or as a tensile failure in the back face. In addition, internal delamination, invisible to the external observer, may occur which can lead to premature failure under subsequent compression loading. Although a fair amount of success has been achieved in predicting low velocity impact damage in carbon, glass and Kevlar monolithic panels [2]. Less work has been preformed on sandwich panels consisting of composite skins supporting a core such as aluminum honeycomb, balsa and foam. Such sandwich structures offer potentially good damage-tolerance, since the core can absorb impact energy by local plastic deformation whilst still effected enough overall support to prevent high local bending strains in the composite skins. Fig. 1 shows three types of event that may occur due to low velocity impact of an aluminum honeycomb or balsa core and glass/epoxy skinned sandwich panel. Fig. 1(a), (d) shows a case where the core has crushed locally under the impacter and the skin has remained attached producing a permanent visible indentation after impact. If the adhesive bond between the skin and core is weak, case Fig. 1(b), (e) can occur, where the relatively stiff skin springs back after impact, breaking the adhesive bond, leaving the crushed core hidden underneath a seemingly undamaged skin. Damage of the upper skin under the impacter, either visible of hidden may also occur. The impact force can produce high through-thickness shear in the skin, which causes local delamination. These delaminations can grow during the impact process, and if spring-back occurs, part of the skin below the delamination may remain attached to the core as the remainder of the skin recovers, opening the delamination further. This case is shown in Fig. 1(c) and (f).

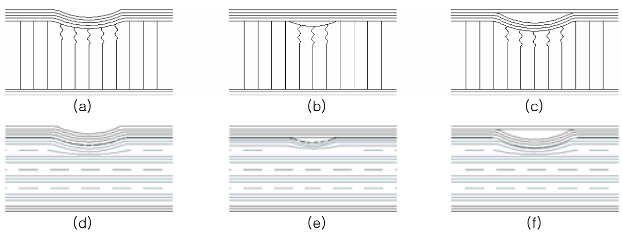


Fig. 1. Diagram illustrating post-impact core damage.

In this paper, an explicit finite element based simulation tool has been developed to predict the damage with in sandwich structures subjected to low velocity impact.

2 Experimental

A series of impact tests were conducted on composite sandwich panels consisting of WR590/NF4000 glass fabric/epoxy and aluminum 5052 skins with an aluminum honeycomb and balsa core.

Table. 1. The list of sandwich panels.

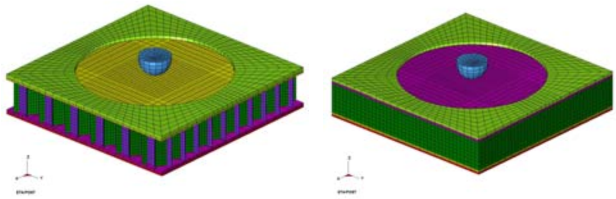
Type	Skin	Core
Sandwich panel-1	Aluminum 5052 Thickness : 1.2mm	Aluminum honeycomb [3/8"-5052-0.0025] Thickness : 25.4mm
Sandwich panel-2	Glass fabric/epoxy WR590/NF4000 Thickness : 3.0mm(top) 1.5mm(bottom)	
Sandwich panel-3		

The panel dimensions were 100mm×100mm× 30mm (long × width × thickness). Both top skin and bottom skins edges were fixed in the impact jig using GA type [3]. The fixture of GA type jig shown in Fig. 2 . The impact tests were conducted using an instrumented impact testing system.(Dyantup 8250)

Fig. 2. The fixture of GA type jig and glass/epoxy and balsa core

3 Comparisons of FE analysis and experimental results

The explicit finite element software LS-DYNA (Version 971) are commercial tools employed within various engineering industries. Both the aerospace and automotive industries have accepted simulation as part of the design process to minimize design costs and o create more efficient structures. Prototyping and testing are always performed to verify the design, but simulation has become standard practice throughout the design process. The explicit FE codes improve and advanced material models become available, such simulations tools will find more widespread application within the automotive sector with increasing computing power and greater modeling realism. The sandwich panels have been modeled using model #58 (*MAT_LAMINATED_COMP-OSITE_FABRIC) and model #158 (*MAT_RAT-E_SENSITIVE_COMPOSITE_FABRIC) of the LS-DYNA material model library were used for shell elements. These constitutive models are based on the theory of continuum damage mechanics [3]. For the core LS-DYNA material model #126(*MAT_MO-DIFIED_HONEYCOMB) was used in combination with the one point co-rotational solid element type. In this orthotropic material model nonlinear elastoplastic constitutive behavior based on experimentally determined stress-strain curves can be defined separately for all normal and shear stress. These are considered to be fully uncoupled. Fig. 3 is shown FE modeling of core-shell model and core-solid model. Fig. 4 is shown striker position of core-shell model. Fig. 5 is shown comparison FE analysis and experiment of post-impact.



(a) (b)

Fig. 3. The FE modeling of core-shell model and core-solid model.

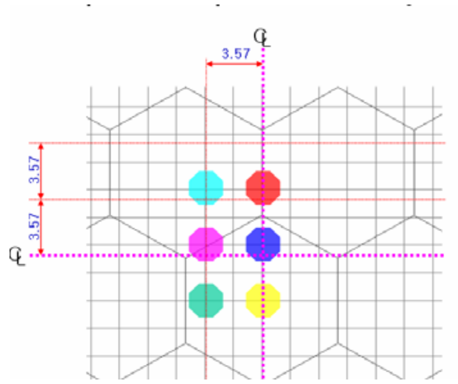


Fig. 4. The striker position of hexagonal core shell model.

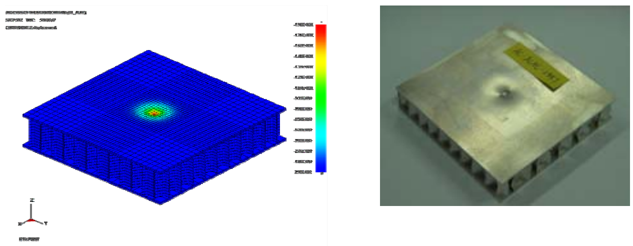


Fig. 5. The Comparison of FE analysis and Experiment.

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