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EFFECT OF CORE ORIENTATION ON LOW VELOCITY IMPACT RESPONSE OF HONEYCOMB SANDWICH BEAMS

Kemal Arslan[1*] and Recep Gunes[2]
[1]Graduate School of Natural and Applied Sciences, Erciyes University, Turkey. karslan@erciyes.edu.tr
[2]Department of Mechanical Engineering, Erciyes University, Turkey. recepg@erciyes.edu.tr

1. INTRODUCTION

Sandwich structures are playing an important role in many engineering fields because of their excellent high flexural stiffness to weight ratio compared to conventional monocoque structures. Accordingly, sandwich constructions exhibit a better mechanical performance than other constructions [1]. Another characteristic feature of sandwich structures is high energy absorption capability that is extremely important for impact applications. Sandwich structures can be exposed to a wide range of impact loads, and it is quite necessary to determine their impact characteristics. For this purpose, different studies are performed on the impact response of sandwich structures designed by various face sheets and core materials using analytical, numerical, and experimental techniques [2-7].

Honeycomb is one of the most popular core material in engineering applications where especially high energy absorption and high mechanical strength are needed. In this study, the effect of core orientation on the low velocity bending impact response of honeycomb sandwich beams is investigated using finite element modeling, and the results are evaluated in terms of contact force, total absorbed energy, and permanent central deflection.

2. STATEMENT OF THE PROBLEM

The structural behavior of sandwich structures depends on the geometrical parameters as well as material properties of the face sheets and core material [8,9]. Accordingly, the main goal of this study is to investigate the effect of core orientation on the low velocity bending impact response of honeycomb sandwich beams. A honeycomb core has two main directions in plane, length in the ribbon direction (L) and width in the direction of expansion (W) (Fig. 1). Therefore, two types of sandwich beam are constructed depending on these directions. The types of sandwich beam are based on L and W directions of the honeycomb core aligned with the length of the sandwich beam, named L-type and W-type beams, respectively (Fig. 2).

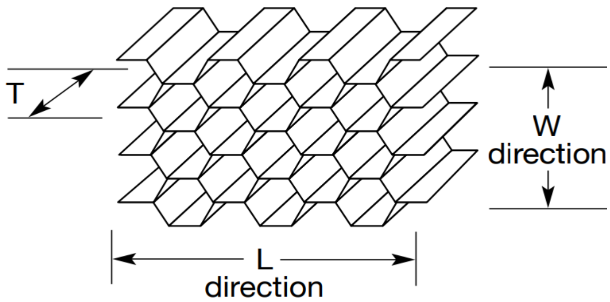
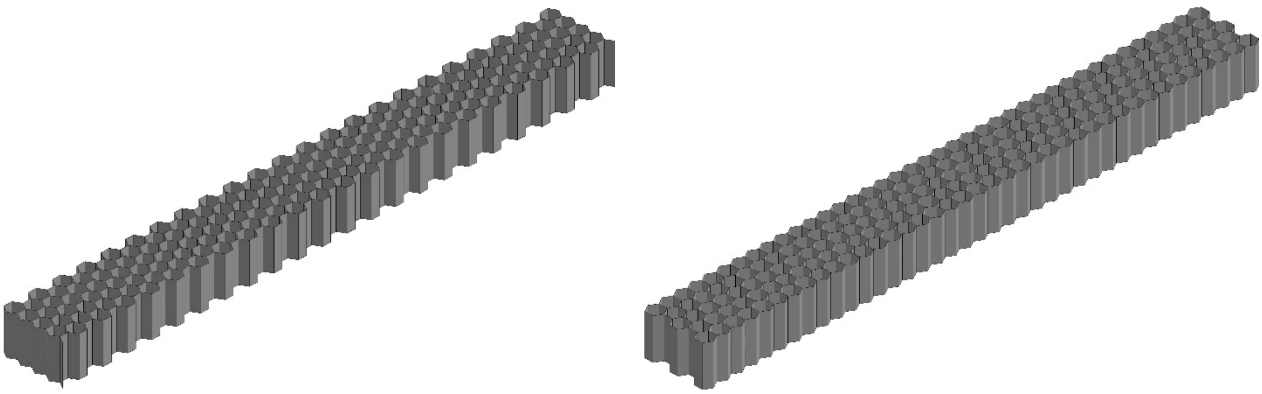


Fig. 1: The description of the in-plane directions of a honeycomb core [10].

To investigate the effect of core orientation, a sandwich beam consisting of two identical aluminum alloy face sheets and an aluminum alloy honeycomb core is considered. The sandwich beam is exposed to low velocity bending impact load by a semi-cylindrical rigid impactor that can properly create the bending deformation.



(a) L-type (b) W-type

Fig. 2: The types of sandwich beam.

3. FINITE ELEMENT MODELING

Modeling of the problem is performed using the nonlinear explicit finite element code, LS-DYNA®. The sandwich beam is considered in dimensions of 30x250 mm and consists of Al2024-T3 face sheets with a thickness of 1 mm and Al3003-H19 honeycomb core with a height of 18 mm. The geometry of this problem is the beam form of the sandwich panel that is investigated in our previous study [11]. In our previous study, the finite element model is verified in good agreement with the experimental tests. Accordingly, the same procedure is utilized in this study, and additionally, a similar concept is used in terms of boundary conditions (clamping supports).

Low velocity bending impact is modeled considering the actual geometry of the honeycomb sandwich beam (Fig. 3). The double wall thickness of the honeycomb cells is also considered in the finite element model. The elastoplastic material behavior of the face sheets and core material is represented with the piecewise-linear-plasticity material model. The behavior of the impactor and clamping supports is assumed to be rigid. The face sheets and honeycomb core are modeled with four-node shell elements, and the impactor and clamping supports are modeled with eight-node solid elements. An automatic-surface-to-surface contact algorithm is defined between the impactor and top face sheet, and an automatic-single-surface contact algorithm is defined for self-contacting surfaces. The contacts between core and face sheets are assumed to be perfectly bonded and defined by tied-nodes-to-surface contact algorithm. The boundary conditions are provided with a clamping force by the top supports according to our previous study [11]. The sandwich beam is subjected to a central bending impact by the semi-cylindrical rigid impactor having a diameter of 10 mm, and the analyses are performed for the impact energies of 2.64, 10.58, 23.80 J.

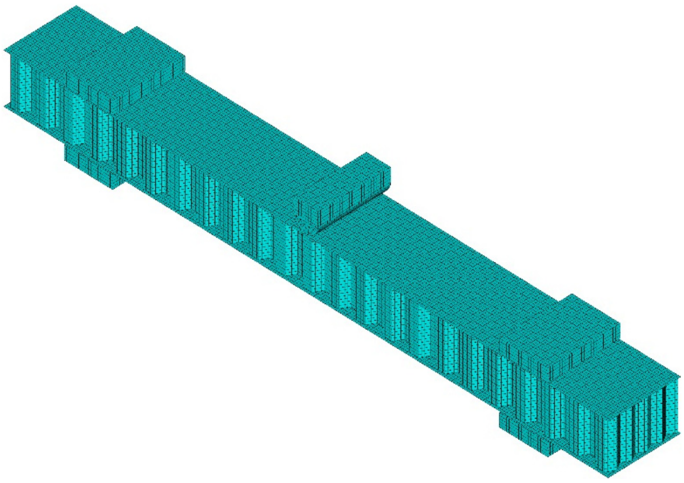
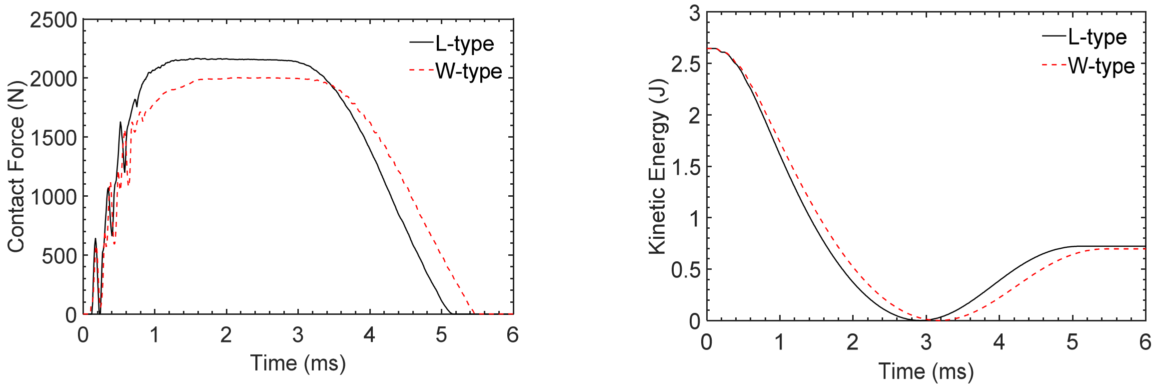


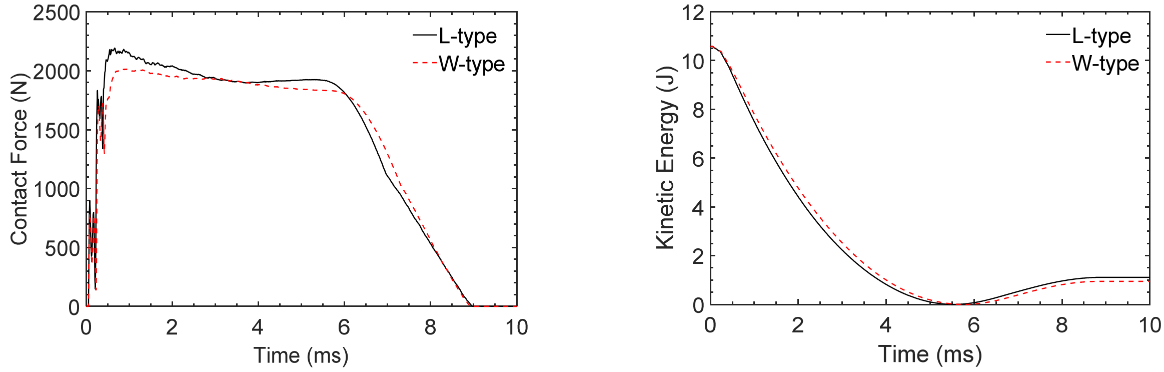
Fig. 3: The finite element model of the sandwich beam, impactor, and clamping supports.

4. RESULTS

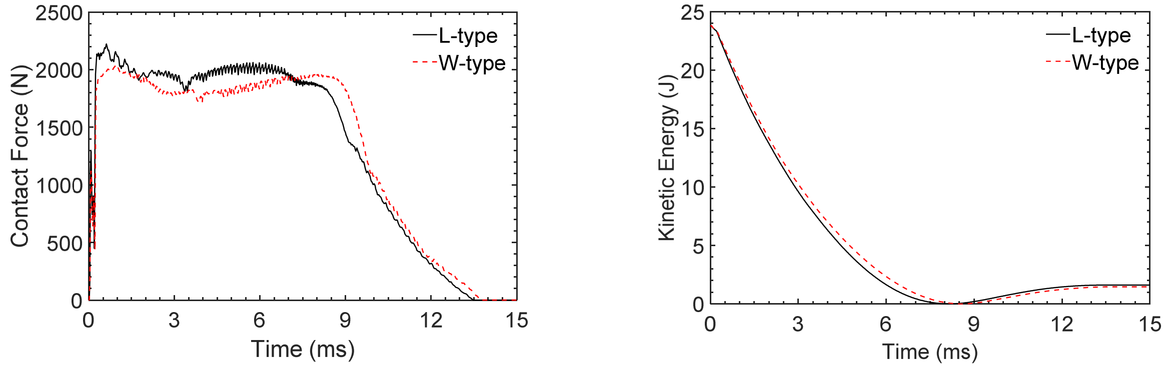
The results are examined in terms of contact force, total absorbed energy, and permanent central deflection. The contact force and kinetic energy histories are shown in Fig. 4. L-type beam exhibits higher peak contact force values than W-type beam in analogy to a static four-point bending test of a honeycomb sandwich beam [12]. The difference between the peak contact forces of L-type and W-type beams are about 8.1%, 8.9, and 8.8% for increasing impact energy. The peak contact force is not strongly influenced by the impact energy. However, some fluctuations are observed in the contact force history by increasing the impact energy depending on the plastic deformation occurred in the honeycomb cells. The core orientation has almost no influence on the energy absorption capacity of the sandwich beam. Namely, the differences between the total absorbed energy are below 2% for all impact energies.



(a) 2.64 J



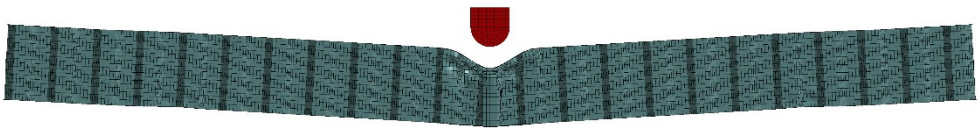
(b) 10.58 J



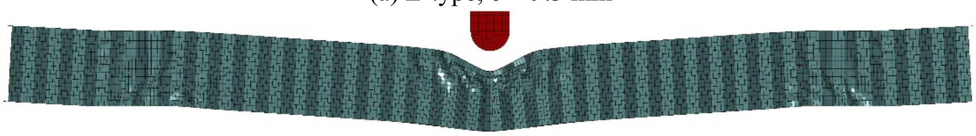
(c) 23.80 J

Fig. 4: The contact force and kinetic energy histories of the sandwich beams for different impact energy levels.

The permanent deformation views of the sandwich beams are given in Fig. 5 for 23.80 J impact energy. W-type beam shows about 11.8% more permanent central deflection and more plastic buckling deformation than L-type beam.



(a) L-type, $\delta = 9.3$ mm



(b) W-type, $\delta = 10.4$ mm

Fig. 5: The permanent deformation views of the sandwich beams.

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