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Effects of honeycomb geometry on stress concentration due to defects

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Abstract

In this study, to investigate the effects of honeycomb geometry on stress concentration due to defects, a symmetric hexagonal honeycomb core was developed and this was followed by performing a series of FEM numerical studies on stress concentration due to defects under uniaxial and biaxial loading. The simulations indicated that the degree of the stress concentration in the front of the defect is influenced by the geometric shape of defects and is also sensitive to anisotropy due to the honeycomb geometry. Furthermore, a new technique is proposed in which honeycomb structures with defects are replaced by orthotropic plates with an elliptical hole to evaluate the stress concentration. The validity of the approximation method is verified by the results of the numerical FEM analysis.

Keywords:Symmetric hexagonal honeycomb, Stress concentration, Defect, Orthotropy, FEM

1 Introduction

Honeycomb structures are widely employed in several engineering applications owing to their desirable mechanical properties such as lightweight, high strength, and high energy absorption efficiency. These desirable mechanical properties still continue to attract significant research interest [1-6]. Ivanez et al. [1] experimentally and numerically examined the in-plane and out-of-plane crushing behavior of aluminum honeycomb cores. Zhang et al. [2] designed a new type of multi-cell honeycomb and investigated the in-plane crushing behavior. Xing et al. [3] investigated the tire-honeycomb interaction for the arresting system of aircraft overrun. Fu et al. [4] and Harkati et al. [5] theoretically and numerically examined the elastic characteristic of auxetic honeycombs. Keshavanarayana et al. [6] experimentally and numerically investigated the effects of the node bond adhesive fillet on the hexagonal honeycomb core.

The aforementioned studies mainly focused on the mechanical properties of perfect honeycombs. With an increase in the safety requirements, several studies investigated the influences of the presence of defects [7-12]. Zhang et al. [7] numerically studied the effects of defects on the in-plane dynamic crushing of metal honeycombs. Simulations indicated that the deformation mode and the energy absorption efficiency are influenced by the location of defects. Mukhopadhyay and Adhikari [8] proposed an analytical formulation to predict the equivalent elastic properties of honeycomb structures with irregular cell angles. Liu et al. [9] investigated the effect of manufacturing irregularity on auxetic honeycombs. Ajdari et al. [10] and Wang and McDowell [11] investigated the effect of missing cell walls on in-plane elastic properties. Su et al. [12] investigated the effect of missing cell walls on creep behavior.

Gibson and Ashby [13] investigated the stress concentration in honeycomb cores subjected to uniaxial loading due to defects in which a few vertical cell walls are consecutively missing along a row as shown in Fig. 1(a). They proposed that this type of stress concentration is approximated by the stress concentration for a homogeneous plate with a crack. The authors [14] extended the study by Gibson [13] to consider more