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Effect of infill pattern of polylactide acid (PLA) 3D-printed integral sandwich panels under ballistic impact loading

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ABSTRACT

This paper investigates the effect of the infill pattern of polylactide acid (PLA) 3D-printed sandwich panels under ballistic impact loading. Fused deposition modeling (FDM) technique is used to manufacture the PLA 3D-printed integral sandwich panels with four infill patterns: cubic, grid, gyroid, and honeycomb. The ballistic data acquisition system is collected the experimental results with three impact velocities: 109.65, 173.97, and 209.48 m/s. It was revealed that the 3D-printed sandwich panel with cubic infill pattern reached the highest maximum impact load than the other three infill patterns. Moreover, it was highlighted that the sandwich panel with cubic and gyroid infill patterns absorbed 1.41 and 1.15 J and provided better impact resistance characteristics. It is highlighted that the infill pattern plays a vital role in the impact resistance of 3D-printed sandwich structures. Furthermore, it is recommended the three-dimensional (3D) infill pattern, e.g., cubic, gyroid, 3D honeycomb, can provide better impact performance than the two-dimensional (2D) infill pattern.

1. Introduction

Nowadays, additive manufacturing (AM) has increasingly developed and enlarged in a wide range of industrial applications, e.g., aerospace [1], automotive, biomaterials [2], medical device [3], etc. Generally, fused deposition modeling (FDM) is used for the continuous filament of thermoplastic material, which is melted and extruded through the nozzle to manufacture commercial 3D-printed products [4]. Polylactide acid (PLA) is a biodegradable thermoplastic polymer material that has been widely used for AM process [5]. In recent years, lots of researchers have chosen the FDM technique to manufacture the required 3D-printed structures, e.g., sandwich structures [2,5,6], thin-walled tubular structures [1], cellular cubic structures [7–9], plate sheet [10]. It is stated that AM has many advantages over traditional manufacturing methods, such as higher component reliability and fabrication accuracy, higher strength-to-weight ratio, higher structural design capability, lower cost, and lower environmental impact [4]. Moreover, some critical parameters can significantly affect the strength properties of 3D-printed structures, e.g., infill pattern [8], infill density [8], layer height [11], print speed, etc. For example, Aloyaydi et al. [12] investigated the infill patterns on the mechanical response of 3D-printed PLA specimens. It was found that the 3D-printed specimen with the triangular infill pattern of 60 % infill density had the highest absorbed penetration energy of 7.5 J, which is highly recommended for implant/tissue/recyclable applications. Furthermore, Praveen Kumar et al. [7] examined the quasi-static compressive performance of 3D-printed polymer composite

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