ICCES, 2023, vol.26, no.3
DOI: 10.32604/icces.2023.09075

PROCEEDINGS

Low-Velocity Impact Response of Sandwich Composite Panels with Shear Stiffening Gel Filled Honeycomb Cores

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ABSTRACT

Over decades, sandwich composite panels (SCPs) have been widely used to fabricate lightweight but strong structural components. However, composite sandwich structures are susceptible to impact damage, which may severely reduce the structural stiffness, stability, and load-carrying capacity[1, 2]. In order to enhance the anti-impact capacity of SCPs, a series of novel core structures[3-5] and filling materials[6-8] have been proposed and tested. One of them is the shear thickening fluids (STFs), which mechanical behavior changed from liquid to solid when subjected to high strain rate shear loading[7, 9]. For example, Fu et al.[10] filled the honeycomb cores of Carbon fiber reinforced plastic (CFRP) SCPs with the styrene/acrylate particle based STF. Low-velocity impact tests showed that the STF-filled core could absorb more energy with less penetration depth compared to the traditional aluminum foam. Warren et al.[11] evaluated the performance of the SCPs with STF-filled honeycomb core as the orbital debris shield of space crafts. Through the hypervelocity impact tests, they found the STF-filled panels sustained significantly less damage than PEG-filled panels.

However, the STF-filled cores may suffer from the leakage or evaporation of solvent liquid, limiting their practical applications. Most recently, shear-stiffening gels (STG), a class of viscoelastic polymer, were developed[12, 13]. Similar to the STFs, STG is soft in unstressed state but becomes much stiffer when subjected to external impacts. In consideration of the fascinating shear thickening characteristic and stable nature, STG could be a promising core material for fabricating high performance SCPs. Currently, only a few work about STG-based composite panels were reported. Xu et al.[14] fabricated the sandwich structures consisting of two layer Kevlar face sheets and a STG core. A large enhancement of energy dissipation compared to neat Kevlar was reported. Similar work was done by Wang et al.[15], who investigated the low-velocity impact responses of Al-STG-Al sandwich panels and chloroprene rubber (CR)-STG-CR sandwich panels. Excellent energy absorption property of STG core was observed.

In this work, the anti-impact performances of the sandwich panels consisting of two CFRP facings and a STG-filled honeycomb core were studied. The rheological property of the STG was examined to quantify its shear thickening characteristic. The STG was filled into the honeycomb cores and the low-velocity impact response of STG-filled SCPs were systematically investigated. The impact resisting mechanism of the STG-filled SCPs were revealed through numerical simulation.

KEYWORDS

Shear stiffening gel; sandwich composite panels; low-velocity impact; energy adsorption

Funding Statement: The authors received no specific funding for this study.

Conflicts of Interest: The authors declare that they have no conflicts of interest to report regarding the present study.

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