MECHANICAL PERFORMANCE OF LIGHTWEIGHT SANDWICH STRUCTURES BASED ON TRAPEZOIDAL CORRUGATED-CORES

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ABSTRAK

Trapezoid teras beralun di reka menggunakan acuan 45°, dan digunakan untuk membentuk pelbagai struktur sandwic yang ringan. Sudut 45° di pilih kerana ia merupakan bentuk yang optimum untuk semua kombinasi lenturan, ricihan dan regangan. Sifat mampatan dan mekanisma kegagalan dalam struktur berdasarkan dua bahan yang berbeza telah dikaji secara eksperimen. Tujuan penyelidikan ini adalah untuk mengkaji sifat teras beralun trapezoid apabila dikenakan tindakan tegangan serta mampatan dan untuk menghasilkan model tindak balas mekanikal teras beralun trapezoid yang mempunyai struktur sandwic dan juga untuk mengkaji kesan perubahan parameter geometri pada sifat teras beralun. Struktur teras beralun trapezoid dibuat daripada gentian karbon bertetulangkan plastik (CFRP) dan gentian kaca bertetulangkan plastik (GFRP). Komposit beralun telah direka menggunakan teknik bengkalai tangan dan kemudian disambungkan pada plat menggunakan pelekat berdasarkan bahan yang sama, untuk menghasilkan pelbagai struktur sandwic yang ringan. Ketebalan dinding sel, bilangan sel unit dan lebar digunakan dalam menentukan sifat struktur mekanikal tersebut. Mod kegagalan awal dalam struktur beralun ini adalah topang, keretakan pada gentian, dan delaminasi dalam struktur komposit bersama-sama dengan nyahikatan antara plat dan teras telah dikaji. Tekanan mampatan kemudiannya diberikan ke atas struktur beralun trapezoid, di mana kekuatan mampatan telah menunjukkan peningkatan pada semua struktur beralun itu. Untuk mensimulasikan tindak balas mekanikal bagi struktur beralun, model unsur terhingga telah dijana menggunakan ABAQUS. Keputusan unsur terhingga dibandingkan untuk mengukur tindak balas daripada eksperimen. Berdasarkan kajian yang dijalankan, kesan jumlah sel unit berbeza, CFRP mencapai 3.48 MPa lebih tinggi daripada GFRP yang 2.08 MPa di tiga unit sel. Ia menunjukkan bahawa pada jumlah unit sel yang tinggi, ia mempengaruhi kekuatan komposit. Bagi kesan ketebalan dinding sel, keputusan menunjukkan semakin tinggi ketebalan dinding sel semakin tinggi kekuatan mampatan. Kekuatan mampatan CFRP dan GFRP masing-masing adalah 3.48 MPa dan 1.74 MPa pada ketebalan 1.75 mm dan 1.90 mm. Dapat dilihat daripada graf pembuktian unsur terhingga dan eksperimen, data dari kedua-dua kaedah ini menunjukkan kesepakatan yang sangat baik. Pemerhatian ini dibuktikan dengan mengira kesilapan peratusan antara unsur terhingga dan keputusan eksperimen dengan purata perbezaan antara 4.97% dalam beban maksimum.

ABSTRACT

Trapezoidal corrugated-core was fabricated using a 45˚ profiled mould, and used to form a range of lightweight sandwich structures. The 45˚ corrugation angle was chosen since it represents an optimal configuration for all combinations of bending, shearing and strain. The compressive behaviour and failure mechanism in the structures based on two different materials have been investigated experimentally. Trapezoidal corrugated-core is made of carbon fibre reinforced polymer (CFRP) and glass fibre reinforced polymer (GFRP). The aim of this research work is to study the behaviour of trapezoidal corrugated-core subjected to compression stress and to produce a model of mechanical response of trapezoidal corrugated-core with sandwich structures and to study the effect of varying the geometrical parameters on the corrugated-core behaviour. Corrugated composites were designed using hand-layup technique and then bonded to skins using adhesive based on the same material, to produce a range of lightweight sandwich structures. The thickness of the cell walls, number of unit and width cell are used in determining the behaviour of the mechanical structures. The initial failure modes in this corrugated structure are struts buckling, fibre cracking, and delamination in the composite structure. Besides that, the debonding between the skins and the core were also investigated. Compression loading was subsequently performed on the trapezoidal corrugated structure, where the compression strength shows increasing for all the corrugation structure. To simulate the mechanical response of the corrugation structure, Finite Element (FE) models have been generated using ABAQUS. The results were compared to measure the experimental outcome. From the finding, the effects of varying the number of unit cell dominate by CFRP are 3.48 MPa higher than GFRP that 2.08 MPa at three unit cell. It shows that the higher number of unit cells it will affects the composite strength. For the effect of cell wall thickness, the results show that the higher the wall thickness, the higher the compression strength. The compression strength of CFRP and GFRP are 3.48 MPa and 1.74 MPa respectively at 1.75 mm and 1.90 mm thickness. The structures show excellent repeatability in terms of their mechanical response. The mechanical response in compression increases with specimen thickness. Validation Finite Element and experimental data, a very good deal is found between experimental and finite element values. This observation is validated by computing the percentage error between the finite element and the experimental results with average difference around 4.97% in maximum load.