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ORIGAMI PATTERN PARAMETER MODELLING OF THIN-WALLED STRUCTURE DURING AXIAL CRUSHING

By

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Axially crushed thin-walled structure that is usually used for impact energy absorption is expected to collapse in a progressive stable manner. However, the collapse process is frequently disturbed by a premature bending that sees the failure of the structure that leads to poor energy absorption. This occurrence of premature bending is due to several factors such as poor design parameter and substandard fabrication of the thin-walled structure.

To diminish the phenomenon of premature bending, a method of applying origami pattern to the wall of the thin-walled structure was seen beneficial, as the origami crease lines would be the guiding lines for the progressive collapse. Several studies have shown positive results where the amount of energy absorption is increased with the origami pattern application, specifically with Yoshimura origami pattern, which has similar pattern with the collapse mode pattern of thin-walled structures. Nevertheless, the relations between the origami pattern parameter configurations with the dynamic axial crushing are not well comprehended, thus, it will result to a costly design iteration.

Therefore, a mathematical model is developed where the responses of the origami pattern parameters to the dynamic axial crushing is known, along with the development of an efficient origami patterned energy absorber structure. Numerical model simulation was employed in analysing the dynamic axial crushing responses of conventional thin-walled and origami patterned thin-walled structures where the origami pattern parameter configurations were quantified through the energy absorption, specific energy absorption (SEA), initial peak crushing force (P_{peak}), mean crushing force (P_{mean}) and crush force efficiency (CFE) values. The numerical simulation was also verified experimentally, using an experimental rig for the dynamic axial crushing operation.

Overall, when the Yoshimura origami pattern was utilized to a thin-walled structure, the results showed an increase of CFE and SEA of up to 206.67 % and 17.49 % accordingly, when compared with the conventional plain square thin-walled structure. On the other hand, when compared with the existing vehicle crash box, an increase of CFE and SEA up to 58.62 % and 6.95 % is seen, accordingly. From the parametric studies of the origami pattern, a mathematical model was also derived, to predict the P_{mean} values of axially crushed origami patterned thin-walled structure, where it has proved to successfully predict the obtained P_{mean} of thin-walled structure, even when having varied origami pattern configurations. Accordingly, the optimum origami pattern parameters were employed to the energy absorbing structure and its crashworthiness is seen comparable with the existing vehicle crash box.