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Analytical approach for progressive failure crushing modes of woven FRP composite box structures

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Abstract

This paper proposed the new theoretical prediction based on friction, bending and fracture mechanisms to predict the mean crushing force for the combination of failure crushing modes. During the progressive crushing of CFRP and GFRP composite box the combination of brittle fracture, lamina bending, local buckling and transverse shearing crushing modes was observed. The brittle nature of the most of FRP composites yields they show high capability in absorbing the crushing energy by introducing various fracture mechanisms. The bundle fracture, frond splitting and delamination crack growth are the most important of them. These kinds of fracture mechanisms contribute to shape lamina bundles and consequently increasing of friction and bending resistance. Compared to other analytical methods, the present work relatively introduces the comprehensive prediction of mean crushing force for combination of all failure modes. It is also shown that axial splitting and bundle fracture mechanisms can contribute the highest effect on the energy absorption of composite box structures for various failure crushing modes.

Key words: *Theoretical predictions, Failure crushing mode, Composite box*

1. Introduction

Various failure crushing modes which are known as lamina bending, brittle fracture, transverse shearing and local buckling affect the progressive crushing of composite box structures. The first mode is transverse shearing (fragmentation) which is characterised by a wedge-shaped laminate cross section with one or multiple short interlaminar and longitudinal cracks. In this mechanism interlaminar crack propagation and bundle fracture control the energy absorption. The second mode is lamina bending which is developed from long interlaminar, intralaminar, and parallel to fibre cracks. This mechanism causes the formation of continuous fronds which spread inwards and outwards. Friction and inter/intra laminar fracture controls the energy absorption of lamina bending mode. The third mode is brittle fracturing mode which is a combination of transverse shearing and lamina bending crushing modes. In this mode the length of the interlaminar cracks are between 1 to 10 laminate thickness. In this case the main energy absorption mechanism is fracturing of lamina bundles. The highest energy absorption of composite tubes has been observed in brittle fracture and lamina bending crushing modes. The fourth mode is local buckling which occurs in brittle FRP composites when, (i) the interlaminar

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