EFFECT OF TRAPEZOIDAL PROFILE SHAPE ON THE CRUSHING BEHAVIOUR OF RADIAL CORRUGATED COMPOSITE TUBES SUBJECTED TO LATERAL QUASI-STATIC LOAD

Elfetori F. Abdewi, A.M.S. Hamouda*

Mechanical Engineering Department,Engineering Academy Tajoura Libya

*E-mail: abdewi301@yahoo.com, *Qatar University, Doha, Qatar*

Introduction

The use of composite materials in different kinds of applications is accelerating rapidly. Composite materials have become common engineering materials and are designed and manufactured for various applications such as energy absorber for crushing. Crushing behavior of tubular structures made of metal and composites under lateral loading received considerable attention for their application as energy absorbers. Gupta and Khullar [1-2] investigated the lateral compression of single tubes of square and rectangular cross section as well as their orthogonal crosses layered configurations. They showed that hinges are formed first at the middle of the vertical arms and then at the four corners of the tube. Gupta and Ray [3-4] studied the behavior of empty and foam filled aluminum tubes of different sizes of square cross-section under lateral impact and quasi-static loading. Many researchers [5-6] investigated experimentally the crushing behavior of composite cylindrical tubes under lateral compression load. They found that the composite tubes have exhibited an effective and stable energy absorption phenomenon in the laboratory testing.

This paper presents the effect of corrugation profile geometry on the crushing behavior, energy absorption, failure mechanism, and failure mode of woven roving glass fibre/epoxy laminated composite tube. Experimental investigations were carried out on composite tubes with two different profile shapes: sinusoidal and trapezoidal. The tubes were subjected to lateral compressive loading. On the addition to a radial corrugated composite tube, cylindrical composite tube, were fabricated and tested under the same condition in order to know the effect of corrugation geometry.

Experimental

The specimens were tested in quasi-static lateral compression between two flat platens. Five replicate tests were conducted for each type of composite tubes. Load platens were set parallel to each other before testing. All composite tubes were compressed at a rate of 15 mm/min until limited crush, which implies complete compaction of tested tube and load records increases sharply. Load and displacement were recorded by an automatic data acquisition system.

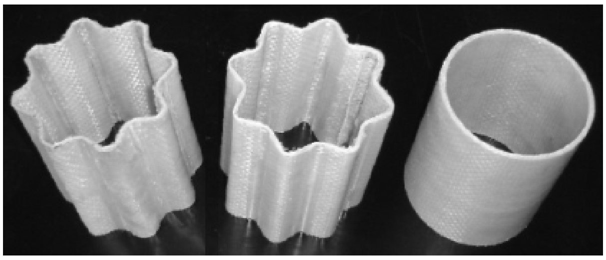

Fig. 1 Tested specimens (composite tubes)

Results and Discussion

As shown in Figure 1, three types of specimens have been tested: Cylindrical Composite Tube (CCT), Radial Corrugated Composite Tube (RCCT), and Trapezoidal corrugated Composite Tube (TZCT). Quasi-static tests were conducted by laterally compressed of specimens between parallel, flat steel platens (see Figure 2), one static and one moving at a constant cross-head speed. As load increases, the testing specimen deform elastically with a minimum resisting force. Further movement of the cross-head, causes declination of the testing specimen resulting in fracture lines formed along the sides of the tested specimen as shown clearly in Figure 3 for the case of cylindrical tube. Complete separation of the upper and lower part of the specimen was observed at the final stage of crushing. Upper and lower corrugated sheets came to contact each other forming double layer of corrugated sheets for corrugated specimens, and forming flat sheets for the case of cylindrical specimens. Finally complete collapse takes place, leads to a sharp increase of the load thus reaching the end point of the crushing test.

In order to examine the corrugation effect on the energy absorption characteristics, different parameters can be obtained. These parameters are: initial failure load P_i, specific energy E_s, crushing force efficiency *CFE*, and stroke efficiency *SE*. Results obtained were presented in Table 1.

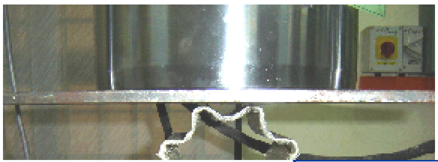

Fig. 2. TZCT specimen under compression load

Load-displacement curves and deformation histories were presented as shown in Figure 4. Based on the load path and observation of deformation history with the aid of photographs that was taken during the test, the two curves of corrugated tubes (RCCT, and TZCT) were mostly coincides each other. However there was a valuable difference between the results of these two corrugated tubes and the cylindrical tube (CCT). The CCT model recorded much higher initial failure load than corrugated tubes. It is a bout two to three times higher as given in Table 1.

Table 1. Crashworthiness parameters of CCT, RCCT, and TZCT

Model	***P_i* (kN)**	***E_s* (kj/kg)**	***CFE* (%)**	***SE* (%)**
CCT	3.27	0.89	87.60	90.23
RCCT	1.61	0.80	89.34	97.12
TZCT	1.20	0.31	55.21	90.63

Changing of corrugation profile did not affect much the crushing behaviour and energy absorption. In spite of corrugation shape, radial corrugation allows the tube to deform elastically with a minimum resisting force.

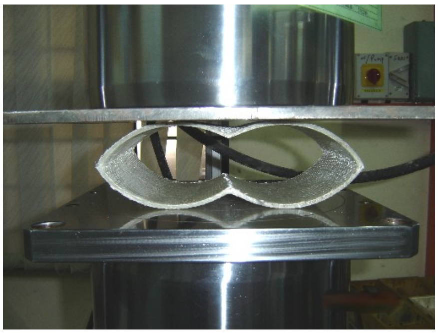

Fig. 3 Formation of fracture longitudinal lines for CCT specimen

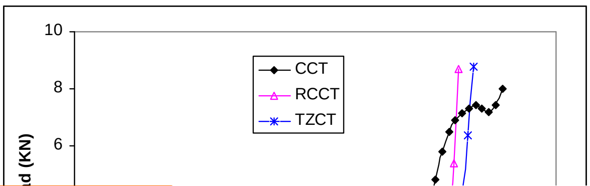

Fig. 4 Load-displacement curve for CCT, RCCT, and TZCT

Conclusion

The objectives of the paper have been achieved. All types of specimens have been fractured approximately in a similar way. The failure takes place due to formation of fracture longitudinal lines. Cylindrical composite tube (CCT) exhibits higher energy absorption capability than the other two models. There is no significant effect of the corrugated profile on the energy absorption capabilities.

References

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