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Improving the Crashworthiness Characteristics of Long Steel Circular Tubes Subjected to Axial Compression by Inserting a Helical Spring

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Abstract : Nowadays, energy absorbing devices have been widely used in all vehicles and moving parts such as railway couches, aircraft, ships and lifts. The aim is to protect these structures from serious damages while subjected to impact loads, or to minimize human injuries while collision is occurred in transportation systems. These energy-absorbing devices can dissipate kinetic energy in a wide variety of ways like friction, facture, plastic bending, crushing, cyclic plastic deformation and metal cutting. On the other hand, various structures may be used as collapsible energy absorbers. Metallic cylindrical tubes have attracted much more attention due to their high stiffness and strength combined with the low weight and ease of manufacturing process. As a matter of fact, favorable crash worthiness characteristics for energy dissipation purposes can be achieved from axial collapse of tubes while they crush progressively in symmetric modes. However, experimental and theoretical results have shown that depending on various parameters such as tube geometry, material properties of tube, boundary and loading conditions, circular tubes buckle in different modes of deformation, namely, diamond and Euler collapsing modes. It is shown that when the tube length is greater than the critical length, the tube deforms in overall Euler buckling mode, which is an inefficient mode of energy absorption and needs to be avoided in crash worthiness applications. This study develops a new method with the aim of improving energy absorption characteristics of long steel circular tubes. Inserting a helical spring into the tubes is proved experimentally to be an efficient solution. In fact when a long tube is subjected to axial compression load, the spring prevents of undesirable Euler or diamond collapsing modes. This is because the spring reinforces the internal wall of tubes and it causes symmetric deformation in tubes. In this research three specimens were prepared and three tests were performed. The dimensions of tubes were selected so that in axial compression load buckling is occurred. In the second and third tests a spring was inserted into tubes and they were subjected to axial compression load in quasi-static and impact loading, respectively. The results showed that in the second and third tests buckling were not happened and the tubes deformed in symmetric modes which are desirable in energy absorption.

Keywords : energy absorption, circular tubes, collapsing deformation, crashworthiness
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