FINITE ELEMENT MODELLING OF FOAM-FILLED TAPERED THIN-WALLED RECTANGULAR TUBES UNDER OBLIQUE IMPACT LOADING

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ABSTRACT

This paper concerns with simulation of foam-filled double, triple tapered and frusta thin-walled tubes under oblique loading. The main aim of this study is to quantify the dynamic crush load and energy absorption response of empty and foam-filled tapered thin-walled rectangular tubes under oblique loading. A finite element model was constructed initially and validated by available experimental and numerical data. Then the validated finite element (FE) model was used to conduct a series of parametric studies on foam-filled tapered tubes under oblique loading. The effect of number of the tapered sides, density of the foam, and the load angle on the response of the foam-filled tapered thin-walled tube were investigated under dynamic oblique loadings. The outcome is expected to assist the application of the tapered thin-walled tubes as energy absorbers due to such impact loading.

Keywords: Thin-walled tube, foam-filled, oblique load

1. INTRODUCTION

Protection of structures under impact loading often necessitates the need for energy absorbers. Such devices designed to absorb the impact energy in a controlled manner and hence protect the structure under consideration. Thin-walled tubes, particularly those of square or circular cross-section, are common types of energy absorbers as they are relatively cheap, versatile and efficient for absorbing energy. The energy absorbers are used in a wide range of applications in industry. For example in automotive structures, aircraft, train, helicopter skids, satellite recovery and so on. Early investigation in this subject was mainly on axial crushing of sheet metal tabular structures. The aim was to understand the behavior of rail coach and vehicle body shells [1].

Tapered thin-walled tubes, in which some of the sides of the tube relative to the longitudinal axis are oblique, are a relatively new type of energy absorbers. Tapered tubes are capable of withstanding oblique impact loads as effectively as axial loads, making them suitable for applications in which the direction of the impact load varies.

There are many publications on the crashworthiness of empty and foam-filled thin-walled tubes under axial loading [2]. However, in reality such as in the vehicle accidents, In fact, the loading is rarely axial and may cover notably large off-axial or oblique components.

Reid et al. carried out a series of experiment on the dynamic oblique crushing of empty tapered thin-walled rectangular tubes to assess stability and energy absorbing properties of such tubes. [2]. Oblique quasi-static loading of empty and foam-filled circular aluminum tubes have been studied by Boerivk et al. [3]. Rayes et al. [4] carried out experimental and numerical studies on oblique loading of square foam-filled aluminum tubes. There are also reports on numerical and experimental studies of square columns under oblique loading.

Recently Nagel and Thambirantam have carried out a study on the energy absorption response of straight and single and double tapered empty thin-walled rectangular tubes under oblique impact loading [5]. They considered the effect of load angle, impact velocity and tube dimensions on the mean load and energy absorption properties of