8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineeering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

TRANSIENT RESPONSE OF COMPOSITE AXISYMMETRIC SHELLS SUBMITTED TO PYROTECHNIC SHOCKS. APPLICATION TO A PAYLOAD ADAPTER

*** A. Legay[1], J.-F. Deü[2]**
Structural Mechanics and Coupled Systems Laboratory
Conservatoire National des Arts et Métiers (CNAM)
2 rue Conté, 75003 Paris, France
[1] antoine.legay@cnam.fr, [2] deu@cnam.fr, www.cnam.fr/lmssc

Key Words: *Pyrotechnic Shocks, Fourier Series, Axisymmetric Shells, Composite Structures, Transient Response.*

ABSTRACT

Current launchers and spacecrafts often utilize pyrotechnic devices to separate structural subsystems generating intense shock stress waves travelling throughout the structure. In particular, during the last separation phase, the payload adaptor is submitted to pyrotechnic shocks characterized by high peak acceleration and high-frequency content. As a consequence, the satellite, which is close to the excitation source, is susceptible to damage making the dynamic simulation of such a system of prime importance.

In a numerical point of view, a tridimensional analysis of the dynamic behavior of the payload adaptor requests a huge number of degrees-of-freedom associated with an extremely fine time discretization in order to capture the very short wave lengths during the wave propagation phenomena. Consequently, it is preferable to take benefit of the axisymmetry of the payload adapter through a Fourier circumferential decomposition in order to reduce computational costs and be able to conduct parametric studies. Let us recall that the development of efficient computational methods for handling ”quasi-axisymmetric” solids with Fourier techniques has been the subject of much work, especially in the US aerospace industry, since 1965 [1]. However this kind of procedure, classical for static, modal and buckling analyses, is still original for transient responses of composite structures submitted to complex shock loading.

It is important to note that the excitation induces by the payload separation is not axisymmetric, is of short duration and moves due to the pyrotechnic cord. It requires special procedures for the reconstruction of the response from the individual Fourier harmonic. Moreover, the type and the number of harmonic components have to be carefully chosen in order to obtain an efficient solution in terms of accuracy and computational cost. Finally, with a Fourier decomposition, the physical interpretation of the response is carried out on an easier manner. In this work, all the previous points will be discussed throughout the analysis of some numerical examples and their comparisons with experimental data.

Below, some preliminary results of this research work in progress are presented. The example concerns a launch vehicle payload adapter (truncated conical laminated structure connected with an aluminium

cylinder base) submitted to a localized dynamic loading (triangular impulse of 0.02 ms duration applied at the bottom of the cylindrical structure in the radial direction). In this example, a two node axisymmetric conical shell element is used. This element is described in detail in a recent reference of the second author [2] which concerns the vibration reduction of axisymmetric composite structures using piezoelectric materials.

A tridimensional shell computation is first made with Nastran in order to compare results as well as the computational time. On a desktop computer, the 3D shell computation takes about 40 hours while it takes less than 30 min with our approach using only 40 harmonics. A comparison of the deformed structure after 1 ms is given on Figure 1. Moreover, the radial displacement at the loading point is compared on Figure 2. This example shows the efficiency of the method in term of computational time as well as accuracy.

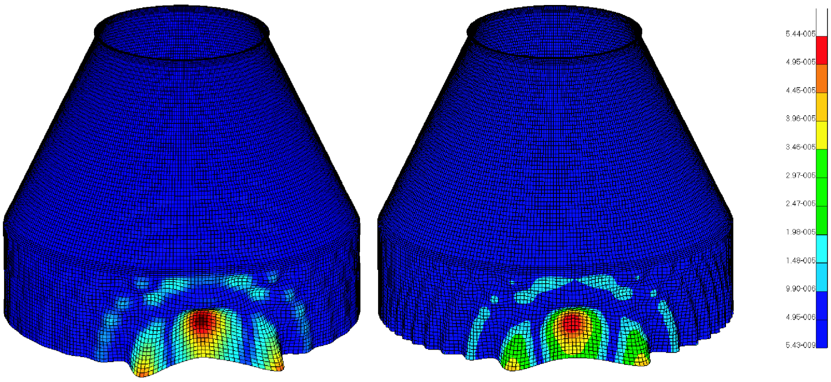

Figure 1: Comparison of the deformed shapes: present approach on the left, 3D shell on the right.

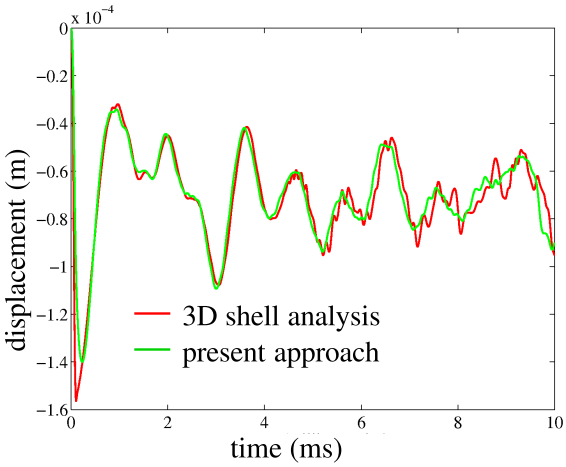

Figure 2: Comparison of radial displacements at the loading point.

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