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A CONSISTENT APPROACH OF DAMPING TREATMENT IN COUPLED DYNAMIC ANALYSIS AND TEST

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Abstract

The coupled dynamic load analysis of space transportation systems like ARIANE 5 makes use of the coupling of mathematical models of the substructures to build the mathematical model of the complete system that is object of the coupled load analysis. The mathematical models of the substructures are condensed and then assembled to build-up the model of the complete system. During this process, special attention has to be paid to the damping matrix.

Traditionally the damping is introduced on subsystem level as modal viscous damping. Experience shows, that coupled dynamic response analysis often reveals strange behaviour. This problem can be overcome, if damping is introduced as an Equivalent Structural Damping (ESD) on substructure level.

The substructure damping is derived from subsystem tests under test boundary conditions and complies with the corresponding component modes of the test configuration. The test boundary conditions are often different from the boundary conditions of the subsystem, when integrated into the complete space transportation system. For use in coupled dynamic analysis, the subsystem mathematical models are condensed with boundary conditions in compliance with those of the integrated substructure. The corresponding component modes differ from those of the test configuration. That is the reason why the damping derived under test boundary conditions has to be re-computed in order to comply with the component modes used for the condensation of the mass and stiffness matrix for use in the coupled dynamic analysis. In order to re-compute the modal damping values, the modal damping matrix of the test configuration has to be transformed into an uncondensed physical structural damping matrix. This is done by the Inflated Damping Matrix (IDM) process. In the following the inflated damping matrix can be condensed by the same transformation as applied on the mass and stiffness matrix. Moreover, at this point the analyst is free to modify the boundary conditions as required for the integration to the complete system.

Dynamic test set-ups generally consist not only of the substructure of interest, but also of test adapters and dummy structures. The question is how to separate the damping properties of substructures of interest from the damping matrix of the complete test assembly. A procedure has been developed, which allows the Separation of this Component Damping (SCD).

The Equivalent Structural Damping (ESD), the Inflated Damping Matrix (IDM) process as well as the Separation of Component Damping (SCD) yield the consistent damping treatment in coupled dynamic analysis and test. The established procedures will be explained within this paper and illustrated with examples.

I. INTRODUCTION

A reasonable approach for the dynamic analysis of large structures is the substructure technique. Large structures are divided into substructures, and condensed matrices of the substructures are assembled for the final dynamic analysis. The steps in the dynamic analysis process are shown in figure 1.