A Strategy for Modelling External User Element in ANSYS: the Bouc-Wen and the Skyhook Case

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Summary

Literature is rich of control devices modelled by the Bouc-Wen model, like magneto-rheological dampers, metallic dampers, rubber bearings, electro-inductive devices often used in bridge engineering. The ability of such model in the simulation of control systems with different characteristics (like passive, semi-active and hybrid) returns it to be very attractive in a multipurpose framework.

The ANSYS environment allows for implementing user elements in Fortran subroutines, compiling a new executable file; however, this requires the user to: a) understand the interfacing routines provided with the ANSYS code; b) to correctly guess how the interfacing routines will be actually called by the ANSYS environment.

This burden can be avoided by exploiting the APDL (ANSYS Parametric Design Language) command \SYS, which allows to call an external executable program from within the main ANSYS analysis procedure, or from within an APDL subroutine. The main idea is to pass quantities of interest (e.g. nodal displacements, velocities, etc.) to the external executable program via an intermediate data file written by standard APDL commands. The external executable replies with some computed quantities (e.g. nodal forces) in a second data file that will be read, processed and applied to the structure by APDL statements. It is worth underline that this implies a decoupling between the process of achieving a structural equilibrium configuration and that of the state determination of the external element.

The usefulness and the limits inherently with this strategy will be shown with reference to the implementation of a new external non-linear element devoted to modelling passive (Bouc-Wen) and semi-active (Skyhook) control devices; these will be used in companion papers for the control of a bridge structure under seismic and wind loading. The external user element is finally evaluated by a comparison with a proven implementation inside the MATLAB environment, which explicitly considers the coupling between the structural state determination and that of the external element, with reference to seismic excitation.

Keywords: structural control, bridges, finite elements, numerical implementation

1. Introduction

Literature is rich of applications of the Bouc-Wen [1] endochronic hysteretic model in the simulation of dissipative passive and semi-active devices such as metallic dampers rubber bearings, piezoelectric dampers [2] magneto-rheological dampers [3] and electro-inductive devices [4], often used in bridge engineering. The choice to idealize passive and semi-active devices by Bouc-Wen law is supported by the physical and mathematical consistency of that model [5] and the excellent correspondence between the experimental and numerical results obtained. In particular it has been demonstrated [6,7] as the appropriate choice of parameters characteristic makes the Bouc-Wen model capable of describing a passive behaviour, in that it does not create energy, and able to reproduce the free oscillations of a system subject only to inhomogeneous initial conditions. This, and the fact that the model is stable in reproducing the limited response to a limited input, makes

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