Fuzzy Finite Element Analysis of Smart Structures

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ABSTRACT

The control of structural vibrations due to earthquakes can be done by modifying the design to include damping devices or by providing active or passive control systems. In practice, it is almost impossible for the dampers to guarantee safety of structures against strong earthquakes because of prohibitive cost necessary for mass dampers and of the large amount of emergency energy power source required to drive the control actuators.

Extensive investigations have been carried out to use smart materials as potential sensors and actuators to actively control vibration. The actuators from smart materials can develop strains in response to applied stimulus such as earthquakes. The resulting strains are then used as control forces. It should be noted that the external loadings related to civil engineering structures due to earthquakes are highly uncertain with respect to magnitude and arrival time.

Many researchers have used the finite element method for designing piezoelectric transducers to control vibrations. Most of these finite element formulations were used to analyse simple beams and plates in relation to aeronautical structures. However, the applications to civil structures are limited particularly in the design of structural foundations.

In the finite element analysis of 'smart structures' adopted for structural vibration control, most of the existing investigations assume the input parameters as deterministic variables and hence the responses of the system are also deterministic. However, it is well known that there are many uncertainties associated with the 'smart structures' such as the piezoelectric, mechanical and physical properties. Besides these, there are also uncertainties associated with the properties of the materials used for structural components, foundations, soil/rock as well as the nature of earthquake loading. Some of these uncertainties are vague and imprecise and hence the use of fuzzy set theory is most appropriate.

This paper presents a unified method combining the finite element technique and the concepts of fuzzy sets for the analysis and design of 'smart structures' which can be used to control the structural vibration due to earthquakes.