SOME ISSUES IN MODELING NONLINEAR VISCOUS DAMPERS FOR MONITORING AND IDENTIFICATION

FARZAD TASBIHGOO*, HAE-BUM A. YUN*, SAMI F. MASRI*, RAYMOND W. WOLFE*, JOHN P. CAFFREY†

* Department of Civil Engineering
University of Southern California
Los Angeles, California, USA
tasbihgo@usc.edu

† Department of Mechanical Engineering
California State Polytechnic University
Pomona, California, USA

This study presents some of the issues encountered in modeling nonlinear viscous dampers, commonly used in large-scale structures, for applications in vibration-based structural health monitoring and in the development of reduced-order computational models. In the past decade, the use of energy dissipating devices has allowed engineers to design or retrofit large civil structures with a greater dynamic capacity and reduction in size of structural members, with the goal of increasing the structural reliability and the saving in the construction cost [1]. It is necessary for the dynamic performance of structures that the incorporated nonlinear energy dissipating devices be healthy and functional during extreme loading conditions, such as earthquakes or excessive wind loads [2]. Accurate computational modeling, and post-construction vibration-based structural health monitoring, would provide tools for a more reliable design as well as convenient on-line structural health monitoring to replace the costly traditional field inspections, for assessing the condition of the dampers.

This study investigates the advantages and limitations of two promising classes of modeling techniques: (1) on-line system identification, based on adaptive-least squares with a forgetting-factor, and (2) batch-processing for developing reduced-order models, based on stochastic optimization techniques. For each class of identification approaches, three different models were used: (i) a simplified design model, that is mostly used by damper manufacturers and design engineers; (ii) a nonparametric, data-based model that is capable of capturing various nonlinear phenomena; and (iii) a parametric (Bouc-Wen) hysteresis model that is capable of generating a broad class of hysteretic behavior.

For validating the analytical studies, the employed methodologies were tested on data sets obtained from experimental studies of large-scale viscous dampers, similar to the dampers used by the California Department of Transportation (Caltrans) on California highway bridges. Some of the issues studied and discussed include: whether the system mass is known; under- and over-parameterization; modeling errors; nature of the basis functions used in the nonparametric fits; computational efficiency and convergence; on-line or batch-processing; data normalization; as well as variety of parameters that control the algorithms such as the forgetting-factor, search bounds, and initial values.

References

[1] George Baker, *Seismic retrofit of the Vincent Thomas suspension bridge, Los angeles, California*, In 1998 Catalog of TRB Annual Meeting Practical Papers - VIII Bridge Design and Performance. TRB, Design and Construction Group, Technical Activities Division, 1998.
[2] Caltrans, *The race to seismic safety - protecting California's transportation system*, Technical report, Caltrans Seismic Advisory Board, 2003.

Keywords: modeling, nonlinear, damper