11th World Congress on Structural and Multidisciplinary Optimisation
07th -12th, June 2015, Sydney Australia

Minimum-cost topology and sizing optimization of viscous dampers for seismic retrofitting of 3-D frame structures

Nicoló Pollini[1], Oren Lavan[1], and Oded Amir[1]

[1] Technion – Israel Institute of Technology, Faculty of Civil and Environmental Engineering, Technion City, 32000 Haifa, Israel

Abstract

This paper presents a new formulation and an effective approach for the topology and sizing optimization of added viscous dampers in 3-D frame structures. The formulation considers predefined potential locations in the structure for dampers, and a limited number of dampers' size groups whose sizes are to be defined in the optimization process. Binary design variables describe the dampers' existence and their association with a particular size-group, while continuous design variables characterize the mechanical properties of the available dampers' size-group. The relevant structural responses are evaluated with time-history analyses, subjecting a structure to realistic ground accelerations. A new realistic cost function for the seismic retrofitting with viscous dampers is formulated and minimized, subject to displacement constraints. The components of the new cost function are related to both the topology and the sizes of the dampers, resulting in an objective function nonlinear and not continuously differentiable. Therefore, the optimization problem is first formulated as a mixed-integer problem and solved with a genetic algorithm. To improve the efficiency of the solution scheme, the problem is then re-formulated using only continuous variables and solved with a first order optimization method. The constraints are aggregated into one single constraint on their maximum value, and its gradient is then calculated with the adjoint analytical method. The well-known RAMP [1] (Rational Approximation of Material Properties) material interpolation function is adopted to achieve an efficient computational procedure, and optimized discrete solutions. The resulting continuous scheme leads to solutions very similar to the ones achieved with a genetic algorithm, but requires a much smaller computational effort. This is demonstrated in the case of two 3-D frame structures [2].

[1] M. Stolpe and K. Svanberg, "An alternative interpolation scheme for minimum compliance topology optimization," Structural and Multidisciplinary Optimization, vol. 22, pp. 116-124, 2001.
[2] N. Pollini, O. Lavan and O. Amir, "Towards realistic minimum-cost optimization of viscous dampers for seismic retrofitting," Submitted.