Dynamic properties of a building with viscous dampers in non-proportional arrangement

Miguel Angel Ortiz Barrios, Juan Escorcia Caballero, Fabián Sánchez Sánchez

Abstract

Any rational approach to define the configuration and size of viscous fluid dampers in a structure should be based on the dynamic properties of the system with the dampers. In this paper we propose an alternative representation of the complex eigenvalues of multi degree of freedom systems with dampers to calculate new equivalent natural frequencies. Analytical expressions for the dynamic properties of a two-story building model with a linear viscous damper in the first floor (i.e. with a non-proportional damping matrix) are derived. The formulas permit to obtain the equivalent damping ratios and equivalent natural frequencies for all the modes as a function of the mass, stiffness and damping coefficient for underdamped and overdamped systems. It is shown that the commonly used formula to define the equivalent natural frequency is not applicable for this type of system and for others where the damping matrix is not proportional to the mass matrix, stiffness matrix or both. Moreover, the new expressions for the equivalent natural frequencies expose a novel phenomenon; the use of viscous fluid dampers can modify the vibration frequencies of the structure. The significance of the new equivalent natural frequencies is expounded by means of a simulated free vibration test. The proposed approach may offer a new perspective to study the effect of viscous dampers on the dynamic properties of a structure