CONCEPTS OF DAMPERS FOR EARTHQUAKE PROTECTION OF EXISTING BUILDINGS AND FOR DISPLACEMENTS RESTRAINTS IN SEISMICALLY ISOLATED BUILDINGS

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Abstract

Tuned Mass Damper (TMD) is one of the methods, known as a passive vibro-protecting device. The attempt to find the optimal parameters of TMD in the form of an additional flexible upper tenth floor (AFUF) in a 9-story frame building is presented. The efficiency of a single mass damper tuned to the first mode of building vibration is not very high. Therefore, three dampers tuned to the first three vibrations modes of the building are considered much more effective. The multi-version analyses of such structure led to the conclusion that in this case optimal stiffness and mass correlations of dampers held the feature of significant reduction of shear forces and displacements (for about 2 times) compared to the building without TMDs. However, the structural solution of TMD in the form of AFUF contains some deficiencies, which are described in the paper. Therefore, the author has suggested providing flexibility to the damper using laminated rubber-steel bearings (LRSB). In such case the AFUF will turn into an additional isolated upper floor (AIUF). Dynamic testing of the existing 9-story apartment frame building before and after erection of AIUF results in the conclusion that the proposed AIUF method leads to upgrading earthquake resistance of buildings bringing to reduction of shear force at the ground floor level by a factor of 1.76 and at the same time the displacement at the 9th floor slab level decreases 2.2 times.

Paper also presents a new concept of Dynamic Damper (DD) to restrict the displacements of seismically isolated buildings. Since the maximum displacement occurs at the level of isolators the proposed damper as a mass-spring subsystem must be attached either above or below the isolation interface. In order to create the DD in low-story structures it is suggested to use as a mass the perimeter pavement around the building and as a spring the LRSBs. The pavement is separated from the superstructure and hung to it by means of LRSBs, which are installed with certain spacing along the whole perimeter and will experience the tension strains.

Another type of damper is suggested for the large multistory buildings where DD is attached immediately above the isolation system. One can imagine various functions for such a subsystem, e.g., an exercise room, a swimming pool, parking space, utilities room, as long as the mass remains relatively constant in time and large displacement can be accommodated. In this case the LRSBs will experience the compression strains. The proposed schemes of DD also have the advantage of increasing the capacity of the base isolated buildings against overturning forces. Earthquake response analyses of the base isolated buildings with and without the damper were performed showing that damper significantly reduces the horizontal displacements and shear forces at the level of isolation system. First real application of DD in construction of a seismically isolated residential house is described in the paper.