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EXTENDED ABSTRACT

The Effect of Soil-Structure Interaction on The Seismic Response of Optimized Structures with Multiple Mass Dampers

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1. Introduction

Tuned mass damper (TMD) is a type of passive damping system that is connected to the main structure as a secondary mass and through spring and damping, it reduces the dynamic response of the structure, which is widely used to control engineering systems and other engineering structures are used (Yang et al., 2021). The purpose of this research is to determine the optimal parameters of the dampers and their position in order to reduce the drift and acceleration response of the roof story. For this reason, a 20-story structure is modeled and after designing structural components, multiple adjustable mass dampers are placed on all stories of the structure. Then, based on the MOPSO optimization algorithm, the mass, stiffness and damping of the TMD's along with their optimal position have been determined. In the following, the effect of soil-structure interaction on the seismic response of the optimized structure has been discussed.

2. Methodology

When the TMD is used for seismic applications, the TMD is usually set for the main vibration mode of the structure. The equation of motion governing the system with a mass damper is relation. In this article, the ratio of mass, stiffness, damping and the placement of dampers in the stories are variables (Sadek et al., 1997).

$$[M]\{\ddot{x}(t)\}+[K]\{x(t)\}=-[M]\{r\}\,\ddot{x}\_g+\{P(t)\} \quad (1)$$

The plan of the structure has shown in Fig. 1. It has 5 spans to the length of 5 meters in both directions with a story height of 3.2 meters for a of 20 stories with special ductility. Additionally, Fig. 2 schematically shows the distribution of dampers in the stories.

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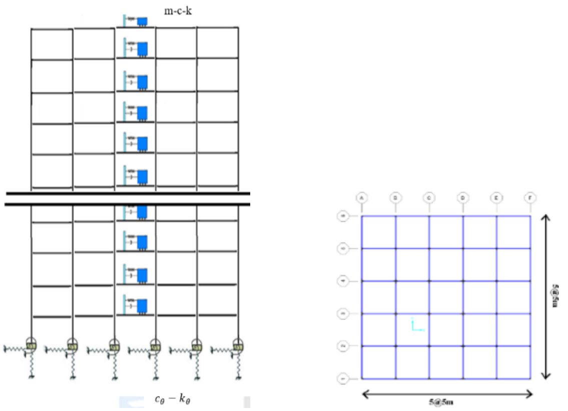

Fig. 1. Plans and views of modeled structures for review

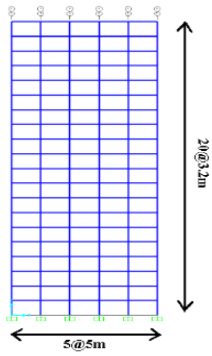

Fig. 2. Schematic of the structure with optimized dampers considering the interaction between the soil and the structure

To investigate the effects of soil-structure interaction, a direct modeling method has been used, and sandy soil has been modeled using Pressure Independent Multi Yield materials in Opensees software. Seismic response of the system under the 7 records of earthquakes near and far from the fault have been obtained. In the “multi-objective optimization” algorithm used in this research, the cost used to optimize the acceleration and drift of the roof story of 20-story structures under the Elcentro earthquake. The variable used in optimizing is mass percentage of dampers compared to the mass of the structure. The mass of the damper in each story is considered as a variable.

3. Results and discussion

Based on the results, it can be seen that the acceleration and drift of the roof story in models with optimized mass dampers (MTMD) in all earthquake records is less than the structure without dampers. Considering soil-structure interaction (MTMD-Soil) has reduced the acceleration value of the roof story compared to the case without dampers and has caused a slight change compared to the model with dampers (MTMD). Based on the numerical results of Fig. 3 and Fig. 4, it can be seen that the use of optimized dampers (MTMD) has caused a significant reduction in the amount of relative displacement of the roof story. Applying the interaction of soil and structure to optimized structures with mass dampers (MTMD-S) has caused changes in the seismic response and the relative displacement of the story, so that in some records it decreased by about 3% and in others it increased by about 2%.

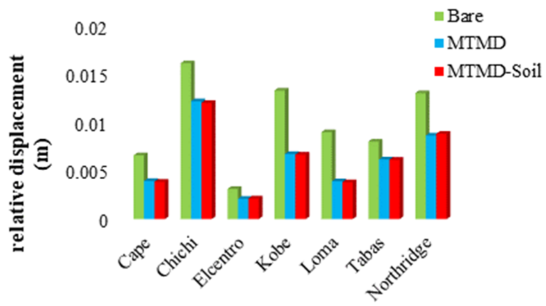

Fig. 3. The maximum relative displacement of the roof floor of the optimized structure with multiple mass dampers (with and without soil-structure interaction) and without dampers

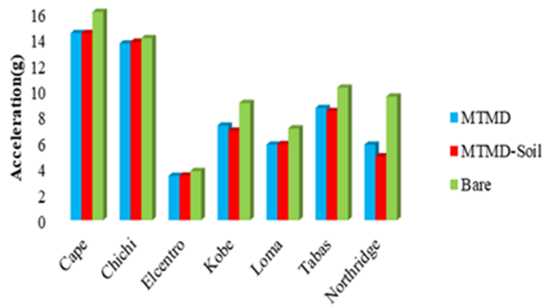

Fig. 4. The maximum acceleration of the roof floor of the optimized structure with multiple mass dampers (with and without soil-structure interaction)

4. Conclusions

The optimization results show that multiple tuned mass dampers (MTMD) should not be distributed uniformly in all stories. As can be seen, in a 20-story structure, in the optimal state, the amount of mass allocated to the damper of the fifteenth story was more than the other stories. Acceleration and relative displacement in optimized structures with mass dampers (MTMD) in all earthquake records are lower than structures without dampers. The maximum reduction in acceleration and drift is about 23% for earthquakes Tabas, and 56% for the Loma earthquake. Considering the soil-structure interaction for the structure with optimized damper (MTMD-Soil) has reduced the amount of acceleration and relative displacement of the roof story in some records and increased it in others, which was 3% and 2%, respectively.

5. References

Sadek F, Mohraz B, Taylor AW, Chung RM, (1997). A Method of Estimating the Parameters of Tuned Mass Dampers for Seismic Applications. Earthquake Engineering & Structural Dynamic, Vol 26, pp. 617-635. https://doi.org/10.1002/(sici)1096-9845(199706)26:6%3C617::aid-eqe664%3E3.0.co;2-z

Yang F, Sedaghati R, Esmailzadeh E, “Vibration suppression of structures using tuned mass damper technology: A state-of-the-art review”, 2021, 28, 7-8. https://doi.org/10.1177/1077546320984305