SEISMIC CONTROL SYSTEMS FOR EQUIPMENT AND BUILDINGS

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INTRODUCTION

Passive seismic control strategies are based on the reduction of energy which may affect a structure in case of earthquake events. Some well known approaches make use of frictional, plastic, or other energy dissipating behaviour of special devices. The following presentation reflects some basic ideas for the increase of elasticity and viscous damping for different types of structures. Spring elements provide local elasticity and they attract a great extend of the seismic energy. In many cases they represent the most flexible part of the structure. In comparison to common structural members they are designed for high operational and seismic demands. Even when considering severe earthquakes the material of these elements can remain in the elastic range. In structural design they can be represented by linear springs, and they can be applied as supports or connecting links. As springs are very soft the frequency of the entire structure is reduced significantly.

Usually Viscodampers are installed beside the spring elements. They have the task to absorb the kinetic energy by the increase of structural damping. Viscodampers serve as a displacement limitation of the structure and of the devices. The safety against collapse and defined states of serviceability of the structures can be assured. Induced accelerations and internal stresses of important members can be reduced drastically when comparing with the behaviour of the unprotected system. In some special cases merely Viscodampers are installed. They possess the ability to damp the relative motion between two structures or between the structure and the 'rigid' vicinity. The effects of a tuned mass damper can be seen as a special case as there is an increase of damping for the related mode of vibration. The decrease of the induced structural responses by viscous damping can be taken from different national and international standards, e.g. Eurocode 8 and AIJ.

EFFICIENCY OF THE PRESENTED STRATEGIES

The efficiency of the presented strategies is outlined. Results of numerical analyses are presented utilizing elastic springs and viscous dampers arranged below or within the discretized models. Several examples, mainly executed projects in seismically active regions are discussed.

Equipment, e.g. for electrical purposes or production processes, frequently consists of sensitive material or requires a vulnerable assembly. Two examples are shown in this category – a capacitor bank with ceramic footings and a draw tower with a high slenderness. The improvement of the seismic behaviour for both structures is based on modified vibration modes. The effects of controlled rocking motions are discussed.

Buildings are usually very complex in regard to the dynamic behaviour, and they require a very high standard in safety questions. A typical RC building and a steel frame structure are investigated. Important responses are computed and induced stresses of significant members are compared. The introduction of a tuned mass damper at the top of the building represents a first attempt for the improvement of the seismic performance. Furthermore the buildings are mounted on 3-dimensional base-control systems which are described in detail.

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CONCLUSION

The proposed integration of the T/G deck in the machine building implies economic advantages regarding the total construction costs. It becomes very important for the reduction of seismically induced turbine accelerations and relative displacements. Additionally the earthquake demands of the entire machine building can be controlled by the proposed visco-elastic support of the T/G deck.

Strategies for the protection of equipment are shown using changes in the support conditions. By controlled rocking effects the structural safety can be increased significantly. In comparison to other strategies the horizontal differential displacements in the control surface are in the range of only a few millimeters even under severe earthquake actions. Even sensitive material like ceramic footings in electrical equipment can be protected effectively.

Finally, (tuned) mass dampers are presented as an economic and effective measure for the improvement of seismic performance of buildings. This strategy can also be used for existing and even elder buildings. In these cases the layout should be based on vibration measurement if possible. More than 25 – 35% increase of structural safety can be achieved by such a system when the discussed conditions are considered. This measure is very cost effective as the building itself and especially the foundation conditions are generally no subject to change.

In the discussed examples helical steel springs and Viscodampers are used as seismic control devices. It is well known that springs are acting in the axial direction as they are usually also carrying the dead load of the structure. For the purpose of earthquake protection the vertical demands usually become higher and the horizontal component becomes more important in regard of the target frequency and mode shape of the seismically controlled structure.