Dynamic performances of a 2 d.o.f. system coupled with rigid block and inerters

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Abstract. The dynamic behaviour of a two-degree of freedom linear system coupled with a rigid block is investigated. An elastic device connects the top of the block to the lower mass of the system. Two inerter devices are considered. The behaviour of the coupled system is nonlinear due to presence of rigid block. Both harmonic and seismic excitations are considered. An extensive parametric analysis is performed to check the effectiveness of coupling to reduce the displacements of the system.

Introduction

This paper analyses the coupling of a frame structure and an external rocking wall aimed to improve the dynamic behaviour of the frame. A two-degree of freedom linear system is used as model for a multi-storey frame structure, whereas the wall is described with the classical model of rigid block. An elastic device connects the top of the block to the lower mass of the system. Two inerter devices are considered. One of them connects the lower mass to the ground through a chevron substructure as in [1], the other one links the vertical sides of the block to the ground as investigated in [2] for stand-alone rigid blocks (Fig. 1). As known, the inerter devices act as virtual added masses since they are able to convert the rotational inertia of a flywheel in a translational inertia. The first inerter device m_{R1} is introduced to virtually increase the lower mass of frame, whereas the other device m_{R2} aims to increase the rotational inertia of the rigid block. As observed in previous paper [3], the coupling between structure and rigid block is effective when the wall has a mass of about 10-30% of the total mass of the structure to be protected. The introduction of inerter devices is intended to make effective the coupling also by using relatively small blocks, since part of the mass of interacting system is provided by inerter devices. The nonlinear equations of motion are obtained and successively numerically integrated to analyse the behaviour of coupled system. Simulations are performed using harmonic excitation and several earthquake records. An extensive parametric analysis is performed and the results are summarized in gain maps. The maps show the ratio between maximum displacements or drifts of the coupled and uncoupled systems in different planes of the system's parameters.

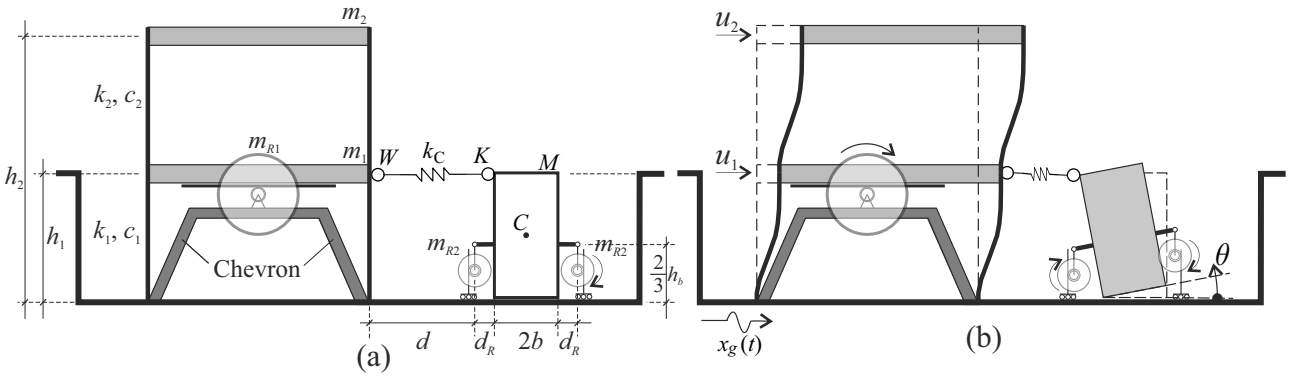

Figure 1: Coupled system: (a) Geometrical and mechanical characteristics; (b) Lagrangian parameters (positive directions).

Results and discussion

It has been found that exist wide advantage regions of the parameters where coupling is beneficial for the structure. In these regions the rigid block acts as tuned mass damper for the lower mass of the 2-d.o.f. system, thus reducing its displacement amplitude. Rigid blocks are able to work as tuned mass damper also when the characteristics of the motion change in time, since they possess the ability to keep tuned by suitably modifying the rocking amplitude. The size of such advantage regions are strongly affected by the apparent mass provided by inerters linked to the block. Instead, inerter devices that connect the first storey of the frame directly to the ground are always detrimental for the performances of coupled system.

References

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