

## INFLUENCE OF A TMD IN ITS CONTROL ACTION OF A SDOF FRAME WITH NON-LINEAR HYSTERETIC BEHAVIOR

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### ABSTRACT

This paper presents a parametric investigation concerning the control parameters of a Tuned Mass Damper (TMD), with the purpose of reducing vibrations of a SDOF frame structure with non-linear hysteretic behaviour, when it is subjected to earthquakes and wind loads. A numerical model (MATLAB/Simulink) is implemented in order to obtain the structural response of a SDOF infilled wall frame structure subjected to two different acceleration signals and evaluate the effectiveness of the applied TMD when the value of its mass is changed. Four different hysteretic behaviour cases will be considered for the infilled wall frame structure. Based on the results obtained, the definition of the mass ratio between the TMD and the main structure will be crucial in finding the ideal performance of a TMD.

**Keywords:** Non-Linear behaviour, Hysteresis, Passive control systems, Tuned mass dampers (TMD).

### INTRODUCTION

Civil structures exhibit non-linear and complex behaviour that are usually linearized to simplify the design procedure. For instance, disregarding non-structural elements constitutes one of the design procedure simplifications that are commonly implemented. When dynamic loads, such as seismic and wind excitations act on framed structures it requires the structural control of the lateral displacements in the structure. In these situations, the presence of non-structural elements highly influences the behaviour and so, the response of the corresponding framed structure. This simplification must be then assed in whether is appropriate to design passive control systems for building structures.

Tuned mass dampers (TMDs) are well-known passive control systems whose main purpose is to reduce building vibrations due to lateral loads. They increase the energy dissipation capacity of the structure in which they are applied.

Tuning the control parameters of a TMD requires knowledge about the dynamic structure properties. Non-linear behaviour can compromise the overall performance of the control system. Therefore, to better define certain control parameters in the design procedure an investigation is carried out regarding the implementation of TMDs in a single degree-of-freedom (SDOF) frame structure with four different cases of non-linear behaviour for the non-structural element.

## RESULTS AND CONCLUSIONS

A Simulink model was implemented based on the properties of the structural system adopted. It was considered in this study two different acceleration signals, a generic harmonic signal and a seismic acceleration signal of the El Centro's earthquake [1].

A Macro-Simulink numerical model is used in this investigation, adapted from Mousavi et al. [2], and is based on a smooth hysteretic model that was first suggested by Bouc [3] (and developed by many others: Wen [4], Baber & Noori [5], Casciati [6], Reinhorn et al. [7], Sivaselvan & Reinhorn [8]).

The graphs from Figure 1 display the resulting hysteretic loops considering the hysteretic behaviour with stiffness and strength degradation with the pinching effect. Each graph presents the controlled and uncontrolled hysteretic responses varying the value of the mass ratio.

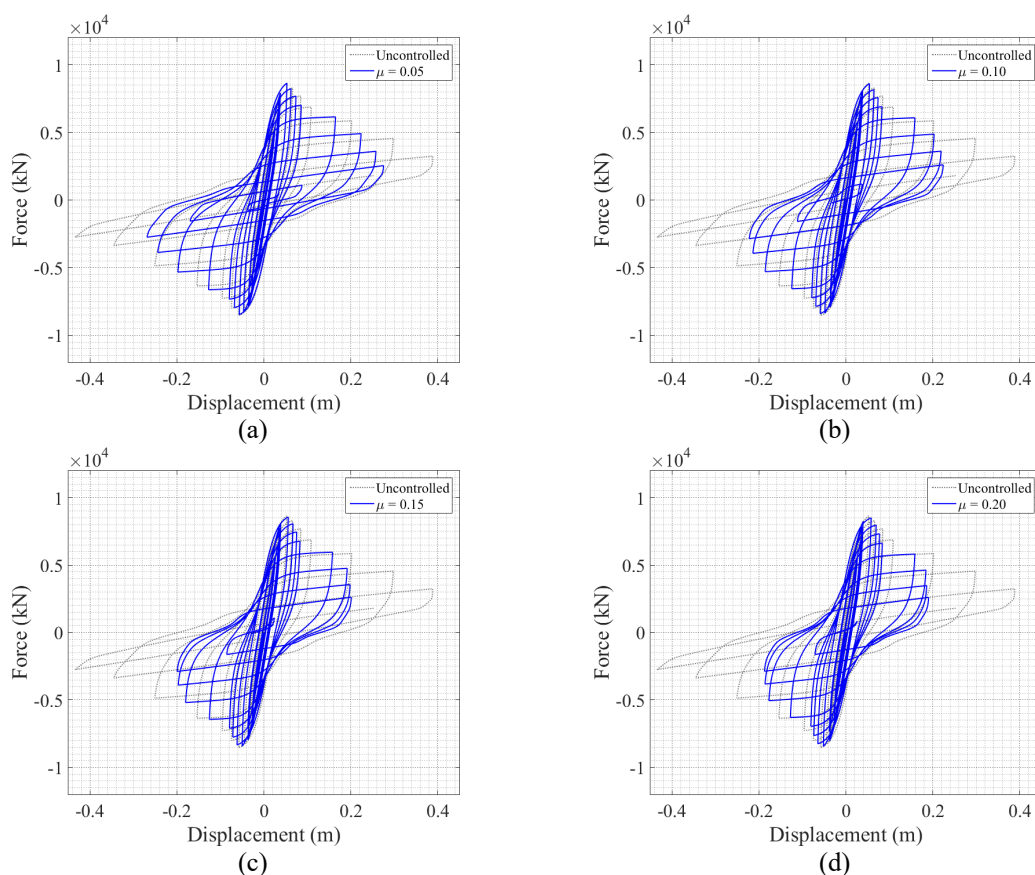


Fig. 1 – Hysteretic loops of the infilled wall frame structure under the generic harmonic signal acceleration, considering the stiffness and strength degradation with the pinching effect: a) Mass Ratio of 5%; b) Mass Ratio of 10%; c) Mass Ratio of 15%; d) Mass Ratio of 20%.

In order to better address this analysis another evaluation criterion, other than just the simple analysis of the peak responses, is suggested for further investigation. This new set of evaluation criteria comprising normalized and RMS (Root Mean Square) responses and also control requirements was used to complete the performance assessment of each controlled case of hysteretic behaviour [9].

The effectiveness of the TMD is evident when observing the reductions of the peak responses and the effect that has on the hysteretic loops in reducing the displacements for the same strength capacity of the infilled wall frame structure, preventing eventual structural instabilities.

The presence of non-structural elements shows very different results from the ones in which they are neglected. They offer more ductility and energy dissipation capability, but can bring serious problems if an out of the plane failure happens. It was verified that the implementation of the TMD can avoid this type of failure, reducing the ductility and energy dissipation demands on the infilled wall frame structure.

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