624. Multi-degree-of-freedom modeling of mechanical snubbing systems

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Abstract. This paper presents a multi-degree-of-freedom model for the design and analysis of mechanical snubbing in elastomeric isolators. The model consists of a three degree-of-freedom rigid body that is assembled to a rigid frame by means of elastomeric isolators and a snubbing system. The isolators are supplemented by the snubbing system so as to limit the displacement of the rigid body in all three directions of motion when the system undergoes transient loading or overloading conditions. The model is piecewise non-linear and uses normalized Bouc-Wen elements in order to capture inherent hysteresis of the elastomeric isolators and the snubbing system as well as the transition in stiffness and damping properties resulting due to inherent coupling between the isolators and the snubbing system. Separate elements are used to model the enhanced stiffness resulting from the snubbing system in the translating directions of motion. A set of elastomeric isolators and snubbing systems is used for data collection, characterization and model validation. The data collection is carried out at multiple strain amplitudes and strain rates. A conventional least squares based parameter identification technique is used for characterization. The completely characterized model is then used for simulating the response of the rigid body and the simulation results are compared to experimental data. The simulation results are found to be in general agreement with the experimental data.

Keywords: snubbing, elastomeric Isolators, Bouc-Wen, hysteresis.

1. INTRODUCTION

Mechanical snubbers are used in multiple engineering applications as displacement limiting or energy absorption devices. Mechanical snubbers are usually designed in conjunction with an isolation system in order to limit the displacement envelope of the isolated system under transient loading, or when the isolated system needs to withstand overloading conditions. Elastomeric isolators are widely used in automotive and railroad applications as passive isolation devices with the elastomer section generally designed to be in shear or compression. A commonly used snubbing system in automotive applications consists of elastomeric elements that are compressed under transient loading conditions so as to progressively limit displacement. Elastomeric isolators exhibit non-linear stiffness and damping properties, especially over a large range of strain rates and varying input displacement amplitudes. This non-linear behavior is furthermore accentuated due to the use of a mechanical snubber as a displacement limiting device. While modeling the non-linear behavior of elastomeric isolators has received a lot of attention from researchers, there is limited literature available on modeling of mechanical snubbing and integration of snubbing models with the models for elastomeric elements. Furthermore, most of the current literature on displacement limiting mechanisms uses piecewise linear models, which may not capture the transition in stiffness and hysteresis phenomena well. This work proposes an integrated piecewise non-linear multi-degree-of-