Optimum Design for Passive Tuned Mass Dampers Using Viscoelastic Materials

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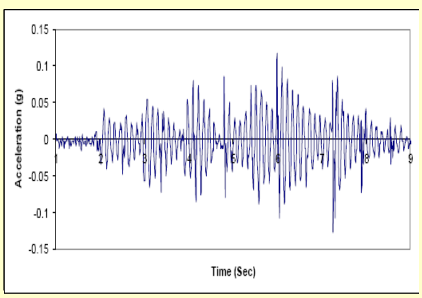
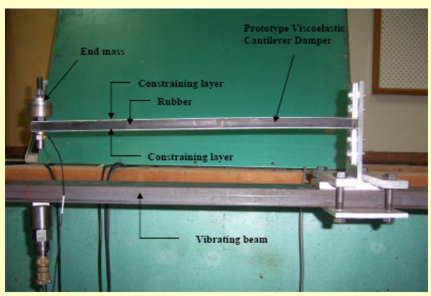
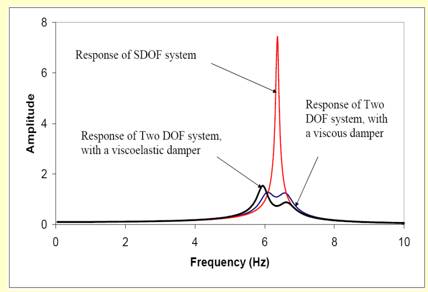
Summary: High levels of vibrations can occur in floor systems due to excitation from human activities such as walking and aerobics. The addition of dampers to reduce excessive floor vibrations can be a practical and cost effectives for floors with low damping, but there are very limited proprietary systems available. They are difficult to design from first principles. This paper forms part of a research project which aims to develop an innovative cost effective Tune Mass Damper (TMD) using viscoelastic materials. Generally, a TMD consists of a mass, spring, and dashpot which is attached to a floor to form a two-degree of freedom system. TMDs are typically effective over a narrow frequency band and must be tuned to a particular natural frequency. The paper provides a detailed methodology for estimating the required parameters for an optimum TMD for a given floor system. The paper also describes the process for estimating the equivalent viscous damping of a damper made of viscoelastic material. Finally, a new innovative prototype viscoelastic damper is presented along with associated preliminary results.



Floor Response Due to Walking Excitation



Viscoelastic Damper, Attached to a Beam



Beam Response

Objectives: The aim is to develop an optimum cost effective viscoelastic damper system to control the excessive vibrations due to human activities. Multi-arm and multi-dampers spatially distributed on vibrating floor will be proposed

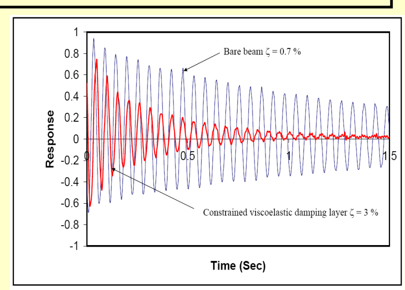
Methodology: An optimum viscous damper is initially designed an then analytically converted into an equivalent viscoelastic damper. The viscoelastic damper is a cantilever beam made of a rubber sandwiched between two metal constraining layers. The composite cantilever beam has a 1% mass ratio. The length of the damper and thickness of rubber are tuned to the fundamental natural frequency of the main system.

Experimental Work: A number of experiments were conducted as part of this study to examine the use of viscoelastic material (rubber) as a mean of providing damping. These experiments are summarised as follows:

(a) Mechanical testing of commercial rubber specimens to determine the basic material properties.

(b) Dynamic testing of simply supported steel beams with and without a constrained viscoelastic layer.

(c) Dynamic testing of a steel beam with and without a prototype viscoelastic cantilever damper.



Decay Rate of Bare and Constrained Viscoelastic Damping Layer

Results: In addition to the mathematical model, the effectiveness of the new cantilever damper was undertaken through two FE models. The FE models of simply supported beam with and without damper were excited using a harmonic force. A summary of the results is shown in the top right Figure. It is clear that the new cantilever damper does perform well, and it produces almost identical reduction in vibration amplitude to a conventional viscous damper. For the optimum cantilever damper the reduction factor in response is in the order of 4. This significant reduction in response was also validated experimentally. The cantilever damper seems to be also very efficient when located at some distance from the centre of the beam.

Conclusion:

The methodology of determining an effective viscoelastic damper for floor vibrations has been developed. A prototype has also been constructed and preliminary experimental and FE are very promising.