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Mechanical Systems and Signal Processing 19 (2005) 537–549
Mechanical Systems and Signal Processing
www.elsevier.com/locate/jnlabr/ymssp

Vibration reduction using passive absorption system with Coulomb damping

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Accepted 21 June 2004
Available online 24 August 2004

Abstract

This research aims at investigating the possibility of using the Coulomb damping, mainly to lessen the vibrations of structures submitted to human loadings. The great advantage in using this type of damping is that we can easily obtain high levels of damping with values well controlled and adjusted to the need of the project.

A computational–theoretical model was developed to represent a structural system with Coulomb damping, containing two degrees of freedom. In order to calibrate this model some experimental tests were carried out with a cantilever beam.

A parametric study was performed after the theoretical–computational model had been adjusted. The results indicate that the system is only applicable to some situations, and care should be taken in the design.

Keywords: Passive absorption system; Computational and experimental analysis; Coulomb damping; Non-linear response

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doi:10.1016/j.ymssp.2004.06.006

1. Introduction

This work follows a research branch of COPPE Structures Laboratory with the objective of reducing vibrations in civil engineering structures. Nowadays, the development and use of new materials and technologies turns the structures more and more slender. So, they are more exposed to dynamic loading. But vibration problems are not confined to modern structures, as traditional ones may also present this kind of problem because loading may change with time. For example, some soccer stadiums and footbridges have been presenting excessive vibrations due to the loads induced by people [1–3]. This kind of loading is still being researched by several authors [4–6] and for this reason it has not been correctly taken into account in some projects [3]. One of the characteristics of this loading is the possibility that the excitation frequency varies in function of the activities imposed by the public.

For the reduction of this kind of vibration several solutions can be used, among them the passive absorption systems. These absorbers are usually systems composed of mass, spring and viscous dampers. The project of this kind of system ends up leading to the need of quite high damping coefficients that are not always easy to be reached in practice. This research aims at investigating the possibility of using the Coulomb damping, mainly to lessen the vibrations of structures submitted to human loadings. The great advantage in the use of this type of damping is that one can easily obtain high levels of damping with values well controlled and adjusted to the need of the project.

A computational–theoretical model was developed to represent a structural system with Coulomb damping containing two degrees of freedom (2 dof). In order to calibrate this model, some experimental tests were carried out with a cantilever beam. Based on simulation results, some ideas about designing an absorption system with Coulomb damping are presented.

2. Theoretical model

The studied model is a spring-mass system with two degrees of freedom, as illustrated in Fig. 1. One degree represents the main system and the other, the absorption system. In this work, we

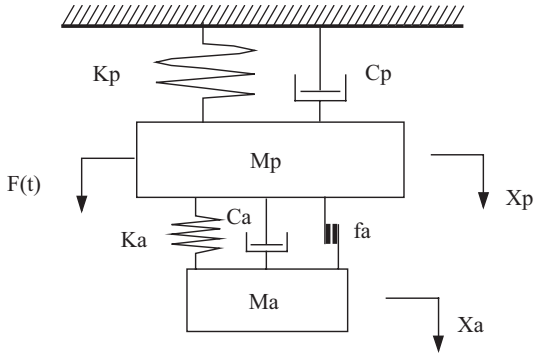

Fig. 1. Theoretical model with 2 dof. *Note:* p—Main system; a—absorption system; k—stiffness; c—viscous damping coefficient; x—displacement; f_a—friction force; M—mass; $F(t)$—force; t—time.