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Control of vibrations induced by people walking on large span composite floor decks

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ABSTRACT

The low damping properties of lightweight large span floor decks composed of a reinforced concrete slab on top of a steel space frame structure may lead to undesirable dynamic responses, even to ordinary human actions such as walking.

This problem was investigated through laboratory tests performed on a 1:1 scale prototype of a composite floor deck structure. Experimental measurements were taken for the structure subjected to several dynamic human loads, especially those produced by the random walking of people.

To compensate for the lack of damping, a passive control system was designed and installed in the composite structure prototype.

The performance of the mechanical control devices was evaluated by means of straight comparisons between the experimental acceleration amplitudes obtained for the controlled and uncontrolled structure subjected to similar dynamic forces produced by one or more persons walking. The most relevant results for both time and frequency responses are presented and used to argue that small and low cost passive control devices can already be included in the design stage of a smart structure as effective accessories to substantially reduce vibrations induced by people in low damped large span composite floor decks.

1. Introduction

Many excitation sources may generate excessive vibrations in low damped lightweight large span floor decks, which may cause discomfort to the users of residential, commercial, or public buildings. Typical examples of these vibration sources are traffic of heavy vehicles on neighboring roads, large machinery in neighboring constructions sites, equipment installed in buildings, and human activities on floor decks, such as walking, running, and jumping. Among these vibration sources, those produced by human activities are the most common, and walking is a daily activity everywhere.

The number of cases of floor deck structures that present human-induced vibration problems has grown with the increasing number of building constructions with composite floor decks spans that are larger and more slender. Vibration problems induced by human walking have been observed for almost two centuries; in 1828, Tredgold [1] *apud* [2] suggested that longer girders should be built with a greater cross-section height to avoid everything shaking in a room when someone walks on the floor. In this same direction, structural stiffening has been largely favored by engineers as a practical design solution and as a remedial measure to reduce vibrations in existing structures; however, in certain cases [3], this may lead to non-practical dimensions of structural components or to a cost-benefit trap.

In the problem addressed in this study, people are simultaneously vibration sources and displeased users, and sometimes they may act as energy dissipation devices [4,5]. Although it is possible to lessen the intensity of the human vibration source by covering the floor with layers of fabric and rubber-like materials, more efficient and lasting solutions are achieved by increasing the damping properties of the structure, by installing dynamic control devices, or, if there is a cost benefit, by stiffening the structure as in common practice.

Whenever allowed by the inner architecture layout, a cheap solution may be achieved by installing partition walls along with struts topped with rubber pads compressed against two floor slabs, combining the required increase in structural stiffness and damping [2,6].

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