The Institution of Structural Engineers

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2014 MSc Research Grant Scheme

Project title: Vibration response of novel composite floors incorporating perforated steel beams for sustainable building construction

University: University of Leeds

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Aims of research: The aim is to develop guidelines to help engineers in the design new lightweight shallow floors with large spans. In recent years, lightweight composite flooring systems have been developed, leading to ultra-shallow floors which do not require the use of shear studs since the concrete slab is embedded within the top and bottom flanges of the steel perforated beams. The fact is that these composite flooring systems can accommodate large and wide spans while being relatively thin results in flexible floor slabs which may become sensitive to loads causing excessive floor vibrations during the service life of the building.

Description of method: Requirements for optimal space utilisation, efficiency during construction, and cost-effectiveness demand the use of long-spanned, shallow, light steel beams in steel structures. In this respect, the vibration response of lightweight composite flooring systems to such dynamic excitations needs to be considered at the design stage.

The issue of characterising the dynamic input loads to floors due to human activities is a well-studied topic in the literature and accurate analytical models exists to model quantitatively these loads. However, prediction of the vibration/dynamic response of floors due to such loads requires solving the “free vibration problem” of structural dynamics. The latter involves the determination of the dynamical properties (DPs) of floors, namely, their natural frequencies and mode shapes of vibration along with a quantification of their level of damping inherent to all dynamically excited structural systems. A closed-form solution of the (damped) free vibration problem for composite floors using perforated steel-concrete composite beams is intractable, even in cases with simple (orthogonal) geometry of the slab.

The project will be assigned to a team of two students with one of them responsible for the analytical/modelling part and the other responsible for model testing. A full-scale prototype benchmark lightweight ultra-shallow composite floor system will be tested at the Heavy Structures Lab within the University of Leeds to obtain high-quality benchmark experimental data. The finite element (FE) models, using the commercial FE-code ANSYS, of the specimen will be developed and fine-tuned to capture accurately the vibratory motion of the prototype specimen. Such models enable comprehensive parametric studies of the vibration response of the original specimen due to any dynamic input load using standard computational algorithms. Modal analyses will also be conducted.

Benefits to structural engineering: This work aims at assessing an innovative composite flooring system which achieves enhanced sustainability in building construction. It is especially tailored for modern mid-to-high rise office and residential buildings with clear benefits to all involved stake holders: contractors, home-owners, occupants, and urban communities. This study will provide knowledge on the response characteristics and a deeper understanding of the performance details of such systems. It attempts to deliver another elegant yet unexplored solution concerning the design of large-spanned and lightweight floors. The work will encourage practising engineers and will be developed to make an impact on design.

Proposed finish date: 07/2014