

A BRIEF OF MY RESEARCH

My research in structural dynamics and structural engineering has focused on such structural problems that are there and to be solved and require significant knowledge in mechanics, and such mechanics problems that have potential applications in engineering. Human-structure interaction, structural response induced by human movements, modelling of structural dynamic behaviour and the use of structural concepts in engineering are the priorities in my current and further research

Human-structure interaction

I have been working to establish a new topic, if it is not large enough to be a new subject, human-structure interaction, since 1994, which treats a group of people and a structure as a whole and studies structural vibration when people are involved and human response to structural vibration. The study requires the knowledge of biodynamics of human body and of structural dynamics and needs both experimental and theoretical investigations. Dr Brian Ellis and I were the first to identify and report the phenomenon of human-structure interaction in 1997. Major progress in the research has been made since a forty-month research project, human-structure interaction – applying body biodynamics into structural dynamics, was awarded by the Leverhulme Trust and started from April 2003. It is found that it may not be appropriate to use the discrete models developed from shaking-table tests from the study of body bio-dynamics in the study of human-structure interaction, although they are widely adopted.

The key publications include:

1. Ji, T., (1995), A continuous model of the vertical vibration of the human body in a standing position, UK Informal Group Meeting on Human Response to Vibration, Silsoe, 18-20 September 1995.
2. Ellis, B. R. and Ji, T., (1997), Human-structure interaction in vertical vibrations, Structures and Buildings, the Proceedings of Civil Engineers, Vol. 122, No.1, pp.1-9.
3. Ji, T., (2003), Understanding the interactions between people and structures, The Structural Engineers, Vol.81, No.14, pp.12-13
4. Zhou, D and Ji, T, Dynamic characteristics of a beam and distributed spring-mass system, International Journal of Solids and Structures, in press
5. Zhou, D and Ji, T, Free vibration of rectangular plates with distributed spring-mass, International Journal of Solids and Structures, in press.
6. Wang, D and Ji, T., The relationships between natural and resonance frequencies of a highly damped TDOF system, submitted to the Journal of Sound and Vibration.
7. Ji, T, D, Zhou and E Duarte, Modelling and testing of human-structure interaction: standing body, submitted to the Journal of Engineering Mechanics, ASCE

Structural vibration induced by human movements

I have been investigated structural vibration induced by human movements since May 1992 when a temporary grandstand was collapsed in Bastia, France, which resulted in 20 died and 2000 injured. My two papers on floor vibration induced by dance type loads published in The Structural Engineer in 1994 were the most requested papers between the years of 1923 and 2001 of the Journal. The load model proposed has been adopted by BS6399 Part 1: Loading for Buildings. The research has covered long-span floors, grandstands and footbridges and included definition of loading induced by jumping, bouncing and walking, modelling dynamic behaviour of these structures and prediction of their response to human loading.

The key publications include:

1. Ji, T. and Ellis, B. R., (1994), Floor vibrations induced by dance type loads -- theory, The Structural Engineer, Vol.72, No.3, pp.37-44. (The paper was awarded the Henry Adams Award Diploma by the Institution of Structural Engineers, 1993/1994 session).
2. Ellis, B. R. and Ji, T., (1994), Floor vibrations induced by dance type loads -- verification, The Structural Engineer, Vol.72, No.3, pp.45-50

3. Ellis, B. R., Ji, T. and Littler, J., (2000), The response of grandstands to dynamic crowd loads, Structures and Buildings, Vol.140, No.4, pp.355-365, The Proceedings of the Institution of Civil Engineers,
4. Ellis, B. R. and Ji, T., (1997, 2004), BRE Digest 426: The Response of Structures to Dynamic Crowd Loads, ISBN 1 86081 1744, October 1997 and the second edition August 2004.
5. Ellis, B R and Ji, T, (2004), Loads generated by jumping crowds: numerical modelling, The Structural Engineer, Vol.82, No.17, pp35-40.
6. Ernesto, E and Ji, T, The action of individual bouncing on structures, submitted to Structures and Buildings, ICE Proceedings.

Modelling of structural dynamic behaviour

I am a Registered Analyst of NAFEMS. In order to predict structural response to human loads, we need to be able to model structures correctly. We have modelled grandstands, multi-panel floors and buildings and provided consultancy on vibrations of grandstands and floors in the past years. The measurements of natural frequencies of structures are often used to improve FE models where possible. We noted from experience that modelling a composite floor is more demanding than modelling a building and calculation of the modal stiffnesses or modal masses of a structure is much less accurate than determination of natural frequencies. Nevertheless, we have proposed appropriate FE model to deal with typical types of floor structures.

The key publications include:

1. Ellis, B. R. and Ji, T., (1996), Dynamic testing and numerical modelling of the Cardington steel framed building from construction to completion, The Structural Engineer, Vol.74, No.11, pp.186-192.
2. Ji, T. and Ellis, B. R., (1996), Applications of finite element modelling in structural dynamics, Benchmark, October 1996, pp.25-28.
3. El-Dadiry, E., Wahyuni, E., Ji, T. and Ellis, B. R., (2002), Improving FE models of a long-span flat concrete floor using frequency measurements, Computers and Structures, Vol.80, pp.2145-2156.
4. Mandal, P and Ji, T, (2004), Modelling dynamic behaviour of a cantilever grandstand, Structures and Buildings, The Proceedings of the Institution of Civil Engineers, 157(3) p.173-184.
5. El-Dadiry, E and Ji, T, (2006), Modelling of the dynamic behaviour of profiled composite floors, Engineering Structures, Vol.28, No.4, pp567-579.
6. El-Dadiry, E and Ji, T., The effect of eccentricity on free vibration of composite floors, submitted to Computers and Structures.

Structural concepts and their applications in engineering

I am interested in identifying new structural concepts from engineering practice, developing new understanding from existing structural concepts and applying structural concepts to solving engineering problems. Some concepts developed are very useful for engineering design, such as the *smaller the internal forces, the stiffer the structure; lateral resonance of a structure can be induced by vertical dynamic loading*. The bracing systems developed through using structural concepts have been used by consulting firms. For helping students to understanding structural concepts, lecturers to teaching structural concepts and engineers to use structural concepts, I and Dr Bell have developed a website, Seeing and Touching Concepts, through using physical models and examples from everyday life and engineering practice. The website contains over 100 sets of model and example.

The key publications include:

1. Ji, T, Ellis, B R and Bell, A J, (2003), Horizontal movements of frame structures induced by vertical loads. Structures and Buildings, the Proceedings of the Institution of Civil Engineers, Vol.156, No.2, pp141-150.
2. Ji, T, (2003), Concepts for designing stiffer structures, The Structural Engineer, Vol.81, No.21, p.36-42.
3. Ji, T and Bell A, Seeing and Touching Structural Concepts, www.structuralconcepts.org