The Institution of Structural Engineers

International HQ
11 Upper Belgrave Street
London SW1X 8BH
United Kingdom
tel: +44 (0)20 7235 4535
fax: +44 (0)20 7235 4294
mail@istructe.org
www.istructe.org

2012/13 Undergraduate Research Grant Scheme – Executive Summary

Project title:
Dynamic loading of footbridges due to people running

University:
University of Sheffield

Supervisor:
Dr Vitomir Racic

Contact details:
Department of Civil and Structural Engineering, Sir Frederick Mappin Building, Mappin Street, Sheffield, S1 3JD
Telephone: 0114 222 5790
Email: v.racic@sheffield.ac.uk

Students:
Gideon Lowes

Project summary:
A recent trend towards lighter & slender bridge designs, incorporating innovative new materials and technologies, has led to an increase in vibration serviceability issues. (ICE 2006) The infamous, Arup designed, London Millennium Bridge's opening day catastrophe served as a catalyst for the advancement of research into human locomotion induced structural excitations. (Dallard et al. 2001) took the opportunity to study pedestrian excitation upon the bridge as well as the influence of synchronization in crowd situations. In the same year, Arup engineers (Young & Willford, 2001) produced a deterministic time domain model of walking induced vibrations.

With a rise in popularity of fitness activities such as jogging and marathon events the next sensible step is to develop a time domain model of running induced vibrations. By utilising 181 time-force histories provided of subjects running upon a double-belt ADAL3D-F treadmill two models have been created for predicting the vertical forces generated by running locomotion.

The first model is a deterministic time domain force model of the first four harmonics of the dynamic load factors. Utilising bootstrapping and robust backwards regression equations of fit were defined in what appeared to be uncorrelated data. This model is very simple and can be undertaken with just hand calculations making it applicable for the typical engineer.

The second model is a probabilistic time domain force model which uses multivariate Gaussian fits to recreate the Fourier spectrum of typical vertical ground reaction force time histories. Subsequently, multiple artificial GRF time-histories can be used to evaluate the probability of excessive vibration exceedance.

References
Dallard, 2001. The London Millennium Footbridge. The Structural Engineer, 79(22), pp. 17-33.
Institute of Civil Engineers, 2006. Fourth International Conference on Current and Future Trends in Bridge Design; Construction and Maintenance, London: Thomas Telford.
Young, P., 2001. Improved floor vibration prediction methodologies. ARUP vibration seminars.