Modelling structure-borne sound transmission from heavy impacts on lightweight floors

Xiaoxue Shen, University of Liverpool

Objectives

Develop prediction models of heavy impact from a standard rubber ball drops on lightweight timber floor.

Introduction

Heavy impacts on floors in buildings, such as from footsteps in bare feet or children jumping can cause annoyance and disturbance. For this reason, two artificial heavy impact sources, the rubber ball and the bang machine, have been developed to allow field and laboratory measurements. The rubber ball is referred to in International measurement standards to assess heavy impacts through measurement of the maximum Fast time-weighted sound pressure level, $L_{p,Fmax}$. For heavyweight buildings it is possible to predict $L_{p,Fmax}$ using Transient Statistical Energy Analysis (TSEA) and with Finite Element Methods (FEM). However, for lightweight buildings there are no validated prediction models that can be used to predict the performance in both the laboratory and the field.

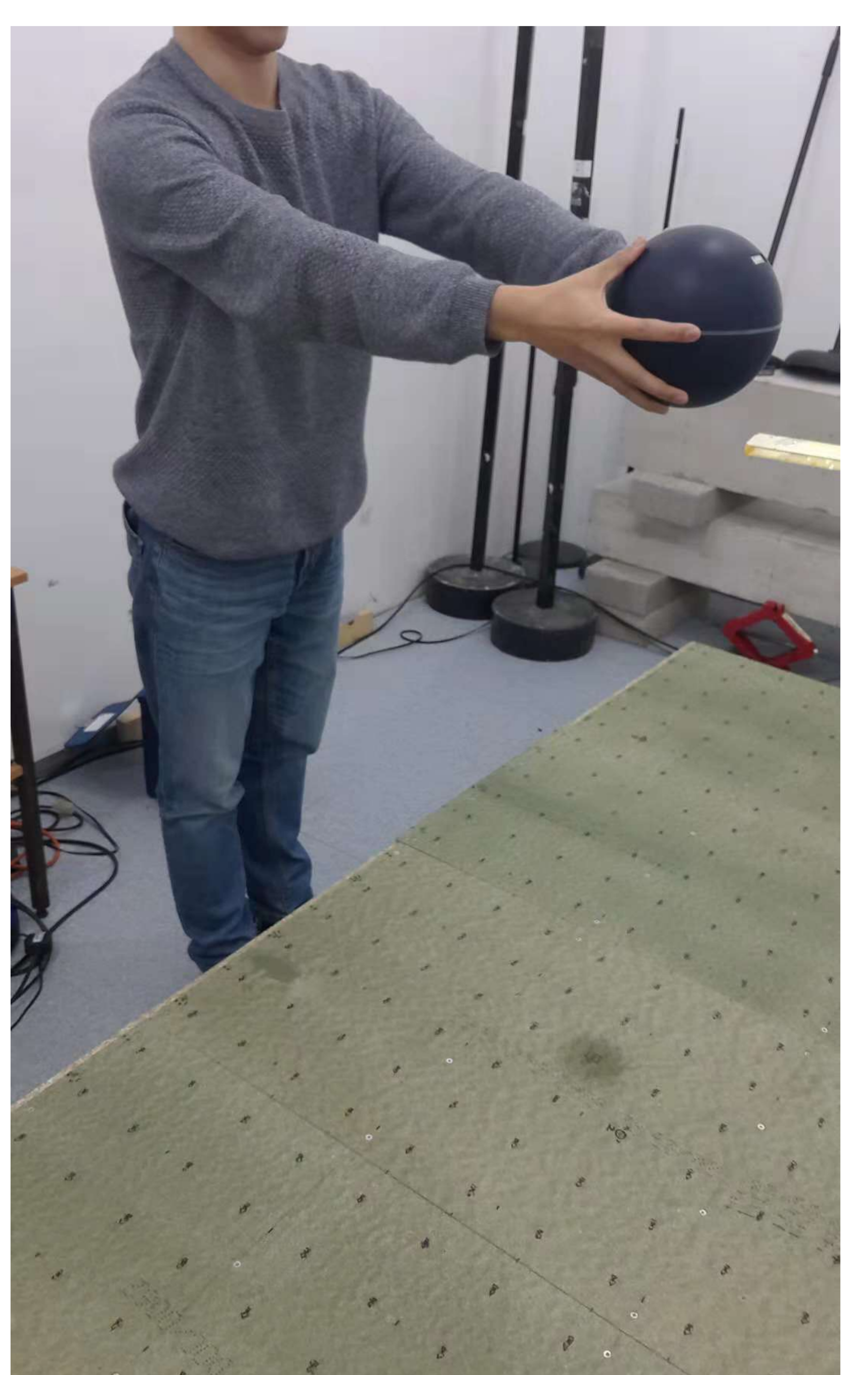

Figure 1:Rubber ball drop on timber floor.

Finite Element Method

- FEM model analysis, EMA, and model updating.

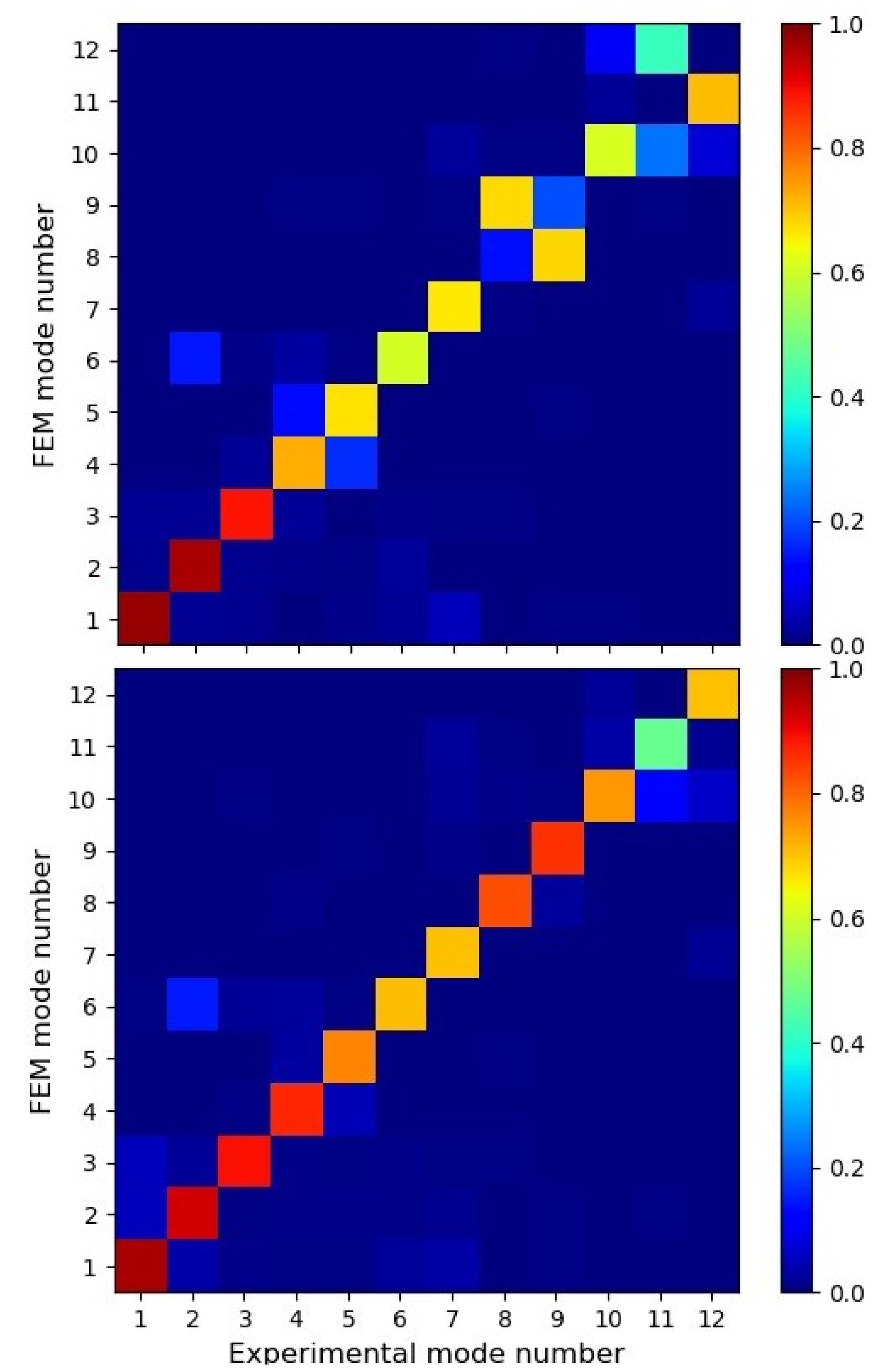

Figure 2:MAC for initial and optimised FE model.

- Experiment and FEM model of rubber ball drops on timber floor.

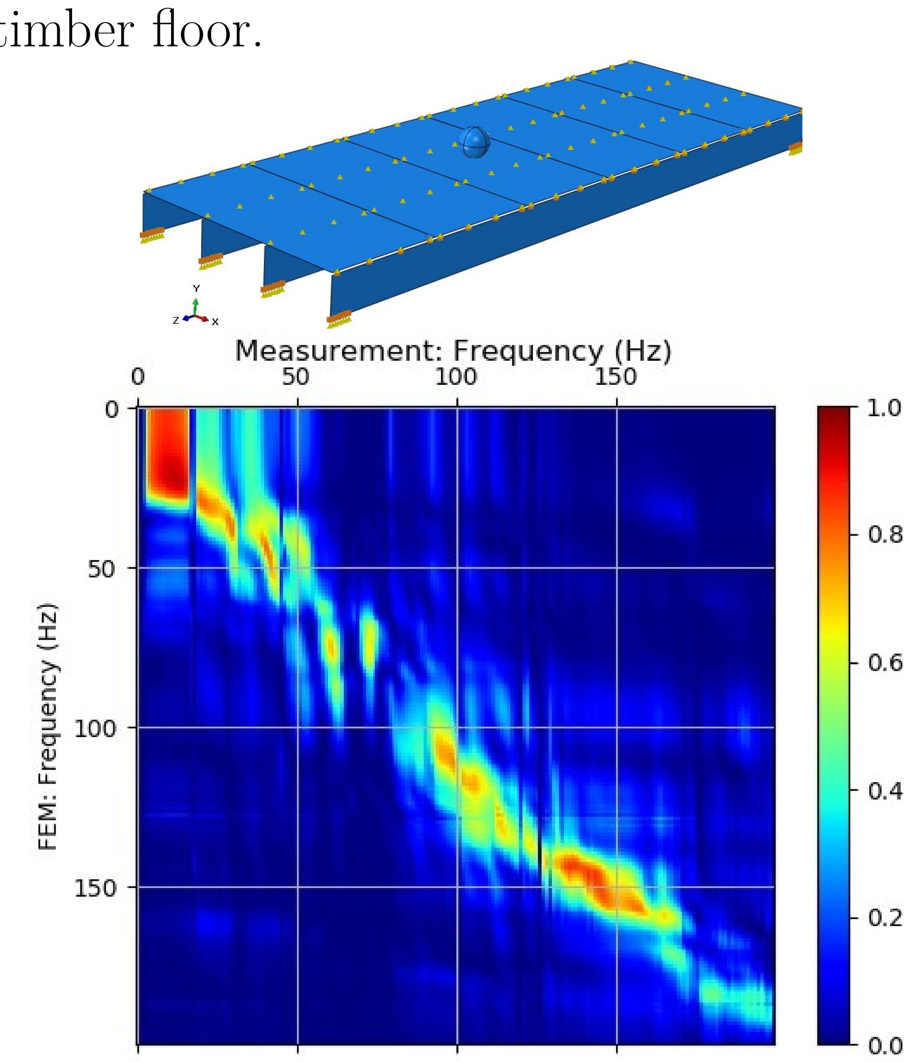

Figure 3:FE model and FDAC.

- Assessing point connections using FEM combined with ESEA.

Transient SEA

- Using FEM to determine the impact force from a single impact from the rubber ball on chipboard.

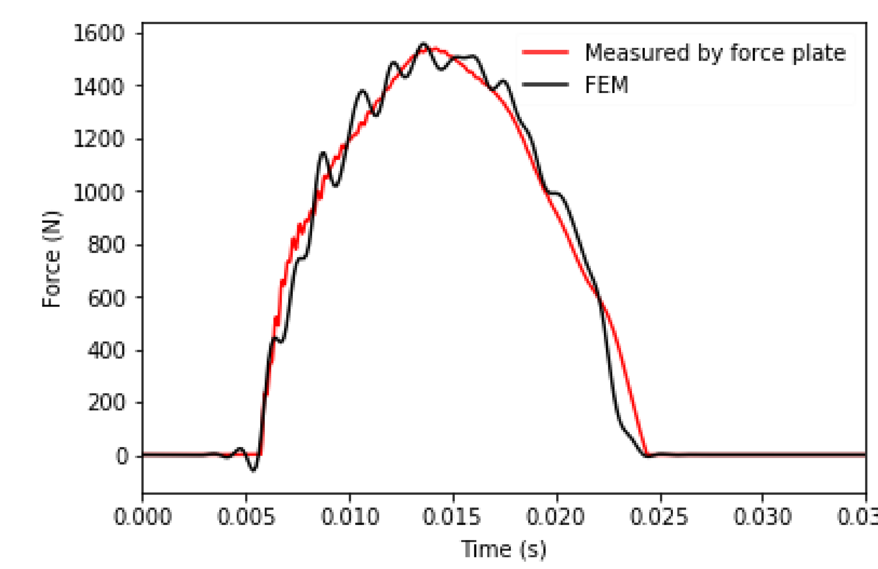

Figure 4:Contact force from the FEM of the rubber ball drops on the chipboard plate, and measured by a rigid force plate.

- TSEA for rubber ball impact on a plate.

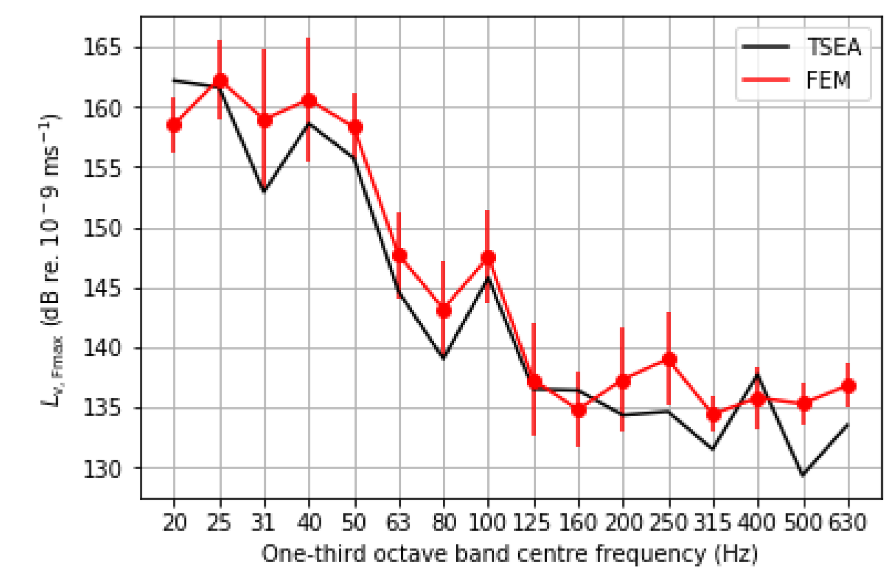

Figure 5:Comparison of $L_{v,Fmax}$ from FEM and TSEA.

- TSEA for rubber ball impact on a timber floor.

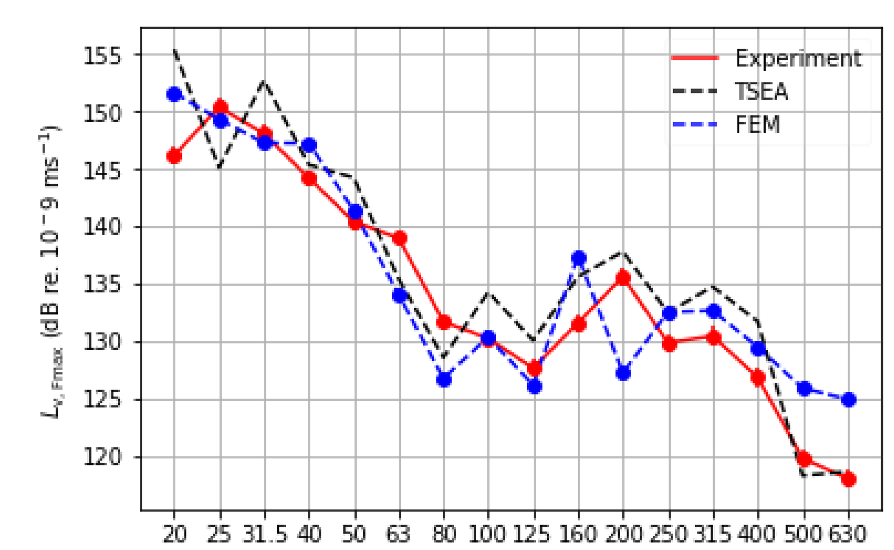

Figure 6:Comparison of $L_{v,Fmax}$ from FEM and one-subsystem TSEA model.

- Assessing whether it is appropriate to use infinite beam/plate formulae to determine driving-point mobility by modelling a large sheet of chipboard, a joist, and a timber floor.
- Prediction of $L_{p,Fmax}$ using FEM for rubber ball impacts on a full-size timber floor built in Building acoustics laboratory in Rosenheim.

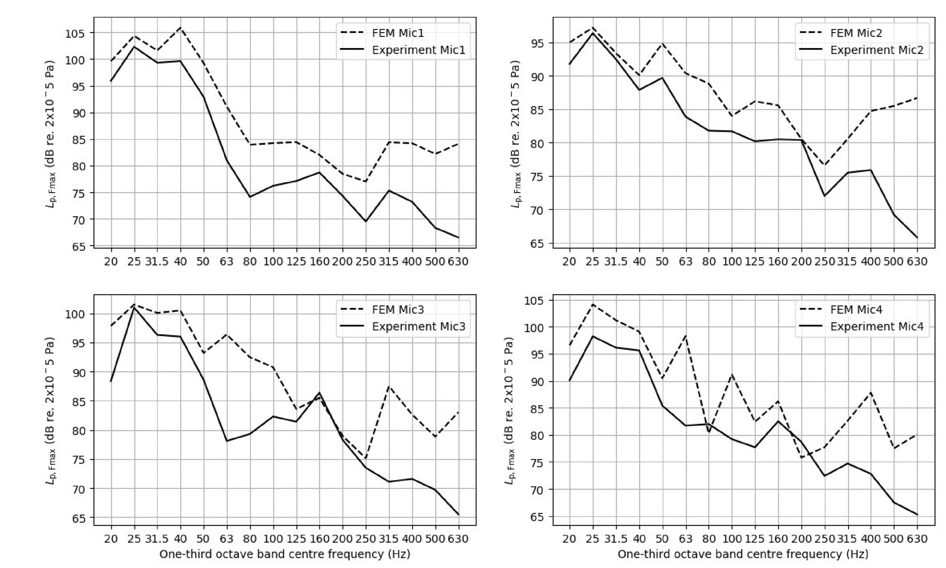

Figure 7:Comparison between FEM and measurement at four microphone positions.

Work to be done

- Prediction of the coupling loss factor caused by unequally spaced screws using wave approach.
- Transient response of the rubber ball under impact load and its contact analysis.
- Radiation efficiency of ribbed plates.
- Structure-borne sound transmission in floating floor and its optimisation design.

List of publications

- Shen X and Hopkins C. (2019). Experimental validation of a Finite Element Model for a heavy impact from the standard rubber ball on a timber floor. Proceedings of the 23rd International Congress on Acoustics, ICA 2019, Aachen.
- Shen X and Hopkins C. (2020). Prediction of maximum fast time-weighted velocity levels from a rubber ball impact on a timber floor. E-Forum Acusticum 2020, Lyon.

Acknowledgements

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No.721536.

UNIVERSITY OF LIVERPOOL

ACOUTECT