# Comparison Between Theoretical Model and Experimental Data of a Light-Weight Timber Floor/Ceiling structure

Hyuck Chung[1],Grant Emms[2], Gian Schmid[3]

[1] Acoustics Research Centre, University of Auckland, Private Bag 92019 Auckland, hyuck@math.auckland.ac.nz

[2] Scion Research, Te Papa Tipu Innovation park, 49 Sala St. Private Bag 3020, Rotorua, Grant.Emms@scionresearch.com

[3] Acoustics Research Centre, The University of Auckland, Private Bag 92019 Auckland, g.schmid@auckland.ac.nz

**Not Refereed**

## Introduction

This article presents the predictions of the vibrations of light weight timber based floor/ceiling structures using a theoretical model. The model predicts the deformation of the structure by solving the differential equations of each component of the structure, such as the floor board, ceiling panel and the joist beams. An improvement over the existing models is that this model includes the effects of interaction between the floor board and the joist beams namely slippage resistance. The existing models assume either the two components are rigidly joined or completely loose.

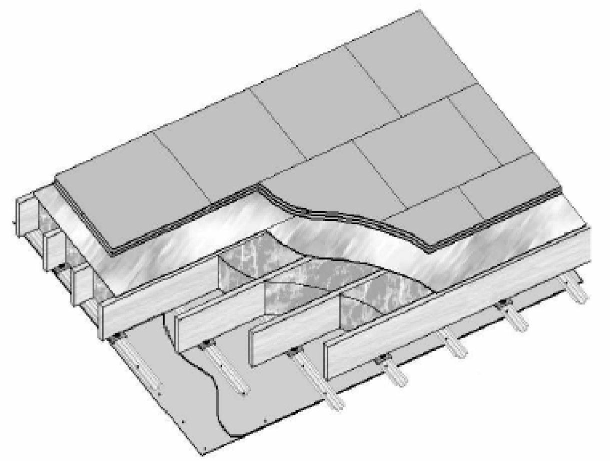

**Figure 1: Schematic drawing of the floor/ ceiling structure.**

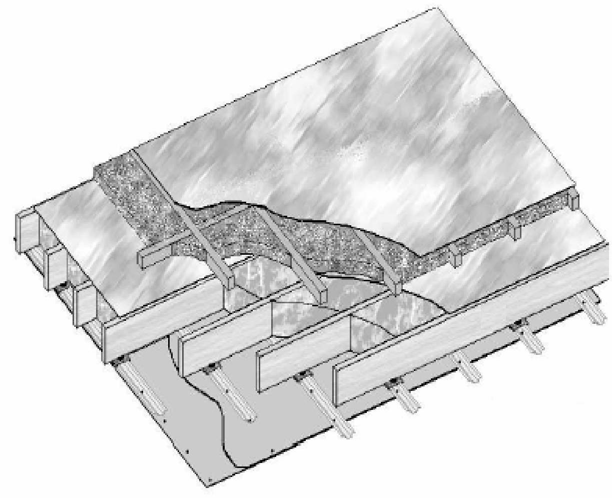

**Figure 2: Schematic drawing of the floor/ ceiling structure. This structure has the same components as figure 1, plus an added layer of sand-saw dust mix on top.**

## Comparison Between Model and Experimental Data

Figures 1 and 2 show the designs of the structures considered here. An electrodynamic shaker was used to provide a vertical force on the floor upper surface. The shaker was connected to the floor through a wire stinger and a reference force transducer. The shaker body was mounted on a beam that straddled the floor and rested on supports sitting on the concrete collar surrounding the floor. Vibration isolation was provided by very resilient pads. A scanning laser vibrometer (Polytec PSV 300) was used to measure the velocity of the floor normal to the surface. A grid with a spatial resolution of 10-14cm was used to obtain a map of the surface velocity of the floor relative to the input force; both amplitude and phase information was recorded at each frequency. The shaker was driven with pseudorandom signal with a bandwidth from 10 to 500Hz, and a length of 2 seconds (to get a frequency resolution of 0.5Hz). An accelerometer was also placed at the force transducer input to determine the input impedance of the floor.

The structure spans 7m in length and 3.2m in width shown in figures 1 and 5.5m long structure in figures 2. The upper plate is plywood boards and 38mm of Gypsum Fibre- board. The ceiling is two layers of 13mm dense plaster boards. The ceiling is connected via a rubber resilient clip, which are clipped on to the steel battens

*(Continued on page 19)*

(Continued from page 17)

on the ceiling. The battens are running orthogonal to the joist beams. The cavity is filled with sound control fibreglass, which has the measured flow resistivity 6000 Rayls/m. The definition of the flow resistivity can be found in Bies and Hansen [1]. The authors are not aware of definitive modelling of the porous media, the glass fibre filling in the cavity, for the frequency range considered in this paper. The fixed flow resistivity for the low frequency range (below 50Hz) is found to be ineffective. One reason may be that the model for the porous media has been built for the fixed media, whereas the whole glass-fibre layer moves with the structure at the low frequency. Hence the flow resistivity is here linearly increased as the frequency becomes higher until the resistivity reaches the conventionally measured value.

The slope of the resistivity is determined by the graphs given in appendix 3 of Bies and Hansen [1]. The mass density and the propagation constant (!/c, c being the speed of sound) of the cavity air are modified using the following formulae.

$$\rho = \frac{\rho_0}{1+s}, \quad k = \frac{\omega}{c}\sqrt{\frac{1}{K\,(1+s)}}$$

where s and K are complex numbers that are determined by the flow resistivity (Rayls per meter) of the fibre-glass.

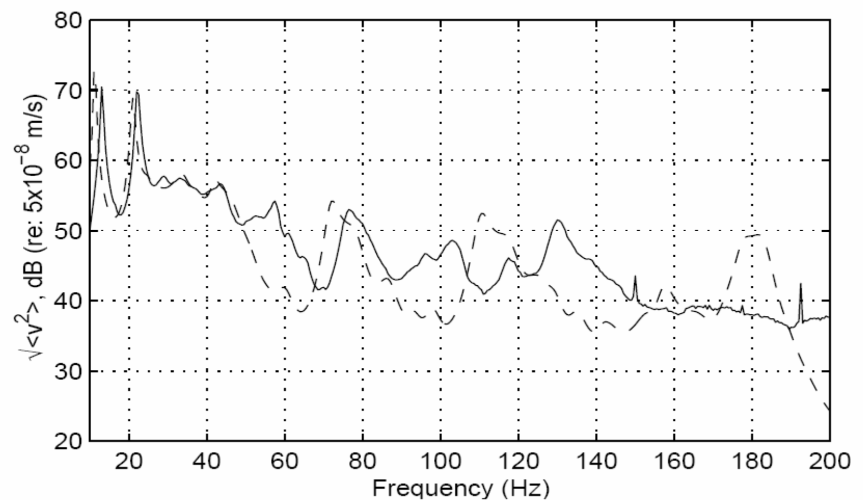


**Figure 3: Comparison of the experimental (solid) and the theoretical (dashed) results from the structure in figure 1.**

The best fitting of the model to the experimental results is given in figures 3 (for figure 1) and 4 (for figure 2). More parameters have been tested in order to achieve the result in figures 3 4. We have only shown here the most significant components. Other parameters such as the stiffness of the upper layers and ceiling panels are taken from the manufacturer's specifications.

The locations of the first few resonant frequencies can be matched even better by adjusting the slippage resistance. However, the value of the resistance was fixed for other configurations in order to avoid arbitrary adjustments of the parameter. In some cases the slippage resistance may have to be truly adjusted because of the changing conditions such as the weight of the upper layer. We did not consider such an adjustment of the slippage resistance because we do not know the exact nature of the changes in the contact conditions between the upper layer and the joist beams. The details of the experiment program will be available from the FWPRDC report [2].

## Concluding Remarks

The slippage between the floor and the joists is shown to have significant effects on the vibration of the whole structure particularly on the locations of the first few resonant frequencies. Therefore, it is inadequate to model the coupling as either completely rigid or free connections. The comparison

(Continued on page 20)

# Min. of Transport Commissions Study on Vehicle Exhaust Noise

Clause 2.7(3) of the Land Transport Rule: Vehicle Equipment 2004 (previously, regulation 81 of the Traffic Regulations 1976) currently states that noise from an exhaust system **must not be noticeably and significantly louder than it would have been when the motor vehicle was manufactured** with its original exhaust system.

However, there are no objective test methods nominated in the new current land transport rules.

Malcolm Hunt Associates have recently been selected to assist the Ministry of Transport assess methods for objective noise testing.

The Minister for Transport Safety, Hon Harry Duynhoven, has recently announced that an objective noise test and a specific decibel limit for vehicle is to be introduced.

The Minister announced this would be based on the international ISO 5130 measurement of exhaust sound level emitted by stationary road vehicles, and the Australian National Stationary Exhaust Noise Test Procedure.

**Dedicated noise monitoring equipment is put through its paces**

The Ministry has commissioned Malcolm Hunt Associates to assist in a programme of technical investigations and field evaluation of sound equipment and test methods to derive recommendations for an objective noise test suitable for adoption in New Zealand. This work will also provide noise level data on the NZ vehicle fleet.

Dedicated equipment from the 01 dB range (from ECS, Auckland) and Bruel & Kjaer (from Avia, Auckland) have been included in the test programme which has covered over 170 vehicles.

Field measurements of vehicles have taken place in Auckland, Wellington and Christchurch.

*Malcolm Hunt* ❑

(*Continued from page 19*)

between the theoretical and the experimental results show that the trend of the vibration of the structure is well predicted by the model. Whether or not including more details of the structure such as separate panels for the upper layer will make a better prediction is still to be seen.

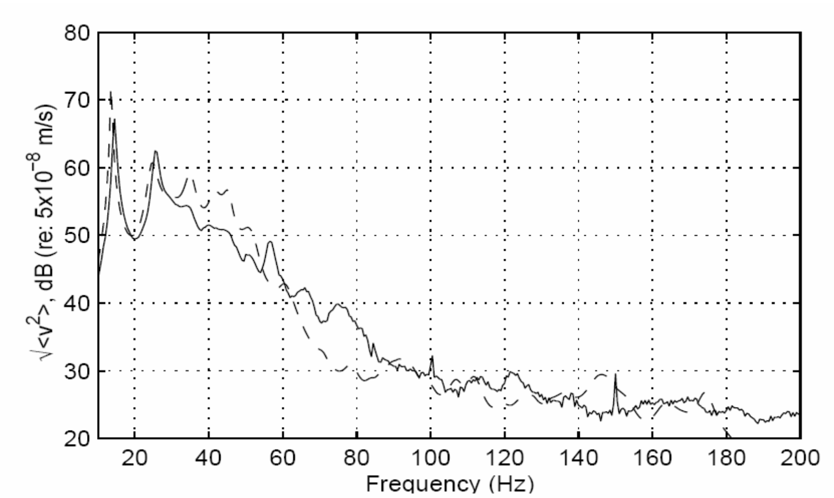


**Figure 4: Comparison of the experimental (solid) and the theoretical (dashed) results from the structure in figure 2.**

## Acknowledgements

H. Chung acknowledges New Zealand Science and Technology foundation post doctoral fellowship (Contract number: UOAX0505).

## References

**[1] D.A. Bies and C.H. Hansen**, Engineering Noise control, Theory and practice, 3rd edition. Unwin Hyman Ltd. London, 2003.

**[2] The Forest and Wood Products Research and Development Corporation**. Australian Government. www.fwprdc.org.au ❑