SOUND TRANSMISSION BETWEEN COLUMNS AND PLATES

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1. INTRODUCTION

While there have been a large number of studies of sound transmission in traditional buildings consisting mainly of walls and floors the same cannot be said for framed buildings. As framed structures become more common in the design of industrial and domestic buildings so understanding the transmission mechanisms between columns, beams and plates becomes more important. The types of joint that can be found include connected columns and floors and joists and walls. Normally a column /floor joint is complicated by beams which support the floor at the top of columns.

In this work the transmission mechanism at such joints is studied both theoretically and experimentally using Statistical Energy Analysis (SEA). The effects of beams at the joint are investigated.

2. COUPLING LOSS FACTORS

The coupling loss factor (CLF), η_{ij} , is defined as the power flow in one cycle of vibration from subsystem *i* to subsystem *j*. For a bending wave on a column which is incident on a joint with another structure the CLF is given by Steel [1] in terms of the transmission coefficient, τ_{ij} , as,

$$\eta_{ij} = \frac{2C_i\tau_{ij}}{\omega L_i} \qquad (1)$$

where C_i is the bending wave speed and L_i is the length of the column. The transmission coefficient can be calculated using expressions for the impedance of the plate structure at the joint [1,2,3].

Predicted CLF's were calculated using equation (1). Measured CLF's were calculated from the product of the measured acceleration level differences and damping.

3. TEST STRUCTURES

Measurements were made on two laboratory models. A steel bar (2.5x0.025x0.006 m) was welded to a steel plate (3x1.5x0.006 m) so that the model investigated by Lyon and Eichler [4] could be studied. Bars were then welded along an edge to the plate and the end of the column, through the joint. This allowed investigation of vibration transmission for symmetric and asymmetric excitation of the plate/beam structure. Another beam was added to form cross beams at the joint. Impedance's derived by Goyder and White [2,3] were used when calculating transmission coefficients and coupling loss factors for the joint for various axis of vibration. A similar process was carried out for a concrete model (column 2x0.1x0.1 m; plate 2.4x2x0.1 m; beams 2.4x0.2x0.2 m). The steel column and plate always had at least one mode of vibration in each 1/3 octave band for the frequency range considered. The concrete column had a number of discrete modes in the frequency range considered. This allowed the study of coupling where there are few modes.

The test structures were excited by tapping a plastic headed hammer over the surface of a subsystem for 15 seconds and measurements were repeated until confidence limits were less than ±3dB.

4. RESULTS

The measured and predicted CLF's for coupling from the concrete column are shown in Figure 1. Two measured results are shown for symmetric and asymmetric excitation of the plate/beam structure. When the column is excited to twist the plate/beam structure, symmetrically, the predicted CLF (solid line) shows a peak at 2000 Hz and the measured results fluctuate about the prediction showing good agreement. When the column is excited to bend the plate/beam structure, asymmetrically, the CLF falls with increasing frequency. Similar results are found with the steel model.

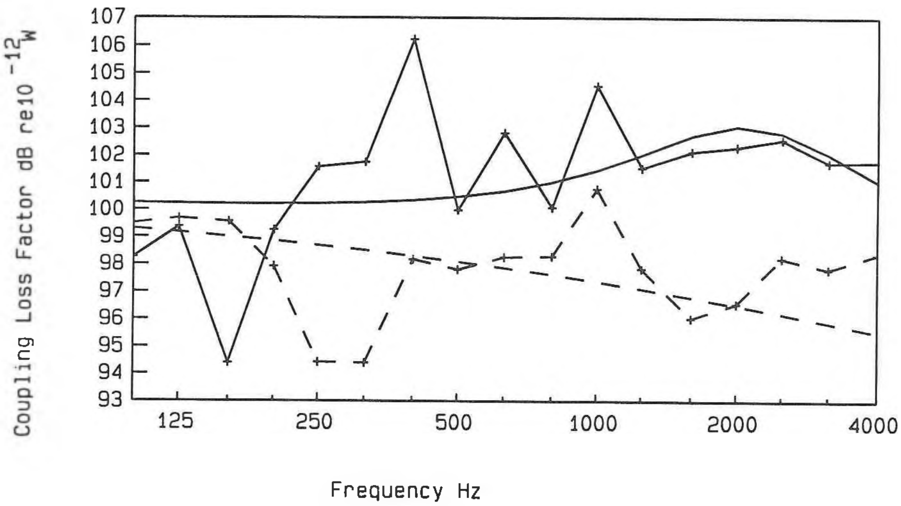

Figure 1. Measured and predicted coupling loss factors for transmission from a concrete column to a plate/beam.— predicted (symmetric); —+— measured (symmetric); – – predicted (asymmetric); – + – measured (asymmetric).

The case where cross beams are found at the joint is also investigated and coupling is found to be similar to the results for asymmetric excitation of a single beam.

When the plate is excited the coupling to the column is dominated by the modal response of the column.

5. CONCLUSIONS

Measured and predicted results show good agreement. Coupling between columns and plate/beam structures has been investigated. The beams can influence the transmission characteristics at these joints. The orientation of the beams effects the coupling at the joint.

6. REFERENCES

1. J. A. Steel and R.J.M. Craik, Sound transmission between columns and floors in framed buildings. *Applied Acoustics.* **39** (1993) 191-208.

2. H.D.G. Goyder and R.G. White, Vibrational power flow from machines into built up structures, Part 1: Introduction and approximate analysis of beam and plate like foundations. *J. Sound Vib.* **68** (1980), 59-76.

3. H.D.G. Goyder and R.G. White, Vibrational power flow from machines into built up structures, Part II: Wave propagation and power flow in beam stiffened plates. *J. Sound Vib.* **68** (1980), 77- 96.

4. R.H. Lyon and E. Eichler, Random vibration of connected structures. *J. Acous. Soc. Am.* **36** (1964), 1344- 1354.