THE SOUND INSULATION OF SINGLE AND DOUBLE PARTY WALLS IN DWELLINGS AT LOW FREQUENCY

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1. INTRODUCTION

To understand and estimate the performance of party walls at low frequencies, a Finite Element Method was used to model sound transmission between rooms in dwellings[1,2]. It was found that, in addition to the party wall, material of construction of the other surfaces influences the room frequency response[3]. Heavyweight materials offer harder surfaces and emphasise the amplitudes of peaks and dips of the room response caused by the different room resonances while the lightweight material of construction tends to dampen the peaks and dips making the frequency response flatter. As the sound insulation at low frequencies is controlled by the different acoustic-acoustic couplings and acoustic structural couplings[1], new FE models were developed for the sound transmission across different types of party wall.

This paper describes attempts to model the most popular types of walls and room dimensions in dwellings. FE models for single and double walls are compared with measurements to validate the sound transmission between rooms of lightweight and heavyweight construction.

2. PARTY WALL AND ROOM DIMENSIONS

The most popular dwellings in UK are terraced houses, semi-detached houses and flats[4].
Terraced and semi-detached house built with heavyweight materials are likely to be two or three storey. The party wall usually is continuous through the house, from front to back and from ground to upper ceiling or roof. The party walls in block of flats are either single or double walls usually built with concrete blocks. In terms of the dynamic response, the wall size depends on the degree of bonding with the side walls and floors and thus with the boundary conditions. If the floor is a precast concrete floor, the wall will have a height equal to the room dimensions. If the floors are suspended, the party wall will run from the floor to the roof. The length of the wall is likely to be continuous from the back or front of the house to the internal corridor. For semi-detached and terraced houses built with lightweight materials, the walls are built according to the height and length or width of the room dimensions.

Most rooms usually are rectangular rooms with a volume varying from $12m^3$ -box rooms- to $40m^3$ -living room or bedrooms-. However, recent designs show more and more large non-rectangular rooms. They are rooms which bring together the dining and living rooms, giving a room volume greater than $40m^3$.

3. DWELLINGS OF LIGHTWEIGHT CONSTRUCTION

The sound insulation of a double wall was measured between two rooms of equal dimensions 4.23x2.84x2.4m. The party wall was of area 2.84x2.4m with a section 38mm/200mm/38mm of 50mm timber studs and a 50mm mineral wool fibre. The sound insulation of the party wall was estimated by measuring the sound pressure level difference only.

A transmission room model was developed by defining an Acoustic FE model and a Structural FE model. The acoustic model was defined as three volumes: the source room, the cavity of the double wall and the receiving room. All surfaces of the source and receiving rooms were assigned an absorption coefficient of 0.15 as in reference [3], while 50mm mineral wool fibre was assigned an admittance equivalent to an absorption coefficient of 0.25. The structural model was defined as two surfaces, each with a thickness equal to twice the thickness of the plasterboard. The boundary conditions of the double wall were assumed simply supported.

Figure 1 shows the measured and predicted sound pressure level differences. The curves show similar signatures although the measured curve is more damped than the predicted. Both curves show a dip at 40Hz which is caused by an acoustic-acoustic coupling of the two rooms mode (100), which is also emphasised by the first cavity resonance of the wall, at 42Hz [5]. Other dips at 60Hz and 71Hz are also caused by the acoustic-acoustic couplings of the room modes (010) and (001). The sound pressure level difference is shown with a third octave resolution in Figure 2. The prediction tends to overestimate the sound pressure level difference up to 63Hz and then underestimate it up to 200Hz. Such differences are likely due to the simplicity of the model. The acoustic finite element model has a constant absorption while, in reality, it will not be so. The structural finite element model does not take account the effect of studs and fixings between studs and plasterboards. However the agreement is promising.

4. DWELLINGS OF HEAVYWEIGHT CONSTRUCTION

Heavyweight double walls are as common as single walls for party walls. Two room configurations were considered. The first was a laboratory transmission suite with a 100/50/100mm double wall. The two leaves were of concrete blocks with no ties. The two rooms were of dimensions (4.88x5.77x4.23m) and (3.03x5.77x4.23m). Figure 3 shows the measured and predicted sound pressure level difference with a narrow band resolution and Figure 4 with a third octave band resolution. The measurements and prediction show the same peaks and dips. Three dips at 29Hz, 40Hz and 50Hz are caused, respectively, by acoustic-acoustic couplings of the mode (010) with the third lowest order structural resonance of the wall, by the acoustic-acoustic coupling of the mode (001) with another structural resonance and by the acoustic-acoustic couplings of the mode (011). The FE model tends to overestimate the sound pressure level difference up to 40Hz as the model shows a dip at 125Hz not indicated by measurements. The receiving room (3.03x5.77x4.23m) was not a perfect rectangular space and this slightly altered the frequency response[6]. The double wall was not a perfect homogeneous concrete wall, but a $10m^2$ concrete wall surrounded by heavyweight brickwork. However, the discrepancy is small; the FE model can then be considered validated.

Double walls in dwellings usually are built with butterfly or steel ties. Measurements were carried out in three-storey houses with a 140/75/140mm double wall built with tied concrete block of $1450kg.m^{-3}$mass density. Field measurements were carried out on a room-pair of equal rectangular rooms of dimensions (2.7x3.88x2.38). All other room walls were of lightweight construction (plaster-studding). An acoustic FE mode was defined as before. The predicted and measured sound pressure level differences of these two models are shown in Figure 5. Measurements and prediction do not display the same signature.

As the two leaves of the double walls are tied by steels ties, the leaves are likely to move together and therefore the wall could be considered to behave as a single wall. Figure 6 shows the predicted sound pressure level difference of the single wall. Good agreement is obtained and confirms the ties have an influence on the sound transmission at low frequencies.

Measurements carried out on the first floor of the same houses also were compared with predicted values. The two rooms formed a L-shaped floor plan and were of equal dimensions. Figure 7 shows the measured and predicted sound pressure level difference. The curves display similar signatures but the agreement is not as good as in the previous case. Such differences could be explained by the workmanship. A lot of mortar is likely to be found in the cavity at the bottom of the double wall making the wall to behave more like a single wall than a double wall. However, the discrepancy between measurements and prediction is relatively small and therefore the FE model is validated.

5. CONCLUDING REMARKS

A FEM model was used to predict the sound transmission in a laboratory transmission suite and between dwellings built with lightweight and heavyweight materials. Good agreement was obtained between measurements and prediction for dwellings of lightweight construction despite many simplifications. Heavyweight double walls with ties were modelled as a single wall. Consequently two types of models need to be defined to represent the sound transmission in real dwellings.

- One model with a double wall and an impedance equivalent to a surface absorption of 0.15 to represent the sound transmission between rooms for dwellings built with lightweight material.
- One model with a single wall and an impedance equivalent to a surface absorption of 0.02 to represent the sound transmission between rooms for dwellings built with heavyweight material.

6. AKNOWLEDGEMENTS

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7. REFERENCES

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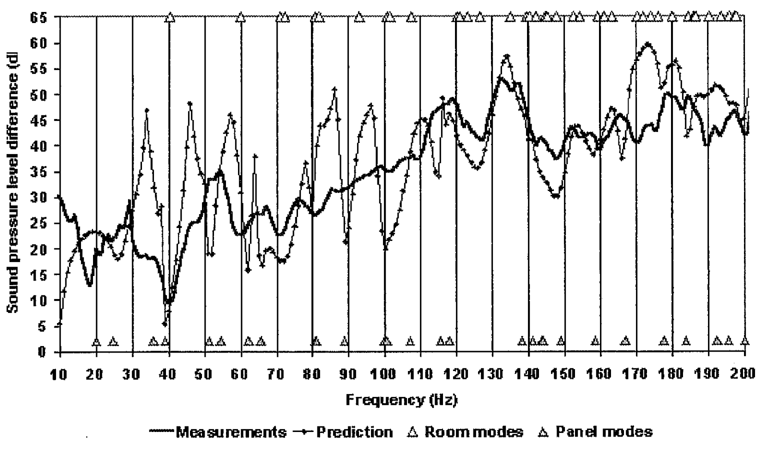

Figure 1. Measured and predicted sound pressure level difference of a double wall

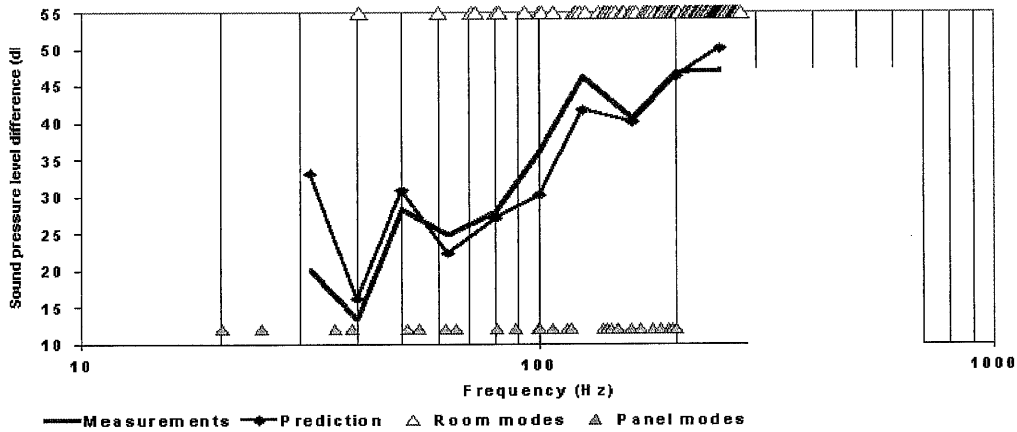

Figure 2. Measured and predicted sound pressure level difference of a double wa ınd resolution

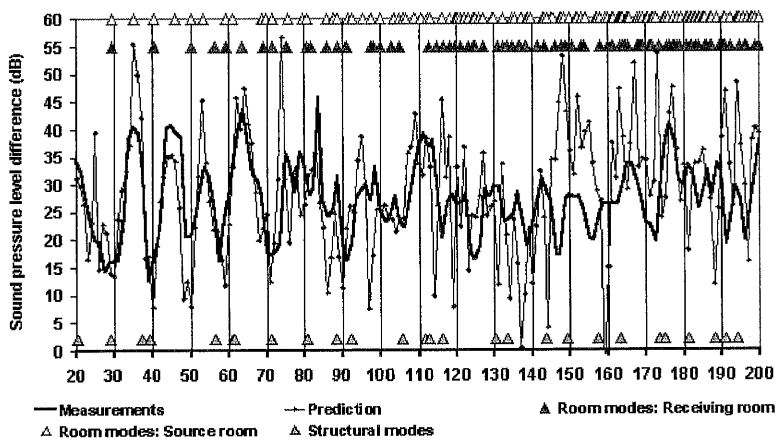

Figure 3. Measured and predicted sound pressure level difference of a heavyweight double wall with a narrow band resolution

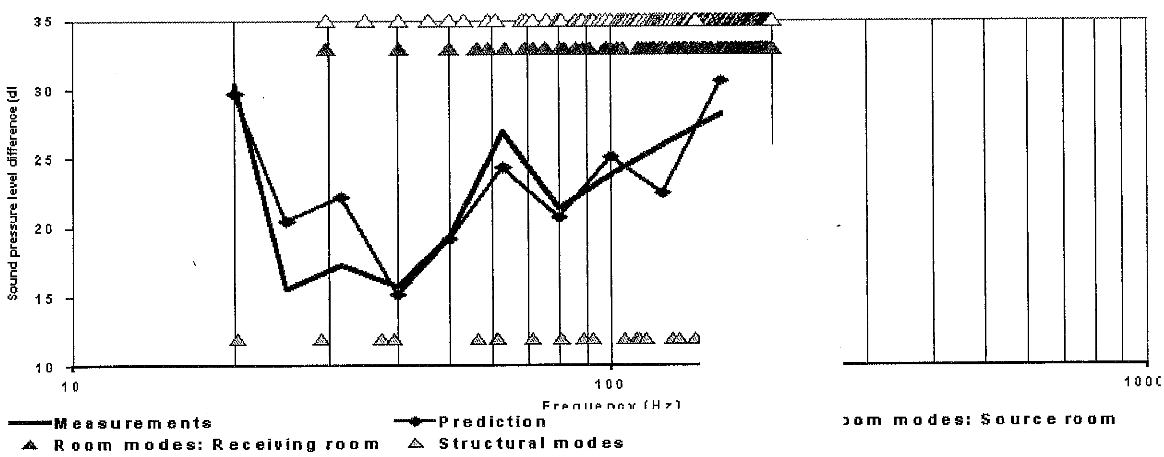

Figure 4. Measured and predicted sound pressure level difference of a hε ble wall with a third octave band resolution

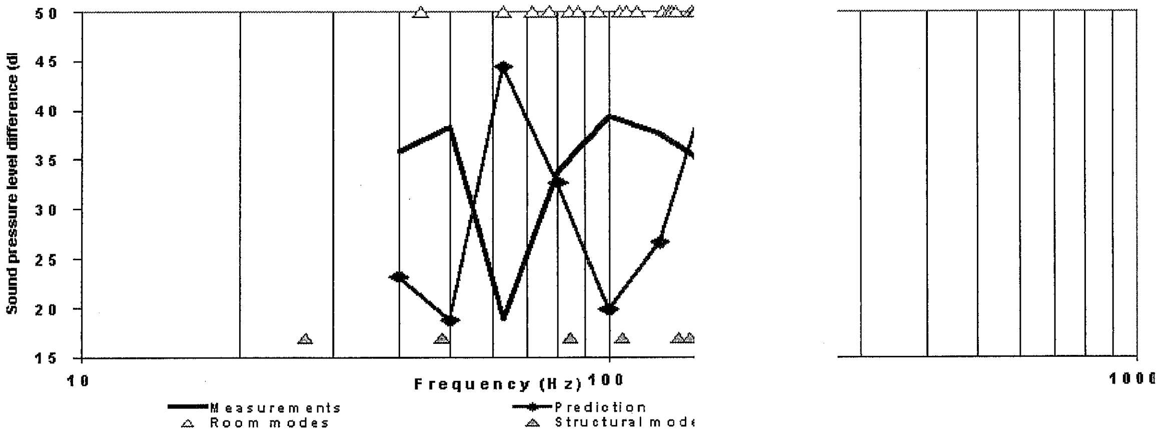

Figure 5. Sound pressure level difference of a 140/75/140mm double wall

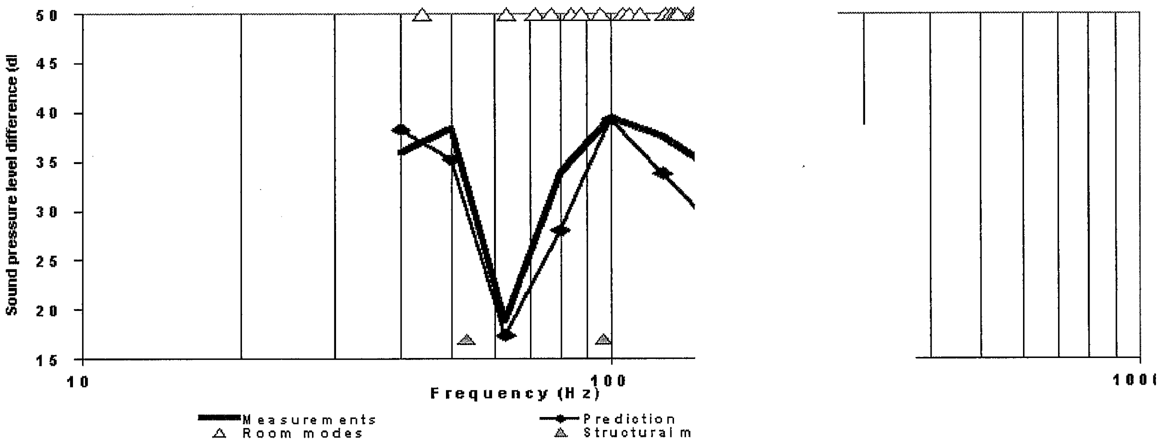

Figure 6. Sound pressure level difference of a 140/75/140mm double wall ɘ wall as a single wall

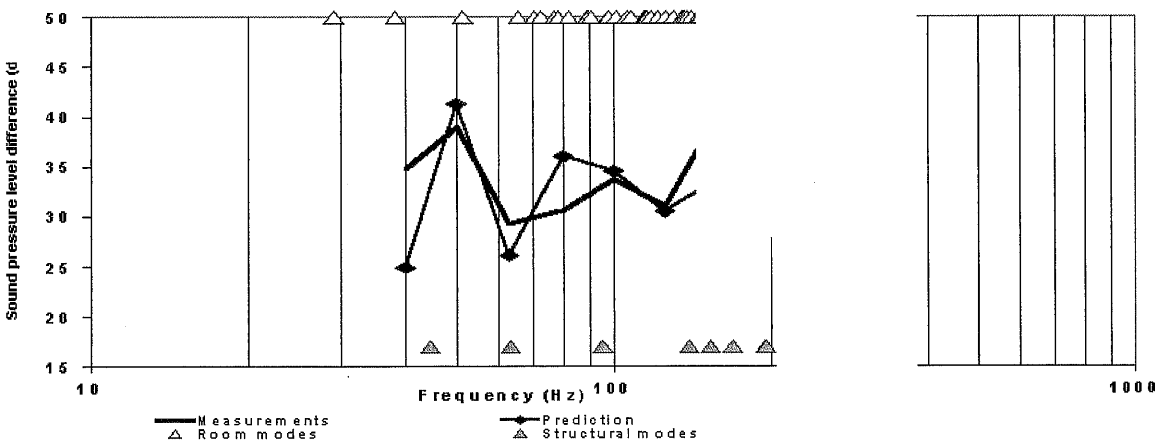

Figure 7. Sound pressure level difference of a 140/75/140mm double wall by mo ɔle wall of the room pair on the first floor as a single wall