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REDUCTION OF NOISE NUISANCE FROM FOOTSTEPS ON STAIRS AND SLAMMED DOORS

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INTRODUCTION

A BRE survey [1] has shown that many people who live in attached dwellings are disturbed by noises from neighbours in other parts of the building, such as footsteps on stairs and banging doors. This paper presents the findings of: (a) A laboratory study on reducing the noise from footsteps on stairs and (b) laboratory and field studies on reducing the noise from banging doors.

The laboratory study of noise from stairs examined the effects of overlaying the treads with resilient materials, isolating the stairs from the building structure and repositioning the stairs within the dwelling. For doors, laboratory experiments were conducted to show how much the noise could be reduced by fitting buffers round the door frame and also to show how the noise reduction depended on the closing speed of the door. Field measurements were made to show how the noise heard in the adjacent room depended on the type of party wall, the type of internal wall and the door location.

THE LABORATORY FACILITY

The same test building was used for both stairs and door studies. This building was brick built with four rooms, each of volume 40 m^3, at ground and first floor levels. The external walls were two leaves of brick separated by a 50 mm cavity, the party wall was 225 mm solid brick and the partition walls were 112 mm brick. All internal wall surfaces had a plaster finish.

Background noise level in the receiving room was mainly due to traffic on the nearby M1 motorway and so varied with wind direction. To increase the room insulation secondary windows and an 'air lock' type door were fitted. The resulting background noise levels are shown in figure 1 for favourable and unfavourable wind directions.

MEASURING EQUIPMENT AND PROCEDURE FOR STAIRS

An ISO tapping machine operating on four treads was used as an impact source. Six microphones in the adjacent room were linked via a multiplexer and 1/3rd octave filter set to a sound level meter. Receiving room reverberation times were measured using the decay method to enable levels to be adjusted to the standard reverberation time of 0.5 seconds. Unless otherwise stated the staircase was fixed to the wall by six equispaced screws, which is representative of site practice.

RESULTS AND DISCUSSION-STAIRS

Addition of Resilient Materials to the Treads

Twelve material combinations were tested and of these the following five gave the greatest reductions in transmission:

a. 3 mm extruded polyethylene foam overlayed with 3 mm felt backed vinyl
b. 4 mm latex foam with polyester surface overlayed with 3 mm felt backed vinyl
c. 6 mm sponge-backed rubber flooring
d. 18 mm hardboard/resilient damping material/hardboard/felt composite
e. contract quality carpet.

Figure 2 shows the impact transmission levels attained.

Contract quality carpet proved to be the most effective material.

Nailing d to the treads reduced effectiveness over the whole frequency range by between 1dB and 8dB.

Staircase Isolation from the Building

In order to establish the importance of the structural path the staircase was isolated by supporting it at top and bottom on various resilient pads up to a stage of 'floating' on a composite of rubber and 60 kg/m³ mineral fibre slab. With the ISO tapping machine running on the tread wood surface the largest reductions in transmission were found at the lower frequencies 125, 160 and 200 Hz as shown in figure 3. Except at 160 Hz the gain from adding the fibre slab to the rubber pad was relatively small and the degree of staircase movement that resulted would be unacceptable in practice.

Repositoning the Staircase Within the Dwelling

To see the effect of fixing the staircase against a wall other than the party wall it was turned through 90° and fixed to an internal wall. With the ISO tapping machine operating on the tread wood surface noise transmission was increased by 7dB at the lowest frequency and up to 4dB at other frequencies.

With the staircase supported on rubber pads the noise level was increased by up to 5dB at low and mid frequencies and up to 2dB at some high frequencies compared to the first orientation.

The Airborne Component

To see if there was appreciable transmission of footsteps noise through the building structure when soft coverings were used measurements were made treating the ISO tapping machine as an airborne source operating in the following three conditions:

a. On the tread wood surface with the stairs fixed to the wall by six screws.
b. On the tread wood surface with the stairs isolated from the wall.
c. On resilient materials over the treads with the stairs fixed to the wall by six screws.

The results were compared to those obtained using a loudspeaker as source as shown in figure 4.

Clearly in case 'a' there is appreciable structural transmission. In case 'b' there is minimal structural transmission and the level difference approaches closely the values obtained with the loudspeaker. For case 'c' structural transmission is still important at low frequencies. The receiving room levels were masked by background noise above 800 Hz.

MEASURING EQUIPMENT AND PROCEDURE FOR DOORS

Doors were closed with reproducible force and their closing speed measured by two purpose made devices. For the field measurements microphones in both source and receiving rooms were linked to a two track tape recorder and a real time analyser with an integration time of 1 second was used for 1/3rd octave analysis. In the laboratory, measurements were made in dB(A).

In the field tests doors were slammed manually.

RESULTS AND DISCUSSION - DOORS

Comparison of Steady State and Impulsive Noise Source

Measurement of noise level difference between source room and receiving room from a slammed door is more difficult than from a loudspeaker. This is because the sound is impulsive and the sound energy on both sides of the separating wall have to be measured simultaneously. To test the measuring technique the level difference was measured in three ways: (a) using a loudspeaker in the standard test; (b) using a pistol as an impulsive airborne source. If the measuring technique is sufficiently accurate the results should be in close agreement with (a); (c) using a slamming door. The results are shown in Figure 5. Close agreement was obtained between the loudspeaker and pistol shot results. The 10dB to 20dB differences between the loudspeaker and slammed door results were due to structural transmission.

Effect of Fitting Buffers to the Door Frame

Three materials sold for draughtproofing were tested. These were:

a. Self adhesive PVC strip 6 mm wide and 4 mm thick uncompressed
b. Self adhesive neoprene strip 10 mm wide and 2 mm thick uncompressed
c. Hollow vinyl strip 6 mm wide and 12 mm thick uncompressed mounted on aluminium extrusion which was screwed to the door frame

Assessing impulse sounds is a subject in its own right. For this investigation dB(A) provided a reasonable compromise between performance as a predictor and simplicity [2].

The door was first slammed hard (2 m/sec closing speed) and later more gently (1 m/sec closing speed). Source room results are shown in Table 1.

The buffers behave non-linearly and are more effective in reducing noise on moderate slams than hard ones.

Noise from the handle mechanism became intrusive at low levels and magnetic holders would be necessary to achieve the full benefit.

Table 1 Source room levels in dB (A) for hard and moderate slams, with and without buffers.

Closing Speed	No Buffers	PVC Buffers	Neoprene Buffers	Vinyl Buffers
2 m/sec	108dB(A)	101dB(A)	99dB(A)	97dB(A)
1 m/sec	99dB(A)	81dB(A)	91dB(A)	85dB(A)

Receiving room results for the same experiment are shown in Table 2.

The PVC and Vinyl buffers produced worthwhile reductions in noise caused by moderate slams but were overcompressed by hard slams. Thicker materials recessed into the door frame would be necessary to achieve better results.

Table 2 Receiving room levels in dB(A) for hard and moderate slams, with and without buffers

Closing Speed	No Buffers	PVC Buffers	Neoprene Buffers	Vinyl Buffers
2 m/sec	80dB(A)	79dB(A)	78dB(A)	76dB(A)
1 m/sec	72dB(A)	62dB(A)	71dB(A)	65dB(A)

Comparison of Insulation of Party Wall Combined with Internal Partition Specifications

In the field experiment measurements were made between one hundred and nine pairs of rooms. Three types of party wall were examined:

a. Plasterboard on Timber Frame
b. Solid Masonry
c. Cavity Masonry

These were associated with two types of internal partition: Masonry and plasterboard

The highest insulation for both impact and airborne noise was attained by Timber Frame construction reflecting the minimal mechanical coupling of party wall leaves. Airborne sound insulation differences between solid and cavity masonry walls were not significant irrespective of internal partition wall type. However markedly less impact noise was transmitted from doors in stud-work internal partition walls than those in all masonry constructions.

For impact insulation construction types were ranked in the following order, the values in brackets indicating the performance of the five types of construction relative to the timber framed type:

1) timber frame (100)
2) cavity masonry party wall with plasterboard internal partitions (91)
3) solid masonry party wall with plasterboard internal partitions (87)
4) cavity masonry party wall with masonry internal partitions (85)
5) solid masonry party wall with masonry internal partitions (80)

Effect of Room Layout

Doors were classified as being in internal partition walls that were either parallel or perpendicular to the party wall. Data analysis of the largest field sample (cavity all masonry construction) showed no signficant difference between door locations.

The effect of hinge location was tested in the laboratory. Impact insulation was 3dB(A) smaller with hinges furthest from the party wall than when the door was reversed. However this effect could not be found in the field data.

CONCLUSIONS

Noise from Stairs

Overlaying stair treads with carpet is the simplest way of reducing noise transmission problems between contiguous households. However, where this would lead to problems of maintenance or a reduction of noise at low frequencies is particularly important, then isolating the staircase from the building structure may be more appropriate.

In the test building locating the staircase next to an internal partition wall did not attenuate noise transmission but increased it by a small amount.

Noise from Doors

Some types of draught proofing strips will operate as impact noise attenuating buffers achieving reductions of up to 18dB(A) in the same room as the door and up to 10dB(A) in adjacent rooms. Thicker materials recessed into the door frame are more effective against hard slams.

Timber frame houses attenuate impact between dwellings better than masonry types. Doors located in plasterboard internal walls transmit less impact noise than those located in building block or brick constructions.

Door location in a room was found to be not significant to impact noise transmission but under laboratory conditions fixing hinges on the door edge nearest to the party wall reduced noise transmission by 3dB(A).

ACKNOWLEDGEMENT

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[2] O J Pedersen, P E Lyregard and T Poulsen. 'The round robin test on evaluation of loudness level of impulse noise'. Report for ISO/TC43/SC/SGB September 1977. Technical University of Denmark, Lyngby

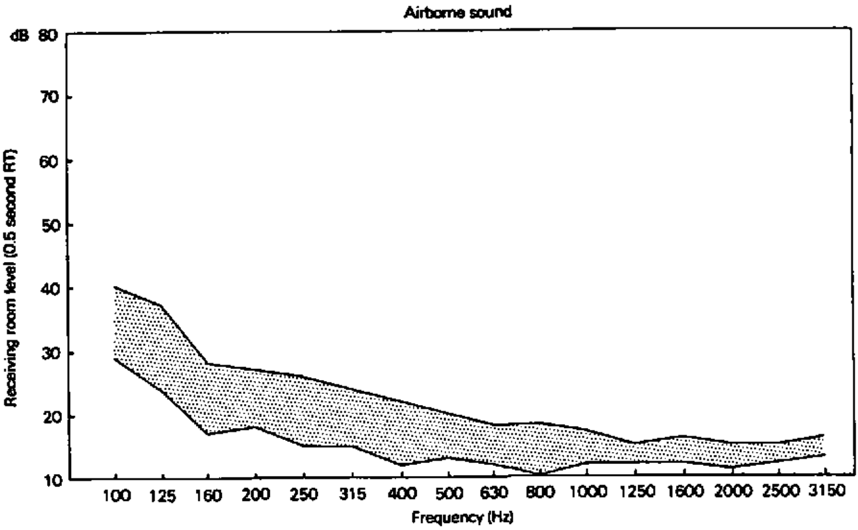

Figure 1 Stairs test facility: background noise levels in receiving room (0.5 second RT)

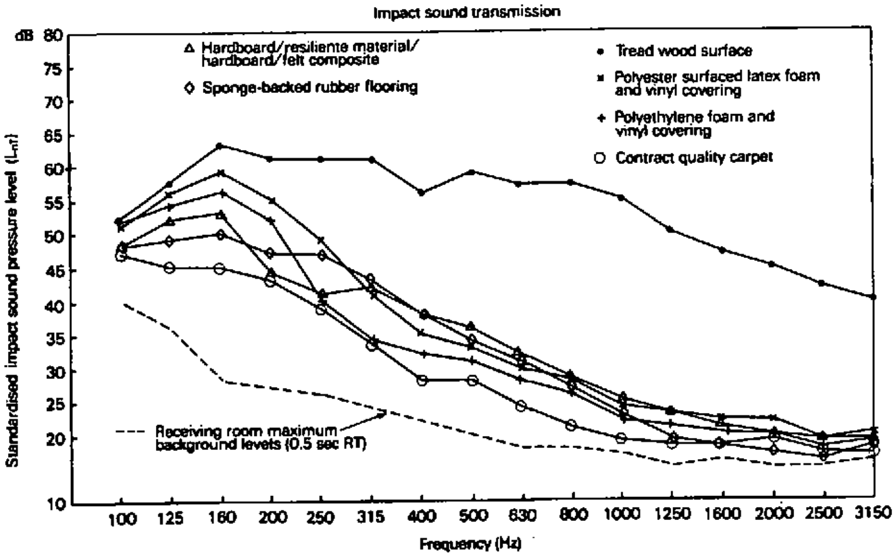

Figure 2 Comparison of composite materials and carpet with stairs tread wood surface

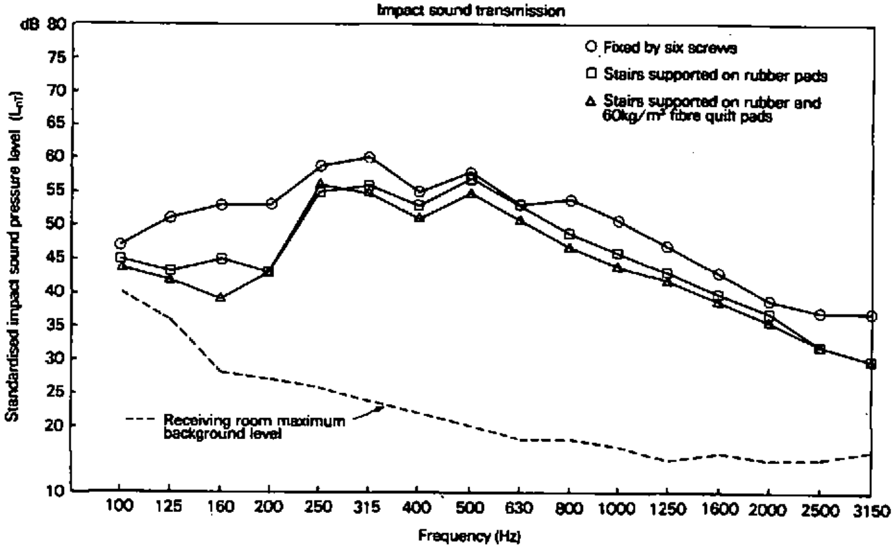

Figure 3 Comparison of impact noise transmission with stairs fixed by six screws and isolated from the building structure

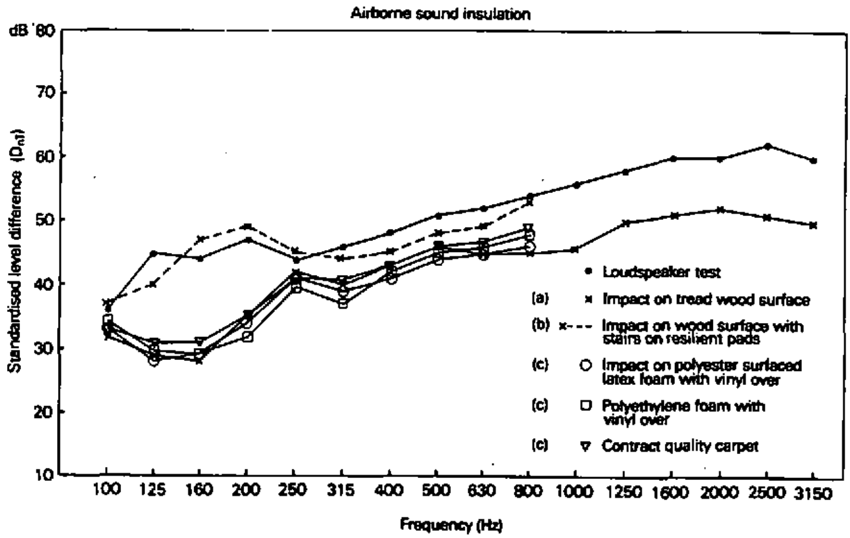

Figure 4 Impact sources measured as airborne source and compared to loudspeaker test results

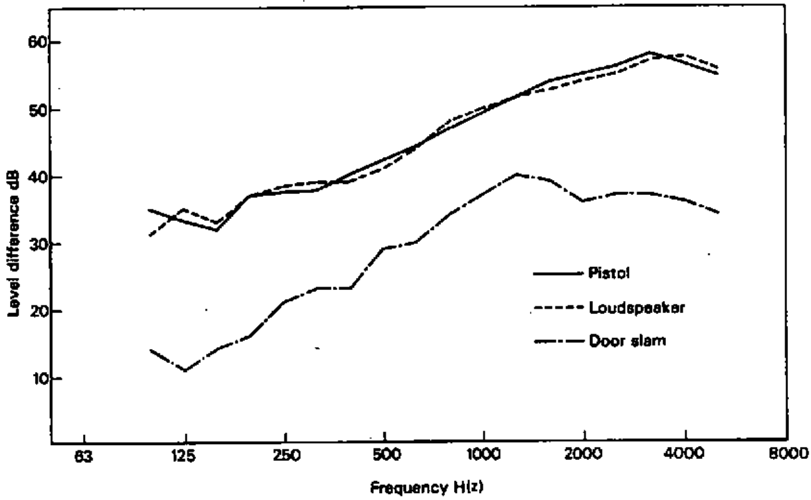

Figure 5 Level difference between rooms measured by conventional method (loudspeaker as source) and impulse method using pistol shot and door slam as source