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SOME EXPERIENCES OF IMPROVING THE SOUND INSULATION OF TIMBER-JOIST FLOORS

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1. INTRODUCTION

The first half of the decade has seen an increasing demand for the conversion of large dwelling houses, built around the turn of the century, into flats and 'bed-sits', particularly in large towns and cities where the availability of suitable Victorian/Edwardian houses has made conversion a viable proposition.

Unlike the houses erected on large estates during the building boom of the 70's conversions tend to be 'one-offs'; even when a number of conversions are being undertaken in one area many individual firms of architects and builders will be involved. Starting with the same type of shell each designer usually opts for a different solution and uses a diversity of materials and techniques to raise the sound insulation to a level acceptable to future tenants; thus each conversion is, in a way, unique.
This diversity has, all too frequently, given rise to tenants complaining of unsatisfactory sound insulation between units. Where it has been possible to to investigate such complaints inadequate floor insulation has been found to be of primary significance, but other features such as :

(i) inappropriate room layout - kitchens above bedrooms
(ii) inadequate detailing - service holes through party floors
(iii) poor workmanship - air paths through party walls & floors

have also played a major role in degrading the protection occupants receive from their neighbours noise.

Within the research programme "The application of remedial methods to party walls and floors", the Building Research Establishment has been seeking solutions to these problems, placing increasing emphasis upon upgrading the acoustical properties of timber-joist floors. This work has been carried out in conjunction with a plurality of housing authorities in two stages:
(i) designing floors to meet the authorities requirements
(ii) conducting sound insulation measurements during and after each stage of the construction has been completed.

The successful monitoring of this work has entailed multiple site visits;

(i) prior to conversion in order that the amount of the improvement finally achieved may be assessed. (In many cases this is not possible due to the poor condition of the property - vis. damaged walls/floors, broken windows, non-existent doors, etc. - or to the conversion time schedule.)
(ii) at each stage of the construction:
  (a) so that its contribution to the whole may be evaluated.
  (b) to ensure that the correct procedures have been followed.

The remainder of this paper will discuss some of the methods used in this work and includes the resulting measurements.

2. TREATMENTS

The performance of a timber joist floor may be improved in three ways:

(i) by modifications to the ceiling
(ii) by enhancing the surface of the floor
(iii) by treating the cavity

these options may be used separately or in combinations but circumstances may prohibit free choice, for example access, room height, budget, or the expense incurred in redecoration.

2.1.1 UNLIMITED BY ROOM HEIGHT

2.1.1.2 USING INDEPENDENT WALL PLATES

Wall plates, secured to the wall below the existing ceiling, carry notched ceiling joists. Unfaced fibre glass, 75 mm thick, is laid between the joists and the floor is completed by two layers of lapped plasterboard.
This type of construction has the advantage that:

(i) access is required only to the lower dwelling
(ii) it is not necessary to disturb the existing ceiling

The disadvantage is that it reduces the room height, an impossible imposition in dwellings designed with a ceiling height below 2.4 metres. Joist size, and remaining room height, will be determined by the width spanned; it follows that this type of floor is best suited to rooms having a narrow span.
In the example below the room dimensions were 6.2 m by 3.2 m in plan, 2.75 m in height; using 125 mm ceiling joists the total depth below the existing ceiling was 275 mm leaving an adequate floor to new ceiling height of approximately 2.45 m. In addition to this ceiling a lining of 6 mm tempered hardboard, laid close fitting, was applied to the floor surface above.

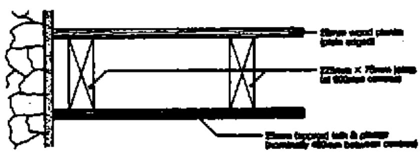


Fig. 1(a) Original floor

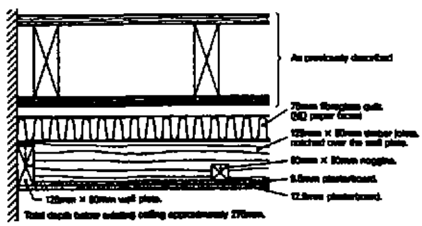
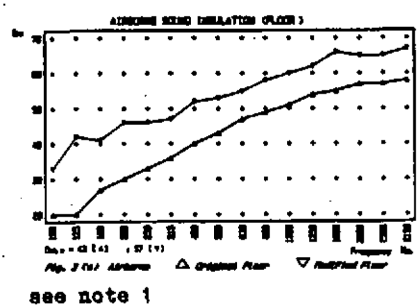
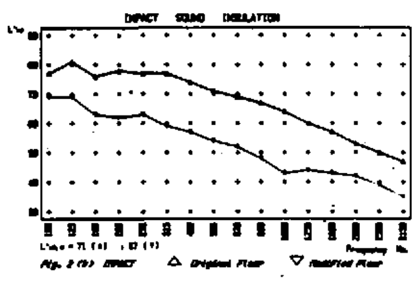


Fig. 1(b) Modified floor





see note 1

2.1.1.3 USING KINETICS MODEL AF 200 FIBRE-GLASS HANGERS

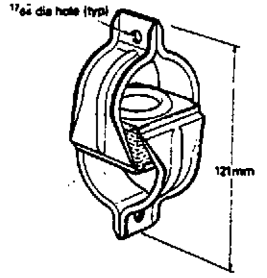
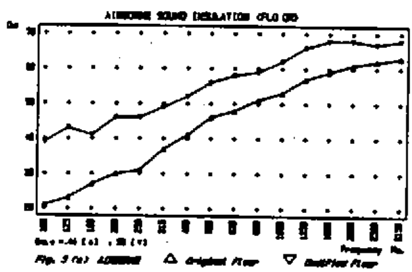
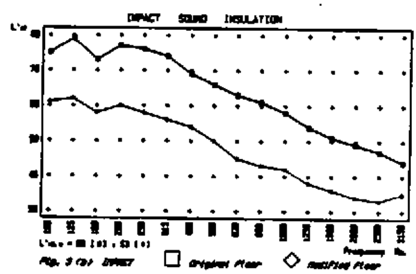


Fig 3. AF 200 Hanger

The main support timbers are secured, via the isolating system, into the original floor joists. One end of the isolator is attached to the main joists via a right angled bracket, the other to the support timbers via a threaded hook, locating these timbers perpendicularly to the main joists - an overall length of some 300 mm. Battens parallel to the main joists are fastened below by diagonal nailing with noggins inserted. A 75 mm unfaced fibre glass quilt is laid over the battens and between the support timbers, the ceiling being completed by two lapped layers of plasterboard (individually nailed). A mastic sealant seals the periphery. The same advantages accrue from this form of construction as from the ceiling on independent wall plates; the disadvantages are (a) it requires greater skill in construction (b) it requires a greater room height.
In the example quoted the room dimensions were: Total ceiling area : 18.9 sq.m. (4.5 m * 4.2 m) Room height: before installation of ceiling : 3.0 m. - after installation of ceiling : 2.65 m
In addition to the ceiling a lining of 6 mm tempered hardboard, laid close fitting, was applied to the floor surface above. The floor construction prior to modification is shown in Fig. 1(a) and after modification in Fig. 4. The sound insulation response for both the original floor and the new floor is shown in Figure 5.

Fig. 4 Ceiling on Hangers





2.1.2 LIMITED BY ROOM HEIGHT
2.1.2.1 USING RESILIENT BARS (Plate 1.)

Light-weight galvanised steel channel partially isolates the additional layers of plasterboard from the existing ceiling. This channeling has a corrugated web to which the plasterboard is screwed and a punched flange through which it is secured by nail or screw to the supporting joists; a stop flange ensures that the screws, by which the plasterboard is fixed to the bar, do not come into into contact with the existing ceiling. Room dimensions were (a) Floor area 18.0 sq.m. (4.3 m by 4.2 m) (b) Room height: original: 3.0 m final: 2.95 m.

Resilient bars were mounted perpendicularly to the existing joists and two sets of noggins were installed, one for each layer of the lapped plasterboard, the second layer being screwed through the first into its own set of noggins.

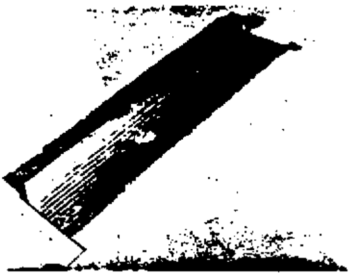


Plate 1. Resilient Bar

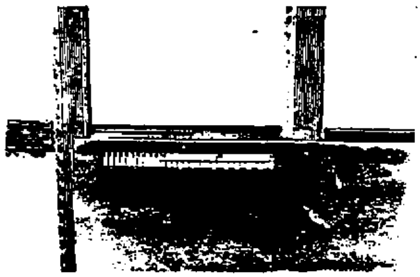
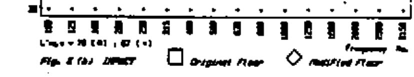


Plate 2. Resilient bars installed

This ceiling requires only minimal depth, in this case some 50 mm., but has the disadvantages that :

(a) double noggins are used - a time consuming operation
(b) it provides less isolation than either of the two previous treatments so that additional treatment to the floor above or to the cavity may be necessary if a moderate increase in the sound insulation is to be achieved.

The original floor construction is illustrated in Figure 1. In addition to the ceiling a lining of 6 mm tempered hardboard, laid close fitting, was applied to the surface of the floor above.



2.1.2.2 USING INDEPENDENT CEILING JOISTS

Perhaps a compromise, this scheme requires more headroom than the resilient bar method but considerably less than either a ceiling supported up on wall plates or a suspended ceiling. To use this system it is necessary to remove the in-situ ceiling and position new joists between the old joists leaving sufficient space to allow a sound absorbing quilt to be laid between the existing floor and the new joists. Two layers of lapped plasterboard nailed to the underside of the new joists complete the floor. Figs. 7(a) and 7(b) show the construction before and after treatment. The joists ran parallel to the party wall and were let into aggregate blockwork.

In as far as these floors tested have shown considerable variability of performance then this example may be said to be 'typical'. Figures 8(a) & 8(b) show the results of measurements made before and after modification. The room dimensions were: Floor area 15.9 sq.m. Room height original 2.37 m final 2.25 m The results show a very large reduction in impact sound transmission but a much smaller increase in airborne sound insulation. This is not an exceptional result amongst a small sample.

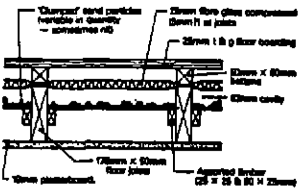


Fig. 7(a) As built

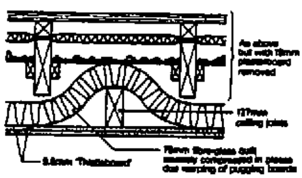
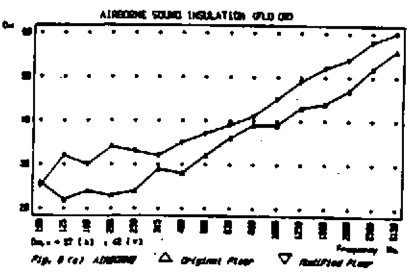
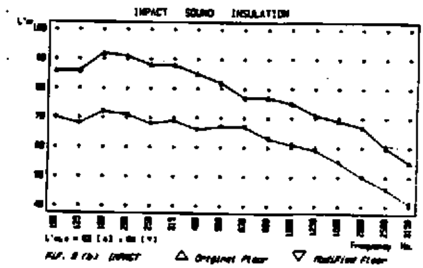


Fig. 7(b) As modified





2.3 ENHANCING THE FLOOR'S SURFACE.

Floor surface treatments may have any of three objectives :

(i) to increase the mass of the floor
(ii) to eliminate air paths
(iii) to provide a resilient layer between surface and joists

all may give an improved acoustical performance; in (i) a theoretical increase of 6dB/Octave per doubling of mass up to the floor's critical frequency (ii) has been discussed previously while in (iii) the resilient layer acoustically isolates the surface from the remainder of the floor.
The result of any such treatment will be a change in floor level which must be accommodated by raising the door thresholds; where all floors are not treated the introduction of a step between adjacent rooms may produce a potential danger, but the principal hazard is at the top of a stairway where an 'unequal' rise results.

SOME EXPERIENCES OF IMPROVING THE SOUND INSULATION OF TIMBER-JOIST FLOORS

2.3.1 USING TEMPERED HARDBOARD.

Laid close fitting over the whole surface this treatment can effectively close any air paths as well as providing a small amount of resilience.

Using the previous example for ceilings, 6mm tempered hardboard was laid over a floor comprising 25mm plain edged timber plank, 225 * 65mm joists and a lathe and plaster ceiling. The floor cavity and ceiling were left untreated. Fig. 1 shows the original construction - Fig. 9 compares the sound insulation of the treated floor with its response prior to treatment.

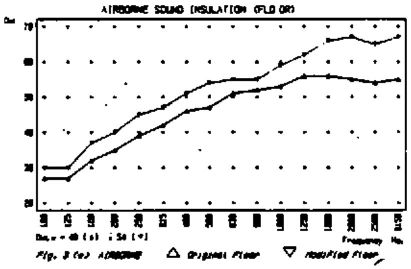


Fig. 9 (a) AIRBORNE △ Original Floor ▽ Modified Floor

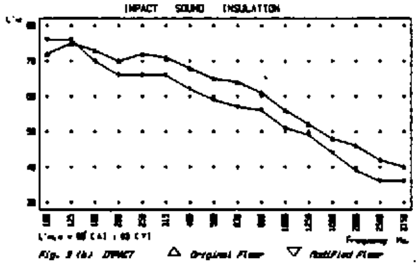


Fig. 9 (b) IMPACT △ Original Floor ▽ Modified Floor

2.3.2. USING A BEARING SURFACE/RESILIENT LAYER SANDWICH.

A proprietory product or materials chosen by the designer may be used. Hardboard, chipboard or plywood are possible surface materials while softboard, glass-fibre, mineral wool, or latex foam might form the the resilient layer. 12mm REDUC, a proprietary product, consisting of two sheets of hardboard bonded by a damping compound, was laid on an existing floor of floorboards, 175 mm by 50 mm joists and 13mm softboard ceiling; the before and after measurements are given in Figure 10.

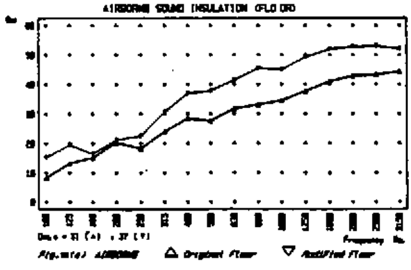


Fig. 10 (a) AIRBORNE △ Original Floor ▽ Modified Floor

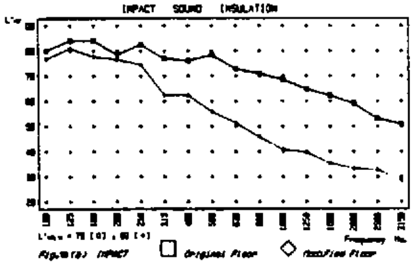


Fig. 10 (b) IMPACT □ Original Floor ◇ Modified Floor

2.4 CAVITY TREATMENTS.

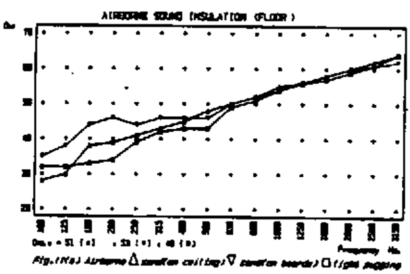
Not the easiest of treatments if the floor is intact but lightweight (mineral fibre), heavyweight (sand) pugging and unfaced glass fibre have been used.

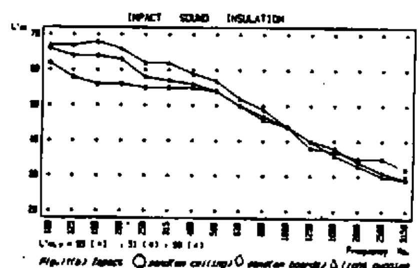
2.4.1. HEAVYWEIGHT (SAND) PUGGING.

Carried on pugging boards or laid directly on the ceiling to increase the mass (and thus the sound insulation) of a floor, it may present many problems - it must be perfectly dry and evenly laid; it must be protected from damp and is heavy to handle: it tends to coagulated if slightly dampened and cannot easily be re-spread; it seeps through holes made for fitments and a plumbing leak may cause the whole ceiling to collapse.
In this example 60mm of sand (96 Kg/sq.m.) was spread (a) directly on the ceiling, (b) on plywood battens

2.4.2. LIGHTWEIGHT (MINERAL FIBRE) PUGGING

Although it has not yet proved possible to obtain "before and after" results for various types of pugging some comparison between the two types may be made. Using a similar floor to 2.4.1 mineral fibre (75mm thick, 15 Kg/sq.m) replaced the sand; the resilient layer was reduced from 30mm mineral fibre (100 Kg/cu.m) to 13mm (36 Kg/cu.m). (The later should have little effect upon a new, unloaded floor). A comparison of these methods of pugging is shown in Figure 11.





3.1 FLANKING TRANSMISSION.

When considering the sound insulation properties of a wall or floor it is necessary to examine not only the direct sound path (i.e. sound passing from the source room through the floor and into the receiving room) but also that sound which travels through other parts of the structure associated with the wall or floor, viz. sound which bypasses the direct sound path.

Fig. 12 illustrates three ways in which a wall and floor may intersect.

(a) by joists into the brickwork (or by use of wallhangers)

(b) dividing studwork partitions

(c) by joists onto studwork

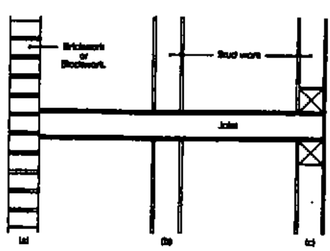


Fig. 12.

(a) flanking is via the brickwall; this path will be the limiting factor when determining the maximum obtainable sound insulation.

(b) the flanking path is broken by the floor; flanking will be minimal and the overall performance will be determined by the floor construction

(c) has two flanking paths (i) along the outer skin (plasterboard or lathe and plaster (ii) along the cavity; the relative contribution of each will vary with the type of stud work used - the thicker the layers plasterboard the less the amount of sound reaching the cavity. In general this form of construction will be less favourable to flanking transmission than case (a)

3.1.2. DIRECT SOUND PATHS

In the case of wood joist floors there are two direct paths, one through the floor/joist/ceiling the other via floor/void/ceiling. There is always the risk of a third path via air paths through the floor.

In the following example a timber joist floor, built in a two storey terraced block of flats with timber-frame structural components was flanked by a gable-end brick/blockwork cavity, drylined wall. To this existing wall, and in the lower flat only, was added:

13 mm fibre-glass quilt; 25 mm cavity; 50 mm paramount partitioning

Timber studding, supporting the partitioning at wall, floor and ceiling, was at no point in contact with the wall. The results before and after modification, shown in Figure 13, clearly indicate a reduced level of flanking transmission.

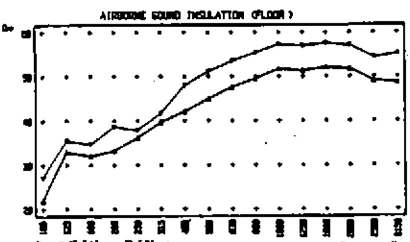


Fig. 13 (a) Airborne △ Original Floor ▽ Modified Floor

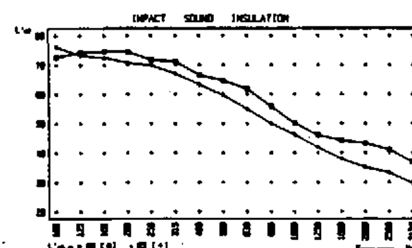


Fig. 13 (b) Impact □ Original Floor ◇ Modified Floor

CONCLUSION

Moderate improvements to both airborne and impact sound insulation can be achieved easily and relatively cheaply - large improvements can be achieved but at a much higher cost. Whether such moderate improvements will be sufficient to satisfy the tenants is now being investigated.

NOTE 1 Average of six 'original' floors in the same building

ACKNOWLEDGEMENTS

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