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IS THE GUIDANCE IN APPROVED DOCUMENT E FOR SOUND INSULATION BETWEEN CONVERTED DWELLINGS BEING FOLLOWED IN PRACTICE ?

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1. Introduction

During the 1980s there was increasing concern about the number of properties converted into multiple dwellings without upgrading the sound insulation [1]. In 1980 it was estimated that in a single London Borough there were at least 5000 flat conversions and this was increasing by approximately an additional 150 flat conversions each year[1]. A national survey into the conversion of flats was undertaken by National Society for Clean Air (NSCA)[2]. The NSCA survey also highlighted the variety of sound insulation requirements placed at the planning stage by different local authorities.

In response to this concern the Building Regulations 1991 extended the requirement to provide "reasonable sound insulation" to include specific situations where a "material change of use" of a building takes place. As a result of this change sound insulation between flat conversions has now been covered by the Building Regulations for over four years.

It should be realised that this requirement is not retrospective and is therefore only applicable to conversions approved after 1 June 1992. Refurbishment of existing flat conversions are not covered by these regulations, however many building owners now refer to the guidance provided in Approved Document E for flat conversions when specifying refurbishment projects.

To investigate the effectiveness of this extension to the Building Regulations the DETR asked BRE to measure the sound insulation of flat conversions approved after the introduction of the new requirements. This paper presents the findings from the field measurements of sound insulation between flat conversions and reports on the problems of installation. The treatments tested in this survey are also commonly used where the sound insulation between dwellings is being upgraded as part of a refurbishment project or in response to complaints.

This paper presents the findings of the sound insulation survey, it updates the information published in Building Engineer and Building Control[3,4].

2. How this requirement is satisfied

Compliance with the requirement in the Building Regulations to provide reasonable sound insulation can be demonstrated by using any of the methods outlined below:

- **Use of an approved construction.** This requires that the construction used follows the guidance provided in Section 5 of Approved Document E.
- **Repeating a construction that has been built and tested in a building.** This procedure is described in Section 6 of Approved Document E.
- **Repeating a construction that has been built and tested in a laboratory.** This procedure is described in Section 6 of Approved Document E.

In the later two cases it is important to note that the test result will only be applicable in situations which are ***similar to*** those where the constructions were tested

In addition to the requirements of the Building Regulations, some Housing Associations also specify a minimum performance requirement that is verified by a post construction sound insulation test as part of a contractual agreement.

3. Sound insulation survey

The survey commenced in March 1993, nine months after the new provisions came into force. The sites selected were provided by Housing Associations, developers, local authorities and architects. Measurements have been obtained for 140 examples of timber floor constructions, 16 examples of concrete floors and 30 examples of walls. Both unimproved and improved separating partitions have been tested, where possible before and after improvement work. This will assist in assessing the effectiveness of the introduction of the treatments used.

4. Analysis of sound insulation survey

The current Building Regulations do not give a numerical performance standard for post construction testing. In this report the floors and walls have been assessed against the field test values provided in Section 6 (for conversions). However it is becoming increasingly common to encounter a requirement that the sound insulation should meet the "mean" values given in Section 3 of Approved Document E (for new build). Such a requirement may be specified at the design stage and it is known to have been required by some local authorities taking action for poor sound insulation under the provisions of the Environmental Protection Act 1990. The performance of the partitions tested are also assessed against these values in this report.

5. Timber floors

The most commonly encountered original floor construction in buildings that are to be converted is a timber joist floor. At 30 % of sites, constructions following the guidance provided in Section 6 of Approved Document E were used. These treatments are divided as follows:

- **Independent ceiling.** The floor is upgraded by the addition of a second ceiling. There is no direct connection between the original ceiling and the new structure. An absorbent material is placed in the void between the two ceilings.
- **Platform floor.** The floor is upgraded by the installation of a floating layer. This treatment would normally consist of an isolating quilt and a composite walking layer of plasterboard and chipboard.

At the remaining 70 % of sites alternative treatments were used. The majority of these treatments were proprietary systems selected on the basis of information provided by the manufacturer. These treatments are divided as follows:

- **Proprietary floating floor.** These are products specifically marketed for upgrading the sound insulation of floors. They are usually supplied as composite tongue and grooved boards to be laid directly onto an existing floor. The original ceiling may be retained or in some cases a new plasterboard ceiling may be fixed directly to the joists.
- **Proprietary floating floor with resiliently mounted ceiling.** This is where a proprietary floating floor has been installed with a new ceiling suspended from resilient mounting bars.
- **Proprietary resilient floor with plasterboard and absorbent in the void.** These are systems where the majority of the work has been undertaken in the floor void. This avoids a significant increase in the thickness of the floor. The system typically consists of resiliently supported floorboards with an underlining of plasterboard fitting in between the joists. The floor void is filled with an absorbent material. The ceiling is normally plasterboard and may be suspended from resilient bars.
- **Suspended ceiling.** These are similar to the independent ceiling. The only difference is that the second ceiling is supported from the original floor by a resilient mounting system. A proprietary metal channel system is often used in place of timber joists. An absorbent quilt is normally placed in the void above the new ceiling.
- **Combined systems.** These are systems where an additional ceiling (independent or suspended) is used in conjunction with a floor treatment (usually a proprietary system).

The findings for all the methods of upgrading timber joist floors that were encountered are summarised in Table 1.

Examining these results we can see the effect of the change to the Regulations. Only 11 % of the floors tested prior to improvement met the criteria in Section 6 of Approved Document E compared to 78 % of improved floors. It is possible that some of these unimproved floors would have been used as a separating floor before the change to the Regulations.

The results for the methods that involve the installation of an additional ceiling demonstrate that floors improved by these methods consistently meet the values provided in Section 6 of Approved Document E. It is important to ensure that suspended ceilings are fixed using suitable resilient mounts, that the original ceiling is retained or replaced and that absorbent is placed above the new ceiling.

Description of treatment	Sample size	Airborne sound insulation ($D_{nT,w}$)		Impact sound transmission ($L'_{nT,w}$)	
		≥ 48 dB	≥ 52 dB	≤ 65 dB	≤ 61 dB
All unimproved	38	11 %	3 %	21 %	5%
All improved floors	111	78 %	54 %	84%	63 %
Approved Document constructions					
Independent ceiling(Type 1)	28	100 %	86 %	100 %	96%
Platform (Type 2)	7	100 %	29 %	71 %	29%
Alternative constructions					
Proprietary floating floor	29	31 %	17 %	48 %	31%
Proprietary floating floor ceiling on resilient bars	4	100 %	50 %	100 %	100%
Proprietary resilient floor plasterboard + absorbent in void	23	87 %	35 %	76 %	38%
Suspended ceiling	14	93 %	93 %	100 %	100%
Combined ceiling and floor treatment	6	100 %	100%	100 %	100%

Table 1 Floor treatments for timber joist floors: percentage meeting the values provided in Section 6 and the "mean values" provided in Section 3 of Approved Document E

The performance of the floor surface treatments was less consistent. The results for platform floors (Type 2) suggest that this construction is capable of meeting the values in Section 6 of Approved Document E. It is likely that the poor impact performance for some of these floors is due to a "bridged" floating layer, highlighting the need for care in the installation of floating floors.

The performance of the proprietary floor surface treatments tested is of concern with only 31 % of the examples tested meeting the values provided in Section 6 of Approved Document E. The low performance of these floors is often attributed to flanking transmission. However, there is no reason to assume flanking transmission is more prominent in the buildings where these systems were tested than in other buildings. We investigated the role of flanking transmission on the sound insulation of a poorly performing proprietary floating floor at one site. We found that flanking transmission was negligible at this site. At several sites we found that the proprietary treatment had been installed to the floor in the upper flat without upgrading the ceiling beneath. In several cases the ceiling of the lower flat was found to be a single layer of 9 mm plasterboard. The specifications provided by the system manufacturers do vary, but often they require the

ceiling to be a minimum thickness of 30 mm of plasterboard. Further, performance data provided by many system manufacturers assume a plasterboard ceiling with a minimum thickness of 30 mm. The effect of such a difference in thickness is likely to be significant.

The majority of the proprietary systems where the floorboards are supported on a resilient mount with additional plasterboard and other works in the floor void tested in this survey exceed the values provided in Section 6 of Approved Document E. The installers of these floors sometimes report difficulty in following the manufacturers instructions and this may account for the reduced performance in some cases.

At several sites we have tested constructions which have included both an additional ceiling and a proprietary floating floor, the performance of these systems has consistently met the values provided in Section 6 of Approved Document E. These systems are often installed to demonstrate that all practical means to upgrade the sound insulation have been taken and to ensure that no additional sound insulation work is necessary once the building is occupied. However the results from this survey suggest that the use of the additional ceiling alone would meet the values provided in Section 6 of Approved Document E.

Where a higher standard of performance is required these results indicate that an additional ceiling used in conjunction with a floor treatment provides the most reliable way of upgrading the sound insulation of a timber joist floor in order to meet the mean values in Section 3 of Approved Document E.

6. Concrete floors

During the course of this study we were presented with a few sites where the original floor was concrete rather than timber joist construction. These sites have tended to be in large purpose built blocks of flats undergoing major refurbishment. The base floor construction was usually hollow clay pot and beam, though some examples of a more recent concrete beam and block floor were also tested. These results are presented in Table 2.

Treatment	Sample size	Airborne sound insulation ≥ 48 dB $D_{nT,w}$	Impact sound transmission ≤ 65 dB $L'_{nT,w}$
Unimproved	9	33 %	44%
Floating treatment	7	71 %	71%

Table 2 Floor treatments for concrete base floors: Percentage of different floor types meeting the values provided in Section 6 of Approved Document E

These results indicate the poor performance of many existing concrete floors, as 67 % of the unimproved concrete floors tested failed to meet the airborne values in Section 6 of Approved Document E. It should be appreciated that many of these floors were likely to have been constructed before the introduction of Building Regulations in 1965. The use of floating floor

treatments on concrete base floors has improved the airborne and impact sound insulation to the Section 6 values in 71 % of cases

7. Walls

During this study we encountered very few examples of conversion by vertical subdivision and the opportunities to measure walls that had become separating walls as a result of conversion work were therefore limited. Appropriate walls that we did encounter were often between bathrooms or between a dwelling and a stairwell or hall. Such pairs of "rooms" present practical measurement difficulties. The results of our tests on existing and upgraded separating walls are presented in Table 3. At a few sites new separating walls had been constructed. Although these are new walls the flanking construction is not controlled and it may be appropriate to compare the results with the values provided in Section 6 and not the "mean values" provided in Section 3 of Approved Document E. In this report the performance of these walls are compared to both sets of values.

These results indicate that where an existing internal partition or an existing separating wall now function as a separating wall in a conversion the performance may not meet the values in Section 6 or Section 3 of Approved Document E. The results emphasise the importance of considering the adequacy of existing separating walls and the suitability of internal walls to perform as separating walls.

Treatment	Sample size	Airborne sound insulation ≥49 dB $D_{nT,w}$	Airborne sound insulation ≥53 dB $D_{nT,w}$
Existing walls (holes filled no upgrade)	24	71 %	33 %
Upgraded walls	2	100 %	100 %
New walls	5	40 %	40 %

Table 3 Treatments for walls: Percentage of different separating walls meeting the values provided in Section 6 and the "mean values" provided in Section 3 of Approved Document E

8. Stairs

In many conversions we found that the staircase acted as a separating floor and was often attached directly to a separating wall. Where there was sufficient headroom available an independent ceiling was sometimes installed. However at the majority of refurbishment sites, and some conversions, the sole treatment was the fixing of extra plasterboard to the underside of the stairs. This is unlikely to provide sufficient sound insulation.

We have tried to measure the impact sound transmission of stairs in conversions, however there are practical problems in carrying out such measurements and there is no accepted guidance as to the interpretation of results.

At a few sites attempts had been made to install a proprietary floor treatment on the stair treads. The effectiveness of such treatments must be severely reduced because the treatments were securely fixed to the tread for safety reasons. We are aware that one of the manufacturers of proprietary floor treatments is now marketing a treatment specifically for use on staircases. However, we have not encountered a suitable example of such a treatment to assess.

9. Expected improvement

At a limited number of the sites we visited we have been able to obtain before and after measurements for some of the systems detailed here. The tests have been conducted on the same floor or floors of identical construction within the same building. The data currently available relates to two of the floor types.

- **Independent ceiling.** Where an independent ceiling is installed an improvement of not less than 7 dB $D_{nT,w}$ was obtained. In some cases the improvement is as much as 20 dB $D_{nT,w}$
- **Proprietary floating floors.** Where these floors have been installed the improvement to the airborne sound insulation has been between 1 dB $D_{nT,w}$ and 18 dB $D_{nT,w}$.

The measurement of sound insulation before and after any work is undertaken provides useful information to assist in the selection and assessment of remedial sound insulation schemes.

10. Installation difficulties and problems

The following points summarise the most common installation problems that we have observed on site during this project:

- **Problems arising from failure to decant tenants during works.** Many of these treatments have been installed with tenants remaining in the dwelling. This can lead to shortcuts in installation, such as not continuing a floating floor beneath kitchen units. The highest performing independent ceilings were encountered in properties where the flats were unoccupied for the duration of the refurbishment.
- **Problems arising from poor sequencing of work.** In some cases little thought appears to have been given to the sequencing of upgrading work. The most commonly encountered problem was that a floating floor would be installed before the installation of central heating or re-wiring which subsequently required the lifting of the floating floor. The reinstallation of floating floors can be difficult and is often undertaken by the plumber or electrician who may not appreciate how it should be re-laid. Some Housing Associations now specify the use of a skirting trunking to carry electrical and plumbing services, this will remove the need to disturb the floor when undertaking maintenance.

- **Problems arising from use of untrained labour**. The installation instructions accompanying some proprietary floating floors are complex. The contractors used may not be familiar with the installation methods for a particular treatment and often will not understand the acoustic principals of floating floors. Common faults include: the bridging of a resilient floor mounting by screwing through a floating floor, failing to leave gaps at the edge of floating floors and screwing ceiling plasterboard through resilient bars directly into the joists.
- **Doors and stairs**. The airborne sound insulation between flats is often compromised by poorly fitted doors, often original internal doors located immediately adjacent to one another off a common hall-way. Many doors have permanent vents and/or single glazed borrowed lights in the wall above them. Doors in existing walls that have become separating walls are also encountered in flat conversions. It is very unlikely that a wall containing a door will provide the required standard of sound insulation. Where such doors have been removed they were sometimes found to have been replaced by an inadequate plasterboard fill. As previously mentioned, independent ceilings are often not provided below separating stairs and floating stair treads could be a safety hazard.
- **Failure to strengthen base floor**. At some sites visited movement of the separating floor was noticed whilst walking across the floor. It is essential to verify that the base floor is both structurally sound and capable of supporting any additional loading placed by the installation of the sound insulation treatment.

11. Summary

The results of the survey demonstrate that, overall, the constructions tested have increased the sound insulation between flat conversions. In addition sound insulation is now an important issue to an increasing number of Housing Associations. When the performance of the different constructions is examined the following trends are apparent:

- The construction of an additional ceiling (independent or resiliently suspended ceiling) provides the most reliable and consistent method of upgrading the sound insulation of a timber joist floor to meet the values provided in Section 6 of Approved Document E.
- The performance provided by floating floors, especially proprietary floating floors is less consistent. Care must be taken to ensure that ***all*** the manufacturers' recommendations are followed and that the situation where the product is to be used is similar to the situation where any tests quoted by the manufacturer were carried out. It is essential that the base floor is capable of supporting the additional loading imposed by the floating floor.
- The only remedial treatment tested in this survey that consistently meets the values provided in Section 3 of Approved Document E, for new build, is an additional ceiling used in conjunction with a floor treatment.

Our impression is that there is currently more "refurbishment" than "conversion" work being undertaken on the housing stock. Whilst the sound insulation of refurbished properties is outside

the scope of the current Building Regulations, the findings of this study will be of considerable relevance to those concerned with such schemes.

12. Acceptable standard of sound insulation

When guidance on the conversion of a building into several dwellings was included in Approved Document E the required level of sound insulation was set at the same value as the minimum acceptable values for individual constructions in the new build section. This decision was made[5] in response to practical and economic arguments, in particular the practical difficulty and expense of carrying out works to control flanking transmission. It may also have been influenced by previous BRE research[6] which found that flat dwellers were less bothered than house dwellers by the same level of neighbours' noise.

A recent study about complaints of poor sound insulation between dwellings[7] suggests that there are fewer complaints about sound insulation when the level of sound insulation exceeds the mean values given in Section 3 of Approved Document E. However, flat conversions were excluded from this study. A social survey of the occupants of the flat conversions tested in this project is now taking place. The objective of this current research is to find out if the standard of sound insulation that is being achieved in modern conversions meets the requirements of the occupants

13. Acknowledgements

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14. References

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