Proceedings of the Institute of Acoustics

THE IMPLICATIONS OF CURRENT CONTROLS ON RESIDENTIAL SOUND INSULATION

N D Cogger The English Cogger Partnership, Winchester

1. INTRODUCTION

The Appeals brought by Mills & Others and Baxter arose as a result of inadequate sound insulation in dwellings that had either been converted for multiple occupancy, or were purpose designed for multiple occupancy, but in either case the properties were built or converted before the Building Regulations 1991 and the concomitant guidance, Approved Document E *Resistance to the passage of sound* [1], came into force. The former document replaced the Building Regulations 1985 and introduced a requirement for building conversions to comply with the Regulations, which had hitherto only applied to new dwellings. The definitions of a conversion to which the Regulations would apply are provided in Regulations 5 and 6, which relate to a "material change of use". Such a change would be deemed to occur if:

- the building is used as a dwelling where previously it was not;
- the building contains a flat where previously it did not.

The Regulations are not retrospective and thus many dwellings converted before 1 June 1992 (the date from which the Regulations took effect) do not comply and there is no incentive for the owners to undertake works to ensure that they do. Indeed, even when purpose built flats or conversions are refurbished, there is no requirement for improvements to be undertaken to ensure that current standards are met, unless there is a material change of use.

The judgements given in the cases of Mills & Others and Baxter provide no additional incentive to improve older properties where sound insulation is clearly inadequate and experience has shown that this only occurs when major refurbishments are taking place and the owners are sufficiently philanthropic to pay the additional costs of the necessary works. Such works would generally then be undertaken so that the property would, insofar as is reasonably practicable, meet the current Building Regulations.

This paper examines those Regulations that relate to sound insulation, in the context of the type of disturbance that lead to the Appeals and whether their application will tend to avoid such problems in new buildings and conversions.

2. THE BUILDING REGULATIONS 1991

The stated aim of the Regulations, which apply to internal partitions separating dwellings in different occupancy, is that "*the relevant parts of the dwelling are designed and built in such a way that noise from normal domestic activities in an adjoining dwelling or other building is kept down to a suitable level that will not threaten the health of the occupants of the dwelling and will allow them to sleep, rest and engage in normal domestic activities in satisfactory conditions*".

There is a further limitation expressed, that the Regulations do not require anything to be done "*except for the purpose of securing reasonable standards of health and safety for persons in or about the building*".

The "relevant parts of the dwelling" are defined in Approved Document E and are to be protected from airborne sound through walls, floors and stairs and impact sound through floors and stairs only. Flanking sound transmission paths are considered and guidance on the control of re-radiated structureborne noise incorporated in the guidance. Whilst the Regulations apply to both new build and conversions, it is recognised that, in the latter case, it is not always practicable to improve the resistance to flanking sound transmission and that the sound insulation achieved may not, therefore, equal that for a new building.

The Regulations are implemented through specific construction methods, which are "*deemed to satisfy*" the stated aims, or, where these standard constructions are not used, by quantitative criteria for airborne and impact sound insulation, which the constructions must be shown to meet. The quantitative criteria and the deemed to satisfy constructions provide the minimum standard appropriate to meet the stated aim of the Regulations. There is no requirement for post-construction testing, to determine whether the buildings meet the criteria in practice.

Experience in consultancy in the UK has demonstrated that there is often dissatisfaction with the level of sound insulation in multiple occupancy and semi-detached or terraced residential buildings that have been built or converted in accordance with the Building Regulations. Whilst these complaints do not now usually relate to speech at normal levels, many other everyday sounds, such as raised voices, amplified speech and music, coughing, sneezing, snoring, or structureborne sound from footfalls, door slams, electrical sockets/switches, plumbing and domestic appliances are cited as giving rise to disturbance, even though they do not necessarily result from unreasonable behaviour.

It is, therefore, appropriate to question whether the Regulations do provide for an appropriate level of internal sound insulation in practice. A comparison of the UK criteria with those of other countries, where these are expressed using broadly similar parameters, demonstrates that the UK criteria are amongst the lowest in the EU and up to 8 dB below the most stringent. The differences are, however, relatively small in most cases and it is necessary to determine whether other factors may influence the level of dissatisfaction.

3. ACHIEVING ADEQUATE STANDARDS

An important aspect in determining whether the standards or regulations are adequate lies in their implementation in practice. Although the criteria have been set to provide a minimum standard, they are often implemented as a *design target*, irrespective of the perceived quality of the building and, by designing just to meet the minimum, the achieved sound insulation too often falls below the criterion.

The latter was highlighted in a UK study of dwellings where complaints of poor insulation had been received [2]. This showed that, of the dwellings investigated, the airborne sound insulation of walls fell below the mean limit specified in the UK Building Regulations in 70% of cases, with 35% falling below the minimum acceptable value for individual walls. Where the complaint referred to the airborne sound insulation of floors, 86% were shown to be below the mean value and 61% below the individual value. Results for impact sound insulation showed that in 57% of the cases sound insulation was worse than the specified mean value, with 20% worse than the individual value. It was concluded from this study that, whilst poor quality of construction could lead to lower than acceptable standards of sound insulation, the criteria adopted in the UK Building Regulations were at an appropriate level.

Consultancy experience, based on investigations of complaints of poor sound insulation, has, however, demonstrated that there is a significant level of dissatisfaction with dwellings which do meet the Regulations, irrespective of the quality of the property, for a variety of reasons, including:

- criteria specified as minima are used as the design norm;
- criteria are based on normal speech levels - raised speech, amplified speech and music, coughing, sneezing and snoring, etc, remain intrusive;
- occupants may have a higher level of expectation;
- impact and structureborne sound through walls are not regulated;
- control of low frequency noise is outside the range of the criteria;
- criteria may be inadequate where adjoining properties are in commercial use;
- control over construction quality is limited;
- post-construction testing is not undertaken.

This can be illustrated by examples from recent investigations on properties undertaken as a result of complaints of poor sound insulation and disturbance from neighbours. In all cases, the buildings were shown to meet the Building Regulations criteria and the noises complained of could be described as *"normal everyday sounds"*.

The first example is a modern semi-detached property, which incorporated a party wall construction comprising two leaves of 100 mm light blockwork, with plaster on the exposed faces and a 75 mm cavity. The sound insulation tests showed that the measured sound insulation generally exceeded the Building Regulations criteria, particularly at the higher frequencies where much of the information in speech is contained. The single figure criterion, the weighted sound level difference $D_{nT,w}$ was shown to exceed the Building Regulations criterion for measurements on up to four rooms by 4 dB and that for individual measurements by 8 dB. In spite of this, speech and the use of the radio and television were said to be clearly audible and disturbing and the tests were required to demonstrate that the developer had met his obligations to the occupant.

Complaints of the audibility of a neighbour's television were the subject of the second example. The television was not being used at high volume, but was said to be causing disturbance. The building in this case was a mews, refurbished to provide high quality, terraced residential accommodation in a quiet city street. The party wall was of single leaf construction, comprising 115 mm dense blockwork, dry-lined each side with plasterboard. The measured sound insulation, expressed as the $D_{nT,w}$ exceeded the minimum required by the Building Regulations for individual rooms by 4 dB.

The third example relates to impact sound insulation. The properties were very high quality apartments in a refurbished Victorian barracks building. The original timber floors on deep joists had been retained, but ceilings replaced and a proprietary resilient flooring system installed. The upper apartment had a fitted carpet, which also removed much of the energy from footfalls and would considerably reduce the risk of disturbance. In this case the insulation exceeded the requirements of the Building Regulations by a margin of 25 dB. The reason for the disturbance was, however, the low frequency energy from footfalls, described as a "thump". This resulted partly from a peak at 125 Hz and partly from the excitation of the natural frequencies of the long span joists, which gave rise to a somewhat lively structure. The latter produced audible sound below the 100 Hz cut-off for the weighted impact sound reduction index, $L'_{nT,w}$.

It is, therefore, considered that, whilst the Building Regulations have led to an improvement in sound insulation standards, the level of control over sound insulation in practice does not remove the risk of problems similar to those experienced by the Appellants in the cases of Mills & Others and Baxter and a review of the Regulations is needed to ensure that the criteria reflect contemporary modes of living and more closely meet public demand.

4. IMPROVED STANDARDS

Higher standards than those in the UK have been developed in other countries, most notably in Germany [3, 4], where three Classes of Acoustical Comfort (CACs), have been proposed and in the Nordic countries, where a recent draft standard proposes four standards of sound insulation between dwellings and also incorporates use of the extended frequency adaptation terms introduced in

EN ISO 717-1 [5, 6]. Both proposals set standards for the external environment, as well as internal sound insulation, and incorporate limits on sanitary equipment, domestic appliances and other technical equipment.

The German code of practice, VDI 4100, is based on the subjective response to noise from neighbours, assuming a background noise level within rooms as low as 20 dB(A), as shown below:

Neighbour Noise	Subjective Response to Neighbour Noise		
	CAC I	CAC II	CAC III
Shouting voice	Intelligible	Generally unintelligible	Generally unintelligible
Raised voice	Generally intelligible	Generally unintelligible	Unintelligible
Normal voice	Generally unintelligible	Unintelligible	Inaudible
Footfalls	Generally annoying	Generally not annoying	Not annoying
Sanitary equipment	Unacceptable annoyance generally avoided	Occasionally annoying	Not, or seldom annoying
Home music, loud radio, TV, parties	Clearly audible	Clearly audible	Generally audible

The differences between the classes are 3 dB for airborne sound (a just perceptible change in broadband continuous noise), 7 dB for impact insulation and 5 dB for equipment and external noise, with the lowest classification (CAC I) being equivalent to the current legal minima specified in the appropriate DIN Standard (DIN 4109 [7]), which are R'_w 53 dB for party walls, R'_w 54 dB and $L'_{n,w}$ 53 dB for floors.

The Nordic system not only has a further class, but also has a higher (5 dB) difference between the classes for airborne sound. A 5 dB difference is also used for impact noise and equipment. Class D is the legal minimum and applicable only to refurbishment of older buildings, Class C meets the general requirements of the Building Regulations and Class A provides the highest standard. The Nordic criteria for sound insulation between dwellings are summarised below:

Element	Class A dB	Class B dB	Class C dB	Class D dB
Airborne sound (walls, floors)	$R'_w + C_{50\text{-}3150}$	$R'_w + C_{50\text{-}3150}$	R'_w	R'_w
	63	58	55	50
Impact sound (floors)	$L'_w + C_{50\text{-}3150}$	$L'_w + C_{50\text{-}3150}$	L'_w	L'_w
	43	48	53	58

Higher criteria are specified for elements separating work premises, garages or other noisy spaces from dwellings and criteria are also specified for partitions within the dwelling itself. Limits for external noise levels are also given for each class. Interestingly, the Nordic recommendations include limits on the reverberation time in stairwells, corridors, etc, to reduce the break-in of noise from communal spaces, and recognise the limitations of the normal frequency range for sound insulation (100 Hz-3150 Hz for the weighted sound reduction indices). This aspect is particularly important for protecting occupants from low frequency noise, which can be a problem with modern lightweight building elements, timber frame constructions and wooden joist flooring.

The use of different classes of sound insulation makes it possible to choose better acoustic standards in a building. This approach not only provides an incentive to the construction industry to produce a higher standard of insulation, but also encourages public demand through an easily appreciated system of classification. Clearly, this would have an impact not only on new build properties, but also for refurbished dwellings.

5. ECONOMIC IMPLICATIONS OF IMPROVED STANDARDS

It is often argued that the additional cost of higher levels of sound insulation would not be justified by the subjective improvement gained. A study in Germany [8], however, has shown that building new properties to the minimum standard only results in a cost reduction of 1.7% relative to that of CAC II and compliance with CAC III represents an increase in costs of just 0.3%. It is, however, important to recognise that compliance with higher criteria does require a greater understanding of acoustic issues at all levels, good planning and design and a high standard of construction practice.

Costs for refurbishment work are more variable and depend on the extent of the required work, which may include wall linings, and floor/ceiling treatments. The latter may need to include both impact and airborne noise control. Many proprietary wall and flooring systems are available, including stud partition treatments for party walls, resilient floor systems and suspended, or independent ceiling systems. Where impact noise control is needed, this can sometimes be achieved simply by the use of a suitable carpet on good quality underlay, particularly if the separating floor is concrete. Timber joist floors can give rise to relatively high levels of low frequency impact noise, however, and additional treatments, such as a suspended plasterboard ceiling may also be necessary in these circumstances. Obviously, when considering additional flooring and ceiling systems the implications on ceiling heights and changes in floor levels must be considered.

Indicative refurbishment costs for party wall sound insulation (independent stud partition with mineral wool lining) are generally in the range £500-£1000 per party wall for each room, depending on area. An independent ceiling, using similar construction methods, can be 50% higher. Proprietary resilient floors, such as mdf panels with a foam underlayer, or plasterboard with a mineral wool underlayer are typically £15-£22/m^2, plus installation costs.

Whilst the costs of refurbishment systems for improving sound insulation are not high, relative to the value of the dwelling and the significant benefit that can be achieved, overall costs can be substantial for the refurbishment of a large housing development, such as the housing stock of a local authority or housing association, hence the importance of the judgements in the Appeals by Mills & Others and Baxter to local authorities and housing associations. It is pertinent to note that, whilst grants have been made available for improvements to thermal insulation of dwellings, such a system has not been provided for improvements to sound insulation.

6. CONCLUSIONS

The regulatory system to protect occupants of dwellings from neighbour noise in the UK is partly based on constructions that are "deemed to satisfy" the requirements of the Building Regulations and, where quantitative criteria are specified (for non-standard constructions and refurbishment works), these provide only a minimum level of noise control. The use of such criteria as design targets, rather than an absolute minimum has led to the situation where constructions based on Approved Document E often do not provide an adequate level of noise control in practice. This is exacerbated by the lack of any post-construction testing to demonstrate that the as built constructions meet the requirements. Where dwellings were built before the date the current Building Regulations took effect, there is no requirement for refurbishment works to incorporate additional sound insulation, even where it can be shown that this is inadequate, unless there is a "material change of use". This would clearly not apply to the refurbishment of purpose built housing stock, or conversions that are not subject to further changes.

These factors result in two areas for concern:

- current standards are low and can lead to dissatisfaction in new buildings or conversions;
- there is no incentive to improve conditions in existing housing stock, built before the current Building Regulations took effect.

In order to achieve a standard that more closely represents the expectations of the occupants, it is considered appropriate to review the minimum legal requirements to ensure that these are at a suitable level relative to occupant expectations. In addition, there is a need to encourage the construction industry to provide higher standards by a classification system that ensures perceptible improvements in the sound insulation quality that can be appreciated by the public. Where properties were built before the Building Regulations were applicable, improvements in the level of sound insulation to at least the minimum provided by the Regulations, where these are not met, should be incorporated in refurbishment programmes.

Without a commitment to improvement in the standard of sound insulation in dwellings, it is considered that the experience of the Appellants in the cases of Mills & Others and Baxter is likely to recur and residents will continue to be disturbed by even the "normal domestic activities" of their neighbours and may be unable to "sleep, rest and engage in normal domestic activities in satisfactory conditions" contrary to the aims of the Building Regulations 1991.

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SOUND TRANSMISSION IN A STEEL-FRAMED BUILDING WITH COMMERCIAL AND DOMESTIC OCCUPIERS

Richard Collman(1) & David Trevor-Jones(2)

(1) Acoustical Control Engineers Limited, Acoustical Control Engineers Limited Broadway, Bourn, Cambs. CB3 7TA
(2) David Trevor-Jones Associates, South Bank Technopark, 90 London Road, London, SE1 6LN

INTRODUCTION

A case study is presented to illustrate some problems arising from the juxtaposition of residential over commercial uses in a recently completed steel-framed building. Airborne noise transmission between the plant and machinery required in a small supermarket and flats immediately above it has been controlled. Structure borne sound transmission in the completed building has emerged as a less tractable problem. In Part 1 of this paper the practical measures taken to control noise transmission during the shop fit-out are described. In Part 2 the deficiencies in the regulatory regime from which the transmission problems might have arisen are discussed. It is proposed that amendments might be made to Approved Document E to the Building Regulations.

PART 1: CASE STUDY

1.1 Planning history

The site is a new development consisting of a ground floor retail unit with three floors of residential flats above. The residential parts were finished and occupied before the retail unit had been fitted out. Residents, led by the sales literature to expect that the retail use might be as inoffensive as antique dealing, were concerned to learn that the retail occupier would be a convenience store, a small supermarket offering extended trading hours and a limited hot take-away food service.

The development is believed to have been permitted without planning conditions relating specifically to the prevention of noise from the retail part from disturbing residents. The retailer who was later to lease the ground floor shell was obliged to obtain planning permission for the addition of a louvered plant room air inlet/outlet. This was granted with a condition that the plant noise should not exceed NR 25 in bedrooms with open windows, which was later altered to NR 25 in habitable rooms with open windows.

By the time that the fitting out was commenced the residents had become sensitive to a range of environmental issues including car parking, road traffic congestion, litter, refuse storage and disposal and cooking smells. Noise seemed to become a focal proxy for the range of their diverse concerns.

1.2 Building Construction

The building is a steel frame construction. The cavity external walls are comprised of a non-load bearing brick outer skin and a load-bearing blockwork inner skin which supports the ground floor beam and block slab. The first floor slab, believed also to be of beam and block construction, and blockwork inner leaf of the external wall bear off the perimter steel I-beam. The party walls between flats appear to be of cavity blockwork resting on steel I-beams. The internal walls are dry-lined on timber battens attached to the blockwork. Drawings of the details of wall/slab interfaces and non-structural construction were not available.

The quality of the building work is poor. There appeared to be gaps at the junction between the shop ceiling slab and the supporting steelwork beams. It was not possible to inspect these areas thoroughly but some of the gaps appeared to be partially filled with expanded polystyrene or mineral wool. It was also not possible to inspect penetrations through the ceiling slab thoroughly, although it appeared that these were of a similarly poor standard to the rest of the slab.

The most significant sources of mechanical plant noise and vibration in the store are the air conditioning and refrigeration systems. After the residents opposed the external siting of the remote air cooled condenser, which is essentially a heat transfer coil with several fans, a plant room was created inside the store. This has an external wall and lies directly below the bedroom of one flat and the living room of another, the steel beam supporting the party wall bisecting the room's ceiling. A louvered opening was required in the external wall to accommodate airflow into and out of the condenser.

An objection to the planning application for the louvre delayed planning consent and led the planning authority to retain its own consultant to assess the residents' concerns, principally that airborne noise from the fans would reach the flats through open bedroom windows during the night in the absence of masking noise in a relatively quiet area. The retailer's consultant was additionally concerned about airborne noise breaking up through the ceiling slab and about vibration energy from the fans causing re-radiated noise in the flats above, or elsewhere in the building.

The final scheme required the installation of three 630mm diameter fans running at 860rpm with a combined sound power level of more than 90dB(A) close to the underside of the ceiling slab. The bedroom of one flat is directly above the condenser and the bed is positioned so that the sleeping residents' ears are within approximately 1 metre of the fans. The louvre is located approximately 2 metres from the living room window of the other flat and the condenser refrigeration pipework is hung from the floor slab of both flats.

Potential non-mechanical noise sources include loud speech or shouting; public address system; security roller shutters; waste bin emptying; delivery vehicles; wheeled cages being rolled in to, out of, or through the store.

The flats are fitted with uPVC, sealed double glazed sash windows which provide reasonable protection from external ambient noise. With the windows open, the background noise level in the bedroom above the condenser is typically 40dB(A) at night. However with the windows and bedroom door closed this falls to 23dB(A) in quieter periods between road traffic, aircraft and other such events.

1.3 Noise abatement solutions

The residents have been closely involved in the project. In addition to meetings between the residents, the convenience store personnel and the local authority, acoustic tests have been undertaken on several occasions. These contacts have highlighted the importance of keeping the residents' expectations within realistic limits.

Construction defects may have compromised the resistance to airborne sound transmission provided by the first floor slab. Quantitative testing of the ceiling slab performance was considered but rejected in case it raised false concerns amongst the residents. The first proposal was to install a secondary mass layer between the slab and the suspended ceiling but this proved to be impracticable as it would have caused a heat build up beyond the design parameters of the electrical cabling that had been installed. The decision was therefore taken to strip out the underside of the entire ceiling slab so that it could be properly treated. The available headroom was restricted, particularly below structural beams.

Gaps in the slab and between it and the beams were made good. A plasterboard layer was applied to the soffit on 25mm timber studs providing a small separation. 100mm timber studs were fixed below the plasterboard layer supporting a further double plasterboard layer. The cavities were loosely infilled with mineral wool, joints between boards were sealed and exposed beams were boxed in with plasterboard. The original fixings into the ceiling were tested for their suitability for the additional load and for everything subsequently suspended from the lower plasterboard layer.

1.4 Mechanical Plant Attenuation and Vibration Isolation

The condenser was designed to draw air for the heat exchange coil through downturned intake louvres and a 2.4 metre long attenuator. After the coil, fans then discharge the air through a similar arrangement to upturned exhaust louvres above the intake louvre to avoid air recirculation problems. The condenser body incorporates mass layers and an acoustically absorptive internal surface to control airborne noise breakout directly to the bedroom above and also via the plant room. The three fans are directly mounted on a fan plate incorporating dividers to reduce recirculation when only one or two fans are operating. The entire fan plate is supported on steel helical compression spring vibration isolators providing approximately 20mm static deflection. A flexible connection is incorporated to prevent air recirculation around the fan plate. The design of the attenuator and weather louvres was critical to ensure that regenerated noise did not compromise the attenuator performance and the resistance to airflow was kept within the fans' capacity.

Pre-commissioning testing of the condenser on site revealed a fan blade passage frequency tone that was not noticeable in the plantroom but was clearly identifiable in the bedroom directly above. This was reduced by replacing the fans.

In addition to vibration isolation of the fan plate, it was also necessary to control vibration from the refrigeration system. All of the pipework was suspended from the underside of the ceiling via steel helical compression spring vibration isolators providing approximately 20mm static deflection. Other equipment such as air conditioning cassettes and air heaters were also treated to ensure that noise and vibration did not affect the residents above.

Other noise control measures included the exclusion of a public address system for in-store communication and the restriction of goods delivery times.

1.5 Unresolved issues

The acoustic treatment carried out as part of the convenience store fitting out has been successful in attenuating the noise and vibration to the intended levels.

However, unforeseen noise transmission became apparent during late night testing. It was demonstrated that the noise of doors being closed in flats around the building propagated through the frame and could be heard remotely. Similarly, impact noise in the store such as food cans being dropped on the floor propagated through the walls into the flats above.

Replacing the original fans changed the fan blade passage frequency and reduced the tonal noise level in the bedroom of the flat directly above the condenser, however the sound remained identifiable and unacceptable to the residents when their bedroom window was closed. A narrow band Zwicker analysis showed that the tone was not dominant. Further analysis indicated that the tonal half wavelength coincides with the spacing between the timber studs supporting the dry lining to the walls. There does not appear to be any absorption in the cavities.

It appears likely that sound is propagating from the plantroom via an acoustic coupling between the slab and the external wall. The inner leaf of the external wall is believed to bear directly on the structural frame. This sound is entering the cavity behind the bedroom wall dry lining where a standing wave is enhancing the fan blade passage frequency tonality and the noise is radiating into the bedroom from much of the wall surface area.

PART 2: THE REGULATORY REGIME

2.1 Requirements of the Building Regulations

It is sometimes said by those unfamiliar with the Building Regulations themselves that they have nothing to say on the question of sound transmission across the partition between residential and commercial accommodation. This is a misunderstanding and probably arises, in a very regulation-driven industry, from a perception that because there is no performance standard specifically for this juxtaposition or approved construction in Approved Document E (1) there is no Regulation.

In fact the Regulations are clear, so far as they go. A wall or a floor which separates a dwelling from another building, or from another dwelling, or from another part of the same building which is not used exclusively as part of the dwelling, shall resist the transmission of airborne or impact sound. This is a condensed summary of Regulations E1, E2 and E3 (2). The Regulations do anticipate the need to take care with sound transmission across the partition separating a residential with a commercial or other use. However, Approved Document E does not advise what should be done.

In the author's experience architects, and perhaps more importantly their clients, the developers, set much store by the Approved Documents. The absence of any specific guidance gives, wrongly, the impression that nothing special need be provided. The lacuna is aggravated by the misconception introduced in the 'Performance' preface to the present edition of Approved Document E which conveys the impression that it is concerned solely with shared partitions between residential units. It states that "In the Secretary of State's view the requirements of E 1, 2 and 3 will be met if the relevant parts of the dwelling are designed and built in such a way that noise from normal domestic activities in an adjoining dwelling or other building is kept down to a level that will not threaten the health of the occupants of the dwelling ...". The implication is that the Regulations are only concerned with sound insulation between neighbouring dwellings, even though the Regulations themselves are drawn more widely. An amendment or supplement asserting that the relevant parts of the dwelling should also be designed and built to resist the transmission of noise from commercial or industrial activities in an adjoining part of the same building or other building would make explicit the wider scope of the Regulations.

2.2 The problems

The present case has raised two important and general problems. One concerns the conflict between adjoining retail and residential uses. The other concerns the inherent characteristics of a steel-framed building.

Retail use is potentially a noisy 'bad neighbour' use. It is not just the obviously problematic source such as a record shop that presents a risk of noise or vibration nuisance to a residential neighbour. Increasingly other kinds of store - clothing, mobile phone and other fashion accessory outlets aimed at a youthful market - generate considerable music noise. There are also traditional retailers such as shoe repair and key cutters - or, indeed, a late-night convenience store - that are quite capable of generating high levels of noise. The diversity of retail uses mostly lie within one use class order, so an inherently quiet use can transform into a very noisy one without any planning or building control intervention. It is well worth thinking twice about the partition between a retail and a residential space.

Approved Document E describes three methods for demonstrating that a proposed construction is likely to comply with the requirements of Regulations E 1, 2 and 3. These are 1) by adopting a form of construction, including junction detailing, described in the document; 2) by adopting a form of construction similar to one which has been shown by field test to comply with the requirements; and 3) by testing a part of the construction under laboratory conditions.

The need to pay special attention to the shared partition between a dwelling and a commercial unit might be addressed through method 2, as expressed in the insulation performance standards recommended in Section 3 to Approved Document E.. It does not seem unreasonable to suggest that a higher standard of airborne sound insulation should be provided between a shop and a flat in separate occupation than between two dwellings. Proprietary products and systems are readily available that are capable of achieving significantly greater resistance to the transmission of airborne sound than the standards recommended in Section 3. There should be no objection on grounds of technical or economic practicability to a higher performance standard for the partition separating residential and commercial uses.

Although no attempt has been made to date to measure the airborne sound insulation between the supermarket and the flats above in the present case study it is clearly from observation very good. The problem is not airborne noise transmission but rather, transmission through the structure. In the absence of any measurable performance standard this is a matter that can only be pursued through method 1, as expressed in the examples of constructions and detailing given in Sections 1, 2 and 5 of the Approved Document.

The issue in this respect is not specifically one of residential and commercial uses adjoining. The problems highlighted in the case study arise from the form of construction. Steel framed construction seem to be enjoying a renaissance but carries with it considerable acoustic risks. In the present case the efficiency with which sound can be distributed around the structure through the frame and radiated into rooms by inappropriately mounted dry wall linings has been illustrated.

New sections should be added to the practical guidance in Sections 1 and 2 (the problem is less likely to be at issue in conversions, though may be becoming so as the trend toward conversion of former office and industrial buildings into flats and 'lofts' gathers pace) to highlight the risk of structure borne noise transmission in steel framed construction and to show how floors and walls should be anchored to the frame in such a way as to avoid 'live building syndrome'. The most essential detail to highlight is the avoidance of direct mechanical coupling between floor and wall finished surfaces and the steel frame itself.

CONCLUSIONS

A case study has been cited to illustrate some of the noise transmission problems associated with both the juxtaposition of retail and residential uses and with modern steel-framed construction. The advice offered in the present edition of Approved Document E is confusing in that it can be read to imply that no special care need be taken at a partition between residential and non-residential uses. It is also deficient in that no guidance is offered on detailing steel-framed buildings to prevent widespread noise propagation through the frame between separate occupancies, and especially into undamped dry wall linings. Although the diversity of non-residential uses within any one use class order is such that general advice might not be useful, consideration should be given at least to providing an explicit warning that shared partitions between residential and non-residential uses may need to provide better sound insulation than between dwellings.

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