THE BUILDING PERFORMANCE CENTRE
SCHOOL OF THE BUILT ENVIRONMENT
NAPIER UNIVERSITY

THE DEVELOPMENT AND PRODUCTION OF A GUIDE FOR NOISE CONTROL FROM LAMINATED AND WOODEN FLOORING

Submitted to:
Department for Environment,
Food and Rural Affairs
Zone 4/G17, Ashdown House
123 Victoria Street
London SW1E 6DE

February 2005

Research Study Conducted for Department for Environment, Food and Rural Affairs (Defra) and through it the Devolved Administrations of the Scottish Executive, the National Assembly for Wales and the Department of the Environment in Northern Ireland

Submitted by

The Building Performance Centre
School of the Built Environment
Napier University
10 Colinton Road
Edinburgh EH10 5DT

Tel: 0131 455 2569
Fax: 0131 455 2563
Email: bpc@napier.ac.uk

Table Of Contents

EXECUTIVE SUMMARY

Chapter 1: Introduction

Chapter 1 provides an introduction to the issues and provides an overview of the primary chapter contents of this document. Four key tasks were required of the study, as reported here:

1. Summarise current UK legislation and Case Law including any EC requirements or guidance and review the use of tenancy agreements by Local Authorities, Registered Social Landlords and Private landlords.

   Task 1 is addressed in Chapter 4.

2. Provide common details of the types of laminated or wooden flooring surfaces and identify any features of such floor finishes that are particularly significant to the impact sound performance of the separating floor.

   Task 2 is addressed in Chapters 6 and 7.

3. Provide an overview of the types of laminated or wooden flooring surface systems available and suggest simple, low cost practicable solutions to reduce the potential for nuisance, and comment upon their likely effectiveness.

   Task 3 is addressed in Chapters 6, 7 and 8.

4. Provide an overview of practicable material, application or structural solutions, giving an indication of the relative cost.

   Task 4 is addressed in Chapter 8 in addition to mitigation measures.

Chapter 2: A review of UK Flatted Dwellings and Building Regulations

To evaluate the scale of the issue the study has estimated the quantity of UK housing stock affected, what were the Building Regulation requirements in-place at the time of construction and what studies have been undertaken to investigate the issue of impact noise in UK housing.

It was found that:

- 20% of the UK population live in flatted dwellings equivalent to 4.92 million homes
- The proportion of flatted dwellings for each of the four home countries in relation to their own total dwelling stock is: England (19%), Scotland (38%), Wales (8%) and Northern Ireland (8%).
- Areas with the highest incidents of impact noise problems are London, Scotland and the South East
- Approximately 66% of the flatted dwellings in England have concrete party floors whilst 72% of the flatted dwellings in Scotland have timber joist party floors.
- The Building Regulations requirements for impact performance on new build and conversions have been getting progressively worse since 1985.
- From 2004 new build dwellings in England and Wales using Robust Detail separating floors will be able to accommodate laminate and wood flooring. Scotland is consulting on adopting Robust Details.
- Noise through residential party floors contributes significantly to the overall number of residential noise complaints received by Environment Health Departments.

Chapter 3: The Mechanism Of Impact Noise with Hard Floor Surfaces

The mechanisms of impact sound transmission, the effects on dweller's health and living, the assessment and examples of case studies on real separating floors are presented. The summary points are:

- Impact sound transmission involves three primary transmission mechanisms: direct transmission, flanking transmission via adjoining structures (walls) and forced motion transmission at low frequencies.
- Forced motion noise transmission at low frequencies is difficult to control, particularly for timber floors due to its lower stiffness properties.
- Concrete and timber floors each have distinct characteristics which are prone to impact noise problems with hard floor finishes.
- Flatted dwellings constructed prior to 1963 were expected to be furnished with carpet thereby providing a higher level of protection against impact sound.
- Building Regulations have been in place for impact sound transmission for over 40 years, however it is only since 1984 (in Scotland) and 2003 (in England and Wales) that regular field testing is undertaken.
- Studies have indicated that high levels of noise transmission between dwellings can act as a catalyst in health deterioration for residents.
- Impact noise is one of the key issues of complaint in relation to household noise studies.

Chapter 4: Current UK Legislation And Case Law

This chapter summarises current UK legislation and case law with regard to noise emanating from hard floor surfaces. The main findings are summarised as follows:

- It is unlikely that actions against normal living activities such as walking on hard floor surfaces can be held as a nuisance.
- The use of tenancy clauses and conditions of sale do not prejudice a dweller's human rights.

Chapter 5: Survey of Extent of Problem And Use Of Tenancy Agreements

Results are presented of the survey undertaken of Local Authorities and Registered Social Landlords. The survey investigated noise from hard floor finishes, complaint rate, mitigation measures and the use of tenancy clauses. The key findings are:

- Survey response was 3.1% of which 42% were from environmental health departments, 46% were from registered social landlords, 5% from private landlords, 5% from Local Authority housing departments and 2% from tenant organisations.
- 60,000 flatted properties were represented by the property management respondents.
- Highest regional response with 23% came from Scotland.
- Average impact noise complaints for the environmental health departments were 22; average annual complaints for the social housing respondents were 12. Extrapolations from these results would provide indicative populations of between 10,000 and 40,000 annual impact noise complaints.
- Footfall noise account for approximately 50% of all complaints.

- The use of carpet is perceived as reducing the likelihood of impact noise problems although a timber laminate floor surface is frequently experienced as problematic.
- Little use is apparently made of tenancy agreements restricting the use of laminate flooring.
- There is significant uncertainty over the use of legal remedies for addressing hard floor surface impact noise problems.
- Mediation was the most widely attempted mechanism for dealing with impact noise problems however it had the lowest success rating. The highest amelioration rating was for the use of soft covers over a hard floor surface, installing a new ceiling lining within the lower property and installing a resilient underlay under the hard surface.
- 36% of respondents claimed beneficial improvements when using a soft resilient underlay under a hard floor surface.
- The response rate from house builders was above average at 8%. 25% of respondent house builders no longer provide laminate floors within flatted developments specifically due to the noise issues.
- House builders using both timber and concrete floors have historically received complaints.

Chapter 6: A Market Review: Laminate And Wooden Floors

This chapter provides details on the types of laminate and wood flooring available today, their current market share and key companies involved. Details are also provided on the range of standard and speciality acoustic underlays. The key findings are as follows:

- typical price range of laminates is £5 to £20 per m^2. The typical price range of engineered wood is £25 to £55 per m^2 and the range for solid wood flooring is £32 to £110 per m^2.

- The cost of standard underlays typically available is £1 to £2 per m^2. The price range of proprietary acoustic underlays is £3 to £19 per m^2.

- During the period 1998 to 2002 the market share of laminates has increased from 4% to 9% of floor coverings by volume (m^2).

- During the period 2003 to 2007 the market share is estimated to rise from 9% to 11% and then plateau. Therefore the rate of complaints from hard floor finishes should not significantly increase above current rates.

Chapter 7: Impact Sound Insulation Performance of Floor Finishes

A variety of laminate and wood floors were tested for impact sound transmission with and without underlays. Testing was also undertaken on carpets on the same floors. Three core floors were tested: a concrete floor, a basic timber floor (worst case) and a timber floor with a pre-installed resilient floating floor system.

Using the laminate floor finish (with no underlay) as the index to compare against other treatments, the following table highlights the problem when carpet is replaced by laminate or wood floors.

Level of noise improvement (dB) comparing laminate / wood only with other treatment			
	Timber Separating Floor	Basic Timber Floor	Concrete Floor
Laminate / wood (no underlay)	0	0	0
Laminate / wood (with underlay)	0	1	6
Carpet only	11	9	25
Carpet + Underlay	22	17	34

- The introduction of an underlay on a timber separating floor with a pre-installed floating floor treatment will not alter the overall performance due to the floating floor controlling most of the impact sound transmission. However, from the frequency analysis it does improve the mid and high frequency response.

- A laminate / wood floor with underlay provides a slight improvement over a basic timber floor although a more significant improvement is achieved on a basic concrete construction.
- The removal of carpets and underlay on a basic timber floor, as with plain sanded floor boards, results in a 21dB increase in impact sound transmission.

Chapter 8: Mitigation and Management of Impact Sound

The physical, legal and other measures that are potentially available to manage and mitigate the issue of noise from hard floor surfaces are discussed. The solutions are split into two sections: those which are pre-emptive in attempting to stop a problem from occurring or reduce its impact and those that can be utilised to alleviate an existing problem. The primary recommendations are:

- Awareness of the issue of noise from hard floor surfaces should be raised through the publication of a guide for Registered Social Landlords (RSL), Housing Association's (HA), Local Authorities and privately owned and rented properties. A short non technical leaflet should also be distributed through DIY stores and other retailers. Examples of possible documents are provided in Appendix A and B.
- Tenancy and deed of condition clauses should be used where there are concerns with regards to noise from hard floor surfaces.
- Underlays should be encouraged for all core floor types.
- Information relating to possible legal courses of action are identified
- Details on structural solutions including secondary ceilings and floating floors are also presented.
- Flow charts for dealing with complaints and mitigation procedures are provided.

Chapter 9: Project Recommendations

This chapter brings together the findings of the previous chapters in the form of recommendations for best practice in dealing with the issue of noise from hard floor finishes and provides recommendations on areas into which further research would be beneficial.

- Information pertaining to the content and style of a non technical leaflet and the more informative guidance document is provided.
- Specific recording by EHO's should be undertaken for noise from hard floor finishes by the CIEH and REHIS adopting an additional complaint categorisation.
- Discussions with the flooring industry on a joint Government-Industry approach to pre-applying underlays to laminate and wood finish floorings within the factory.
- Recommendations of areas of further research are given, these include research into the performance of floor structures, the creation of a Code of Practice to assess noise complaints resulting from hard floor finishes and research into improved underlay performance.

Chapter 1: Introduction

The Building Performance Centre were asked by Defra and through it the Devolved Administrations of the Scottish Executive, the National Assembly for Wales and the Department of the Environment in Northern Ireland to undertake a six month research programme to examine the noise implications of either installing (laminate / wood block) or revealing (sanded floorboards) hard timber floor surfaces within flatted residential dwellings.

The acoustical issues relate specifically to impact noise caused by everyday domestic activities such as footsteps, dropped objects, scraping furniture or jumping children as heard within adjacent, lower properties. The increased prominence of impact sounds is commonly attributed to the increased incidence of hard timber over traditional carpeted floor surfaces boosted by recent shifts in the floor coverings markets; particularly within the DIY sector.

Neighbour impact noise becomes a problem once it is considered excessive. Whilst this point is problematic to objectively define it is frequently anecdotally identified by a sudden increase in footfall noise following the installation of a neighbour's new hard-finished floor. Remedial possibilities in such circumstances, particularly for the affected downstairs resident are limited, precipitating the potential for complaints and a reduction in amenity. Effects of unwanted noise can include immediate annoyance and sleep disturbance as well as potential longer term health implications as highlighted by recent research [1] showing causal links from noise exposure to hypertension and heart disease.

The tripartite objectives of the study were to provide an outline of the size and severity of the problem across the UK, review current management practice and provide amelioration and good practise advice to alleviate and forestall excessive residential impact noise. Relevant findings from the study have been provided in a preliminary guidance document format intended as a good practice resource for members of the public, flooring trades and stake-holding professionals. Preliminary copies of the guides, 'Guide for the control of sound from laminated and wooden flooring surfaces' and 'Noise associated with laminate and wood flooring' are included as Appendices A and B respectively.

1.1 STUDY STRUCTURE

The project has been performed though several distinct strands. An early requirement was to define the issues, their size and relevance to feed through to concurrent secondary research phases examining the legal and physical mechanisms available to contend with excessive residential impact noise.

Following an initial review of existing studies [2,3], two surveys were designed and circulated to those considered to be at the forefront of residential complaint assessment i.e. social landlords, private landlords, Local Authority Housing departments, Environmental Health Officers and Housebuilder Customer Services departments. The main 'Stake-holder' survey was distributed to named individuals within the social, private or Local Authority housing sectors and to dedicated Noise Teams within Local Authority Consumer Services departments. The survey set out to secure details of impact noise complaints, causes, instigating factors and current management practice. A reduced secondary survey was designed and distributed to customer services departments of the top 100 housebuilders. The intention of the second survey was to ascertain the attitude to hard floor timber finishes within the housebuilding sector and gain insight into the occurrences and management of excessive impact noise. The survey was sent with the support and assistance of house building organisations.

Professionals in the fields of acoustics were informed of the study and invited to comment by bulletins circulated by the Association of Noise Consultants and the Institute of Acoustics.

Technical Managers from laminate and hardwood floor product manufacturers were informed of the study and their assistance solicited for the supply of market products to use within an acoustic testing programme. Impact sound insulation tests were performed on a wide range of timber floor products with and without proprietary underlay products.

Tests were performed on three distinct floor constructions, a basic timber compartment floor, a resiliently floated residential timber floor and a solid concrete floor.

The specific project tasks are reproduced here:

1. Summarise current UK legislation and Case Law including any EC requirements or guidance and review the use of tenancy agreements by Local Authorities, registered Social Landlords and Private landlords;

2. provide common details of the types of laminated or wooden flooring walking surfaces and identify any features of such floor finishes that are particularly significant to the impact sound performance of the separating floor;

3. provide an overview of the types of laminated or wooden flooring walking surface systems available and suggest simple, low cost practicable solutions to reduce the potential for nuisance, and comment upon their likely effectiveness, and

4. provide an overview of practicable material, application or structural solutions, giving an indication of the relative cost.

Task 1 has been addressed by a review of current UK legislation and case Law provided in Chapter 4 and by the review of the tenancy clauses derived from the survey respondents as reproduced in Chapter 5.

Tasks 2 and 3 are answered within Chapters 6 and 7, by an overview of the timber floor covering market and analysis of the product testing results undertaken on a range of common timber floor coverings.

The solutions sought from Task 4, mitigation methods for reducing the potential nuisance derived from hard floor surfaces are summarised within Chapter 8.

---

[1] Noise and health in the urban environment. Stansfield SA, Haines MM, Brown B (2000).Reviews of environmental health 15(1-2): 43-82

[2] Domestic Noise Complaints. Grimwood C, Ling M (1999). BRE report 204732

[3] Neighbour Noise – Public opinion research to assess its nature, extent and significance. MORI Social Research Institute (2003). Defra research study.

Chapter 2: A Review of UK Flatted Dwellings and Building Regulations

2.1 INTRODUCTION

The scale and severity of the issue of impact noise between apartments and flats are not presently well defined; however the increasing resources reported by Local Authority Noise Teams to address neighbour complaints and disputes arising from stripped-board, laminate and wood block floors does indicate an increasing, if un-documented problem. To evaluate the scale of the issue this chapter will estimate the quantity of UK housing stock affected, what were the Building Regulation requirements in-place at the time of construction and what studies have been undertaken to investigate the issue of impact noise in UK housing.

2.2 THE AFFECTED POPULATION - APARTMENTS & FLATS

Additional complicating factors in determining the scale of the problem are the limited population sections affected and their physical variation. The properties affected, i.e. flatted dwellings, come in a wide range of construction types and permutations from high rise blocks to warehouse refurbishments. There are a range of construction issues which will dictate the level of impact noise from a hard floor surface in an apartment. These issues include the architectural type (style) of apartment or flat construction and supporting walls, the materials adopted for the structural core floor, the floor decking layers present, the presence of any resilient linings, the adoption of floor cavity insulations and the type of ceiling and its connection to the structural core floor. The structural core floor type will play a significant role.

To estimate the number of affected dwellings and the break down of core floor types an analysis of the UK dwelling stock has been undertaken. The following key statistics on dwelling type have been collated from the English House Condition Survey 2001[1], the Scottish House Condition Survey 2002 [2] and the Northern Ireland House Condition

Survey 2001[3], the Welsh House Condition Survey 2001[4], NHBC Statistics[5] and National Statistics 2004 Regional Trends[6]. Data is presented where there is sufficient information, which is comparable between the four home countries of the UK. Table 2.1 gives a summary table of the UK statistics available for flats.

Table 2.1. UK Flatted Dwelling Statistics in relation to UK Housing Stock

	England	Scotland	Wales	NI	UK
Housing Stock (millions)	21.1	2.19	1.28	0.65	25.2
Flats Stock (millions)	3.95	0.826	0.09	0.05	4.92
% Flats	19	38	8	8	20
% Purpose Built	83	95	-	85	
% Owner Occupied	33	43			
% Privately Rented	20	11			
% Registered Social Landlord	17	11			
% Local Authority Housing	30	35			
% Concrete Construction *	66	28			
% Timber Construction *	34	72			

* The primary statistics presented in Table 2.1 have been used to obtain an analysis of the basic breakdown of construction type across UK flatted dwelling stocks. The calculation is based on available data on dwelling types and period construction rates. An estimation of the base-floor constructions, in terms of concrete or timber joist separating floors, has been undertaken, of which concrete core floors include in-situ, precast wide slab and beam and block constructions.

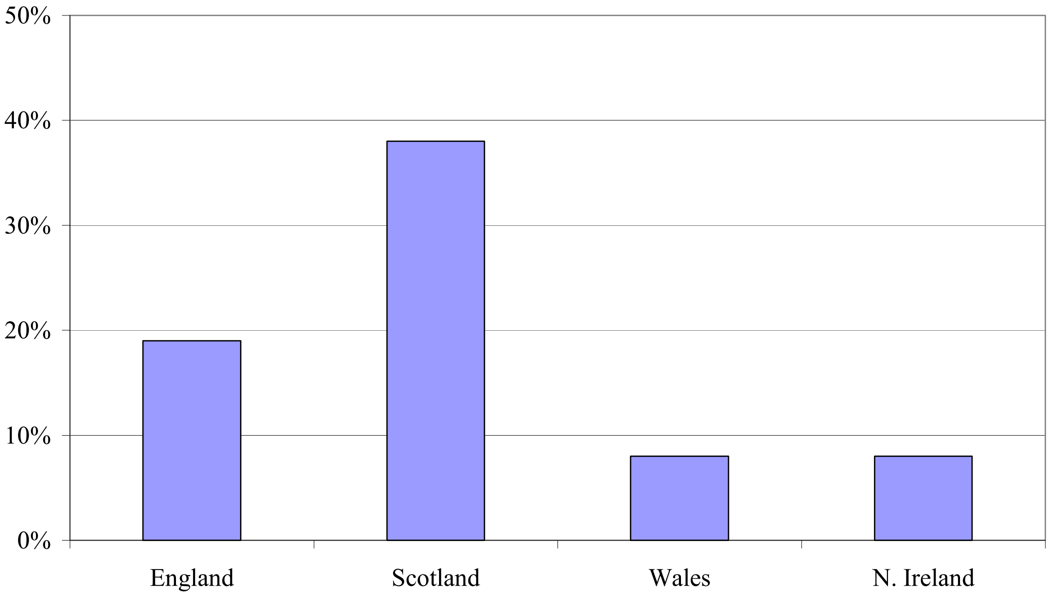
Total Housing Stock: In 2001 the total UK housing stock was approximately 25 million dwellings composed of 21.1 million (England), 2.2 million (Scotland), 1.28 million (Wales) and 650,000 in Northern Ireland.

Flats / Apartments: As separating floors will be present in only apartments or flats, only these dwelling types will be considered for this study. The percentage of the flats and apartments in relation to the total stock for each country is shown in Figure 2.1. It can be seen that Scotland has a significantly higher proportion of flats (38%), England (19%) and Wales and Northern Ireland having approximately 8% each. The total number of flats and apartments across the UK is approximately 20% (4.92 million) of the total housing stock of roughly 25 million, with Scotland contributing 826,000. London, Scotland and the

South East of England have the majority of flats.

Flats and apartments are also sometimes listed as either purpose built or conversions. Examples of purpose built groupings include high rise towers or tenements (Scotland). The percentage of purpose built flats as a percentage of all flats for each country is approximately 83% (England), 95% (Scotland) and 85% (Northern Ireland). No exact data was available for Wales.

Figure 2.1 Proportion of flatted dwellings across the UK



Tenure: Using England and Scotland as examples of the spread of tenure of apartments and flats it can be seen that tenure is quite variable. Owner occupied flats accounted for 33% in England and 43% in Scotland. Privately owned flats (which were rented) accounted for 20% in England and 11% in Scotland. Registered Social Landlords (RSL's) account for 17% in England and 11% in Scotland (HA/Co-op) and Local Authority flats accounted for 30% in England and 35% in Scotland (LA & Others).

Other statistical findings: In England 92% of apartments and flats are "low rise" (less than 6 storeys). In Scotland almost 230,000 flats are traditional stone tenements with 85% built before 1919 and 710,000 flats are classed as either tenement or four-in-a-block. In relation to high rise construction using monolithic or in-situ construction 343,000 flats were built in England with 137,000 (40%) at 11 storeys or more. In Scotland 56,000 dwellings were constructed in high-rise towers. Northern Ireland has very few dwellings with 4 or more storeys, approximately 1%.

Core floor construction: One of the key components for impact sound insulation performance of a separating floor is the type of core floor material and structure used. From the available data on dwelling types and levels of construction during different periods an estimation of the number of apartments and flats with either concrete or timber joist core separating floors has been calculated approximately for England and Scotland. Concrete core floors can cover a wide range of types including in-situ, precast wide slab and beam and block. Although more recently steel lightweight floors have been built their overall contribution is still extremely low when considering the whole housing stock (less than 1%).

In England the predominant core floor construction up to 1944 for low rise apartments was timber. High rise were still using timber floors until 1899. At the turn of the century concrete was being used in high rise apartments in a limited form until 1944. Following the Second World War and the significant increase in demand for housing, high rise purpose built flats were being widely built in major cities. In addition, low rise apartments were increasingly using concrete as the separating core construction.

Currently (2004) in England, the proportion of flats being built annually has risen to 38% from 17% in 1999. The trend has been attributed by NHBC to the need to create high-density housing, Planning Policy Guideline 3 [7], changes in lifestyle, higher divorce rates and longer life spans.

In Scotland the primary core floor construction in the major cities until 1944 was timber joists, as found in traditional stone tenements (230,000) and 4-in-a-block (141,000). Similar to other parts of the UK, apartment construction changed to high rise monolithic construction using concrete floors of which 53,000 flats were built prior to 1982 in the form of tower/slab. Between 1965 to 1996 the majority of flats were built using concrete floors. At present approximately 40% of annual dwelling construction in Scotland are flats with an increasing proportion using timber frame.

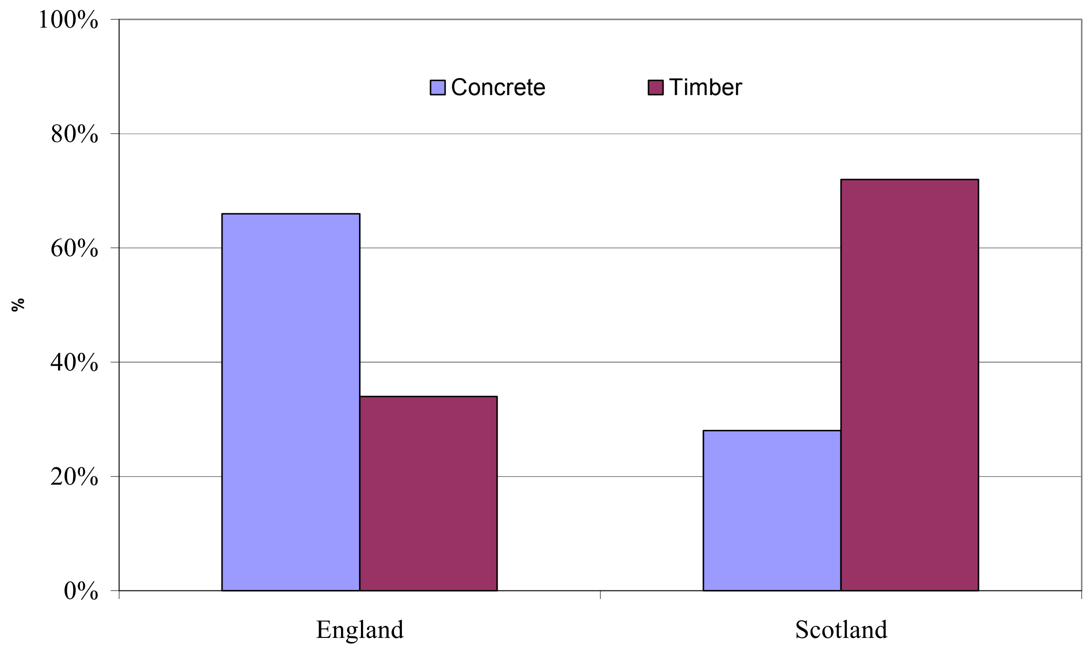
In all countries the growth of converted flats has largely been associated with houses built pre 1919, using timber joist floors. Since the 1980's new fashions or growth areas for conversions have included dock buildings, shore warehouses and more recently city centre office blocks and former hospitals and as such the range of core floor types has widened.

It is estimated that the total number of apartments and flats in England is approximately 3.95 million of which 2.6 million have a concrete core floor and 1.35 million have a timber joist core floor. The timber joist core floor may be further sub-divided into converted flats 1.0 million and purpose built flats 350,000.

The total number of apartments and flats in Scotland is approximately 826,000 with over 600,000 being timber-joisted floors, of which 40,000 are in conversions, and 220,000 use concrete floors.

These estimates indicate 66% of the apartment separating floors in England are concrete and 34% are timber. In Scotland approximately 28% of the flat separating floors are concrete and 72% are timber, see Figure 2.2.

Figure 2.2 Estimation of core floor type for England and Scotland



2.3 IMPACT SOUND TRANSMISSION AND BUILDING REGULATIONS – A HISTORICAL OVERVIEW

"IS THERE NO REMEDY?"

The earliest attempt at building control within the UK as recorded in the Fitz Alwynne Assize of 1189, required party walls to be built of stone at least three feet (0.9 m) thick, essentially for reasons of structural stability. Whilst no mention was made in the regulations specifically to sound insulation, it is recorded that one of the reasons for the requirements in the Assize was "for appeasing contention which sometimes arise between neighbours". Following the Great Fire the London Building Act called for a solid masonry wall of 9 inches (230 mm) minimum thickness however, impact sound transmission had not yet been addressed.

Sound insulation was apparently adequate until the mid-nineteenth century, when the piano became common place within certain sections of society, although more crucially the development of adjoining dwellings became prolific. An 1857 editorial in the 'Builder' read:

"There is no greater nuisance in modern housing than that of the transmission of sound through party walls. Solid walls and solid floors transmit sound in the highest degree … There is no objection to neighbours' children learning music and singing; quite the reverse; but it is most objectionable that the walls should so readily transmit sound… Is there no remedy? "

During the latter part of the nineteenth century the use of the phonograph became increasingly popular, raising the issue of sound insulation, although it was not until the introduction of the radio, in the 1920's, that noise from neighbours became a significant source of annoyance, particularly with the ability to play continuously. In 1926 under the Edinburgh Corporation (streets, buildings and sewers) Order Confirmation Act (Section 46), the Building Rules provided clear details on the heavy construction requirements for walls and floors which were geared principally for fire prevention and structural stability, nevertheless under Article 15 the requirement of floor deafening was clearly stated.

In 1944 the Report of the Acoustics Committee of the Building Research Board recommended a rating of 55 dB, which was duly adopted into the 1948 British Standard Code of Practice for Building. Subsequent field studies correlating wall insulation ratings with occupants' satisfaction, demonstrated general satisfaction with a 9 inch (230 mm) solid brick wall construction.

In 1956 the Building Research Station Digest No.88 set out impact sound guidance for two grades of floor, classed as Grade I and Grade II. The adverse deviation between the sound level difference (airborne) or the sound pressure level (impact) and the Grade I or II curves was calculated at each third octave value in the range 100–3150Hz. A tolerance of 23dB Aggregate Adverse Deviation (AAD) was allowed in order to determine the measured result in relation to the Grade curve. A Grade I floor was described as follows

– “Noise from the neighbours causes only minor disturbance; it is no more of a nuisance than other disadvantages which tenants may associate with living in flats”. A Grade II curve, which was set 5dB below (worse) than the Grade I level, was describe as follows – “ With this degree of insulation the neighbours’ noise is considered by many of the tenants to be the worst thing about living in the flats, but even so at least half the tenants are not seriously disturbed”.

Similar guidance was published in 1957 by the Department of Health for Scotland and was entitled Technical Memorandum 3 ‘Sound Insulation in Houses’ [8]. The descriptions and technical drawings of this publication are very detailed and describe the construction of solid and cavity walls, resilient quilts, floating concrete screeds and floating wood floors.

These guidelines were also adopted in 1963 in Scotland into the first statutory building regulations, The Building Standards (Regulations) Scotland 1963 and two years later in England and Wales in The Building Standards Regulations 1965.

In Scotland the Grade II curves were discontinued in The Building Standards (Consolidation) Regulations Scotland 1971.

The Regulations were revised in 1981 to update the deemed to satisfy constructions, but the grading procedure remained unchanged.

In 1985 (England and Wales), and 1987 in Scotland, new methods were introduced into the regulations following a revision of the International Standard[9]. The shape of the grading curves were altered significantly and of the use of new single value criteria introduced viz. $D_{nT,w}$ (for airborne sound transmission) and $L'_{nT,w}$ (for impact sound transmission) single figure numbers for impact. These new single figure numbers were based on sliding standard curve being adjusted until the adverse deviations were no greater than 32dB.

The new permissible maximum target values for a single test or a mean of tests standardised impact sound pressure level, $L'_{nT,w}$, was set at 61dB with no value in a group test to be higher than 65dB. These values were selected so as to provide an equivalent level of performance to the former Grade I criterion. The values proposed would allow constructions, which had passed or failed previously under the Grade I/AAD, to also pass or fail under the new calculation method. However, whilst the single value airborne sound insulation values for walls and floors were similar in their performance the new impact values for apartment floors were a reduction in the required performance, i.e. worse. In 1993 Adams [10] published a paper on the implications of the post 1987 performance standards, single value rating, when compared to the Grade I/AAD system. Using measured results from 40 floor tests in the range AAD 0 to 50, 78% satisfied the pre 1987 requirement of Grade I/AAD 23, but 100% passed the new mean $L'_{nT,w}$ of 61dB. The poorest mean impact performance permissible of 61dB under the new standard was equivalent to the previous rating of an AAD of 47. The previous standard would not permit higher than 23, as such the new standard could be collectively 24dB worse across a range of frequencies. Adams' concluded that there had been a considerable reduction in the acceptable impact performance for separating floors between flats and that the overall 'single' target criteria was 5dB worse.

In terms of the future apartment construction and impact noise requirements for England and Wales, the Building Regulations (Approved Document E 2003 – resistance to the transmission of sound) has set impact performance no higher than 62dB $L'_{nT,w}$ for new build and 64dB for conversions. The standard of impact sound insulation required under successive regulations has declined steadily from 1985.

However, also in England and Wales in 2004 a new form of optional regulatory compliance for sound insulation has been introduced viz. "Robust Details for new build construction". Robust Details for sound insulation are separating wall and floor constructions for houses and apartments where the target standard being set is 5dB better for both airborne and impact performance than the regulatory maximum. All the constructions are field tested to a minimum of 30 floors, each on 4 different sites and the current separating floors are all designed to accommodate laminate flooring.

Scotland has recently consulted on the possibility of using Robust Details and a decision is expected shortly.

In recognition of the problem of poor sound insulation standards, a number of major housing associations now ask contractors not only to meet the requirements of the Regulations, but also the housing associations' own performance criteria. Typically this criteria specifies a standard 5dB better than the regulatory standard.

Building Regulations and Fashion Trends

For many years the final finish applied to a floor has been carpet. Through various reasons, such as fashion and media programmes, health issues, ease of cleaning and durability (for some floors) the use of laminate and wood flooring has increased in the last few years. The impact requirements of the Building Regulations have been set at an insufficient standard for hard flooring finishes in apartments and secondly can only incorporate the physical components of the building that are included in a warrant or building application. The final floor finish is generally not included. The original pre 1919 and pre 1944 dwellings would have had large carpets or rugs across the room with perhaps a wood floor border for the furniture to rest on without damaging the rug or carpet. The large proportion of purpose built flats of the 60's, 70's and 80's were primarily designed with the intention that the dweller would have "fitted carpets". It is these carpets and rugs, being removed today, to be sanded as original floorboards or lined with wood or laminate, which are generating the majority of the complaints for impact sound.

If the Building Regulations were improved or followed similar standards or set even higher standards than Robust Details this would only deal with the new build and conversions and not the status quo.

The current measurement and range of criteria, $L'_{nT,w}$, L'_{nT}, L_w, C_I etc. are not intuitive for the public particularly when improved impact performance is indicated by the lower rating, the converse of airborne sound insulation. Product statements frequently exploit the perceived confusion surrounding acoustic terminologies to describe product performance. Examples of such advertising include the use of percentage energy reductions attributed to floor lining systems, which have no correlation with the in-situ subjective performance. Misconceptions are most readily introduced because of the logarithmic nature of the decibel, where small decibel changes result in high percentage change in sound energy.

Factors of Influence Relating to Complaints

An external factor that can influence impact sound and its perception is the ambient noise environment, which is the everyday residential noise level due to external influences. The increasing drive to improve the thermal performance of new build and existing dwellings through the use of double or triple glazing and cavity fill insulation can result in additional benefit in reducing residential ambient noise levels. Impact noise however becomes increasingly disturbing when the relative difference between it and the background environment increases, therefore a very quiet noise environment within a flatted dwelling actually provides an increased potential for disturbance from neighbour noise.

The Building Performance Centre database covers 30 years of field testing in real dwellings over all types of construction. A consistent correlation to poor impact sound insulation of residential party floors is the poor level of airborne sound insulation.

Occasionally, footfall noise is not particularly loud or noticeable except when the dweller upstairs walks on an area of the floor where the floorboards squeak. Whilst still disturbing to the neighbouring resident the separating floor can provide a 'good' level of impact sound insulation.

The level of expectation of new flat owners, particularly if previous residencies did not have vertically adjacent neighbours, can be significantly higher than existing sound insulation standards.

2.4 ATTITUDES TO NOISE: EXISTING LITERATURE

The National Society for Clean Air (NSCA) [11] undertakes an annual noise survey with data gathered from local authority noise teams. The results are presented for the UK and separately for England, Wales, Northern Ireland and Scotland. Impact noise is not however directly addressed by their survey. The 34% of local authorities who responded for the 2004 survey overwhelmingly identified amplified music and barking dogs as the top two neighbour noise issues.

Annual data published by the Chartered Institute of Environmental Health (CIEH) [12] does not specifically feature footfall or impact noise although the figures for 2002/03 have identified 'Domestic' noise as being the source of 74% of all 305,000 complaints received from the contributing authorities of England and Wales and 82% for Wales. Domestic noise categorisation is shown in Appendix D.

A comprehensive Defra study was completed in October 2003 by the MORI Social Research Institute and entitled 'Neighbour Noise: Public opinion research to assess its nature, extent and significance'[13]. The study included 6,116 general resident interviews, 2066 urban 'risk' resident interviews and a series of focus group discussions. The 'risk' residents were identified as living within high density, urban areas considered to have a higher exposure to neighbour noise. A basic result did identify those living in flats within urban centres were most affected by neighbour noise with 51% of medium/high rise residents and 42% of low-rise residents bothered, annoyed or disturbed by neighbour noise compared to 27% of respondents resident in semi-detached properties. Footstep noise was classed as a disturbance by 4% of the total sampled population. The proportion of flat dwellers within this group is not however known.

In February 2002 the Building Research Establishment (BRE) published 'The 1999/2000 National survey of attitudes to environmental noise'[14], prepared for Defra, the National Assembly of Wales, the Scottish Executive and the Department of the Environment for

Northern Ireland. The survey questioned 2,782 individuals, of whom 201 were flat dwellers, over their attitude to environmental and neighbour noise. If a respondent had a particular issue then a further, more detailed survey was answered. Of the respondents some 37% reported being bothered to some degree by noise from their neighbours; 55 individuals (2% of the overall sample) were further probed about a specific footstep noise issue. Of these only 22 (0.8% of whole sample population) respondents reported that the footstep noise they were bothered by was caused within another attached home. A specific relationship between flat dwellers and impact noise sufferers was not however established.

The Royal Environmental Health Institute for Scotland (REHIS) in their 2002-2003 statistics[15] of reported noise complaints. Since 1998 there has been a 37% increase in domestic noise complaints, of which complaints relating to hard wood flooring has been identified as a major issue facing many urban EHO officers in Scotland.

The published results from these recent surveys do not provide a definitive scale of UK impact noise problems. Indicative extrapolations from these studies provide an approximation between 0.8 and 4 % of the affected population.

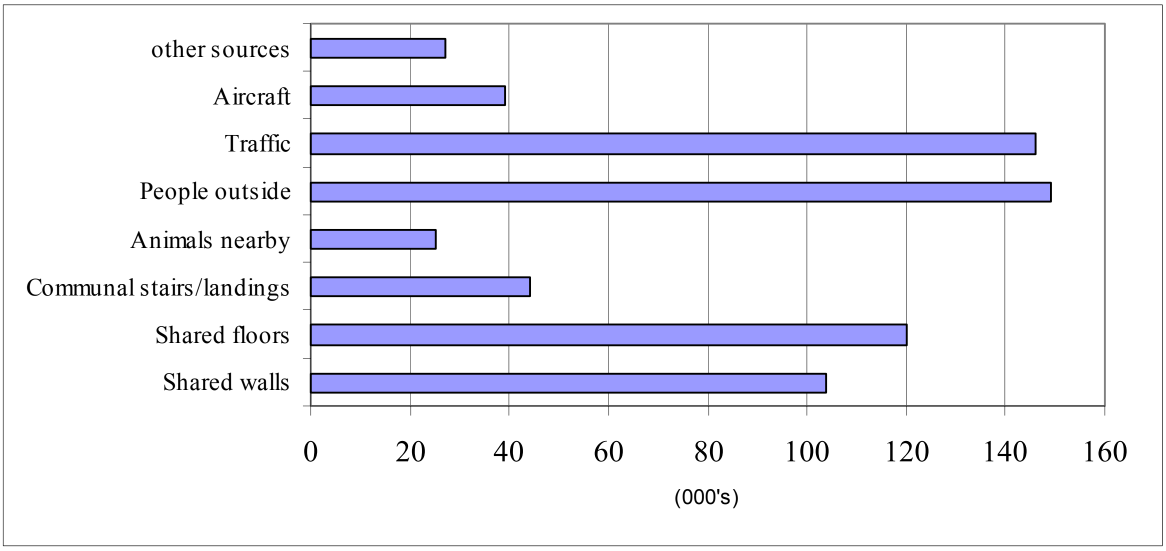
2.5 SOUND INSULATION STUDIES: EXISTING LITERATURE

During the seventies, major studies were carried out into sound insulation by the Building Research Station and published in 1978. In the study by Sewell and Scholes [16] of 1700, party walls and floors, 63% of the floors failed to meet the impact sound insulation criteria given in the Building Regulations with 33% giving a particularly poor performance.

A comprehensive residential sound insulation study published in 1981 by Langdon et al [17]estimated 3 to 5 million people in the UK to be bothered by noise from their neighbours. Respondents to a Building Research Establishment survey in 1982 considered sound insulation to be the worst defect amongst typical house problems.

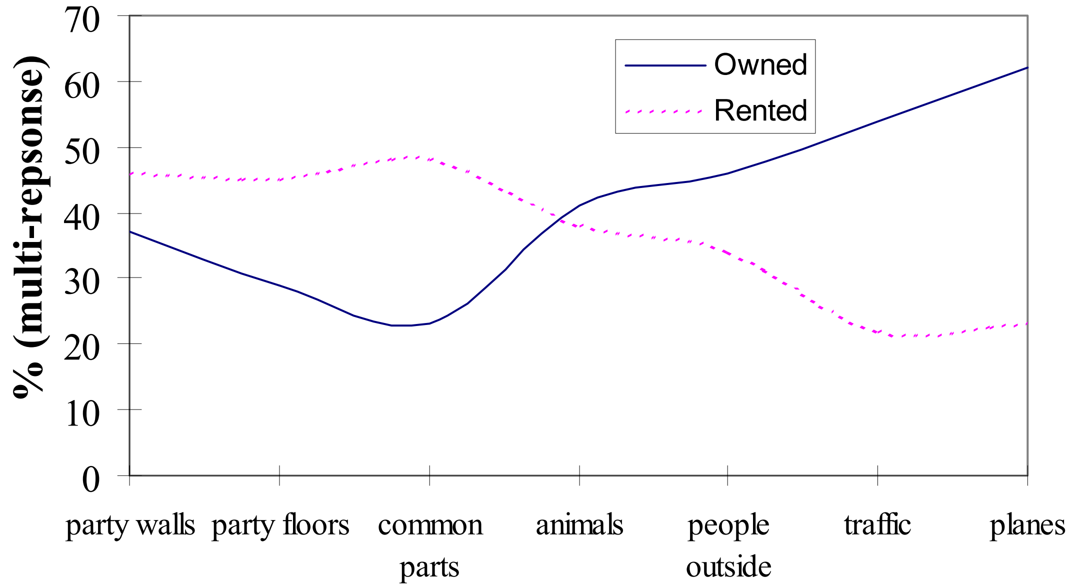
The 1996 Scottish House Condition Survey undertaken by Scottish Homes [18] indicated that 19% of households (403,000) were bothered by noise. It can be seen from the reproduced results in Figure 2.3 that noise transmission, particularly through separating floors, was identified as a significant issue.

Figure 2.3 Types of noise source most annoying to residents



Recent findings by the Scottish House Condition Survey 2002 show similar patterns to the 1996 survey. In addition, further subdivisions show the relationship between the rented and owner sectors as shown in Figure 2.4. As expected the rented sector being predominantly more associated with flatted developments has a higher score for shared floors. Interestingly, when analysing the whole of the Scottish housing stock there appears to be a division in relation to the importance of these issues per sector group and who may be more exposed to these sources of noise.

Figure 2.4 Types of annoying noise by tenure



In 2001 the Scottish Executive Building Standards Division commissioned the Building Performance Centre at Napier University to investigate the current performance of sound insulation in Scottish domestic construction, focusing on new build and conversions. It was found that the rate of failure had reduced significantly over the last 20 years from 40% to less than 5% as a result of housebuilders adopting resilient floating floor treatments as opposed to screed floor finishes. Over 90% of the separating floors in Scotland built annually use floating floor treatments composed of either resilient battens or cradles, which significantly improve impact performance.

In 2002 the Building Performance Centre at Napier University undertook an extensive field insulation testing study for a large Scottish urban housing association. The study involved airborne and impact testing of separating walls and floors throughout their stock of pre 1919, 1919-44 and post 1982 flats. The data collection exercise also included resident interviews with the occupiers from either side of the test partition. In total over 150 tests with interviews with dwellers both sides of the separating floor were collated. Pertinent findings include: 58% of the sampled residents rated the impact insulation of their floors to be unsatisfactory; 60% identified footfall noise as the most annoying noise heard within their dwelling and 66% of the floor samples tested failed to achieve the current Building Regulation impact insulation standard. The floor construction types of the housing stock were dominated by masonry supported timber separating floors similar to approximately 1.5 million other UK flats.

Summary

- 20% of the UK population live in flatted dwellings equivalent to 4.92 million homes
- Largest areas affected include London, Scotland and the South East
- Approximately 66% of the flatted dwellings in England have concrete party floors and 72% of the flatted dwellings in Scotland have timber joist party floors.
- The Building Regulations requirements for impact performance on new build and conversions have been getting progressively worse since 1985.
- From 2004 new build dwellings in England and Wales using Robust Detail separating floors will be able to accommodate laminate and wood flooring. Scotland is consulting on adopting Robust Details.
- In relation to other noise issues for dwellings noise through party floors contributes significantly towards disturbing dwellers and urban EHO's in Scotland have recorded laminate flooring as a major issue.
- The external noise environment of the dwelling can influence the perceived noise heard within the dwelling from an adjacent dwelling.
- The current rating system using decibels as the only means of interpreting the impact performance should be extended to accommodate a non technical system using either a STAR rating or descriptive rating.

[1] English House Condition Survey 2001. The Office of the Deputy Prime Minister (2003).

[2] Scottish House Condition Survey 2002. Communities Scotland (2004).

[3] Northern Ireland House Condition Survey 2001. Housing Executive (2003)

[4] Welsh Housing Statistics (2004). National Assembly for Wales (2004).

[5] National House-Building Council. www.nhbc.co.uk

[6] UK 2004 – The official yearbook of the United Kingdom of Great Britain and Northern Ireland. The Office for National Statistics (2003).

[7] Planning Policy Guidance note 3 Housing. The Office of the Deputy Prime Minister (2001).

[8] Sound insulation in houses. Technical Memorandum 3. Department of Health for Scotland (1957).

[9] Methods for rating the sound insulation in buildings and of building elements. Method for rating the impact sound insulation. BS 5821:Part 2:1984, ISO 717/2-1982

[10] Sound Insulation, the implications of the new performance standards. Adams MS. Royal Institute of Environmental Health of Scotland (1993)

[11] Noise Survey 2004. National Society for Clean Air (2004)

[12] Noise Complaints and Prosecutions 2003 – 2004. Chartered Institute of Environmental Health

[13] Neighbour Noise – Public opinion research to assess its nature, extent and significance. MORI Social Research Institute (2003). Defra research study.

[14] The 1999/2000 National Survey of Attitudes to Environmental Noise. BRE report 205216f. Defra research study (2002)

[15] Noise Complaints and Prosecutions 2002 – 2003. Royal Environmental Health Institute for Scotland (2004)

[16] Sound insulation performance between dwellings built in the early 1970s. Sewell EC, Scholes WE. Building Research Establishment Current Paper 20/78 (1978).

[17] Noise from neighbours and the sound insulation of party walls in houses. Langdon FJ, Buller IB, Scholes WE. Journal of Sound and Vibration Vol 79 (1981).

[18] Scottish House Condition Survey 1996. Scottish Homes (1998)

Chapter 3: The mechanism of impact noise and hard floor surfaces

3.1 INTRODUCTION

Impact noise is essentially structural vibration, transmitted from a point of impact through a structure and experienced as radiated sound from a vibrating surface. In a building, this is most commonly caused by an impacting body hitting the floor, from where the vibration is transferred into the complex structural combination of plates and beams. The most readily available vibration path will generally lead to the ceiling of the lower property where impact noise results. The amount of impact noise heard within a lower storey will depend upon many factors although primarily on the force with which the impacting object struck, the vibration transmission characteristics of the floor structure and the floor covering.

The most readily controllable characteristics of a residential separating floor in regards impact sound transmission are therefore the structure and floor finish, although of these it is commonly only the floor finish which is considered. Softer finishing materials provide for better levels of impact sound insulation, as the material acts as a cushion, increasing impact time and so reducing the force input. In situations where soft coverings are not suitable due to hygiene, dampness or high traffic requirements, it is typical to 'float' a hard floor surface. This is achieved by using resilient products to isolate the walking surface from the floor structure.

The ability of a structure to withstand the transmission of impact noise is termed the impact sound insulation. New and refurbished residential properties are controlled under the Building Standards Regulations to ensure a minimum performance standard. This minimum standard should be met on the basic hard floor finish provided by the floor structure, such that regardless of the future surface covering, as chosen by the owner or resident, the minimum regulation impact sound insulation level should still be achieved. The standard method of measuring and rating sound insulation is provided within

International and British standards, BS ISO EN 140 [1] and BS ISO EN 717[2] respectively.

Sources of Domestic Noise

Noise is a complex quality to measure and control due to the variation in frequency spectrum, volume and perception. The method of noise transmission may be via air or structure with the source then described as airborne or impact respectively. The following are some typical sources of domestic noise:

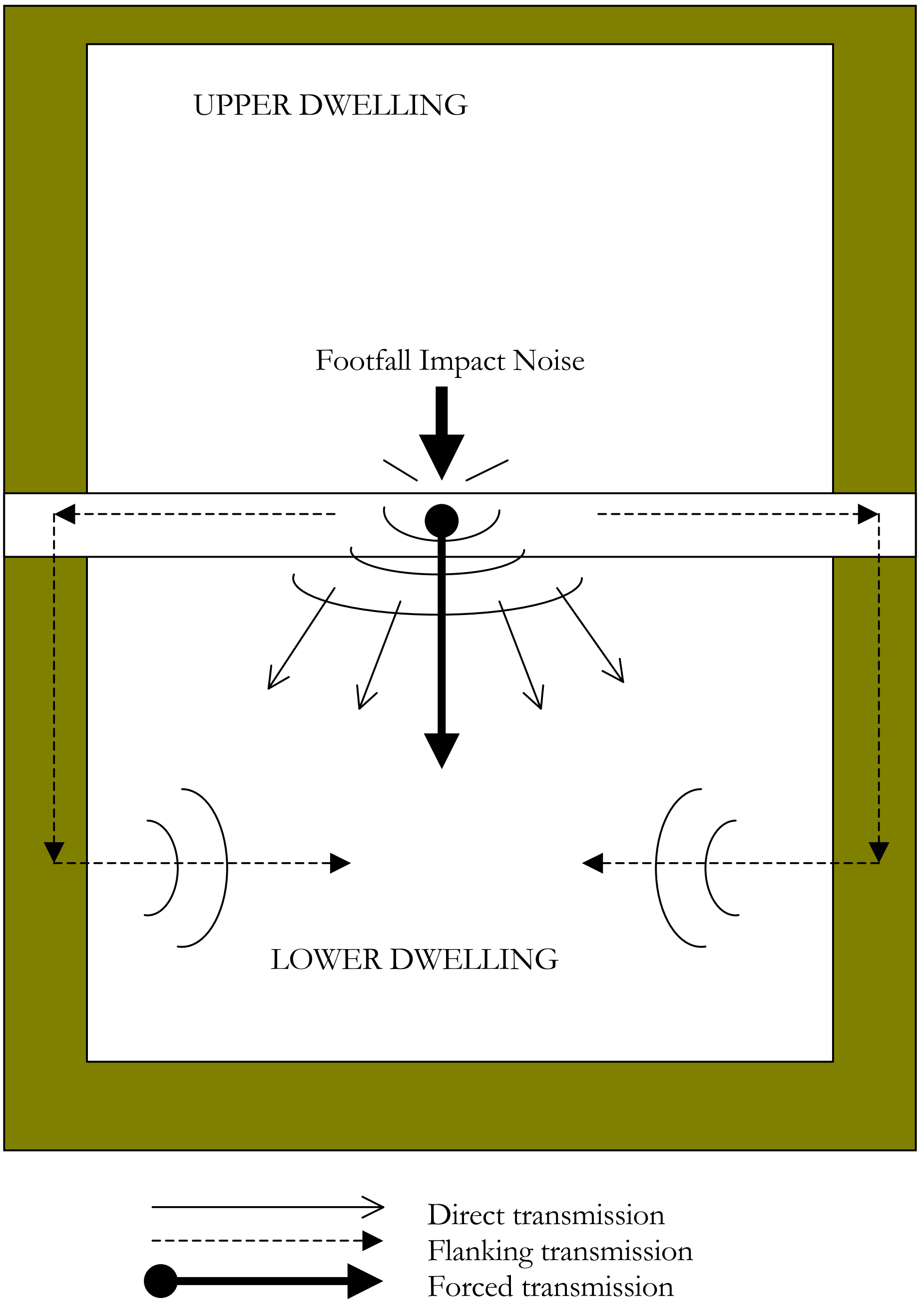
- television / radio (airborne)
- amplified music and non amplified music (airborne)
- people speaking or shouting (airborne)
- doors / cupboards closing (impact)
- plugs being pushed into sockets (impact)
- footfall noise (impact)
- furniture being moved such as chairs (impact)
- vacuum cleaners or washing machines (airborne and impact)

Impact Noise and Hard Floor Finishes

Residential impact typically occurs within the range of frequencies between 40Hz to 2500Hz, although with a dominance at the 63Hz to 250Hz low frequencies. The frequency characteristics of any noise transmission is dependent on the surface finish, core floor construction, ceiling finish and supporting walls or structure.

The transmission of footfall noise occurs by three distinct mechanisms as shown graphically in Figure 3.1:

Figure 3.1 Sound transmission mechanisms of footfall noise



- **Direct transmission** - resonant motion (floor radiating sound to the room below).
- **Flanking transmission** - resonant motion (floor transmitting sound to the adjacent walls which radiate to the room below.
- **Specific low frequency transmission** - non-resonant motion (forced motion of the floor causing the floor to deflect and compress the air in the room below which changes the pressure out the eardrum).

In traditional separating floors where the structural support is provided by walls (not columns) all three of the above will be present. In the case of hard floor finishes such as bare wood finish or laminate floors with no underlays the direct transmission will be high and the flanking transmission is dependent on floor-wall structural coupling (the noise level will increase if the laminates are butted up tightly to the skirting boards and perimeter walls). The specific low frequency transmission is strongly dependent on the stiffness of the core floor structure.

The low frequency noise generated by forced motion is more prevalent in timber than concrete core floors due to their lower stiffness. This has important ramifications for the number of complaints being recorded with these type of dwellings.

In the case of concrete floors, which are not often ‘flush’ level, and if there is no underlay or the laminate is abutted tightly to the walls a higher frequency “slapping” noise can be generated as the laminate deflects suddenly over 2-4mm.

Creaking noise can also occur with older timber finished floors and there is often a strong correlation with the installation of services such as heating, water and electrics and the presence this noise source.

Impact Noise and Health

"Noise from adjacent dwellings may act indirectly as a catalyst towards detrimental health effects "

Exposure to impact noise from adjacent dwellings may impact on the householders health and well being. The effect of noise on health and its indirect effects have been studied in a wide range of studies [3, 4, 5]. In '*Hazards in The Home*' [6] the authors found that there was a wealth of research work and discussion on the non-auditory effects of noise on health and well-being but there was little systematic research into the direct effect of domestic noise on health. However, noise from adjacent dwellings may act indirectly as a catalyst towards detrimental health effects through a variety of mechanisms. The extent of the effect on health and well-being is dependent on an individual's sensitivity, health profile, circumstance and perception of, or control over the noise problem [3]. A review by Stansfield, Haines and Brown [4] identified non-auditory effects of domestic noise as:

- sleep disturbance
- annoyance
- activity disturbance
- emotional response

The disturbance to sleep by noise depends on the stimulus (type of noise, intensity, duration, repetition etc.), on the stage of sleep at which the disturbance occurs, on the environment, as well as on individual variables such as age or state of health [3]. Studies have shown that there is an influence of age on waking reactions due to noise during sleep, with sensitivity increasing with age[3]. Deprivation of sleep due to noise can be measured qualitatively and quantitatively, depending on which stage of sleep the interruption occurs. Sleep deprivation can result in physiological and psychological effects. Some of these effects include:

- increase in tension, stress and irritation

- increase in fatigue
- reduction in performance for tasks requiring vigilance
- reduction in mental task performance
- evoked reflexes diminish
- somnolence increases
- reduced discharge of human growth hormones in the blood
- REM (rapid eye movement) sleep stage becomes more insensitive to sound stimuli.

Some of the effects due to sleep deprivation will also affect the householder's work environment leading to reduced work output and leading to increased risk to health and safety. In the case of young children, who have persistent sleep deprivation, this can result in poor school performance.

Impact noise from footfalls is quite unique as the exposed dweller feels they are unable to avoid it, no matter which room they are in. Impact noise from footfall can occur at all times of the day and night dependent on the living style and sleep patterns of the upper occupants. This then creates a strong feeling of lack of control over their own environment even though the person upstairs may be undertaking normal living activities. As a result impact noise from footfalls leads to high levels of annoyance and high levels of complaints.

Activities such as resting and listening to television/radio are the most common noise-disrupted activities and unwanted noise may result in feelings of anger, depression and fear. Thus, noise transmission between dwellings and its non-auditory effects causes increased tensions between neighbours and can lead to disputes, even physical assaults.

Can the level of impact sound transmission be quantified?

Impact sound transmission is typically measured in-situ and rated using the International Standards ISO 140-7 [1] and ISO 717-2 [2] respectively.

Impact sound transmission tests are carried out on floors to quantify the level of noise which may be transmitted by such impacts as footfall noise. The sound pressure measurement is typically carried out in the 16 third octave bands from 100Hz to 3150Hz with the standardised impact sound pressure level calculated, L'_{nT}. Figure 3.2 shows a typical measurement set up of a party floor between two adjacent dwellings.

To provide a suitable and repetitive impact source a standard tapping machine is used and placed in the source room on the upper level. This machine consists of five 500g metal hammers dropping sequentially onto the floor from a 40mm height in a repeating cycle of ten impacts per second. The metal hammers are not exactly representative of footfall noise as they do not simulate the forced motion of the floors, however the tapping machine does provide an international standard test method for impact sound insulation.

Impact sound insulation measurements only require the microphones to be in the receiving room. In effect what is measured is the impact sound transmission and not the insulation. When tests are carried out the floor should have no carpets, soft coverings or non permanent finishes so that the tapping machine is exciting a hard floor surface directly i.e. screed, chipboard or flooring boards.

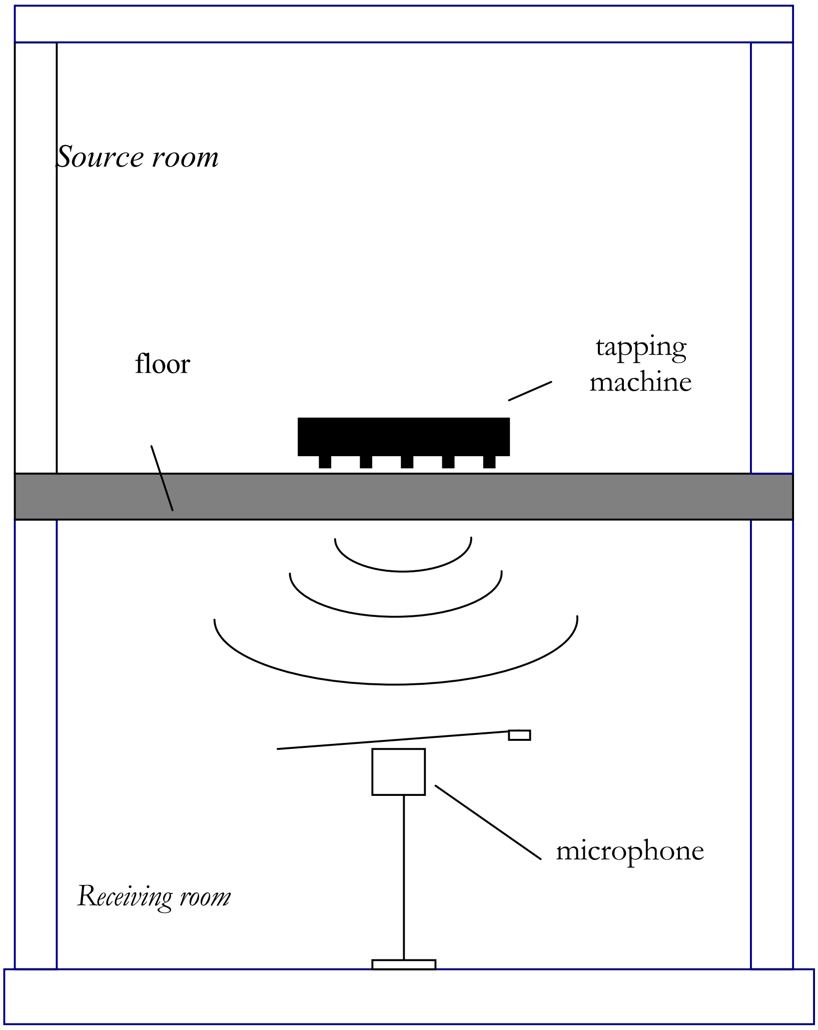
The reverberation time is measured in the receiving room and is compared to a standard room reverberation time of 0.5 seconds.

The standardised impact level, L'_{nT}, is calculated from:

$$L'_{nT} = L - 10 \log_{10} (T / 0.5)$$

L = Measured Impact Source Pressure Level dB (re 2 x 10^{-5} Pa)
T = Measured Reverberation Time (S)

Figure 3.2 – Measurement set up for impact sound transmission of a floor.



For the impact transmission test, a high value of $L'_{nT,w}$ indicates a poor level of impact sound insulation. As such the higher the value of impact the worse the level of insulation from footfall.

Scotland has increasingly used field testing (known as post construction testing) following a court case in 1984[7], which permitted a sound test to be used as a means to determine " *that the workmanship was satisfactory* ". However, the above methods of field testing (known as pre-completion testing in England and Wales) have only just been brought into the Building Regulations in England Wales, 2003 for conversions and 2004 for new build. In England and Wales conversions have a lower level of compliance than new build, in

Scotland new build and conversions have the same compliance level of which the target value is higher than in England and Wales.

Types of Separating Floors in the UK

The types of apartment separating floors found in the UK covers a wide range of core structures, supporting mechanisms, cavity insulations, ceiling types and systems and flooring finishes. Pre 1919 many timber floors had deafening laid between the joists on support trays, which can raise the impact performance by 6dB. In some cases the deafening has slipped down the side walls or been removed during access for works. The majority of pre 1944 timber floors did not have a resilient layer beneath the walking surface and often connected directly to the timber joists. Resilient surface treatments for timber floors in the last 30 years have used a variety of resilient timber floating floor system such as platforms, battens and deckings.

Mineral wool is shown in many Building regulations as being placed under the flooring battens. Under dynamic loading this breaks down easily into small particles and within the 6 months of installation the floor impact performance can be reduced considerably. More recently timber solid joists have been replaced by engineered timber ‘I’ joists. Figure 3.3 shows a range of different timber separating floor constructions, which have been built across the UK at different time periods.

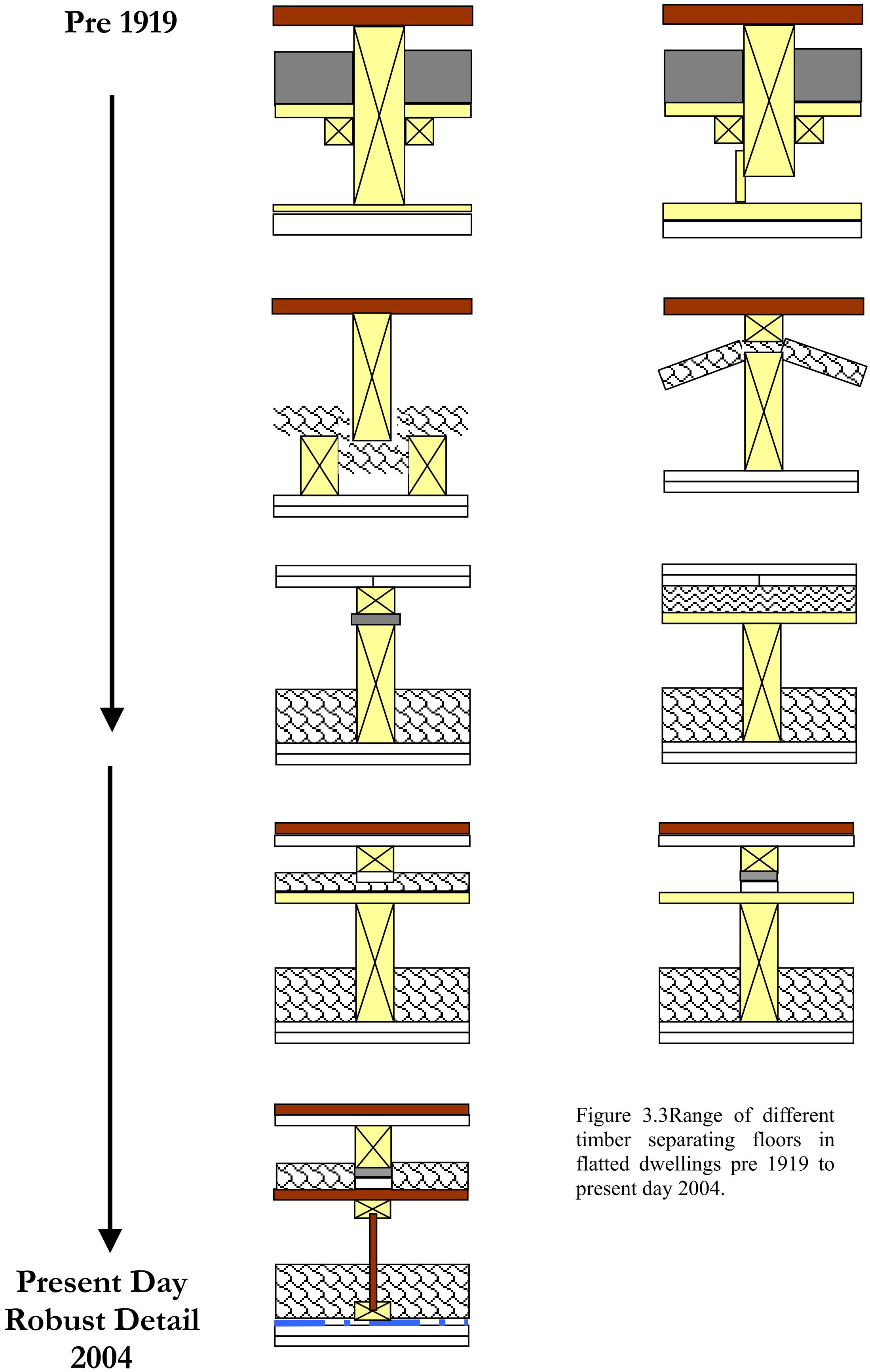


Figure 3.3Range of different timber separating floors in flatted dwellings pre 1919 to present day 2004.

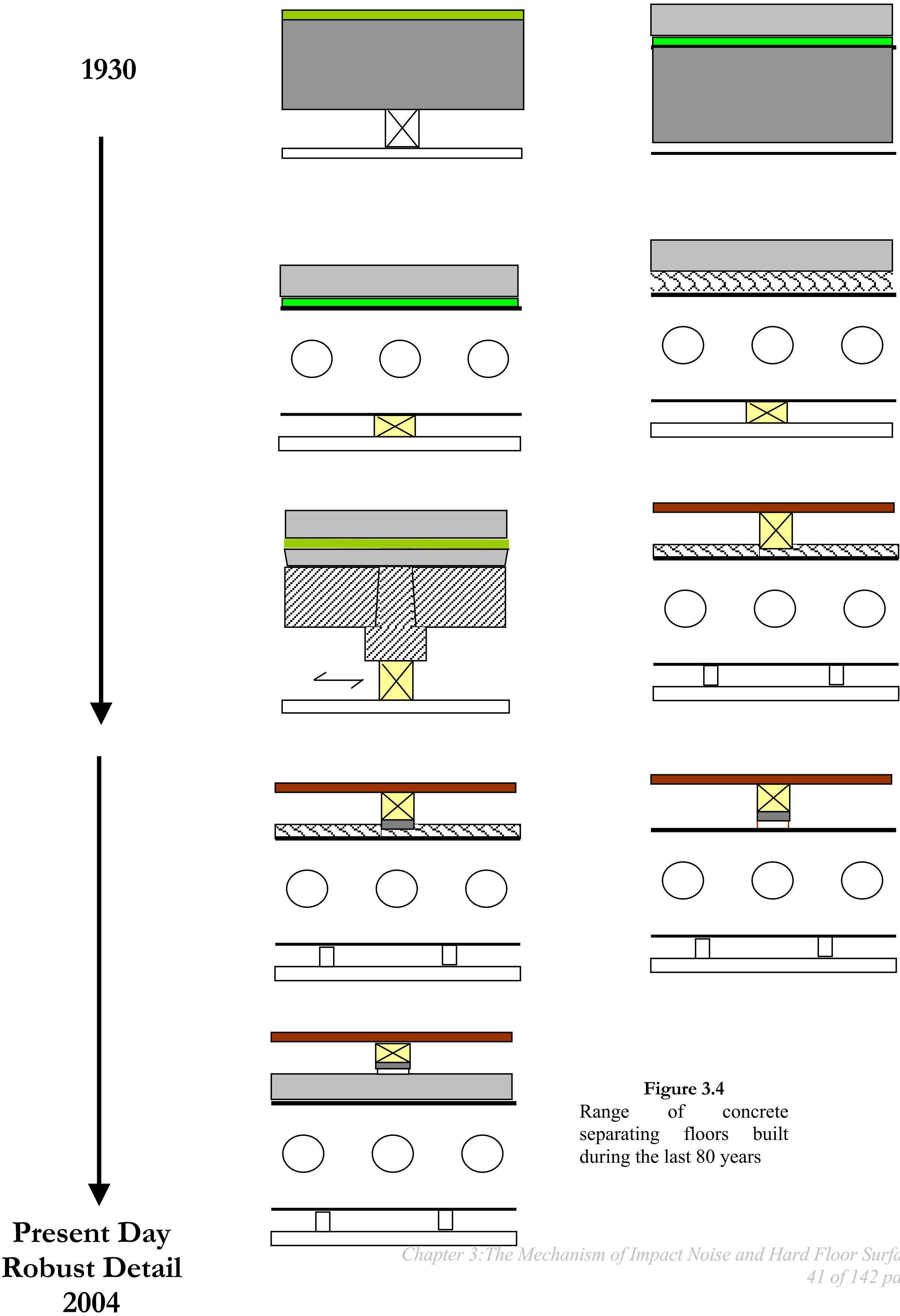


Figure 3.4
Range of concrete separating floors built during the last 80 years

Some of the poorest results for impact sound insulation for timber floors can be found in purpose built flats and apartments of the pre 1919 period and the period till 1964. In the case of the flats built after 1944 many had no deafening and used quilts such as mineral wool.

For concrete floors the core structure may be in-situ concrete, precast wide slabs or beam and block construction. During the 50’s, 60’s and 70’s the dominant core structure for flats and specifically high rise was in-siti concrete. The dominant floor finish for the last 30 years has been screeds (particularly in England), which float on a resilient layer. However, poor workmanship can often occur with these materials creating high levels of impact sound transmission to dwellings below. Most concrete separating floors in Scotland use timber floating floor treatments due to frequent screed failure rates. Figure 3.4 shows a range of different concrete floor constructions, which have been built across the UK at different time periods.

Conversion v Purpose Built

For Georgian or Edwardian style house conversions to flats, the typical make up of the floor construction includes direct floorboards on to the joists, with either independent ceiling joists, ash pugging or deafening and heavy lath and plaster ceilings or plaster based ornate ceilings of high mass. In addition, the joists are generally thicker and deeper than the late tenement construction (post 1919), 4-in-a-block and low rise apartments are as a result.

The majority of conversions are likely to be from the pre1919 period and will have had generally fewer residents and changes of ownership than say purpose built apartments for private ownership, local authority, housing association or rented accommodation. As such these forms of conversion will have had less separate works undertaken for services works. In the case of purpose built apartments pre 1964, there is a higher chance that multiple works will have been undertaken at different times, with different trades and with less inspection. Services penetrations may been individually undertaken for water, gas, electrics, ductwork, central heating and IT all using different workers.

Typical impact performance results for period constructions

Table 3.1 shows typical values of impact sound transmission for real dwellings for a range of period constructions.

Table 3.1 Typical impact performance of floors for periods of dwellings

Period	Construction	Core Floor	Other Insulation	Floor Finish	Impact Performance
pre 1919	Low rise	Timber	Yes Deafening	Floorboards	59 dB
pre 1919	Low rise	Timber	No	Floorboards	72 dB
pre 1919	Low rise	Timber	No	Lino	64 dB
pre 1919	Low rise	Timber	No	Laminate	66 dB
1919-1944	Low rise	Timber	No	Floorboards	70 dB
1945-1965	Low rise	Timber	No	Floorboards	71 dB
1945-1965	Low Rise	Insitu Concrete	No	Hard Vinyl	70 dB
1965-1982	High rise	Insitu Concrete	No	Concrete	65 dB

The performance values shown in Table 3.1 are extremely poor. From studies undertaken by the Building Performance Centre with interviews with tenants (subjective) and physical impact measurements (objective) it has been found that values in excess of 61dB can lead to dwellers describing the impact insulation as poor, very poor and intolerable.

Each dweller has their own perceptions of the impact insulation quality and some may regard 59dB as very poor whilst others find this acceptable. But values which are in excess of 61dB can lead to high levels of annoyance, frustration and a poor quality of life. The new performance target for the Building Regulations Part E 2003 for England and Wales is 62 dB for new build and 64dB for conversions., Scotland and N Ireland use 61dB for newbuild (and Scottish Conversions) with no value higher than 65dB for a group set of measurements and N Ireland have a maximum of 65dB for conversions.

Summary

Standard impact tests do not replicate each impact sound transmission mode, resulting in a poor correlation between objective measurements and subjective reaction.

Concrete and Timber floor constructions each have distinct characteristics, which are prone to high impact noise levels with hard floor finishes.

Building Regulations have previously set performance standards assuming that floors will subsequently be carpeted; problems therefore arise when hard floor surfaces are used instead.

After almost two decades of reduced impact insulation standards, residential floors are only recently now regulated, through the Robust Details Scheme, such that a hard timber floor finish can be used with a reasonable level of impact insulation.

---

[1] BS EN ISO 140-7:1998 Acoustics. Measurement of sound insulation in buildings and of building elements. Field measurements of impact sound insulation of floors

[2] BS EN ISO 717-2:1997 Acoustics. Rating of sound insulation in buildings and of building elements. Impact sound insulation

[3] The impact of noise pollution. Bugliarello G, Alexandre A, Barnes J, Wakstein C. Pergamon Press (1976).

[4] Noise and health in the urban environment. Stansfield SA, Haines MM, Brown B (2000).Reviews of environmental health 15(1-2): 43-82

[5] Healthy Housing. Ranson R. E & FN Spon (1991).

[6] Hazards in the home. Scottish Executive (2000).

[7] Scottish Special Housing Association v Glasgow District Council. Appeal against a refusal to grant a Completion Certificate (1984).

Chapter 4: Current UK Legislation and Case Law

4.1 INTRODUCTION

Rather than simply give a narrative description of the common law of nuisance (which can be found in a variety of textbooks[1]) it is intended to concentrate on that part of the law which is particularly pertinent to the issue of noise from hard timber floor surfaces.

4.2 THE COMMON LAW OF NUISANCE

The law recognises that a proprietor has the right to the free and absolute use of his property, but only to the extent that such use does not discomfit or annoy his neighbour. In other words, the law recognises one's right to enjoy one's land by imposing a reciprocal duty on one's neighbour not to interfere with such enjoyment.[2] The law of nuisance is, therefore, concerned with striking a fair balance between the competing rights of proprietors of land, each of whom has the right to enjoy that land. This conflict is pragmatically resolved by the courts imposing reciprocal duty on a proprietor of land not to use his or her land in such an unreasonable way that the pursuer's enjoyment of his land is prejudiced. The law was succinctly summarised by Lord President Cooper in *Watt v Jamieson*[3] where he stated:

'The balance in all such cases has to be held between the freedom of a proprietor to use his property as he pleases and the duty on a proprietor not to inflict material loss or inconvenience on adjoining property; and in every case the answer depends on considerations of fact and degree…..

The critical question is whether what he is exposed to was *plus quam tolerabil*e when due weight has been given to all surrounding circumstances of the offensive conduct and its effects. If that is satisfied, I do not consider that our law accepts as a defence that the nature of the user complained of was usual, familiar and normal. Any type of use which in the sense indicated above subjects adjoining proprietors to substantial annoyance or causes material damage, is *prima facie* not a reasonable use.'

The *Watt* decision also emphasises that whether any given state of affairs constitutes a nuisance is a question of both fact and degree.

The relevance of *Stannard v Charles Pitcher Ltd* [2003] Env LR 10 and *Baxter v Camden LBC* [2000] Env LR 112.

In *Stannard* (S) the claimant was the tenant of an apartment. The owners of the flat, which was situated above the claimant, carried out alterations to that apartment. The alterations included the removal of floor carpets and the replacement of such carpets with hard surfaces, such as marble and ceramic tile floors. The upshot of this was that the noise which permeated S's premises, increased substantially. S claimed that the noise in question amounted to a nuisance in law. At first instance it was held that a nuisance existed. The following points are particular relevance in the decision.

Firstly, it was held that in ascertaining if the noise constituted a nuisance one should employ an objective test, that is to say, whether the adverse state of affairs would have affected a reasonable individual. One should not take into account the claimant's social class, age or state of health.

Secondly, in determining whether the relevant state of affairs constituted a nuisance one should take into account the standards envisaged by the lease which the majority of the tenants hold in the various flats in the block in question.

In *Baxter* the claimant (B) lived in a block of council-owned flats. The insulation between the flats in question was inadequate. The upshot of this was that the various residents of the flats could hear so-called 'everyday noises' which each other made. The House of Lords held that the noise in question comprised noise which emanated from the 'normal' use of the premises in question, and, therefore, did not constitute a nuisance. Before an adverse state of affairs could constitute a nuisance in law it had to unreasonably interfere with the utility of the claimant's land. This was not so in the instant case. The noise in question was the inevitable consequence of the ordinary occupation of residential property.

As far as *Stannard* is concerned this is a first instance decision. It is my view that Mr J Slater QC (who was sitting as Deputy judge of the High Court) erred in holding that in determining if noise from the flats in question ranked as a nuisance one should take into account the terms and conditions of the relevant lease. There was, indeed, no authority by way of decided cases on this point. Of further interest is the fact that the judge made no reference to *Baxter* in his decision. One could have argued, with no little justification, that the noise from the hard surface flooring was simply everyday or ordinary noise which people make in their own homes. It is suggested that *Stannard* is not authority for the proposition that noise from such flooring will always rank as a nuisance in law. Rather, whether such noise does rank as a nuisance should simply be determined by utilising the various factors which have been indicated earlier in the report. *Stannard*, of course, is not binding on the Scottish courts. The outcome of any case would, of course, depend on its own particular facts. In the last analysis, the court would have to ascertain if the noise in question was *plus quam tolerabile* (more than reasonably tolerable) which would be a question of degree.

The relevance of Pettigrew v Inverclyde Council 1999 hous LR 31.

This sheriff court case concerned an action by P who was a tenant of the defender which was local authority. P claimed that her house was inadequately insulated the upshot of which was that she could hear noise made by her fellow tenants. (The summary of the report contains no details of the noise which P was exposed to but it would seem to have been ‘ordinary everyday noise’) It was held that if the noise in question did rank as a nuisance in law the nuisance in question could rank as a statutory nuisance in terms of s82 of the Environmental Protection Act 1990. Furthermore, the poor sound insulation was capable of ranking as a structural defect in terms of s82(4)(b) of the Act.

Pettigrew does not take the law forward in any way, it is suggested rather, it follows

Southwark LBC v Ince in which it was held that in determining if a nuisance existed in relation to premises one could take external factors into account. Furthermore, the case does not derogate from the general principle that it is a matter of fact and degree whether a given state of affairs can rank as a nuisance in law.

4.3 ELEMENTS OF THE LAW OF NUISANCE

It is important to emphasise that it is only unreasonable conduct which is capable of being categorised as a nuisance in law. In order to ascertain whether any given conduct is unreasonable the law has focussed on the relevant conduct from the viewpoint of the pursuer.[4]

The social utility or usefulness of the defender's conduct is taken into account. The more socially useful the conduct the less likely will it be regarded as a nuisance. While, in theory, this element is of general application in the law of nuisance, it has featured more commonly in the context of industrial nuisances where the courts have explicitly recognised the social benefits which accrue from factories.[5]

This factor is of little relevance to noise from laminated floors, etc.

4.4 MOTIVE OF THE DEFENDER

If the relevant state of affairs is generated simply to punish the pursuer, in other words, if the state of affairs is motivated by spite, the courts lean heavily towards the view that the state of affairs is a nuisance in law.[6]

This factor is of little relevance in the present context.

4.5 LOCALITY

This no relevance in the present context.

4.6 DURATION AND INTENSITY

Essentially, the length of time that a state of affairs exists as well as its intensity are taken into account.[7] Noise from laminated flooring, etc is more likely to be louder and therefore a nuisance than noise from floors which are carpeted.

4.7 TIME OF DAY

The courts are more inclined to regard noise a nuisance which takes place during the night than noise which exists solely during the day.[8]

Since noise from floors would take place at all times this factor would have some relevance.

4.8 COULD THE NUISANCE HAVE BEEN AVOIDED BY THE PURSUER?

The question here is to what extent, if any, the court can take account of whether the pursuer could have avoided the state of affairs which gave rise to the action. For example, is the occupier of a flat which is affected by noise under any obligation to provide sound insulation to the flat? On the authority of *Webster v Lord Advocate*[9] there is no such obligation.

4.9 IS THE STATE OF AFFAIRS TYPICAL OF MODERN LIFE?

The case of *Hunter v Canary Wharf Ltd*[10] is authority for the proposition that if the state of affairs which is complained of is typical of modern life it is less likely to be characterised as a nuisance. It is possible, therefore, that a court which is considering a noise nuisance which emanates from laminated flooring could be less inclined to hold that the state of affairs ranks as a nuisance on the basis that such a form of flooring is now quite common.

4.10 LIABILITY IN NUISANCE-WHO MAY BE SUED?

The author of the nuisance

The person who creates the noise nuisance (ie the author of the nuisance) is liable in law. He need have no interest in the land concerned.[11] It is therefore, possible to argue that the builder, joiner, etc who installs the relevant laminate flooring, etc. could be categorised as the author of the noise nuisance.

The occupier

The occupier of the relevant land is normally liable for any nuisances which emanate from the land.[12] The occupier of the flat in which there is laminate flooring the upshot of which is that neighbours suffer from noise pollution, would, therefore, be liable.

The landlord

A landlord is liable for nuisances which emanate from the premises only if the relevant nuisance is the ordinary and necessary consequence of the lease.[13] If the relevant adverse state of affairs is created by the landlord prior to the property being leased the landlord is solely liable for the manifestation of the nuisance during the currency of the lease.[14]

4.11 LIABILITY UNDER THE ENVIRONMENTAL PROTECTION ACT 1990

Under s79(1)(a) of the above Act:

‘any premises in such a state as to be prejudicial to health or a nuisance ranks as a statutory nuisance. ‘

The subsection, in effect, comprises two quite separate limbs, namely one limb comprising premises which are, ‘prejudicial to health’ and the other comprising premises which rank as a nuisance.

‘Prejudice to health’

That which renders the premises prejudicial to health need not emanate from the premises in question. It can arise from outside the relevant premises.[15] Therefore, it is possible that external noise generated (say) by laminated flooring which affects the flat below could rank as a statutory nuisance by virtue of harming the health of residents of the flat. However, in *Oakley v Birmingham City Council*[16] it was held that the risk to human health had to derive from some source of possible infection or disease or illness such as dampness, mould, dirt or evil-smelling accumulations or the presence of rats. *Oakley* would, therefore, be authority for the proposition that noise caused by laminated flooring and which pervades the flat below would not be deemed prejudicial to health within the scope of the paragraph.

'Nuisance' limb

If the state of affairs causes discomfort in the residents below, this would rank as a statutory nuisance. It is not necessary that the adverse state of affairs (the noise) should impact on human health in order to rank as a nuisance. Rather, it is suffices that the noise simply causes discomfort.[17]

Under s79(1) (g)

'noise emitted from premises so as to be prejudicial to health or a nuisance (ranks as a statutory nuisance).

Noise[18] which is emitted from premises by way of laminate flooring would, therefore, fall within the scope of the paragraph. There is no requirement that scientific evidence is presented to the court.[19] The courts give the expression, 'noise' as used in the statute its ordinary common law meaning.[20] In other words, when a court has to determine if a given state of affairs constitutes a nuisance in terms of the statute, it takes account the same factors as those which are discussed above. However, in *Robb v Dundee City Council*[21] it was held that the expression, 'nuisance' as used in s79(1)(a) was different to that at common law. While nuisance bears a different meaning to that at common law the degree of invasion which is required under either head is similar.

It is not necessary that a particular noise level be exceeded before a nuisance can be said to exist.[22]. To what extent, if any, this decision influences the interpretation of the expression, 'noise' as used in para. (1)(g) can only be resolved by case law.

4.12 THE EFFECT OF THE HUMAN RIGHTS ACT 1998 ON THE ENVIRONMENTAL PROTECTION ACT 1990

Under s 3 of the Human Rights Act 1998 (HRA) legislation must be read and given effect in a way which is compatible with the Convention rights. To what extent, if any, will the

HRA impact on the way in which s79(1) of the Environmental Protection Act 1990 is interpreted? Thus far no United Kingdom court has held that the HRA 1998 imbues the EPA with a different dimension. For example, in *Robb v Dundee City Council*[23] where the Inner House held that the word, 'nuisance' bore a different meaning to that at common law, it was open to the court to hold that in light of the Convention, a less onerous threshold was applicable. However, it declined to do so. Again, as far as the expression,' prejudicial to health' was concerned it was open for the court to hold that a more subjective approach, and, therefore, one more sympathetic to the well-being of specific individuals was appropriate. Again, it declined to do so. The point was not argued.

Human Rights Law –The significance of Art 8 of the ECHR

One specific issue which the researchers were asked to look at was the issue of whether there would be an infringement of Art. 8 (which guarantees the right to respect for private and family life) if a local authority or, indeed, a private landlord, refused, by way of a provision in a lease, to allow residents of a local authority house to lay a laminate floor in a situation where such flooring was necessary to protect the health of a resident (for example, a child) because of allergies caused by mites etc in carpets. There is no authority on this point. The law relating to human rights and the suppression of pollution is in an incipient state of development. It is our view that there would be no infringement in such a scenario on the grounds that the courts have not, thus far, accorded protection to such a form of invasion of personal integrity.

Culpa or blame

An interesting and, indeed, fundamental issue is whether the concept of *culpa* or blame, which requires to be proved in order to ground liability in the law of delict, is relevant as far as liability as far as statutory nuisance is concerned. In *Robb* it was held that *culpa* had no relevance as far as s79(1)(a) was concerned. It would be strange if *culpa* had no relevance to s79(1)(a) but of relevance to s79(1)(g). It is suggested, therefore, that *culpa* has no relevance to s79(1)(g). As far as noise from laminated flooring there would be no need to prove fault on the part of the relevant occupier of the premises.

4.13 EU LEGISLATION

There is no relevant law. The principle of subsidiarity would militate against the EU legislating here.

4.14 ANTISOCIAL BEHAVIOUR ETC (SCOTLAND) ACT 2004

As far as the above Act is concerned the provisions relating to noise are adoptive, that is to say, that they apply to the area of a local authority only if the authority has so resolved. (s41(1)). The gist of the Act is that an officer of a local authority (normally an environmental health officer) is empowered to serve a warning notice in relation to noise which exceeds the permitted level and is being emitted from the relevant property (an expression which includes any accommodation- s53(1))-s43(3). Under s45(1) an offence is committed by any person who is responsible for the noise which exceeds the relevant permitted level. It is possible that noise from laminated flooring could, in certain circumstances, exceed the permitted level. The expression, 'person responsible' is not defined in the Act. This is likely to give rise to case law in the future. In the absence of authority the expression, 'person responsible' would cover the occupier of the premises. It may also cover a landlord or even contractor etc who has commissioned/installed the flooring.'

4.15 NOISE ACT 1996 (AS AMENDED BY THE ANTI-SOCIAL BEHAVIOUR ACT 2003)

The Act makes analogous provisions to the Anti-social Behaviour (Scotland) Act 2004 in relation to noise from dwellings during night hours, that is to say, noise which takes place between 11PM and 7AM. The relevant warning notice may be served on the 'person responsible' for the noise. The expression, 'person responsible for noise' which is emitted from a dwelling is the person to whose act, default or sufferance the emission of the noise is wholly or partly attributable-s3(5). Noise from dwellings which is caused by laminated flooring could possibly fall within the scope of the Act. If it does the installer of the flooring, and possibly the landlord could be held liable.

4.16 NORTHERN IRELAND

As far as the common law of Northern Ireland is concerned the case law previously referred to would be applicable in that jurisdiction.

As far as statutory law is concerned relevant legislation is Part III of the Pollution Control and Local Government (Northern Ireland) Order 1978. Under art 38(1)-(2) if a district council is satisfied that a noise amounting to a nuisance exists or is likely to occur or recur in its area a council must serve a notice on the person responsible. If that person cannot be found, or the nuisance has yet to occur, the notice may be served on the owner or occupier of the premises from which the noise is being or would be emitted. A notice which is issued under art 38(1) may impose any or all of the following requirements.

(a) the abatement of the nuisance or prohibiting or restricting its occurrence or recurrence;

(b) the execution of such works, and the taking of such other steps, as may be necessary for the purpose of the notice or as may be specified in the notice.

The notice must also specify the time within which the relevant remedial action must be taken.

Under Art 38(4) the contravention of a notice without reasonable excuse constitutes an offence.

Under art 39 of the Order a court of summary jurisdiction can act on a complaint by the occupier of any premises affected by noise nuisance. The court can make an order for either or both of the following:

(i) requiring the defendant to abate the nuisance within a time which is specified in the order and to execute any works which are necessary for that purpose;

(ii) prohibiting the recurrence of the nuisance and requiring the defendant within a time which is specified in the order to execute any works necessary in order to prevent a recurrence.

Under art 39(5) anyone who contravenes any part of the order commits an offence. The defence of best practicable means applies in relation to noise from business premises. Proceedings may be brought against the author of the nuisance or, if he cannot be found, against the owner or occupier of the premises from which the noise is being or would be emitted. After a person has been convicted of an offence the court may direct the local authority to do anything which the court had ordered the relevant author to do.

---

[1] Noise and Noise Law. A practical approach. Adams MS, McManus F. John Wiley Chancery (1994)

[2] *Fleming v Hislop* (1882) 10 R 426

[3] 1954 SC 56 at 58

[4] Ibid

[5] *Bellew v Cement Ltd* [1948] IR 61.

[6] *Christie v Davey* [1893] 1 Ch 316.

[7] *Bamford v Turnley* (1862) 31 LJQB 286.

[8] Ibid

[9] 1984 SLT 13 at 15.

[10] [1997] 2 WLR 684

[11] *Slater v McLellan* 1924 SC 854.

[12] *Sedleigh-Denfield v O'Callaghan* [1940] AC 880.

[13] *Tetley v Chitty* [1986] 1 AllER 202.

[14] *Metropolitan Properties Ltd v Jones* [1939] 2 AllER 202.

[15] *Southwark LBC v Ince* (1981) 21 HLR 504

[16] [2001] 1 AllER 385

[17] *Robb v Dundee City Council* 2002 SLT 853.

[18] The expression 'noise' includes vibration. S79(7).

[19] *Westminster City Council v McDonald*

[20] *A Lambert Flat Management Ltd v Lomas* [1981] 2 AllER 280

[21] 2002 SLT 853.

[22] *Godfrey v Conwy County BC* [2001] Env LR 674.

[23] ibid

Chapter 5: Survey of Extent of Problem and Use of Tenancy Agreements

5.1 QUESTIONNAIRE SURVEY

In an attempt to provide more detailed data on the scope of this problem, postal surveys were distributed to all UK local authority housing and environmental health departments as well as UK registered housing associations. A project internet site was also established to provide an on-line survey facility.

An aim of the project was to assess the extent of noise problems associated with the normal use of hard timber floor surfaces within upper storey residential flats. To provide the data necessary to assess the scope and scale of the problem, postal surveys were designed and distributed to those expected, or likely to be exposed to residential noise issues. Three main groups were targeted. Local Authority Environmental Health departments, those on the front line of residential noise complaints; landlord organisations, both within the social housing, local authority and private sectors and house builder customer services. Two designs were distributed, the first Stakeholder survey was provided to all UK Local Authority Environmental Health and Housing Departments, Private landlords and Housing Associations. In addition to the 4,500 surveys distributed, a web-survey was also established.

The second House Builder survey was distributed to the top 100 leading house builders through the House Builders Federation. A copy of each survey is shown as Appendix B.

In order to get a reasonable picture of the issues involved in footfall noise, sections of the surveys were necessarily technical; specifically in the questioning of construction types, acoustic mitigation methods and their effectiveness. The resultant research is therefore prone to a degree of mis-interpretation of technical details.

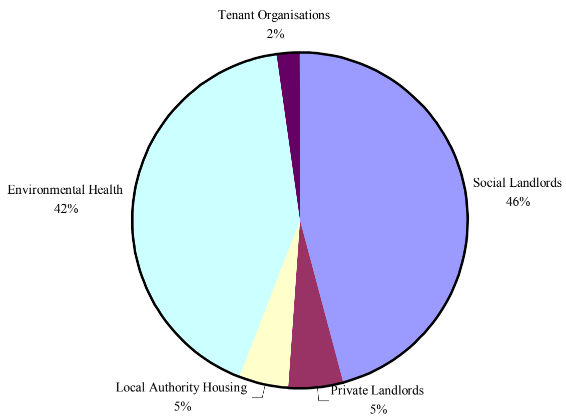
Detailed surveys typically attract a response rate of between 3-5%. The survey therefore took cognisance of only a section of the professionals involved in housing and noise issues, the results are therefore indicative only and limited in their statistical significance. The overall response, including postal, web and faxed replies was 3.1 % for the Stakeholder and 8.0% for the House builder surveys.

5.2 STAKEHOLDER SURVEY RESPONSE

Q1. Please provide an indication of your professional involvement and an estimate of the number of flatted residential dwellings with which your organisation is annually responsible for, if applicable.

The response to the Stakeholder survey was split predominantly between Environmental Health professionals (42%) and Social Landlords (46%). The remainder of replies came from Private Landlords (5%), Local Authority Housing Departments (5%) and Tenant Organisations (2%).

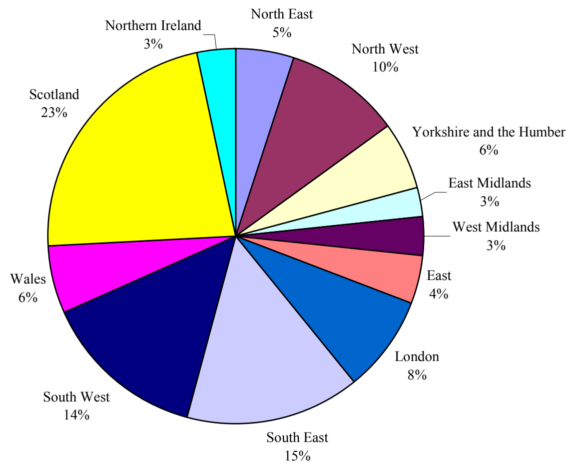
Fig. 5.1: Response Rates to Stakeholder Survey



Base: 129 Postal and e-mailed respondents

The geographic spread of the responses shows that the largest response was from Scotland (23%), the South East (15%) and South West (14%).

Fig. 5.2 Regional Response to Stakeholder Survey

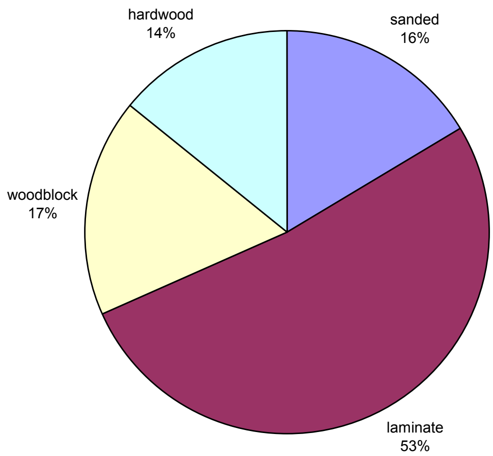


Base: 129 Postal and e-mailed

Q2. Of these properties, can you estimate the percentage where timber hard floor finishes have been installed:

The property management respondents, including Registered Social Landlords, private landlords, Local Authority landlords and Tenant Associations, reportedly represent a combined housing stock of 60,000 flatted properties, of which approximately 12 % have a timber hard floor finish, the remainder are assumed to be predominantly carpeted. The most popular hard floor finishes reported were timber laminates (53%), woodblock (17%), sanded floorboards (16%) and hardwood planks (14%). The figure of 12% of the overall stock containing a hard floor finish is supported by market research undertaken by MSI [1], which forecasts the laminate share of the 2004 floor coverings market to be approximately 10%.

Fig. 5.3 Break-down of Hardfloor Surfaces:



Base: 56 Property Management respondents

Q3. Please indicate the annual number of complaints received by your organisation relating specifically to impact noise from hard floor surfaces…. and their background cause….

The number of impact noise complaints addressed to each professional group varies according to the organisations size. Environmental Health respondents generally admitted to receiving the largest number of annual complaints specifically concerned with residential impact noise although there is significant variation across the data with some reporting annual complaints using single figures whilst others reported annual complaint numbers in excess of 100. The regional figures, from all environmental Health Departments who responded indicated that the London Boroughs received the highest proportion of these complaints with 49%. Of those indicating they had received complaints, the average annual number of complaints was 22, though it was indicated by some that this was just the level of official complaints and substantially more 'grumbles and moans' had been heard. A number of local authorities indicated that they only recorded complaints in line with CIEH sub-codes, resulting in no specific impact complaint data being recorded.

Private landlords generally hold a significantly smaller individual stock of housing, as reflected in their low number of complaints recorded.

Of the social landlords who responded, the average annual number of noise complaints was 12.

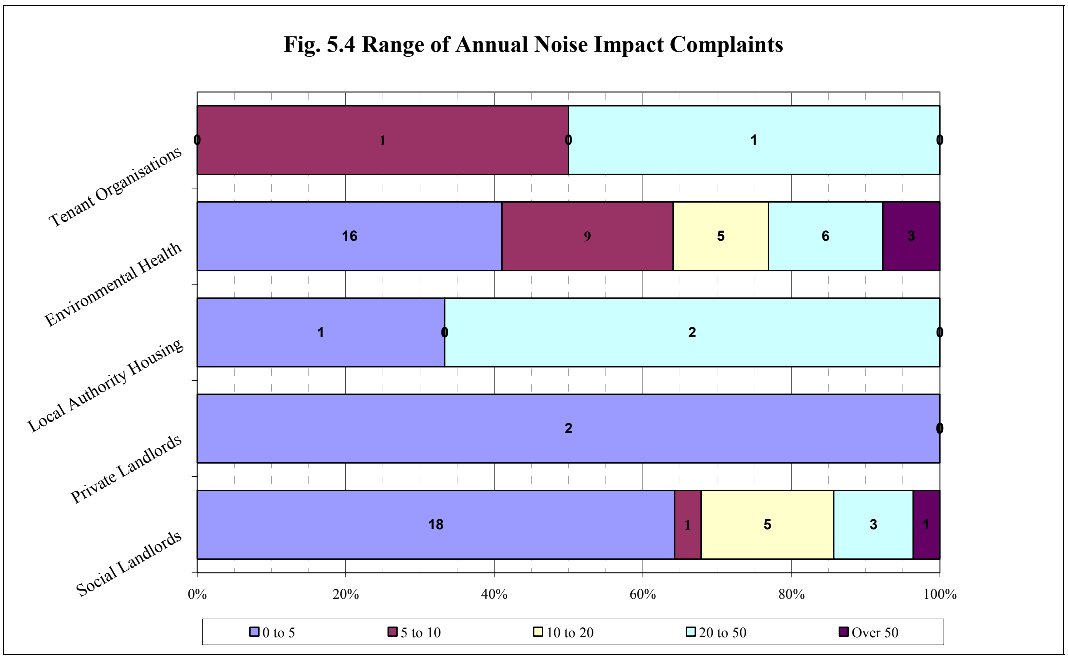
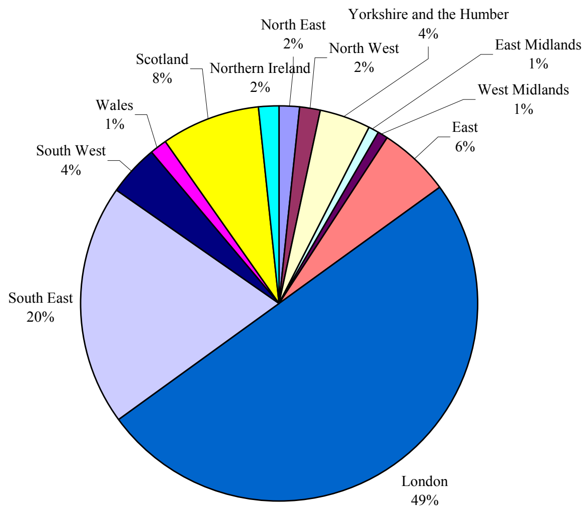
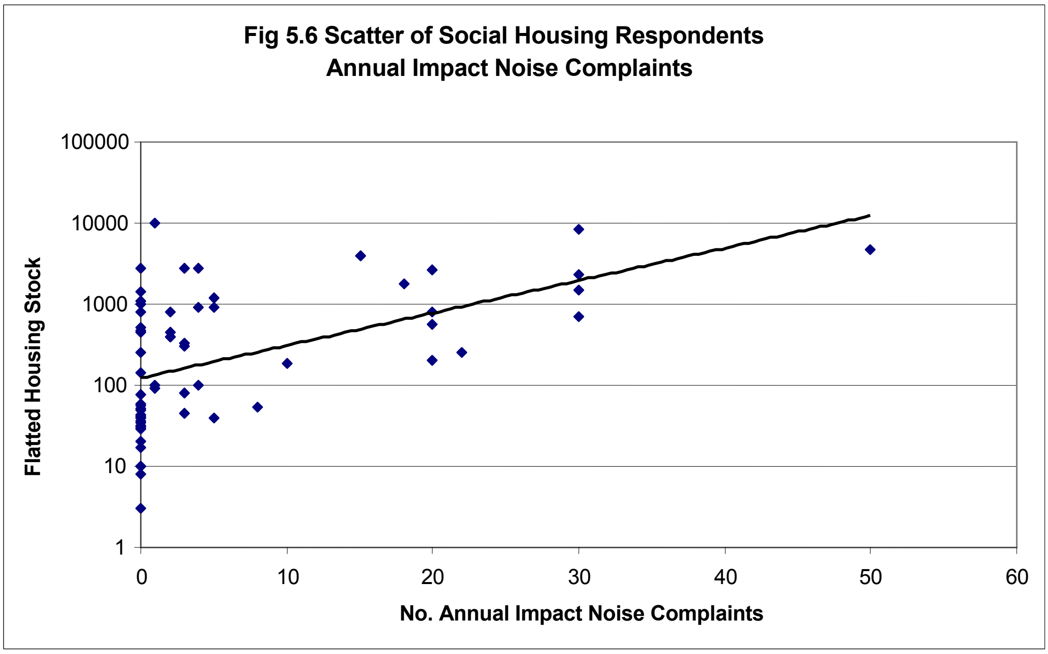


Fig. 5.5 Annual Impact Noise Complaints by Region from Enviromental Health Departments



Base: 39 EHO survey

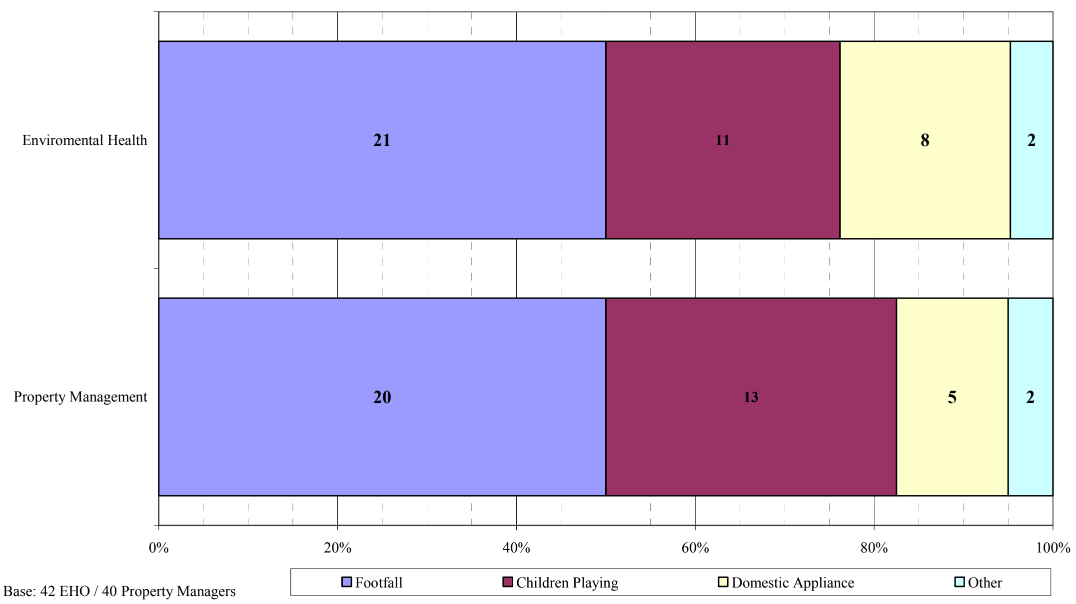
An analysis of the impact noise complaints reported by social housing associations indicate a range of between 20 and 10000 flats per impact noise complaint. An indicative calculation from the total number of flatted premises (59,589) and the total number of reported impact noise complaints (376) results in an average rate of complaint of impact noise of 1 per 158 flats, or approximately 31,000 UK householders. This figure provides a suggestion of the scale of the impact noise issue within the flat dwelling population, although the significant variance in the data, as shown in Figure 5.6, is likely to be caused by basic construction differences within the sampled population, indicating that additional parameters need to be considered to gauge a UK estimate of the problems' scale.



The consensus over the cause of these complaints is evenly distributed between the installation of a new floor surface and the introduction of new residents. There are however several comments indicating that impact noise is often complained of whilst being a secondary issue.

The physical sources of impact noise have been ranked, in reported order, as footfall noise, children playing and domestic appliances. There is a good level of agreement of this result between the property managers and environmental health officers. Additional comments included other complaint inducing impact noises as door bangs, dropped objects and everyday activities.

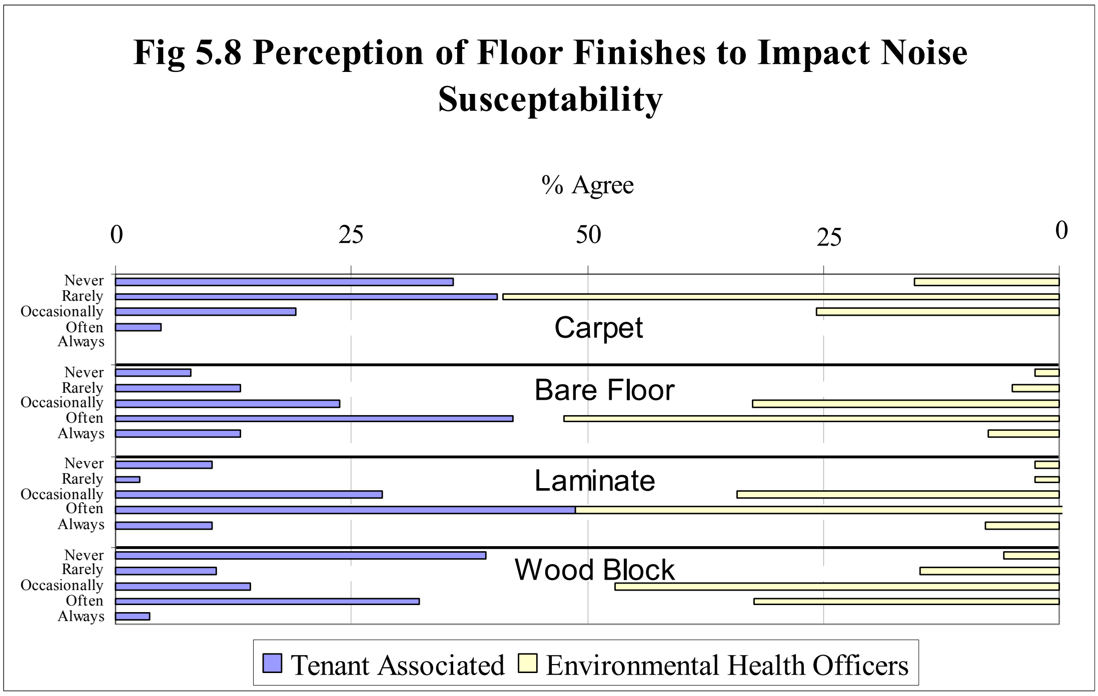
Fig 5.7 Source of Impact Noise Complaints



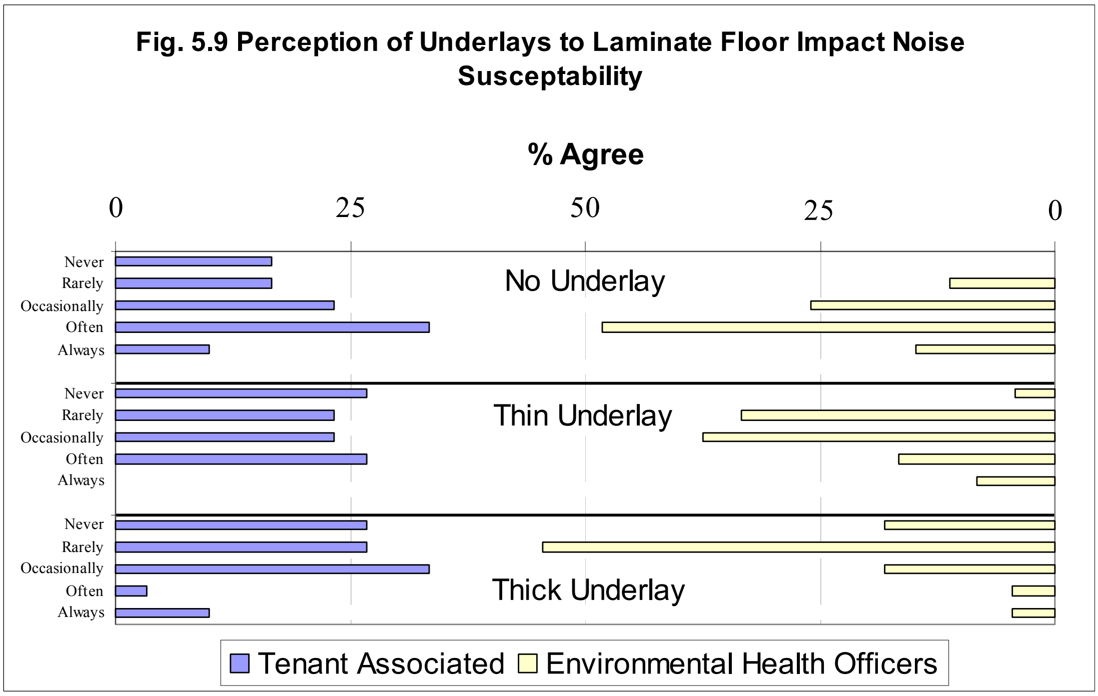
Base: 42 EHO / 40 Property Managers

Q4. From your experience, please estimate for each floor component the susceptibility to impact sound problems.

The survey asked respondents to grade the susceptibility of particular floor components, such as surface type, resilient underlay and sub-floors to problems of impact noise. The responses have been divided between the property managers and environmental health officers. The response from both groups are very similar indicating that carpets are rarely involved in impact noise problems whilst bare-boarded floors, laminated and solid timber surfaces are all often implicated. The culprit surface, considered to be most susceptible to problems of impact noise was the laminate floor finish.



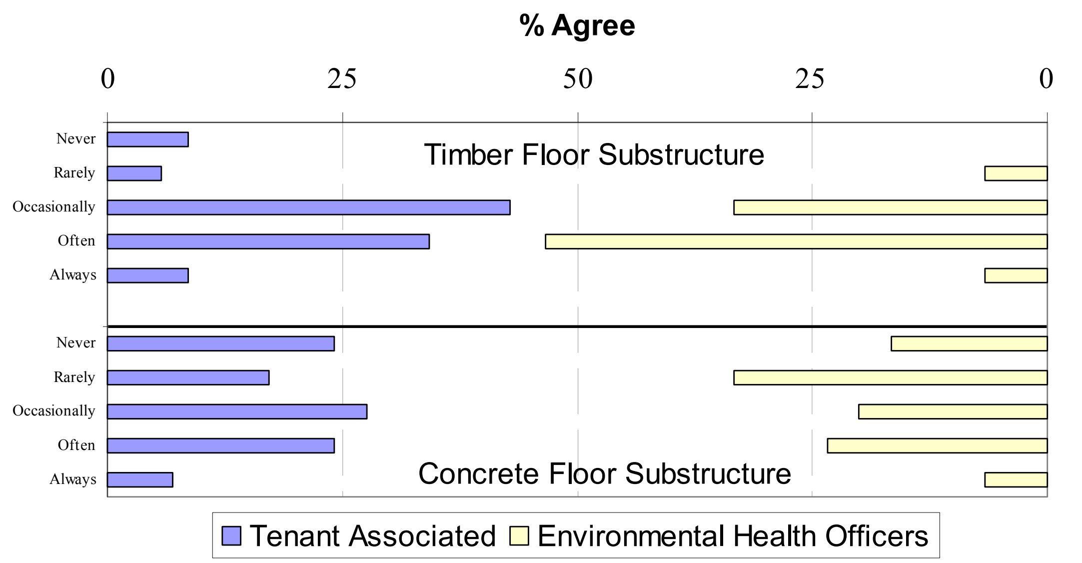
The use of an underlay installed under a floor surface was widely considered to be beneficial for improving impact sound insulation, the common perception being that thicker is better.



The influence of the sub-floor construction was picked up equally by both groupings, with timber floors considered by most respondents, particularly environmental health officers with 53% of respondents considering timber floors to be often susceptible to impact noise problems.

An initial analysis of returns has indicated that the majority of complaints have occurred where there is a timber floor structure as opposed to concrete floors. Caution must, however, be exercised in drawing conclusions from this, as it is likely that there is a higher proportion of the respondents' housing stock with a timber sub-floor.

Fig 5.10 Perception of Sub-Floor Construction to Impact Noise Susceptability



Q6. Has your organisation attempted to restrict the use of laminate flooring within flatted residential properties through the use of a written clause incorporated into a tenancy agreement, deeds, condition of sale etc.

It would appear that the use of tenancy clauses to restrict the use of laminate flooring within flatted residential properties is rare. Of those that responded, only 8% of Social landlords indicated that they were used, whilst none of the private or Local Authority landlords indicated any use.

Several of the respondents have indicated that, whilst they do not have a specific agreement, they do try to discourage tenants from installing a hard finish.

Several have also indicated that they are responsible for the installation of floor finishes and as a matter of policy do not install laminate flooring and only use carpet or linoleum.

One housing association stated that it had a policy of removing any laminate flooring when a property was refurbished or the tenant was changed.

Q7. Is the clause used only for new residents or has it been applied retrospectively? If used retrospectively how were the changes implemented?

Tenancy agreements, where introduced could not be enacted retrospectively, however one Local Authority respondent did provide information where a secure tenancy agreement was introduced across the board which included a clause specifically restricting the use of laminate and hard floor finishes.

Q9. Has the clause been enforceable in practice? If no, please provide details.

The response to these questions was low, with only 3 surveys completed on the question of enforcement. The main problem identified with the clause were practical enforcement difficulties. Certain circumstances were however mentioned where the refurbishment of heating systems etc. had provided an opportunity for removing tenants laminate floors, although such events were acknowledged as being rare.

Q10. Has any impact noise dispute necessitated legal recourse?

The overwhelming response to the question of resorting to legal recourse following unresolved impact noise complaints was 97% and 92% against its use for social landlords and environmental health officers respectively. A common theme in the comments of respondents was their inability to use legal action in light of the Baxter v Camden case.

Q11. How are nuisance complaints from impact noise generally assessed?

When investigating a complaint the majority of respondents, 73% of the social landlords and 81% of environmental health officers, sought to quantify the problem by undertaking acoustic tests.

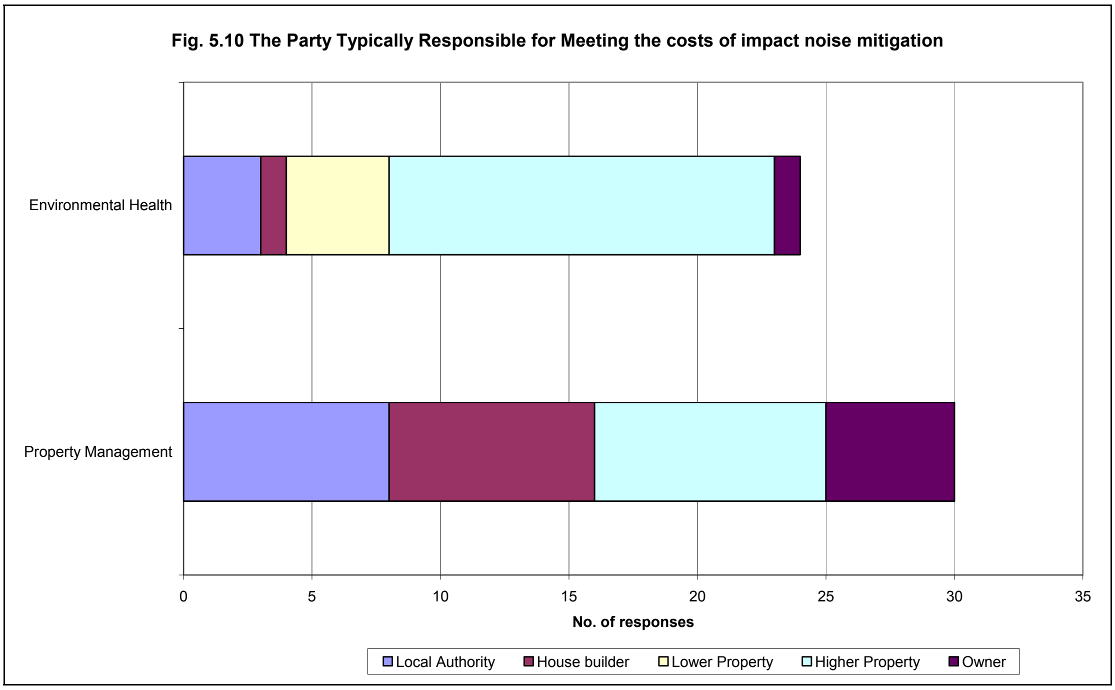
Q12. In response to impact noise complaints, has your organisation been involved in undertaking mitigation measures?

Remedial measures to attempt mitigation of impact noise had been attempted by only a small number of respondents although just under half of all respondents (46%) had admitted to using mediation. Half (51%) of the respondents who provided an opinion of the effectiveness of mediation gave negative feedback though one–fifth (21%) thought mediation worked completely.

Physical remedies such as a soft covering layer, ceiling treatment or installing an underlay under an existing floor where suggested as possible mitigation means, however only 4, 11 and 6% of respondents had attempted these respectively. Of those who judged the effectivness of these mitigation methods, 43% thought a soft covering layer would provide an improvement, compared to 32% who were positive about the benefits of ceiling treatments and 36% who claimed beneficial improvements for a soft resilient layer installed under a hard floor surface.

Q13. Which party is typically responsible for meeting the cost of remedial measures?

The majority of respondents considered the residents within the upper property to be liable for the payment of impact noise mitigation works. The secondary group to arrange for mitigation work were house builders, providing an indication that the problem is not limited to the existing housing stock but also to new build properties also.



Q13. Which party is typically responsible for meeting the cost of remedial measures?

Not surprisingly, the most significant factor determining the use of mitigation measures was cost, followed by physical restrictions on site.

Tenancy Agreements

Some examples of tenancy and deed clauses used to restrict the use of laminate floors are reproduced here:

'You must get our prior written permission if you want to install laminate flooring within your property. We will not refuse permission unreasonably. ….. We will only grant permission to install laminate flooring if you live in a house or a ground floor flat'

‘Before carrying out improvements or alterations to your house, you must get our written permission. We may pay you compensation at the end of your tenancy for these. If you don’t get our permission, we can charge you for restoring the house.’

’You are responsible for taking reasonable care of the house. This responsibility includes carrying out minor repairs and internal decoration. You are not permitted to carry out internal decoration or any other works which could prejudice the health and safety of the occupants or neighbours. It also includes keeping the house in a reasonable state of cleanliness. However, you are not responsible for carrying out repairs which are due to fair wear and tear.’

‘If you want to 1) Alter, improve or enlarge the house, fittings or fixtures; 2) Add new fixtures or fittings (for example kitchen or bathroom installations, central heating or other fixed heaters, laminate flooring, double glazing or any kind of external aerial or satellite dish); …

You must first get our written permission. We will not refuse permission unreasonably. We may grant permission with conditions including conditions regarding the standard of the work. Such works will not be taken into account in determining rent levels…’

Improvements to Your Home

You do not need to ask for permission to decorate the inside of your home but you should be careful about the materials you use, see Decorating Advice opposite…

Examples of Work that Requires Permission

- Installations of bathrooms, showers or fitted kitchens, central heating, loft and cavity wall insulation.
- Fencing, driveways, extensions or conservatories.
- Window replacements, double or secondary glazing.
- Erection of garages, sheds, etc.
- Removal of dividing walls, laying laminate flooring…’

Letter of Deeds

'Not to reside or permit any other person to reside in the Premises unless the floors thereof (including the passages) are completely covered with sound hardwearing material in the kitchen and bathroom and carpet (with underlay) on floor covering with sound deadening properties in the remainder of the Premises except while the same shall be removed for cleaning or repairing or redecorating the Premises.'

5.3 SURVEY OF HOUSEBUILDERS

The survey is also attempting to establish the extent of the use of hard floor surfaces in new build properties, the rate of complaints and the use of mitigation measures including conditions of sale.

The main findings of the house builders survey are that 25% of the respondents do not offer any laminate or hard floor surfaces specifically to avoid impact noise issues. Whilst a further company provided details of their deeds documents promoting the use of carpet and underlay or floor covering with sound deadening properties.

Complaints were received by 35% of respondents on both timber and concrete floor constructions.

Laminate floors were offered by 63% of the house builders of whom only 20% did not always use a resilient underlay fitted under the laminate layer.

Summary

- Survey response was 3.1% of which 42% were from environmental health departments, 46% were from registered social landlords, 5% from private landlords, 5% from Local Authority housing departments and 2% from tenant organisations.

- 60,000 flatted properties were represented by the property management respondents.

- Highest regional response with 23% came from Scotland.

- Average impact noise complaints for the environmental health departments were 22; average annual complaints for the social housing respondents were 12. Extrapolations from these results would provide indicative populations of between 10,000 and 40,000 annual impact noise complaints.

- Footfall noise account for approximately 50% of all complaints.

- The use of carpet is perceived as reducing the likelihood of impact noise problems although a timber laminate floor surface is frequently experienced as problematic.

- Little use is apparently made of tenancy agreements restricting the use of laminate flooring.

- There is significant uncertainty over the use of legal remedies for addressing hard floor surface impact noise problems.

- Mediation was the most widely attempted mechanism for dealing with impact noise problems however it had the lowest success rating. The highest amelioration rating was for the use of soft covers over a hard floor surface, installing a new ceiling lining within the lower property and installing a resilient underlay under the hard surface.

- 25% of respondent House builders no longer provide laminate floors within flatted developments specifically due to the noise issues.

- House builders using both timber and concrete floors have historically received complaints.

---

[1] Domestic Floorcoverings: UK. MSI Marketing Research for Industry Ltd (2003)

Chapter 6: Laminate and Wooden Floors: a Review

6.1 INTRODUCTION

The product that we know today as laminate flooring was originally developed in Sweden in the early eighties. The original high-pressure melamine laminate product was created with a base of several layers of paper impregnated with special resins which were pressed together under a high pressure into a composite material. The decorative paper determined the design and the finished laminate was then glued onto a carrier and cut into sections. This decorative laminate product was extensively used on kitchen benches, tables and wall panels, but not as yet for floors. The product was resistant but not yet durable enough to bear the additional wear and tear qualities necessary for a floor. The potential for a flooring product was realised however, and within time the product was researched and developed to provide the first laminate flooring. As research and technology progressed, the relative strength of the flooring laminate increased dramatically.

When laminate flooring was first introduced, wood flooring was its main counterpart. Wood flooring at the time was usually sold in long strips approximately 2.4m long, and was required to be installed by a skilled professional. When laminate flooring was first introduced into the market its advantages were recognisable immediately. Laminate flooring was released in a more manageable carton size, 8 planks approximately 1.2m long. The easy to handle carton was fairly lightweight and could easily be transported by car. These factors, together with the ease of installation, ensured that laminate flooring was on the road to success.

The popularity of laminate flooring today stems from three main attributes: durability, design/physical appearance, and ease of installation. In addition the cost, health benefits of a non-carpeted floor, and the ease of care and cleaning further reinforce the positive aspects of laminate flooring.

6.2 TODAY'S FLOORING PRODUCTS

The range of flooring products available today is extensive. Timber floors have advanced to provide a durable surface with installation methods simplified substantially in recent years. Laminate floors have progressed in a range of patterns and surface finishes. In addition, new engineered products have been developed to combine the positive aspects of a timber floor with laminated properties. For the flooring products referred to in this report, the following flooring types are listed with a brief product description:

Wooden flooring – This is a hardwood flooring which is manufactured either as solid wood or multi-layered engineered wood boards, and is available in a range of forms such as strips, planks, and parquet.

Solid wood flooring – is simply defined as one piece of wood produced in varying widths and lengths. The flooring is available 'pre-finished' with factory applied surfaces, or 'unfinished' which can be stained and coated on site.

Multi-layered engineered wood flooring – is manufactured from individual layers of wood bonded together with adhesives at high temperatures. This is typically produced in a three or five layer construction. The layering system usually consists of a backing layer and core (usually made of a softwood such as pine) covered with a solid hardwood surface. The flooring is available 'pre-finished' with factory applied surfaces, or 'unfinished' which can be stained and coated on site.

Laminate flooring – This type consists of several layers including a backing, a core, a decorative surface and a protective finish. The backing is used to form a moisture barrier to prevent distortion, and provide a secure base. The core is made from processed wood such as Medium Density Fibreboard (MDF), high density fibre or resin bonded particleboard, and constitutes the majority of the floor thickness. The next layer provides the decorative finishing and is usually a paper lining with prints of a huge variety of patterns, upon which an overlay finish is placed. This overlay typically consists of resin-coated cellulose or hardwearing melamine that provides a hard-wearing, durable surface.

Originally in laminate floors the segments of a laminate floor were glued together. Today the simplicity of a ‘click’ or ‘tongue and groove’ locking system has eliminated the need for gluing. Products are now available in the original glued method, a glueless method, or a pre-glued laminate in which the pieces glue on connection. In addition, some laminated floor boards come with an underlay adhered to the underside.

6.3 MARKET OVERVIEW OF COSTS AND PRODUCTS

Laminate Flooring:

Regarding laminate floors, there are known to be at least 30 independent manufacturers or importers operating in the UK. The various products are manufactured basically from timber materials bonded into a laminate form. The products from independent sources tend to differ from each other in respect of their physical properties such as density and thickness. They also vary in the way they are secured to the substrate. The earlier laminate methods based on the use of glue are now progressively giving way to a ‘click’ system which is based on the tongue and groove principle.

Laminate flooring is generally available in standard package sizes. From the range of products reviewed the thickness only varied from 6.5 to 8 mm. The price range varies depending on the quality of the laminate finish and the securing system. A typical range is from £5/m^2 to £20/m^2.

Most manufacturers recommend the use of underlays in order to reduce noise. There appear to be three key types available on the market. The most common is a 2 mm polyethylene foam, which costs approximately £1/m^2. Manufacturers’ literature typically claims an 18 dB impact improvement through the use of this product. Another common underlay is 6mm thick fibreboard. This typically costs about £2/m^2 with claims of 19 dB impact improvement and 26 dB airborne improvement. Finally, there is a 3mm flexible cellular foam sheet available, which provides a combined acoustic impact and moisture control layer. This costs approximately £1.5/m^2 and claims a 23 dB improvement in impact insulation.

Proprietary acoustic mats are also available, normally marketed by companies specialising in sound insulation products. Examples of these include:

5 mm closed-cell polyethylene foam costing approximately £3/m^2

4.5mm styrene butadiene rubber latex mat costing approximately £7/m^2

18mm laminate of two 4mm rubber mats on either side of a 10mm reconstituted foam sheet costing approximately £19/m^2

A substantial number of overlay boards are also available, which typically involve a composite of resilient layer bonded to MDF or chipboard. However, given that these tend to be between 17mm - 40mm in thickness, it is unlikely that those, other than boards with the shallowest of profiles, would be suitable as remedial treatments.

Manufacturers have recognised that problems arising from sound impact transmission are increasing and they are making composite products, which incorporate an integral acoustic foam layer. A typical example involves a 7mm wood laminate bonded to a 2mm thick acoustic foam. However, at £29.50/ m^2, it is obviously substantially more expensive than buying the laminate with separate acoustic foam.

Wooden Flooring:

Stricter product specifications have ensured that the wooden flooring industry has increased the product performance, improving durability and the resistance to the damaging effects of burns, spills and staining. The ability for timber raft floors to accommodate under-floor heating and to provide an increased sound insulation has also increased the practicality of wooden flooring. The finishes applied to the wood flooring ensure that most of the wear and tear is absorbed by the finish rather than the wood itself. This allows the wood to be sanded and refinished. This finish can now be applied prior to installation, further increasing the ease of installing the product.

The price range varies depending on the quality of the wood, and the securing system. A typical range for solid wood flooring varies from £32/m^2 to £110/m^2, while an engineered wood product ranges from £25/m^2 to £55/m^2. While skilled professionals have traditionally installed wooden floors, advances in production are creating simpler systems to allow the DIY installation of these floors in their homes.

6.4 THE USE OF LAMINATE AND WOODEN FLOOR FINISHES IN THE UK MARKET

A review of the market for hard floor finishes has been carried out in order to provide some background information for the study, in particular their increased use, as this is the most significant factor in the rise of complaints. A summary of the findings is presented below.

It is clear from discussions with contractors and DIY retailers that the use of wooden or laminate floors is markedly on the increase. A market research report by MSI entitled Data Report: Floorcoverings: UK [1] carries a wealth of data that testifies to this trend. Indeed the report indicates that the year on year increase in usage of laminate floors over the past five years has itself been rising steadily from around 14% to 20%.

From MSI data, it appears that the UK market for domestic wooden flooring has grown substantially in the period 1998-2002. See Table 1.

Table 1: Volume Distribution of Floor Finishes in the UK Market (%)

Floor Type	1998	1999	2000	2001	2002
Carpets	82.7	80.9	78.4	76.6	75.1
Linoleum	10.4	10.7	11.7	11.9	11.9
Laminate	4.0	5.0	6.0	7.3	8.6
Tiles	2.5	2.9	3.3	3.6	3.7
Wood	0.4	0.5	0.6	0.6	0.7

There seems no reason to assume that the upward trend in the use of laminate and wood floors, shown in Table 1, will not continue for the foreseeable future. Television programmes now appear regularly on the subject of home improvement and a visible increase in retail outlets selling laminate flooring products further supports this view.

MSI state that UK sales of laminate flooring rose by 120% in volume terms during the period 1998-2002. During the latter half of the review period, laminate flooring was increasingly used in contract applications for new housing developments as well as for refurbishment and DIY purposes.

In the domestic refurbishment market, laminate flooring has proven popular with many homeowners resulting from its perceived durability; ease of maintenance and attractive finish and, in some cases for health reasons, for example the replacing of carpets because of potential asthma links.

An increasing awareness by house builders and specifiers of the marketing advantages of laminate/wood flooring over other types of floor coverings has also contributed to increased demand. In addition, stricter product specifications have increased product performance within the hardwood sector, improving durability and resistance to damage.

MSI forecast continuing growth in the volume of the domestic laminate floor market and that this will increase by some 23% during the forecast period to reach 35.9 million m^2 by 2007. The value of the market will rise by 25% in real terms between 2003 and 2007, largely due to an increase in demand for higher specification products. Beyond 2007, the market share is expected to reach a plateau around 11% for laminate and 1.1% for wood flooring. See Table 2.

Table 2: Forecast of Future Distribution of Floor Finish Market, (%)

Floor Type	**2003**	**2004**	**2005**	**2006**	**2007**
Carpets	74.2	73.6	73.2	72.9	72.7
Linoleum	11.8	11.7	11.6	11.4	11.2
Laminate	9.4	9.9	10.3	10.7	10.9
Tiles	3.8	3.9	4.0	4.0	4.1
Wood	0.8	0.9	0.9	1.0	1.1

Product innovation is expected to be of increased importance, both in design and style, with the development of more contract specific products, development of acoustic backing for laminates and further enhancement of the click installation processes, which are expected to rise to almost 100% of the market by 2007.

The wooden flooring sector of the domestic market is also expected to grow, partly due to product development and new methods which will allow the installation of wood flooring without the need for expert fitters. MSI believe that the market for pre-finished wood flooring will continue to grow at a faster pace than that for unfinished boards due to the timesavings possible during installation.

6.5 MARKET STRUCTURE

The UK wood and laminate flooring industry is relatively concentrated, with the leading twenty companies accounting for the majority of the market share. The number of wooden flooring manufacturers is reported to be greater than the number of laminate flooring manufacturers.

Leading UK and international companies for laminate flooring include Kronospan, Western Cork, Pergo, Egger UK, Tarkett Sommer, Sonae Tafriba (UK) and Alloc. Trade sources report that Kronospan is the leading company in the market and is reported to represent some 30% of the market in volume terms. These 3 companies are estimated to control 60% of the market.

Companies such as Junckers, Western Cork Berry, Grundorf and Bruce Hardwood flooring are leading companies operating in the wood flooring market. Trade sources report that Junckers and Western Cork together account for over 30% of the wood flooring market in volume terms.

A large proportion of laminate flooring is imported from sources in continental Europe, North America and the Far East, although there are a small number of prominent manufacturers in the UK. Leading companies operating in the wood flooring market import a large proportion of their products from overseas and sell the product under their own brand name.

Trade sources report that some 70% of the value of the market for laminate and wood flooring in the UK is distributed from the manufacturers, both UK and international, to a distributor in the first instance, then onward to the retail sector. The remaining 30% of the market value is distributed directly to the retailer.

---

[1] Domestic Floorcoverings: UK. MSI Marketing Research for Industry Ltd (2003)

Chapter 7: Impact sound insulation performance of floor finishes

7.1 INTRODUCTION

This chapter discusses the measurements carried out to identify the features of floor finishes that are significant to the impact sound performance. Section 7.2 defines the methodology of the test procedures used and describes the three different test sites used during the measurement phase. The range of materials tested for floor underlays and floor surface finishes are listed in Section 7.3. Sections 7.4 and 7.5 show the single figure differences between the three core floors and finishes of underlay only, floor finish only and both combined. Section 7.6 provides an in-depth frequency analysis of some of the key floors tested. Finally Section 7.7 provides a summary of various systems tested comparing their performance on different floor systems.

7.2 MEASUREMENT METHODOLOGY

During the course of the project three separate sites were used to undertake sound insulation measurements. Initial measurements were conducted at the APG Acoustic Laboratories on a basic timber floor to evaluate the worst case scenario for a timber floor. Following this, materials were re-tested on a concrete floor within the Napier University Built Environment Laboratories. Finally a selection of materials were tested under normal site conditions within Bankton House, a residential development with a masonry supported timber separating floor incorporating a resilient floating floor.

Suppressed flanking laboratory

Measurements were undertaken at the APG Acoustic Test Laboratries, Blairgowrie, Perthshire on Monday 5th July 2004, Tuesday 6th July 2004 and Friday 6th August 2004.

Measurements were conducted by Tim Waters-Fuller B.Eng. M.I.O.A., Richard Mackenzie B.Sc., M.I.O.A., M.Inst.S.C.E. and Chris Steel B.Sc.(Hons), M.Phil., M.I.O.A., I.C.I.O.B.

Table 7.1 defines the measured temperatures and relative humidity measured during the three measurement periods.

Table 7.1 – Measured temperature and relative humidity

Date	Temperature (^oC)	Relative Humidity (%)
05/07/04	21	58
06/07/04	20	54
06/08/04	20	68

The test suite design was based on a cavity construction compressing a high-density masonry leaf isolated from the internal timber frame lined with plasterboard. A concrete ring beam supported on brick columns provided the aperture for the test floor. The ring beam was isolated on a high performance isolating polyelastomer strip with the columns separated and acoustically isolated from the surrounding structure.

The base floor construction upon which all materials were tested was as follows;

- 18mm t&g chipboard flooring
- 220mm timber engineered joists at 400mm centres
- 100mm mineral fibre quilt (12 kg/m^3)
- 2 No. 15mm standard plasterboard

For each material a 2m^2 test sample was formed on the base floor. For measurements where a laminate, composite or hardwood floor was included in the sample build up, a load of 22 kg/m^2 was applied to the surface of the test sample.

The area of the test specimen was 11.7m^2. The volume of the receiving room was 56.7m^3.

The equipment used conformed to the requirements of BS EN ISO 140: 1998, "Measurement of sound insulation in buildings and of building elements".

The following test equipment was used;

- Brüel & Kjær Modular Precision Sound Level Meter Type 2260
- Brüel & Kjær Building Acoustics Module Type BZ7204
- Brüel & Kjær Prepolarised Condenser Microphone Cartridge Type 4189
- Brüel & Kjær Sound Level Calibrator Type 4231
- Brüel & Kjær Sound Source Type 4224
- 2 Brüel & Kjær 10m Microphone Extension Cables Type AO0442
- Norsonic Rotating Microphone Boom Type NOR-252

The measurement procedure conformed to the methodology given in BS EN ISO 140-3:1995 'Acoustics – Measurement of sound insulation in buildings and of building elements – Part 6: Laboratory measurements of impact sound insulation of building elements'.

Measurements were also conducted in accordance with the APG's ISO 9001 quality management system.

The test sample was placed in the centre of the floor ensuring a minimum distance of 1m from the perimeter of the base floor.

Separating concrete floor

Measurements were undertaken at the Napier University Building Engineering Laboratories, Colinton Road, Edinburgh between 6th and 8th of August 2004.

The test suite design utilised a high-density masonry wall built off a ground bearing concrete slab.

The test floor was a 130mm cast in-situ concrete slab.

For each material a $2m^2$ test sample was formed on the base floor. For measurements where a laminate, composite or hardwood floor was included in the sample build up a load of $22kg/m^2$ was applied to the surface of the test sample.

The area of the test floor was $60.7m^2$. The volume of the receiving room was $175.7m^3$.

Equipment

The equipment used conformed to the requirements of BS EN ISO 140: 1998, "Measurement of sound insulation in buildings and of building elements". The following test equipment was used:

- Brüel & Kjær Modular Precision Sound Level Meter Type 2260
- Brüel & Kjær Building Acoustics Module Type BZ7204
- Brüel & Kjær Prepolarised Condenser Microphone Cartridge Type 4189
- Brüel & Kjær Sound Level Calibrator Type 4231
- Brüel & Kjær Sound Source Type 4224
- Brüel & Kjær Tapping Machine Type 3704

Measurement procedure

The measurement procedure conformed to the methodology given in BS EN ISO 140-3:1995 'Acoustics – Measurement of sound insulation in buildings and of building elements – Part :7 "Field measurement of impact sound insulation of floors".

The test sample was placed in the centre of the floor ensuring a minimum distance of 1.0m from the perimeter of the base floor.

Separating timber floor

Measurements were undertaken at Bankton House, Tranent, between 8th and 10th August 2004.

Bankton House is a traditional stone built manor house that has been separated into a number of apartments. The existing external solid masonry walls have been retained and new timber party floors and internal walls have been constructed. Party walls are constructed from traditional masonry walls.

Measurements were conducted between the lounges of the “South Flat” and the “East Flat”. The floor construction upon which all materials were tested is as follows;

- 18mm chipboard flooring
- 19mm plasterboard plank
- 45 x 45mm timber battens with an acoustic isolation layer
- Orientated Strand Board (OSB) deck
- 235mm timber joists at 600mm centres
- 100mm mineral fibre quilt (12kg/m^3)
- 19mm plasterboard plank
- 12.5mm plasterboard

For each material a 2m^2 test sample was formed on the test floor. For measurements where a laminate, composite or hardwood floor was included in the sample build up a load of 22kg/m^2 was applied to surface of the test sample. The area of the test specimen was 17.5m^2. The volume of the receiving room was 50.0m^3.

The equipment used conformed to the requirements of BS EN ISO 140: 1998, “Measurement of sound insulation in buildings and of building elements”. The following test equipment was used:

- Brüel & Kjær Modular Precision Sound Level Meter Type 2260
- Brüel & Kjær Building Acoustics Module Type BZ7204
- Brüel & Kjær Prepolarised Condenser Microphone Cartridge Type 4189
- Brüel & Kjær Sound Level Calibrator Type 4231
- Brüel & Kjær Sound Source Type 4224

- Brüel & Kjær Tapping Machine Type 3704

The measurement procedure conformed to the methodology given in BS EN ISO 140-3:1995 'Acoustics – Measurement of sound insulation in buildings and of building elements – Part :7 "Field measurement of impact sound insulation of floors".

The test sample was placed in the centre of the floor ensuring a minimum distance of 1.0m from the perimeter of the base floor.

7.3 TEST MATERIALS USED FOR FINISHED FLOORS AND UNDERLAYS

The materials tested fall into two main categories, finished floor materials and underlay materials. Table 7.2 shows generic descriptions of the finished floor materials tested and Table 7.3 shows generic descriptions of the underlay materials.

Table 7.2 Finished floor materials included in test programme

Reference	*Description*
F1	12mm MDF beech effect click joint laminate flooring
F2	15 mm Oak solid wooden flooring
F3	15mm Natural Bamboo solid wooden flooring
F4	7mm MDF Tile effect laminate flooring
F5	6mm MDF Cedar effect click joint laminate flooring
F6	6mm MDF Cherry effect click joint laminate flooring
F7	15 mm Oak finished engineered wood flooring
F8	8mm MDF Oak effect laminate flooring
F9	Twist pile carpet
F10	8mm MDF Teak effect laminate flooring with printed underlay
F11	15mm Beech finished engineered wood flooring
F12	8mm MDF Beech effect click joint laminate flooring
F13	4mm Vinyl flooring

Table 7.3 Underlay materials included in test programme

Reference	*Description*
U1	4.5mm latex mat
U2	x2 layer 4mm rubber mat bonded either side of a 10mm reconstituted foam
U3	x1 layer 4mm rubber mat bonded to one side of 10mm reconstituted foam 8
U4	x2 layers silver foil bonded either side of 3mm of a closed cell polythene foam
U5	3mm Polyurethane sheet
U6	Approx 10mm rubber crumb sheet bonded to thin textile
U7	Approx 10mm solid rubberised sheet bonded to thin textile
U8	5mm closed cell polythene foam
U9	5mm fibreboard panels
U10	3mm foil faced polyurethane sheet
U11	2mm foil faced extrude polystyrene sheet
U12	3mm textile faced polyurethane sheet
U13	2mm fleece sheet
U14	5mm approx. textile backed rubber crumb sheet
U15	5mm foil faced reconstituted foam
U16	Silver underlay 5mm foil faced textile backed polyurethane sheet
U17	Carpet underlay
U18	5mm textile faced textile backed rubber crumb sheet

7.4 MEASUREMENT RESULTS

Tables 7.2 and 7.3 outline the materials under consideration. For the initial controlled laboratory tests at APG laboratory each underlay and finished floor treatment was tested separately. This provided core data on the level of impact improvement provided by each individual material and also allowed for the selection of a single finished floor material to be used as a "generic" finished floor under which to test the underlay products.

The measurements undertaken on the concrete floor and the timber separating floor were also used to provide reference data for the materials on alternative constructions and to allow for validation of the laboratory controlled measurements. Subsequently the number of measurements undertaken for both the concrete floor and the timber separating floor were reduced from the number tested at the APG laboratory.

Each sub-section outlines the measurement results at each test site defining the level of acoustic improvement achieved.

Tabulated data shows the level of acoustic improvement over the base construction evaluated from the single figure value result calculated according to BS EN ISO 717: 1997 "Rating of sound insulation in buildings and of building elements, Part 2 Impact sound insulation". These measurement results are hereafter referred to as the standard rated results.

This data is presented in graphical form along with two additional indices calculated from the overall A and C weighted average sound pressure levels over the 50 Hz – 5 kHz frequency range and again given in terms of the improvement over the base construction. The A weighted results have been included as this more accurately define human perception. The C weighted results have been included to highlight any low frequency emphasis (See Glossary of Terms).

Basic timber floor (suppressed flanking laboratory) – Measurement Data

The timber base floor construction at the APG Laboratories gave an $L_{n,w}$, weighted normalised impact sound pressure level, of 78dB. Tables 7.4 to 7.6 display the level of acoustic (impact noise) improvement over the base construction achieved by each material and material combinations measured.

Table 7.4 APG Lab - Improvement, over base floor, of finished floor materials

Reference	*Description*	**Impact noise improvement ΔL_{nw} (dB)**
F1	12mm MDF beech effect click joint laminate flooring	3
F2	15 mm Oak solid wooden flooring	4
F3	15mm Natural Bamboo solid wooden flooring	3
F4	7mm MDF Tile effect laminate flooring	5
F5	6mm MDF Cedar effect click joint laminate flooring	3
F6	6mm MDF Cherry effect click joint laminate flooring	3
F7	15 mm Oak finished engineered wood flooring	2
F8	8mm MDF Oak effect laminate flooring	4
F9	**Twist pile carpet**	**13**
F10	8mm MDF Teak effect laminate flooring with printed underlay	3
F11	15mm Beech finished engineered wood flooring	4
F12	8mm MDF Beech effect click joint laminate flooring	3
F13	4mm Vinyl flooring	6

Table 7.5 APG Lab – Improvement, over base floor, of underlay materials without finished flooring

Reference	*Description*	**Impact noise improvement ΔL_{nw} (dB)**
U1	4.5mm latex mat	8
U2	x2 layer 4mm rubber mat bonded either side of a 10mm reconstituted foam	23
U3	x1 layer 4mm rubber mat bonded to one side of 10mm reconstituted foam 8	26
U4	x2 layers silver foil bonded either side of 3mm of a closed cell polythene foam	12
U5	3mm Polyurethane sheet	12
U6	Approx 10mm rubber crumb sheet bonded to thin textile	17
U7	Approx 10mm solid rubberised sheet bonded to thin textile	6
U8	5mm closed cell polythene foam	20
U9	5mm fibreboard panels	6
U10	3mm foil faced polyurethane sheet	10
U11	2mm foil faced extrude polystyrene sheet	9
U12	3mm textile faced polyurethane sheet	10
U13	2mm fleece sheet	3
U14	2mm closed cell polythene foam	9
U15	5mm foil faced reconstituted foam	8
U16	Silver underlay 5mm foil faced textile backed polyurethane sheet	6
U17	Carpet underlay	8
U18	5mm textile faced and textile backed rubber crumb sheet	13

Table 7.6 APG Lab – Improvement, over base floor, of underlay with finished floor

Reference	*Description*	**Impact noise improvement Δ L_{nw} (dB))**
F2+U11	Solid floor +2mm foil faced extrude polystyrene sheet	5
F5+U11	Laminate floor + 2mm foil faced extrude polystyrene sheet	5
F7+U1	Engineered floor +4.5mm latex mat	4
F7+U2	Engineered floor + x2 layer 4mm rubber mat bonded either side of a 10mm reconstituted foam	6
F7+U3	Engineered floor + x1 layer 4mm rubber mat bonded to one side of 10mm reconstituted foam 8	6
F7+U4	Engineered floor + x2 layers silver foil boned either side of 3mm of a closed cell polythene foam	4
F7+U5	Engineered floor + 3mm Polyurethane sheet	4
F7+U6	Engineered floor + Approx 10mm rubber crumb sheet bonded to thin textile	5
F7+U7	Engineered floor + Approx 10mm solid rubberised sheet bonded to thin textile	6
F7+U8	Engineered floor + 5mm closed cell polythene foam	4
F7+U9	Engineered floor + 5mm fibreboard panels	5
F7+U10	Engineered floor + 3mm foil faced polyurethane sheet	4
F7+U11	Engineered floor + 2mm foil faced extrude polystyrene sheet	3
F7+U12	Engineered floor + 3mm textile faced polyurethane sheet	4
F7+U13	Engineered floor + 2mm fleece sheet	5
F7+U14	Engineered floor + 2mm closed cell polythene foam	4
F7+U15	Engineered floor + 5mm foil faced reconstituted foam	5
F7+U16	Engineered floor + Silver Underlay 5mm foil faced textile backed polyurethane sheet	6
F7+U17	Engineered floor + Carpet underlay	3
F7+U18	Engineered floor + 5mm textile faced textile backed rubber crumb sheet	3
F9+U17	**Carpet + Carpet underlay**	**21**

Figures 7.1 to 7.3 graphically present the standard rated, A-weighted and C-weighted improvements in acoustic impact insulation conducted on the lightweight timber floor at the APG laboratory when applying various floor surface layers.

Figure 7.1 - APG lab tests, finished floor ONLY results

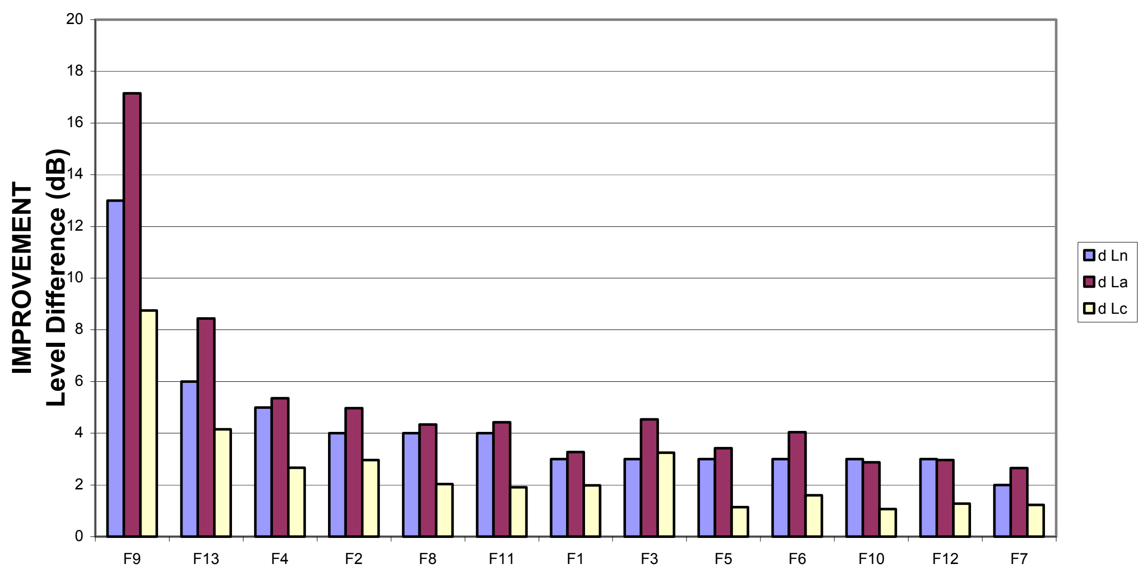


Figure 7.2 - APG lab test, underlay ONLY results

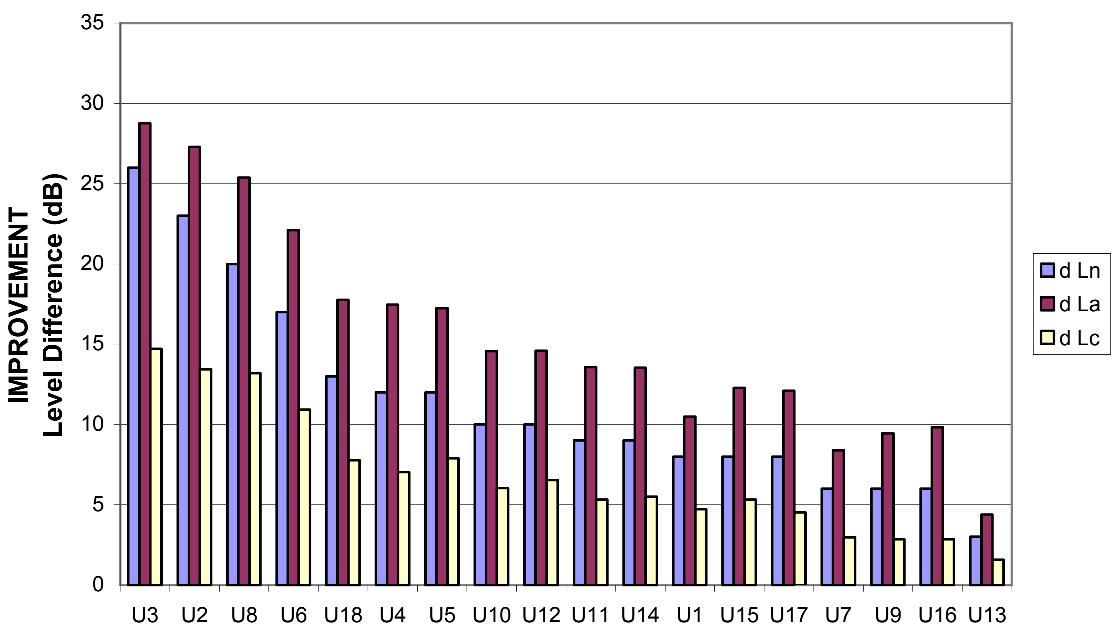
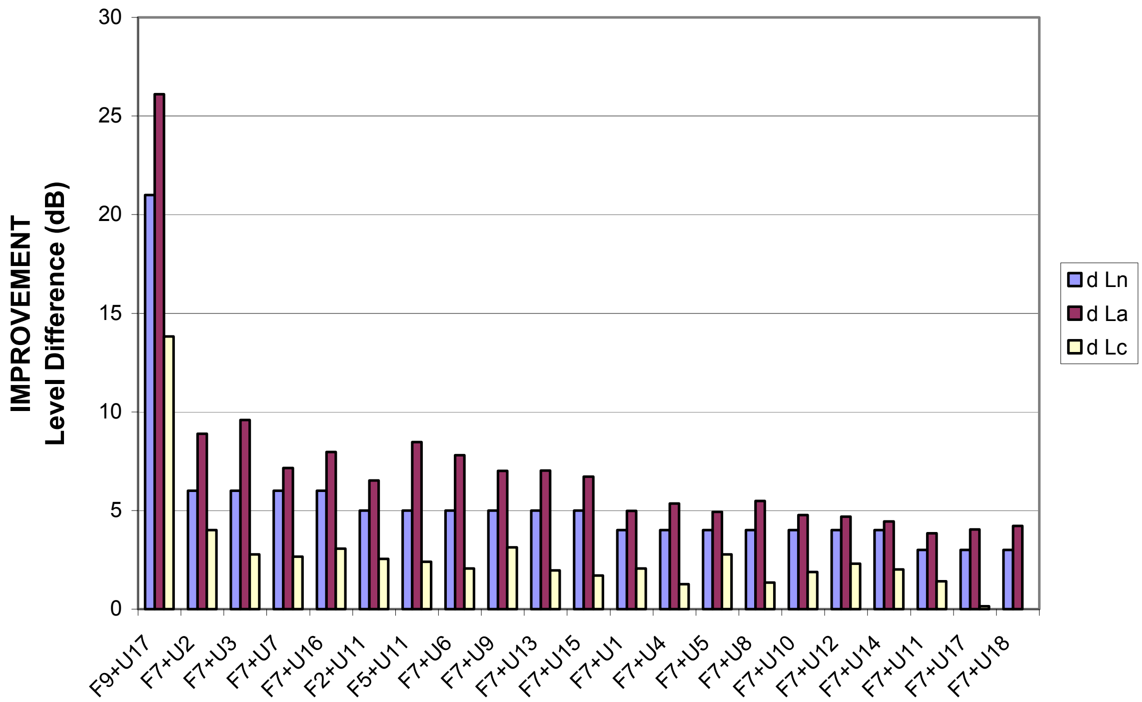


Figure 7.3 - APG lab tests, underlay + finished floors



Concrete floor – Measurement Data

The base construction of the concrete floor gave a $L'_{n,w}$, weighted normalised impact sound pressure level, of 86dB. It was noted during the initial stages of the measurements that the uniformity of results from the finished timber floor surface exhibited on the basic timber floor was no longer observed, therefore tests on the underlay materials were conducted with both an engineered (15mm) and laminate (6mm) flooring finish.

Tables 7.7 to 7.9 display the level of acoustic improvement over the base construction achieved by each of the materials and material combinations measured.

Table 7.7 Concrete floor – Improvement, over base floor, of finished floor materials		
Reference	*Description*	**Impact noise improvement Δ L_{nw} (dB))**
F3	15mm Natural Bamboo solid wooden flooring	15
F5	6mm MDF Cedar effect click joint laminate flooring	18
F9	**Twist pile carpet**	**44**
F4	7mm MDF Tile effect laminate flooring	19
F8	8mm MDF Oak effect laminate flooring	19
F7	15 mm Oak finished engineered wood flooring	21
F12	8mm MDF Beech effect click joint laminate flooring	22
F13	4mm Vinyl flooring	29

Table 7.8 Concrete floor – Improvement, over base floor, of underlays		
Reference	*Description*	**Impact noise improvement Δ L_{nw} (dB))**
U2	x2 layer 4mm rubber mat bonded either side of a 10mm reconstituted foam	49
U3	x1 layer 4mm rubber mat bonded to one side of 10mm reconstituted foam 8	47
U4	x2 layers silver foil bonded either side of 3mm of a closed cell polythene foam	34
U5	3mm Polyurethane sheet	35
U6	Approx 10mm rubber crumb sheet bonded to thin textile	44
U7	Approx 10mm solid rubberised sheet bonded to thin textile	25
U9	5mm fibreboard panels	31
U11	2mm foil faced extrude polystyrene sheet	33
U12	3mm textile faced polyurethane sheet	37
U13	2mm fleece sheet	11
U15	5mm foil faced reconstituted foam	31
U17	**Carpet underlay**	**30**
U18	5mm textile faced textile backed rubber crumb sheet	38

Table 7.9 Concrete floor – Improvement, over base floor, of underlay + finished floor

Reference	*Description*	Impact noise improvement ΔL_{nw} (dB))
F3+U11	Solid floor + 2mm foil faced extrude polystyrene sheet	23
F5+U11	Laminate floor + 2mm foil faced extrude polystyrene sheet	25
F9+U17	**Carpet + Carpet underlay**	**53**
F8+U2	Laminate floor + x2 layer 4mm rubber mat bonded either side of a 10mm reconstituted foam	27
F8+U3	Laminate floor + x1 layer 4mm rubber mat bonded to one side of 10mm reconstituted foam 8	27
F8+U4	Engineered floor + x2 layers silver foil bonded either side of 3mm of a closed cell polythene foam	27
F8+U5	Engineered floor + 3mm Polyurethane sheet	26
F8+U6	Laminate floor + Approx 10mm rubber crumb sheet bonded to thin textile	26
F8+U7	Laminate floor + Approx 10mm solid rubberised sheet boned to thin textile	22
F8+U9	Laminate floor + 5mm fibreboard panels	26
F8+U11	Laminate floor + 2mm foil faced extrude polystyrene sheet	26
F8+U12	Laminate floor + 3mm textile faced polyurethane sheet	27
F8+U13	Laminate floor + 2mm fleece sheet	28
F8+U15	Laminate floor + 5mm foil faced reconstituted foam	27
F8+U18	Laminate floor + 5mm textile faced textile backed rubber crumb sheet	27
F7+U2	Engineered floor + x2 layer 4mm rubber mat boned either side of a 10mm reconstituted foam	24
F7+U3	Engineered floor + x1 layer 4mm rubber mat bonded to one side of 10mm reconstituted foam 8	23
F7+U4	Engineered floor + x2 layers silver foil bonded either side of 3mm of a closed cell polythene foam	23
F7+U5	Engineered floor + 3mm Polyurethane sheet	21
F7+U6	Engineered floor + Approx 10mm rubber crumb sheet bonded to thin textile	23
F7+U7	Engineered floor + Approx 10mm solid rubberised sheet bonded to thin textile	21
F7+U9	Engineered floor + 5mm fibreboard panels	24
F7+U11	Engineered floor + 2mm foil faced extruded polystyrene sheet	21
F7+U12	Engineered floor + 3mm textile faced polyurethane sheet	24
F7+U13	Engineered floor + 2mm fleece sheet	23
F7+U15	Engineered floor + 5mm foil faced reconstituted foam	24
F7+U18	Engineered floor + 5mm textile faced textile backed rubber crumb sheet	23

Figures 7.4 to 7.7 define the standard rated, A-weighted and C-weighted measured improvements in acoustic insulation conducted on the concrete floor when applying various floor surface layers.

Figure 7.4 Concrete floor - laminate ONLY results

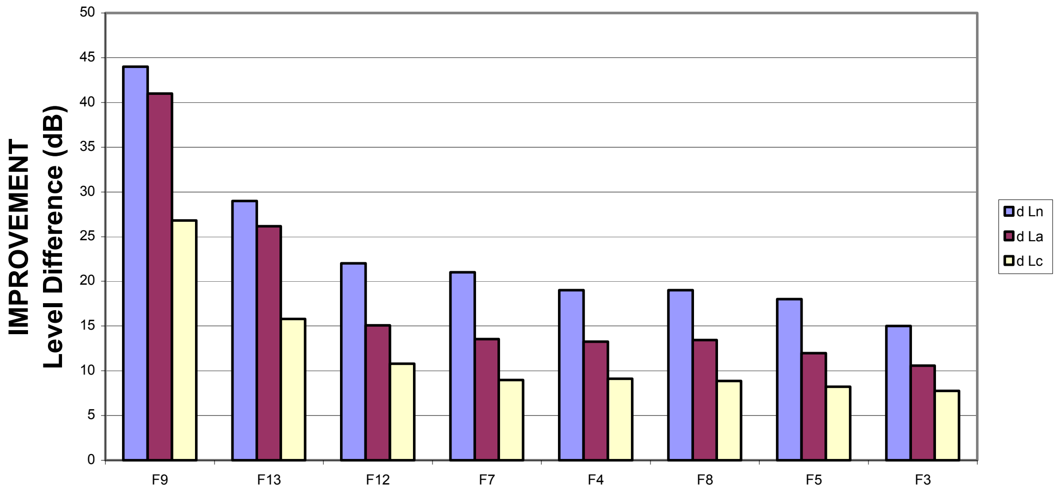


Figure 7.5 Concrete floor - underlay ONLY results

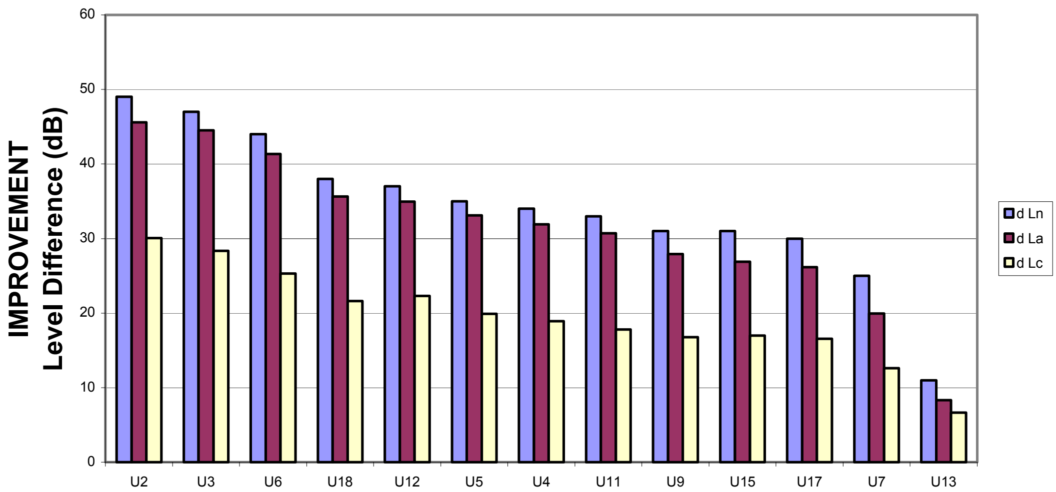


Figure 7.6 Concrete floor - 6mm finished floors + underlay

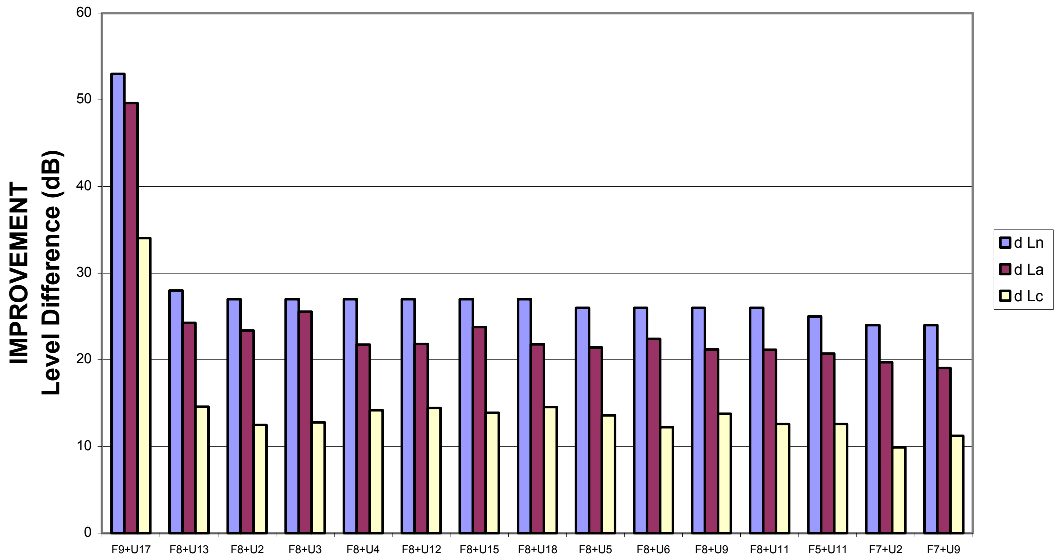
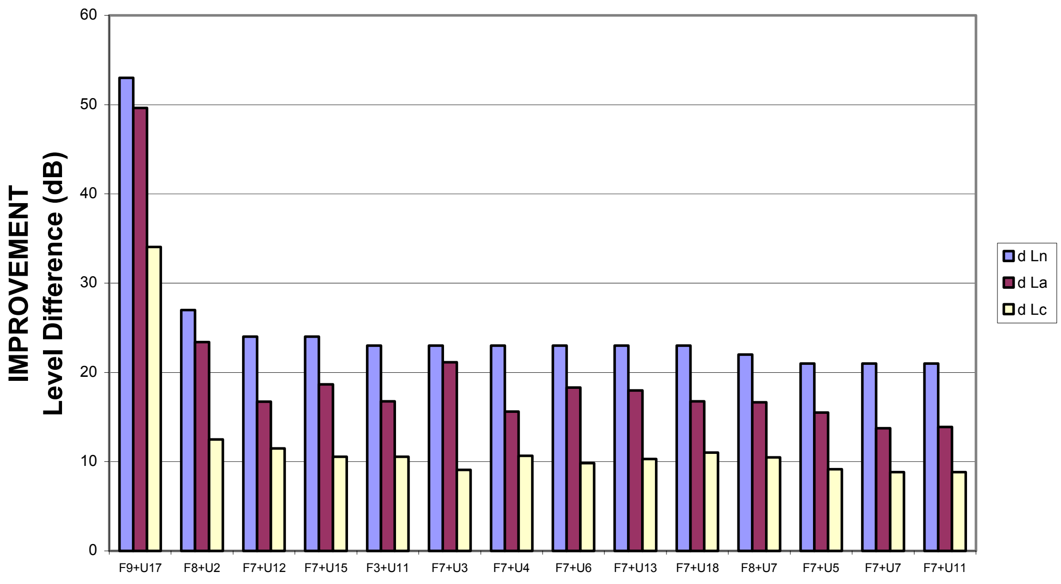


Figure 7.7 Concrete floor-15mm finished floors + underlay



Separating timber floor – Measurement Data

The base construction of the timber separating floor at Bankton House gave an $L'_{n,w}$, weighted normalised impact sound pressure level, of 66dB. Table 7.10 to 7.12 display the level of improvement over the base construction achieved by each of the materials and material combinations measured.

Table 7.10 Timber separating floor – Improvement, over base floor, of ONLY finished floor materials

Reference	*Description*	**Impact noise improvement ΔL_{nw} (dB))**
F9	Twist pile carpet	12
F7	15 mm Oak finished engineered wood flooring	0
F8	8mm MDF Oak effect laminate flooring	1
F13	4mm Vinyl flooring	1

Table 7.11 Timber separating floor – Improvement, over base floor, of ONLY underlay materials

Reference	*Description*	**Impact noise improvement ΔL_{nw} (dB))**
U3	x1 layer 4mm rubber mat bonded to one side of 10mm reconstituted foam 8	20
U9	5mm fibreboard panels	1
U11	2mm foil faced extrude polystyrene sheet	3
U17	Carpet underlay	5

Table 7.12 Timber separating floor – Improvement, over base floor, of BOTH underlay + finished floor materials

Reference	*Description*	**Impact noise improvement ΔL_{nw} (dB))**
F9+U17	Carpet + Carpet underlay	23
F7+U3	Engineered floor + x1 layer 4mm rubber mat bonded to one side of 10mm reconstituted foam 8	1
F7+U9	Engineered floor + 5mm fibreboard panels	0
F7+U11	Engineered floor + 2mm foil faced extrude polystyrene sheet	1
F8+U3	Laminate floor + x1 layer 4mm rubber mat bonded to one side of 10mm reconstituted foam 8	3
F8+U9	Laminate floor + 5mm fibreboard panels	-1
F8+U11	Laminate floor + 2mm foil faced extrude polystyrene sheet	0

Figures 7.8 to 7.10 show the standard rated, A-weighted and C-weighted measured improvements conducted on the timber separating (party) floor when applying various floor surface layers.

Figure 7.8 Timber separating floor - laminate ONLY results

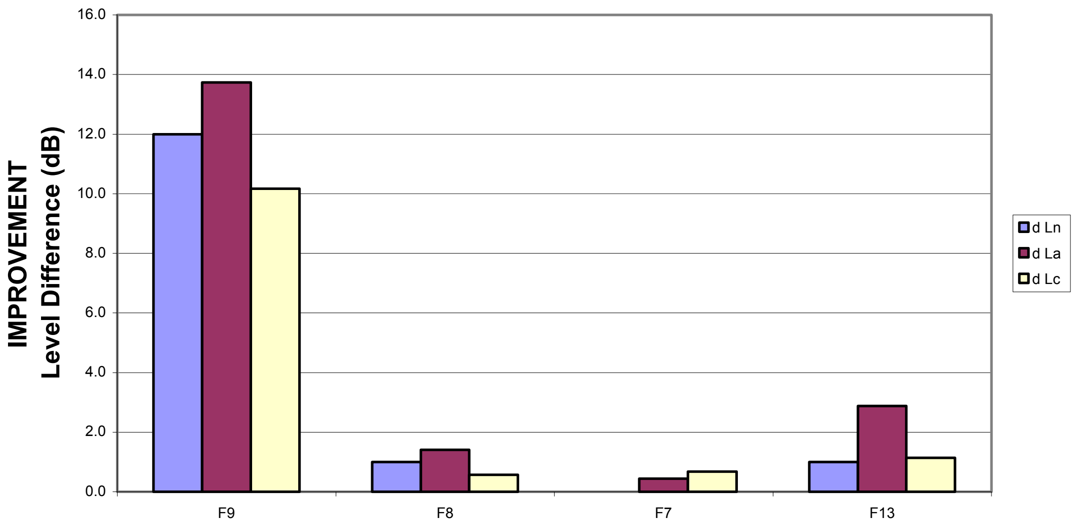


Figure 7.9 Timber separating floor - underlay ONLY results

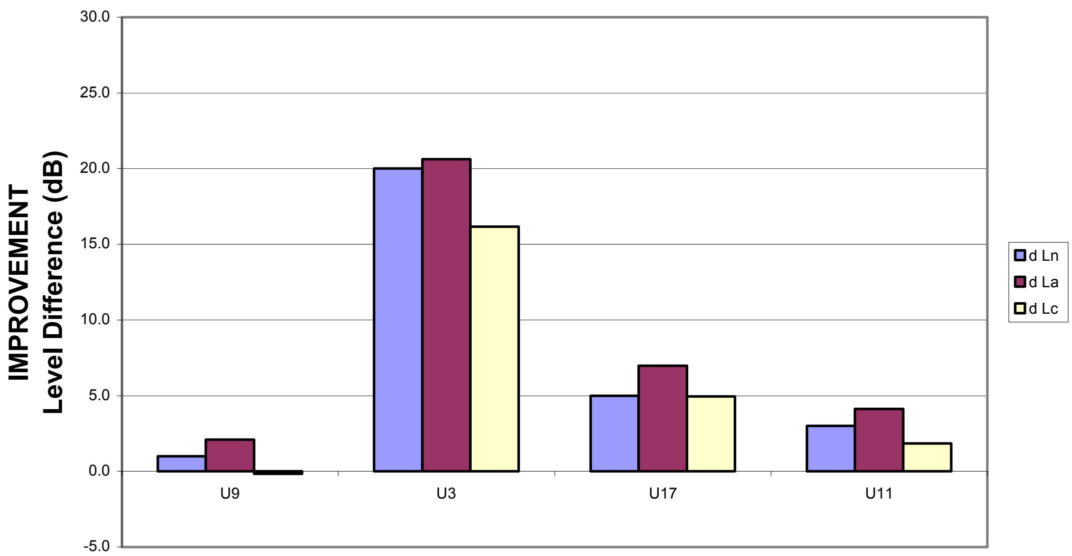
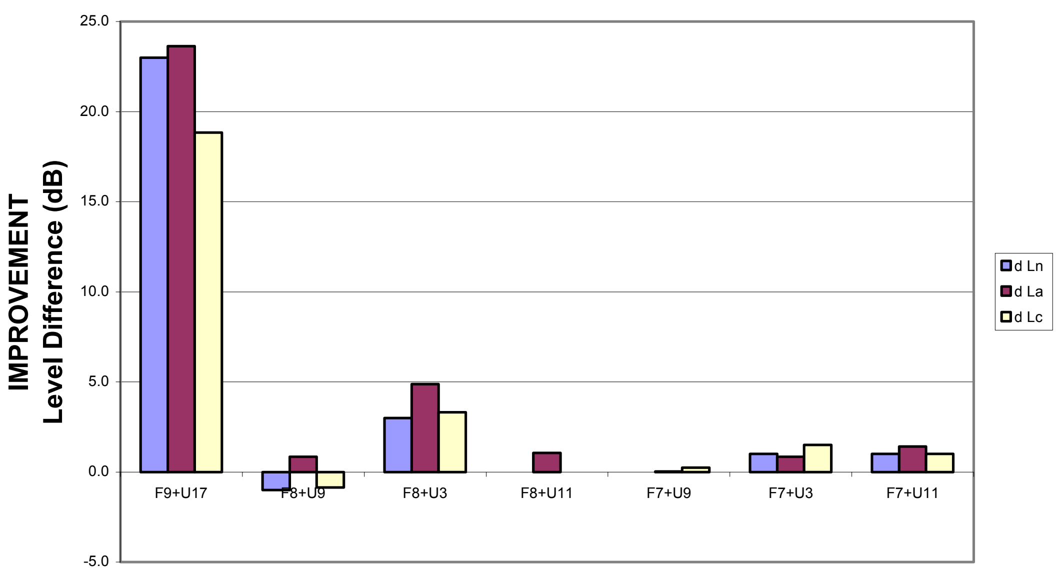


Figure 7.10 Timber separating floor - underlay + laminate



7.5 ANALYSIS OF SINGLE FIGURE VALUE PERFORMANCE

The following section examines the results displayed previously under Section 7.4. Full analysis of the frequency data along with comments on perception of performance are covered in Section 7.6.

Each set of test data from the three test situations is examined in isolation and comparisons are then made between the three data sets in order to identify any trends in performance which may arise.

Basic timber floor (Suppressed flanking laboratory)

It is clear that there is a marked difference between the use of soft and hard floor coverings. Results for the impact measurements conducted on the twist pile carpet indicate that it performs some 7-11dB better than any alternative floor finish on its own.

When used with an underlay the performance of the carpet is further increased indicating a performance which exceeds any of the other finished floor products with underlay by 14-18 dB. This supports the significant reduction in impact sound insulation performance, which some dwellers complain of when carpet is replaced by laminate on a basic timber floor, even when an underlay is present.

Many of the underlays when tested in isolation provide very good levels of impact sound insulation, in some cases twice as much a carpet on its own. However, the addition of the hard floor finish drastically reduces the impact performance.

For example a triple layer underlay which incorporates two layers of rubber and one of foam provide impact noise improvement of up to 23dB however once the hard finished flooring layer is added this improvement is reduced to 6dB. Only 4dB better than the tested hard finish flooring material tested in isolation.

Impact noise test results, for a basic timber floor, show the influence of a wide range of underlay materials installed under timber finished floors as an additional improvement of between 3 and 6dB.

Of the underlay samples tested, the thick rubber crumb or rubber mat materials and thick composite materials (rubber+foams) provide the best levels of insulation with slim foamed polyurethane and fibreboard panels products providing intermediate results. Thin polythene foam and fleece or textile materials provide the poorest levels of impact sound insulation.

Concrete floor

As with the measurements conducted on the lightweight timber floor there is a marked difference in performance between the use of a carpet and a hard finished floor material.

The hard finished floor materials when tested in isolation show an improvement of between 15-22dB. The results also indicate that the thinner laminate products provide better levels of impact insulation in comparison to the solid timber flooring materials at higher frequencies and the thicker panels performed better at low frequencies. This is due to the thinner panels having less stiffness, creating a point load causing the floor to deflect more easily with forced motion at low frequencies. At high frequencies the panels will absorb and disperse the impact energy more easily into the underlays.

The underlay materials when tested in isolation provide substantial levels of impact sound insulation of between 11dB to 49dB.

The rubber crumb and composite rubber/foam materials provide the highest levels of impact insulation (38-49dB) with the fibrous and solid rubber materials giving the lowest level of improvement (11-25dB).

With the addition of the hard finished floor materials to the underlay materials there is a marked reduction in performance (around 20dB in some instances).

One of the most notable results is that of the 2mm fleece material. When tested in isolation it performs poorly in comparison to the other underlay products however when coupled with a thin laminate finished floor material it provides the highest level of impact insulation for any of the underlay and finished floor treatments.

If the underlay materials were to be rated in terms of impact sound insulation when used in connection with a hard finish floor material it would be seen that thick crumb rubber and composite rubber/foam underlay materials provide the highest performance along with thin fleece materials when used in conjunction with thin laminate floors. Polyurethane sheet materials also provide a good level of impact insulation however solid rubberised materials and thin extruded polystyrene materials provide the poorest level of insulation.

If an individual were to consider the use of a hard finish flooring product with underlay on a concrete party floor or separating floor they should be made aware that

1) **There will be a marked reduction in impact insulation in comparison to carpeting.**

2) **The use of an underlay with a laminate / wood floor will make a significant contribution on a concrete floor.**
3) **The inclusion of a thick section or costly underlay material is unlikely to provide any greater level in acoustic comfort than a standard underlay material.**
4) **The fibreboard underlay was particularly poor.**
5) **If a thick engineered or solid finished floor material is to be used then a rubber crumb or rubber/foam composite underlay would be advisable.**
6) **If a thin laminate finished floor material is to be used then a thin fleece material would be advisable.**

Separating timber floor

As expected carpet and carpet with underlay outperforms any of the other materials tested. However in this instance the margin is far more significant (up to 22dB difference is some instances.

The hard finished flooring materials provide a negligible level of improvement of impact sound insulation with no material giving an increase of more than 1dB. This would imperceptible to most people's hearing.

The underlay materials also provide poor levels of improvement when tested in isolation with the exception of the composite rubber/foam product which provides an increase of 20dB over the base floor construction.

When the underlay materials are tested with the hard finished flooring materials it is noted that there is little improvement in performance from that of the hard finished floor materials when used in isolation. The one exception to this is the use of a composite rubber/foam material which provides a 3dB improvement. However, it should be noted that this level of improvement is of marginal significance in terms of human perception in performance.

The fibreboard underlay materials showed either no improvement or made the level of insulation marginally worse.

If the underlay materials were to be rated in terms of their acoustic performance when used in conjunction with a hard finished flooring material it would be seen that the rubber/foam composite materials perform best with all other underlay materials providing no improvement over the use of just the hard finished flooring materials. The fibrous materials indicated a loss in performance due to stiffness effects and non-linear motion of the floor creating an amplification of floor forced motion.

If an individual were to consider the use of a hard finish flooring product with underlay on a timber party floor they should be made aware that

1) **There will be a marked reduction in impact insulation in comparison to carpeting.**
2) **The inclusion of an underlay material is unlikely to provide any greater level in acoustic performance when single rated. However, a slight improvement may be noticed at mid and high frequencies.**
3) **The only exception to this would be the use of a composite rubber/foam underlay which does provide a reasonable level of improvement throughout.**
4) **The use of a rigid fibre based underlay is likely to have either no effect or result in a loss in acoustic performance.**

Comparison of the three data sets

In all instances the underlay materials performed substantially better when tested in isolation with all underlay materials losing significant levels of performance when placed under a hard finished flooring material.

The use of underlay materials has a greater effect on concrete sub-floors than on timber sub-floors. It should be noted that many manufacturers used a ΔL_w term to define the performance of their underlay or flooring materials. As these measurements are conducted on a concrete floor they tend to *flatter* the product in terms of its performance particularly when compared to measurement undertaken on a timber floor or if the underlay is tested with a hard finish floor on top.

It was noted that many of the underlay materials perform better on particular sub-floor constructions such as concrete. For example the use of a fleece material on a concrete floor can provide good levels of impact sound insulation however when tested on a timber floor the level of improvement is drastically reduced.

Only the composite rubber/foam and rubber crumb materials provided consistent performance in the sense that they can provide some level of improvement on all the floor constructions tested.

The results generally indicate that the use of an underlay material is always preferable even if a thin underlay material is selected, however in some instances the effects of these materials is minimal. It can be seen that in some instances the levels of improvement would be barely perceptible in terms of human response to the impact sound and for floors, such as floors which already incorporate an acoustic isolating layer (i.e. floating timber raft).

7.6 ANALYSIS OF THE SPECTRAL TEST RESULTS

The following section discusses the tests undertaken on the three core floors, concrete, basic timber floor and timber separating floor. The test results reported over the full frequency spectrum provide an overview of the potential performances of different surface treatments and underlay linings.

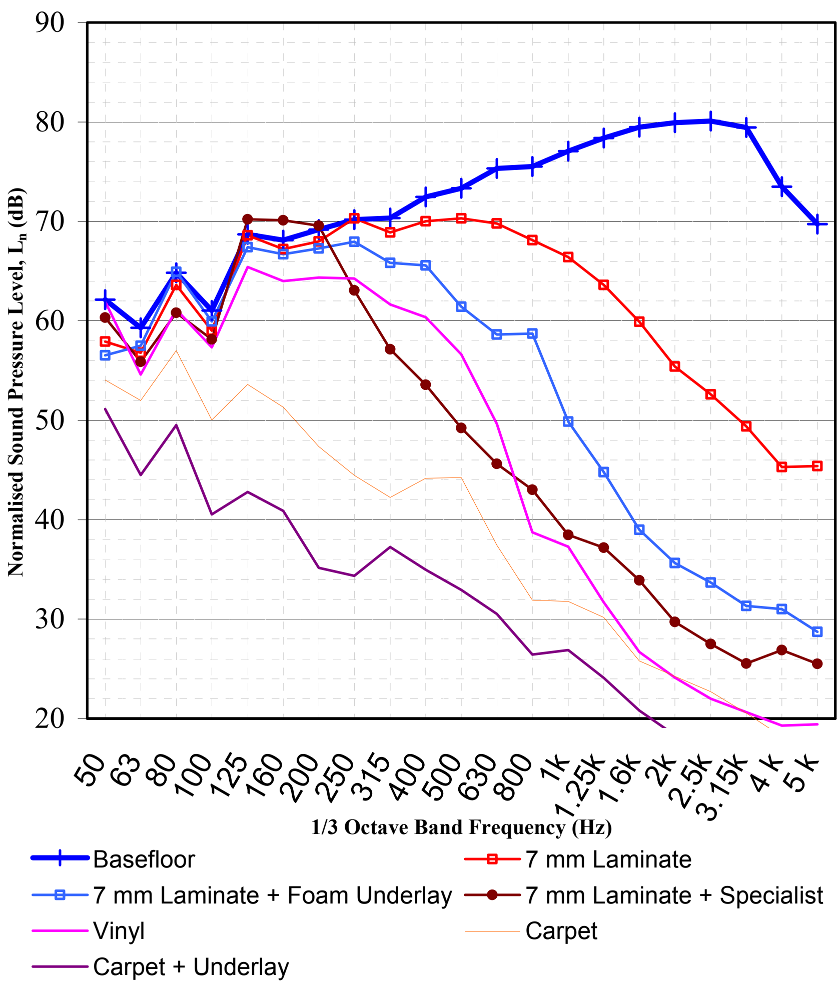
The following representative floor finishes have been collated for a comparison of the materials performance for each base floor (concrete, basic timber and timber separating floor):

- 7mm laminate only
- 7mm laminate + foam underlay
- 7mm laminate + specialist (high grade or high performance acoustic underlay)
- vinyl floor only
- carpet only
- carpet + underlay

CONCRETE FLOOR TESTS

Figure 7.11 shows a range of impact test results for the Concrete Core Floor. Concrete floors, which have no surface treatments and are subjected to impact noise have very poor insulation properties at all frequencies. In particular the mid and high frequencies can be easily transmitted. The results of the bare concrete floor "basefloor" show this characteristic poor performance.

Figure 7.11 Impact Sound Insulation: Concrete Floor



With the application of laminate only there is an improvement in the high frequencies but the mid frequencies are still very poor. This test result is typical of the types of performance being recorded by BPC following complaints of a laminate floor being installed directly to concrete. One of the primary issues that can occur in real houses with a concrete floor is that the floor may not be flush finished and may be slightly uneven. In addition, the bare floor may not have been cleaned and swept properly prior to the underlay being installed. As a result the underlay is not evenly supported and “slaps” against the concrete surface for each footfall noise. This noise is generated in addition to the normal footfall noise being transmitted and is associated with mid frequencies and would be clearly audible in the lower dwelling.

The use of a foam underlay for the laminate makes a considerable difference for mid frequencies and high frequencies for the concrete floor base. This difference would be clearly audible for dwellers, however, at low frequencies there is very little improvement. In the case of a laminate with a specialist (high grade) underlay there is further improvement at mid and high frequencies but at low frequencies there is a slight worsening in performance. This is due to the forced motion of the laminate floor on the specialist underlay. The underlay's function is to isolate the laminate from the core floor, however, in doing so it lowers the potential stiffness properties of the laminate, making the floor finish "more bouncy". The increased flexibility of the floor surface will accentuate slightly the core floor resonance.

For vinyl only there is an improvement over all frequencies but only moderately (2 to 4 dB) at low frequencies. The vinyl has some damping qualities and the omission of the laminate as the source material under the hammer has dampened slightly the impact sound energy being forced into the floor.

In the case of carpet only, there is significant damping and with the impact energy of the hammers being highly absorbed there is considerable improvement across all frequencies, particularly at low frequencies. With the addition of an underlay beneath the carpet the damping is further increased, the energy transmission is further decreased and the level of sound being transmitted to the lower dwelling at all frequencies is extremely low.

At low frequencies, less than 100Hz the carpet and carpet+underlay still provide a dampening mechanism and reduce sound transmission to the dwelling below. It is these frequencies which can cause most annoyance to dwellers and are outside of the Building Regulations frequency test range (100-3150Hz).

Summary – Concrete Floor

The removal of carpet or carpet and underlay will significantly reduce the concrete floors performance for impact sound insulation at all frequencies. The use of laminate with no underlay would create an intolerable condition for the occupant below and the use of an underlay would provide some benefit. However, the use of a high grade underlay would be preferable to at least recover the majority of the mid and high frequency insulation that was available with the carpet. No matter which current underlay is used the low frequencies will be unaffected. At very low frequencies carpet and carpet+underlay still have an effect.

Concrete Floor Recommendation – underlays should be used for all laminate and wood finish floors

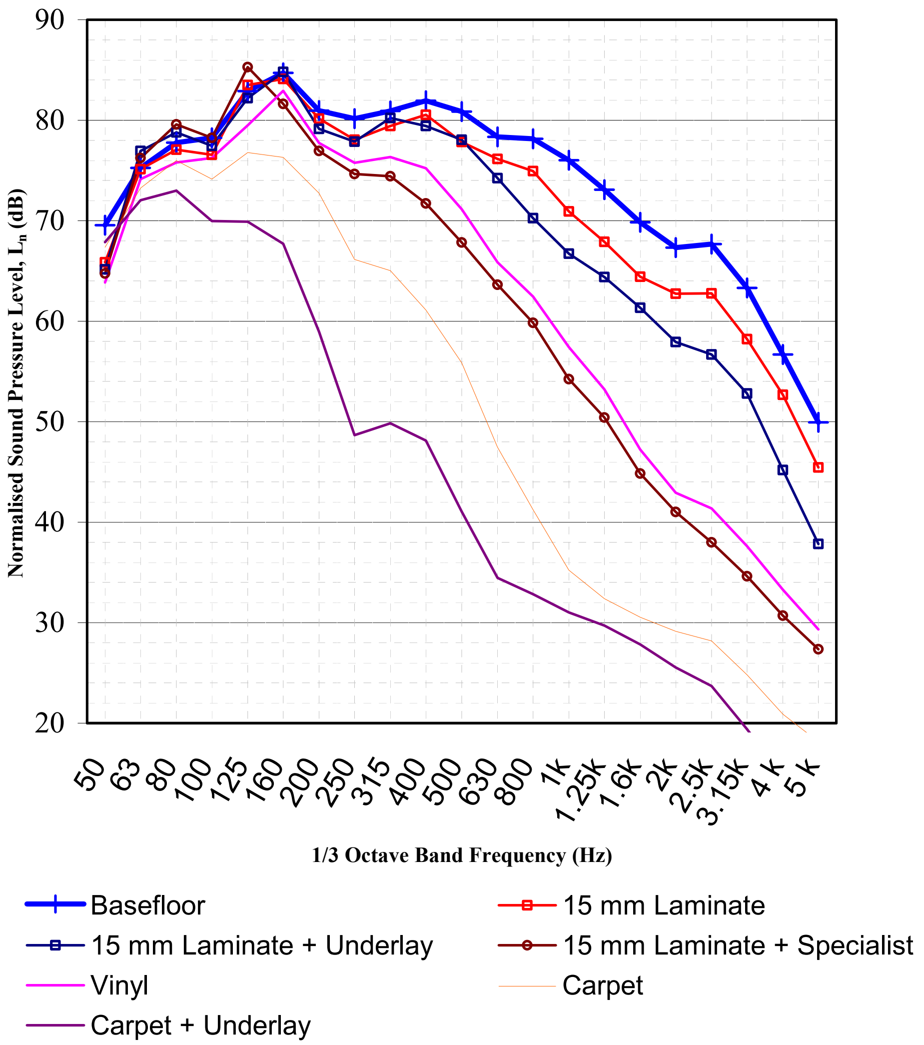
Summary - Basic timber floor tests

Figure 7.12 shows a range of test results for the Basic Timber Core Floor. This floor structure represents many typical poor performing floors which are found across the UK for masonry supported timber separating floors as found in low rise apartments, tenement floors which have lost deafening and 4-in-a-block floors.

The base timber floor has a very poor performance across a wide range of frequencies and is typical of sanded floors with no acoustic measures applied (such as lowered or secondary ceilings). The performance at low frequencies is particularly poor as a result of the floor's low stiffness and high forced motion contribution towards sound transmission to the dwelling below. The addition of a laminate improves the high frequencies marginally by 5dB. The use of a laminate with underlay contributes a 10dB improvement, which is a subjectively noticeable.

The use of a high grade underlay provides a considerable improvement over many of the mid and high frequencies and again, similar to concrete, there is a slight drop in performance at the low frequencies do to forced motion.

Figure 7.12 Impact Sound Insulation: Basic Timber Floor



The use of carpet makes a considerable difference to mid and high frequencies but only a marginal difference at low frequencies, of 4dB. However, if carpet and underlay are used together the improvement at low frequencies is greater than 10dB, which is a noticeable difference. This improvement is due to the high damping of both the carpet and underlay.

At very low frequencies, less than 100Hz, the use of carpet and carpet+underlay has very little effect, unlike concrete floors.

Summary – Basic Timber Floor

The use of carpet and underlay or carpet does improve low frequency impact performance, but timber floors do not have the mass, stiffness and impedance properties at low frequencies as found with concrete floors. As a result the forced motion sound transmission is still highly dominant with carpet as a finish. Similar to concrete floors, if the carpet is replaced by laminate only there will be a significant increase in impact sound transmission. The inclusion of a standard thin underlay with laminate on a timber floor will make a slight improvement but would generally require a specialist or high grade underlay to improve mid and high frequencies but resulting in a slight decrease in low frequency performance.

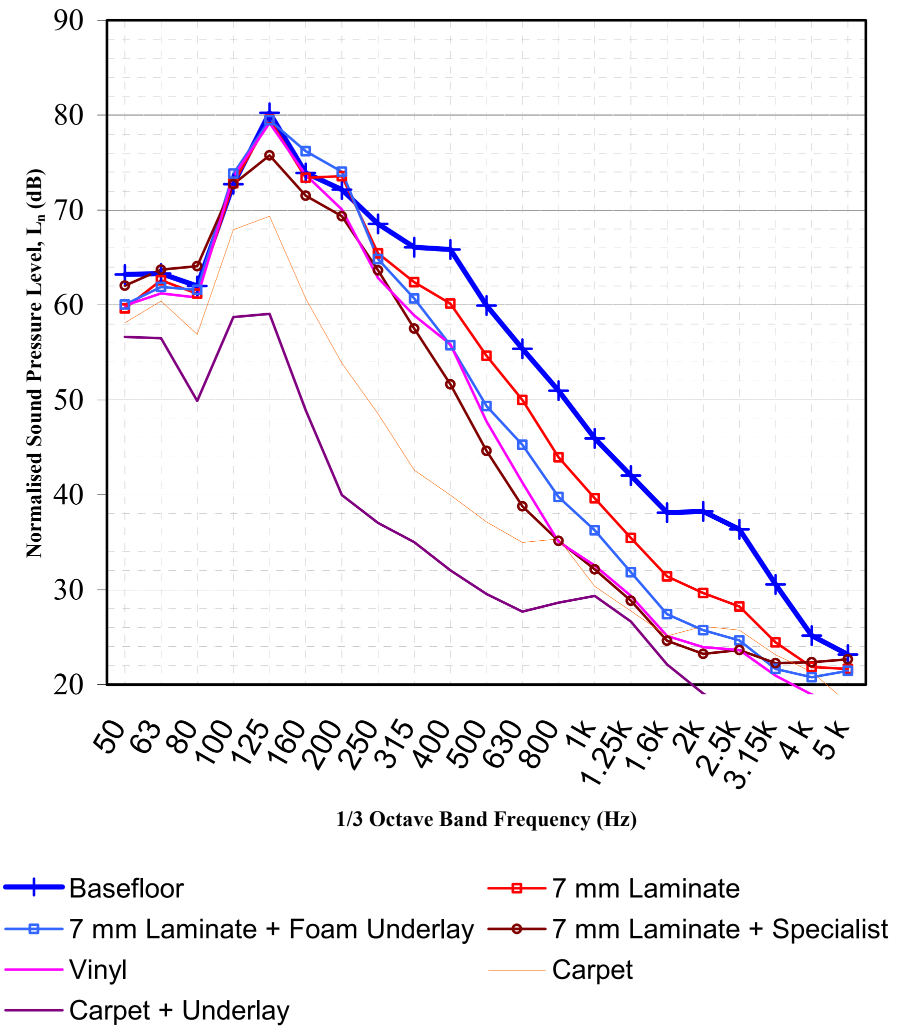
In poor performing timber floors with carpet, the low frequency impact noise (through forced motion) is almost unaffected and would still be felt by the neighbours in the property below. In cases where BPC has interviewed occupants in flats with basic separating floors, many residents mention they would expect to hear someone moving above them in the flat above. With carpets they do hear a dull “thud” and many find this tolerable.

Basic Timber Floor Recommendation – underlays should be installed for all laminate and wood floor finishes and preferably high grade underlays should be used.

7.7 TIMBER SEPARATING FLOOR TESTS

Figure 7.13 shows a range of results for the tests undertaken on the timber separating floor. This floor is different in the floor lining in that there is already a floating timber floor resting on the basic timber floor. This is similar to a timber floor construction which has been widely used since the early 80’s and methods used in conversions from houses to apartments. As such there is already a resilient layer in place creating a decoupling mechanism for some frequencies. There are over 30 different timber floating floor products on the market and all have individual characteristics in their performance. The floating floor system used within this floor system has poor performance in comparison to many other products on the market, and as such is seen as a ‘worst case’ scenario.

Figure 7.13 Impact Sound Insulation: Timber Separating Floor



The base floor with no laminates or underlays has a floorboard finish. It can be seen from the results that there is a high resonance at 125Hz due to the floor structure interaction with the floating floor and forced motion taking place. The level of impact sound transmission then decreases rapidly with frequency. This is quite different to the base floor basic timber floor or base floor concrete floor which both performed poorly at all frequencies. The improvement at high frequencies of this floor, as opposed to the other base floors, is due to the floating floor system already providing a resilient function at these frequencies.

With the addition of laminate only the floor thickness of the floating floor is increased and there is some attenuation provided by the thickening of the floor surface. With the addition of the laminate and foam underlay there is only a slight improvement at mid and high frequencies, about 4dB, and a slight decrease in performance at low frequencies due to forced motion of the floating layer already in place.

The use of vinyl or specialist underlay provides similar improvements, except for the mid frequencies, of about 2 to 5dB. The low frequencies are generally unaffected although the stiffer specialist underlay does improve the low frequency performance due to dampening the floating treatment resonance.

The use of carpet provides a significant improvement at low and mid frequencies but provides no noticeable improvement at high frequencies, as the floating floor layer is already providing this function. The use of carpet and underlay provides a considerable improvement over all low and mid frequencies due to the significant damping at source of the impact but again at high frequencies the floor performance is similar to other systems.

At very low frequencies, less than 100Hz, carpet alone would not alter greatly the level of impact sound insulation. Using carpet and underlay would make an improvement at some low frequencies, e.g. 80Hz.

Summary – Timber separating floor

Low frequency sound transmission for this floor is concentrated (peaks) at particular frequencies and as such there is not the same broad range of sound transmission across a wide range of low frequencies, unlike the basic timber floor. The use of a floating floor does provide an improvement over a range of mid and high frequencies. The addition of an underlay beneath the laminate makes very little improvement as the floating floor resilient layer is already performing that function. Even with a specialist underlay as opposed to normal underlay is limited.

7.8 SUMMARY

Three primary core floor structures were tested involving a concrete floor, a basic timber floor and a timber floor with floating floor pre-installed. Tests were undertaken to evaluate the performance of laminate / wood floor finishes only and underlays only and both combined on all three core floor types. The basic timber floor structure was chosen for testing as it would identify the performance for a "worst case" scenario. The separating floor with a resilient decking was chosen to evaluate the improvement by applying other resilient layers such as underlays, as some flatted dwelling floors do have a resilient floating floor treatment already installed. The following summarise the key findings in relation to finish, core floors and other features found.

The table below shows the improvement in performance in relation to the bare floor. It is also possible to compare the improvement of each surface finish relative to the other finish floor layers.

Table 7.13 - Summary of results

Level of impact noise improvement (dB) using various surface finishes for 3 different core floors

	Timber Separating Floor	Basic Timber Floor	Concrete Floor
Base floor	0	0	0
Laminate / wood (no underlay)	1	4	19
Laminate / wood (with underlay)	1	5	25
Carpet only	12	13	44
Carpet + Underlay	23	21	53

Table 7.13 shows that in comparison to the base floor the introduction of laminate alone will not raise the performance of timber separating floor with floating floor treatment pre-installed. There will be a slight increase in the performance of a bare timber floor and this will make a difference on a bare concrete floor. From the frequency spectrum analysis adding laminate will improve the results at mid and high frequencies for the basic timber floor and the concrete floor. This table provides an indication of using sanded floorboards which would be similar to the basic timber floor.

Table 7.14 uses the laminate floor finish as the index to compare against the other treatments that may be used. This table provides a single figure snap shot of what is actually happening in many homes where laminate or wood floors are being installed to replace carpets or where an underlay is not installed.

Table 7.14 - Summary of results

Level of impact noise improvement (dB) comparing laminate / wood only with other treatments

	Timber Separating Floor	Basic Timber Floor	Concrete Floor
Laminate / wood (no underlay)	0	0	0
Laminate / wood (with underlay)	0	1	6
Carpet only	11	9	25
Carpet + Underlay	22	17	34

The introduction of an underlay on a timber separating floor with a pre-installed floating floor treatment will not alter the overall performance when shown as a single value due to the floating floor controlling most of the impact sound transmission. However, from the frequency analysis it can improve mid and high frequencies slightly.

A laminate / wood floor with underlay on a basic timber floor will provide a slight improvement and will provide a marked improvement on concrete floors. In relation to the frequencies affected the single figures do not fully represent the actual change as even though there only 1dB improvement on basic timber floors this slight improvement will improve mid and high frequencies and would be a noticeable improvement.

In relation to the reduction in performance from carpet to laminate / wood floor there is a significant decrease in a wide range of frequencies for all floors. The transfer from carpet + underlay to laminate / wood flooring will result in a substantial reduction in impact sound insulation performance. These results provide supporting evidence in relation to the level of complaint which occurs with the installation of laminate / wood flooring as opposed to carpet or carpet + underlay.

Table 7.15 shows the installation of laminate / wood flooring + underlay as the index floor. It can be seen that even with an underlay installed under the laminate or wood flooring that there is still significant shortfall in performance when compared to carpets or carpets+ + underlay.

Table 7.15 - Summary of results

Level of impact noise improvement (dB) comparing laminate / wood + underlay with other treatments.

	Timber Separating Floor	Basic Timber Floor	Concrete Floor
Laminate / wood (with underlay)	0	0	0
Carpet only	11	8	19
Carpet + Underlay	22	16	28

Using the above tables and the frequency analysis it is recommended that although some underlays beneath laminate / wood flooring may not appear to provide much improvement there would be subjectively noticed improvement at mid and high frequencies for all floors. In relation to timber floors, versus concrete floors laminates + underlay would have the most effect on concrete floors.

In all the test results to date it has been found that the low frequencies are the dominant controlling mechanism when evaluating single figure performances of various treatments. Timber floors are most restricted in the ability to improve performance with underlays as they are controlled primarily by the forced motion response of the timber joist structure.

It is the recommendation of this chapter that underlays should be installed under laminate / wood floors for all core floors and that for timber floors specifically high performance or specialist underlays would be more beneficial.

Chapter 8: Mitigation and management of impact sound

8.1 INTRODUCTION

This chapter discusses the physical, legal and other measures that are potentially available to manage and mitigate the issue of noise from hard floor surfaces. The solutions are split into two sections: those which are pre-emptive in attempting to stop a problem from occurring or reduce its impact and those that can be utilised to alleviate an existing problem.

8.2 PRE-EMPTIVE MEASURES

Raising awareness of the issue

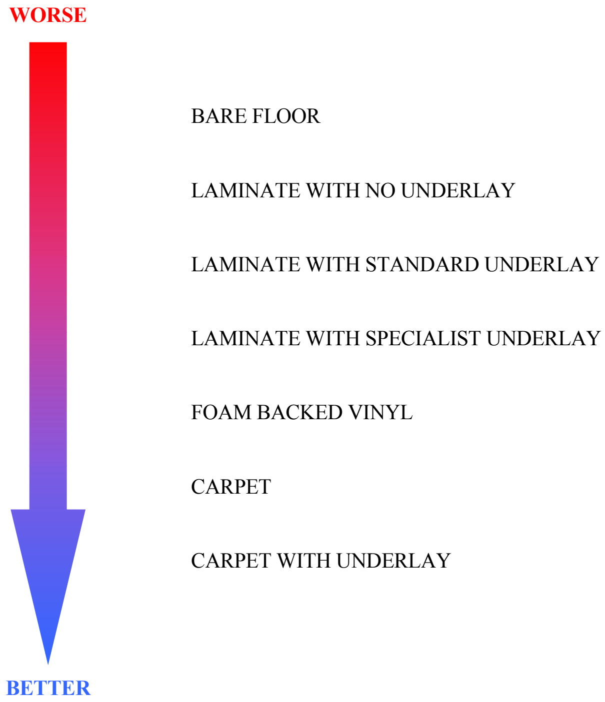
One of the key measures in reducing the rate of complaints in the long term will be the ability of local authorities, registered social landlords and product suppliers to raise awareness of the issue with the general public.

This could be facilitated through the publication and distribution of the guide which is being prepared as part of this project. We would also recommend that all local authorities, registered social landlords and product suppliers be encouraged to include details on the issue and the information available on their web sites and publications.

Simple non-technical explanation of the difference in noise level experienced by people living below a hard floor surface should help to discourage the use of hard floor surfaces in apartments or at least encourage the use of underlays to help reduce the impact. However, care should be taken in targeting the information at the appropriate constructions and not to include high performance floors designed to achieve a high level of impact sound insulation.

The figure below demonstrates the relative impact noise performance of common floor finishes.

Figure 8.1: Relative impact noise performance of common floor coverings



Given that a 'good practice' guide is more targeted at helping professional bodies to manage and resolve problems when they occur, we have recommended that a short information leaflet also be produced specifically to raise awareness of the issue.

Encouraging product retailers to stock the leaflet is likely to be critical to its success and therefore it will require to be presented in a positive manner and not simply highlighting problems with this type of product. Positive features of using an underlay with a laminate floor include better durability and reduced fall impacts.

One note of caution however with raising awareness is that it may actually lead to an increase in the number of complaints in the short term as those experiencing problems find increased corroboration for their complaint.

8.3 TENANCY AND DEED OF CONDITION CLAUSES

As already indicated in Chapter 5, tenancy agreements and deed of condition clauses can be successful in reducing the instances of complaints, despite some problems being identified by registered social landlords with regard to the enforcement of tenancy clauses.

It has been indicated that the use of a tenancy agreement to restrict occupants from using hard floor finishes is legal and does not infringe a tenant's human rights.

We would therefore recommend that, where registered social landlords or house builders are experiencing complaints or are concerned about noise from laminate floors, a restrictive clause be inserted into the tenancy agreement or deed of condition of the property.

The various examples of tenancy agreements reproduced and discussed in Chapter 5 have been reviewed by the Building Performance Centre's legal advisers and the following clause has been drafted as providing good examples of wording in terms of clarity and defensibility.

"You must obtain our prior written permission if you want to install a hard floor finish such as laminate or hardwood overlay, ceramic tiles or if you want to have bare floorboards in any room in your property. We will not refuse permission unreasonably however; it is likely that we will only grant permission if you live in a house or a ground floor flat. Permission is not required for the use of carpet tiles or foam backed linoleum.

As the use of laminated flooring could prejudice your neighbours enjoyment of their property due to noise transmission, if you carry out any of the above alterations without our written permission we will be entitled to restore the property to its previous condition during, or at the end of, your tenancy. If we do so, we are entitled to recover reasonable costs from you for carrying out this work."

It is recommended that the above clause be introduced for new housing, existing housing receiving new tenants and existing housing undergoing extensive renovation. It is not considered appropriate to introduce the clause retrospectively for properties which may already have hard floor finishes. This clause would also allow for conditions to be placed on the granting of permission for upper floor flats, such a condition could be - "*an approved high quality underlay must be installed*."

For new private housing the floors should be designed with an integral resilient layer which will help to reduce the impact of hard floor finishes. However, it is likely that builders and developers may still wish to include a clause in the deed of condition if they have experienced problems or should they wish to use it for specific developments. Examples of some instances where such a clause might be relevant are given below:

For floors designed to provide a marginal compliance with the performance standard for sound insulation laid down in the Building Regulations residents would still notice a significant increase in transmitted noise in most dwellings if a soft floor covering was replaced with a hard floor finish.

For renovated properties in England and Wales the Building Regulations 2003[1] set a low minimum performance standard for impact sound transmission viz. $L'_{nT,w}$ 64 dB. Floors with marginal compliance would give rise to complaints if laminates were used.

Conversions of historic buildings in England and Wales are also not required to meet any specific target and therefore may have poor sound insulation due to restrictions on upgrading works.

The following clause has been arrived at as providing a good example of wording in terms of clarity and defensibility.

"As the use of laminates could prejudice your neighbours enjoyment of their property and ultimately their heath you must not install a hard floor finish such as laminate or hardwood overlay, ceramic tiles or bare floorboards in any room in your property. The use of carpets, carpet tiles, foam backed linoleum and any other soft floor finish is acceptable."

An alternative less restrictive clause would be:

"If you install a hard floor finish such as laminate or hardwood overlay, ceramic tiles etc, in any room in your property you must also install an approved high quality acoustic underlay."

8.4 PHYSICAL MITIGATION MEASURES

Whilst there are a large variety of methods of reducing impact sound transmission, the use of a resilient underlay is likely to be the only pre-emptive measure a person fitting a new hard flooring surface would consider to be reasonably practicable.

Using a resilient underlay will assist in reducing noise transmission. The choice of the most appropriate underlay will be dependent on which type of hard flooring finish is being installed and the construction of the floor on which it is being laid. The effectiveness in controlling the amount of noise transmitted through the floor will also depend on the construction of the floor.

Chapter 7 of this report has identified the typical performance of the 'commonly' available underlays and the most effective type for each base floor structure.

Whilst a slightly better performance can be achieved through the use of an *'acoustic'* underlay, it is unlikely that this would be considered an option for the majority of people installing a hard flooring surface where there is no history of problems with noise, given the high cost of the acoustic underlays currently available on the market – typically £10-20 per m^2 compared with the standard underlays at £1-3 per m^2.

Advantages of underlays:

- They reduce noise transmission to your neighbours.
- They prolong the life of your laminate or wood floor.
- They reduce noise and vibration in your own home.
- The floor is more resilient and reduces fall injuries.

To get the best performance from the underlay, it must prevent the wood floor or laminate from touching the perimeter walls or skirting.

8.5 GOOD PRACTICE GUIDELINES FOR INSTALLING LAMINATES AND WOOD FLOORS

Step 1 - lay your underlay so that it lies flat and is not uneven

Step 2 - ensure the underlay edges are abutted and do not overlap as this will create an uneven surface for your laminate /wood floor

Step 3 - lay the underlay so that it has at least 10cm extra, turned up at each perimeter wall

IF EXISTING SKIRTING NOT BEING REMOVED

Step 4 - lay the laminate/wood floor so that it stops at least 2cm from the wall or existing skirting

Step 5 - pull the underlay around the edge of the laminate (see over)

Step 6 - fix a small wood channel to the base of the skirting or wall, so that the underlay passes between the floor and channel

Step 7 - trim off any protruding underlay

IF USING NEW SKIRTINGS or REMOVING AND RE-USING OLD SKIRTINGS

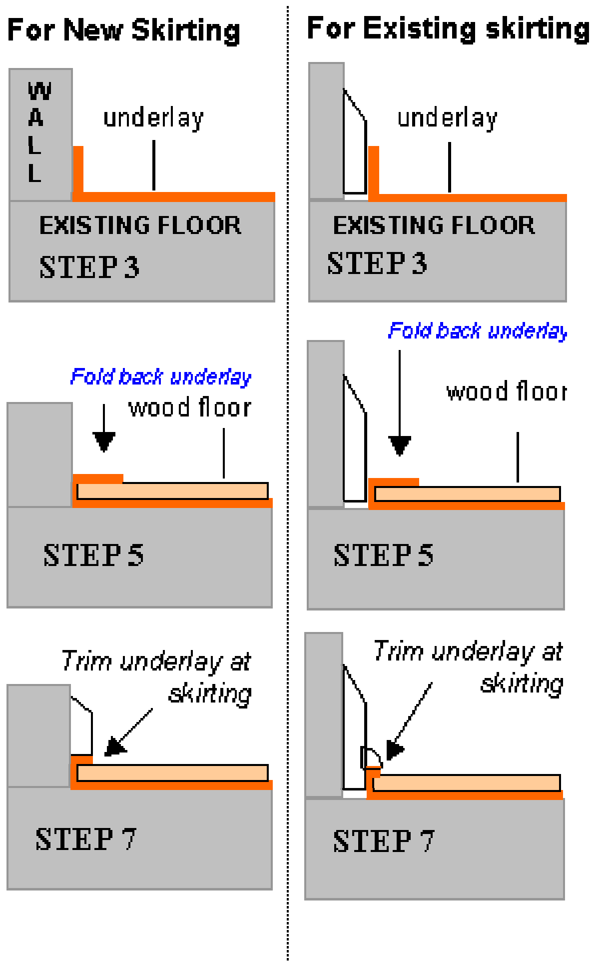
Step 4 - lay the laminate/wood floor so that it stops at least 2 cm from the wall

Step 5 - pull the underlay around the edge of the laminate (see over)

Step 6 - fix the skirting to the wall, so that the underlay passes between the floor and skirting base

Step 7 - trim off any protruding underlay

The following figure illustrates the correct method of isolating the perimeter of the flooring material.



Even with the use of an underlay, problems may occur on certain floor structures, as discussed in Chapter 7. It is therefore recommended that occupants be encouraged not to fit laminate in areas which see the greatest foot traffic such as hallways and children's playrooms.

Reducing the noise at source also achieves significant benefits in reducing the transmitted impact noise. Effectively, this means reducing the impact force on the floor. This can be achieved through the use of rugs. Also wearing soft soled shoes, such as slippers, will reduce the amount of noise generated.

Where a carpet is being lifted and existing floorboards sanded, the remedial measures limited to those discussed in the two paragraphs above.

8.6 PROCEDURES FOR DEALING WITH PROBLEMS WITH NOISE FROM HARD FLOOR FINISHES

When a problem has occurred which is suspected to be due to excessive impact noise as the result of a hard floor finish it is recommended that the investigating organisation/person follows set procedures in order to isolate the source of the problem and identify the correct remedial measures or legal path to implement.

Initially it will be necessary to establish if the complaint is justified and disturbance is occurring. Local authorities and other bodies already have robust procedures in place for investigating such problems. It is however outwith the scope of this assessment to establish a policy for investigating complaints and determine the level at which a complaint is justified. Further guidance on these aspects is currently under consideration within the draft documents "Noise management policies and practice for local authorities and their officers" [2] and the equivalent document in Scotland "Consultation on draft guidance on noise management"[3].

If a complaint is justified it will then be necessary to establish if this is due to unreasonable behaviour of the upstairs neighbour or if it is as a result of poor sound insulation. This can be achieved by carrying out sound insulation testing of the party floor.

At any point during this process the best method of resolving the problem is often mediation between the parties to try to establish a common understanding and agree on practical ways of minimising the disturbance.

Beyond this basic method of resolving the problem is taking either physical or legal measures to resolve the problem. The most common options available are discussed in the next section.

A flow diagrams have been prepared, and are presented at the end of this chapter, which will assist parties investigating complains in establishing the best procedure for investigating and resolving complaints.

8.7 LEGAL ACTION

The advice given here is likely to be significantly influenced by future case law changes to legislation. The remedies for dealing with problems in a variety of scenarios are discussed below. It is assumed in these scenarios that it has been determined by the Local Authority or other third party that excessive noise transmission is occurring and that the occupant of the lower property is not overly sensitive to noise.

Scenario 1 – Property with **no alterations** and with upper storey occupants not displaying anti-social behaviour.

As identified in Chapter 4, any action under the Environmental Protection Act [4]is unlikely to be successful given the outcome of the Baxter-v-Camden [5] case, however each case would be assessed individually with the 'matter of degree' influencing the eventual outcome. Also action under the Anti-Social Behaviour Act 2003 would not be appropriate. Therefore in this scenario it is unlikely that a legal remedy is currently possible.

The lack of possible legal remedy highlights the need for further guidance such as a Code of Practice which could be used in such instances, as discussed further in the recommendations.

Scenario 2 – A property which **has been altered** by the occupier such that the sound insulation has potentially been reduced. The upper storey occupants not displaying anti-social behaviour.

In this situation action under the Environmental Protection Act 1990 is more likely to succeed.

Scenario 3 – Property with the upper storey occupant displaying anti-social behaviour.

Action under the Environmental Protection Act 1990 could potentially be successful. Action may also be possible in this scenario under the Anti-Social Behaviour Act[6].

8.8 MEDIATION

From the social survey it was identified that by far the most common way to resolve problems with noise from neighbours is through encouraging them to talk to each other and explain their concerns. It is often the case that the resident upstairs is unaware of the problem and will be happy to discuss a solution.

If the parties have difficulty talking directly to each other, it is expected that the local authority or registered social landlord will be able to put the residents in touch with a free mediation service who are expert in dealing with disputes.

A good starting point in cases where an underlay has not been installed will be to suggest that a resilient layer is fitted. An agreement between the parties to share the cost of this may help to persuade the upper floor occupant to comply. Alternatively laying rugs on the areas of the floor where problems are experienced most may be less costly and would be far more effective in reducing the noise level.

8.9 PHYSICAL REMEDIES

Underlay

If the flooring finish is not laid on a resilient layer, improvement will be achieved by lifting the floor finish and installing an underlay. As discussed in the previous section, the type of underlay chosen will be dependent on both the floor structure and the floor finish. Recommendations were also given as to which of the standard underlays performed best on each floor structure in relation to each type of floor surface finish.

However, given that a problem has already been identified, it would be prudent to aim at a greater level of improvement by installing one of the acoustic underlays available on the market. Chapter 7 identified the best performing underlays for different floor structures.

Rugs

The level of noise transmission can be significantly reduced by placing rugs on to the hard floor finish in the areas which are giving rise to the greatest level of disturbance, for example the hallways or children's play room.

Carpets

The most effective solution to the problem is to replace the hard floor finish with a carpet and underlay.

Acoustic Ceilings

Where it is not possible to reduce the impact noise from above or in situations where airborne noise is also considered to be a problem, the best solution is to install an independent ceiling within the lower property.

An independent ceiling comprises of a timber framework supported from the walls and not the existing ceiling. The frame must create a minimum cavity depth from the existing ceiling to the bottom of the frame of 150 mm. The cavity should incorporate 100 mm thick glass fibre or mineral fibre insulation. Rigid polymer foam, such as polystyrene, should not be used. The framework should then be sheeted with two layers of plasterboard, the joints of which should be staggered and sealed with a flexible sealant.

It is recommended that the available space for a new ceiling be established by measuring the distance from the top of the window and door frame to the underside of the ceiling. If the room has ornate cornicing, it is recommended that the occupant consult the Local Authority Planning Department with regard to any historic building restrictions prior to installing the ceiling.

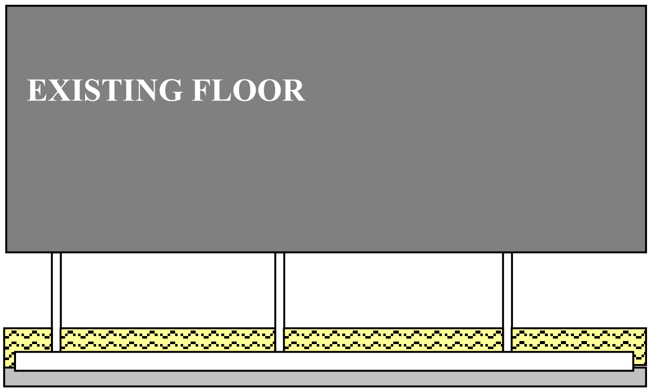
Installing an independent ceiling with 150mm depth should reduce the noise level experienced in the room below by between 15-20 dB. Note that a 20 dB reduction represents approximately a 75% reduction in loudness.

An alternative to an independent ceiling is a suspended ceiling. This option will give a slightly reduced performance over an independent ceiling, typically 10-15 dB, but may be more practical where head height is limited or there is a large span between walls.

A suspended ceiling comprises of a timber or metal framework supported from the existing ceiling using hangers. (Note: The existing ceiling finish should not be penetrated by the new supports.) The frame must create a minimum cavity of 100mm from the existing ceiling to the bottom of the frame. The cavity should incorporate with 100mm thick glass or rock based mineral quilt, not polystyrene or similar rigid plastic foam. The framework should then crossed at right angles with resilient metal bars. Manufacturers' installation instructions must be carefully followed. The ceiling should then be sheeted with two layers of plasterboard, the joints of which should be staggered and sealed with a flexible sealant.

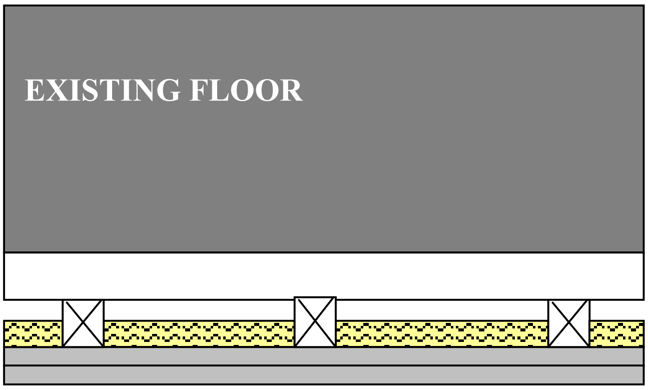
The diagram overleaf illustrates independent and suspended ceiling options.

Options for installing a suspended ceiling



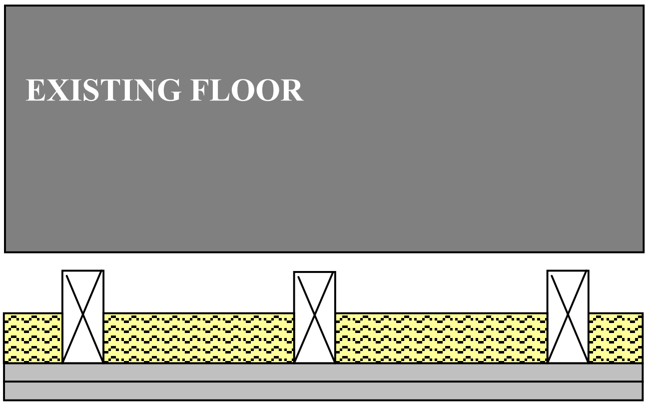
OPTION A

Suspended metal frame ceiling system with a minimum 150mm cavity, minimum 50mm mineral wool quilt and 1 layer of 15mm gypsum based board.
Ensure metal frame does not touch perimeter walls, leave 15mm gap. Use flexible sealant to seal wall/ceiling junctions.



OPTION B

50x50mm ceiling battens and 50x50mm counter battens with 25mm mineral wool quilt and two layers of 12.5mm gypsum based board.
Ensure ceiling layers have overlapped joints. Ensure battens and counter battens do not touch perimeter walls, leave 15mm gap. Use flexible sealant to seal wall/ceiling junctions.



OPTION C

Independent ceiling joists not connected to existing floor. Minimum 150mm void to new ceiling layer. 50mm mineral wool quilt and one layer of 15mm gypsum based board.
Ensure ceiling joists do not touch existing floor. Use flexible sealant to seal wall/ceiling junctions.

ADDITIONAL INFORMATION

a) *Ceiling option chosen will depend on performance increased required and height possible within other features such as window surrounds.*
b) *Use of coving and cornicing will increase acoustic performance in addition to sealing wall/ceiling junctions.*
c) *For options A & B check that existing floor can take additional load.*
d) *For OPTION B timber joist floors first ceiling batten should run perpendicular to joist direction.*

Floating Floor

An alternative to a suspended or independent ceiling is to install a floating floor. There are a number of options available on the market such as resilient battens or cradles.

A typical remedial treatment would be to install 55 mm resilient battens with integral resilient layer incorporating open and closed cell foam or fibre together with a 25 mm insulation quilt or semi rigid mineral fibre batts resting between the battens. The floor should then be finished with 18 mm chipboard or equivalent to which a hard flooring finish could be applied. Care should be taken to isolate the new walking surface from the perimeter wall through the use of a flanking strip.Installing a floating floor should reduce the experienced loudness in the room below by approximately half or in physical acoustic terms by 10 dB.

It should, however, be noted that installation of these systems would require significant alterations to the property including the trimming of doors, re-positioning of electrical sockets and re-fitting of kitchen and bathroom units. In addition, a step at the front door of the property is likely to be formed.

An alternative, which would not require as extensive an alteration to the doors and skirting, would be to use resilient overlay boards.

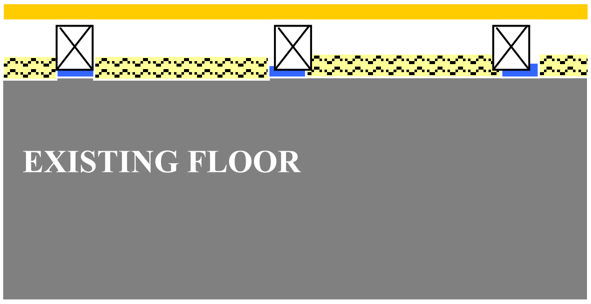
A typical remedial treatment would be a 8 mm MDF or equivalent board bonded to 9mm foam or fibre underlay. These systems can vary in depth from 17mm to 40mm. Generally the thicker and heavier the system, the higher the performance that will be achieved.

Installing an overlay board should reduce the noise level experienced in the room below by approximately 4-8 dB. Care should be exercised when using this type of system on a timber floor, if the problem involves low frequency noise. As identified in Chapter 7, the level of improvement for this type of board can be small.

The diagram overleaf illustrates various floating floor options.

It should be noted that prior to undertaking any structural alterations a structural engineer should be consulted in order to ensure that the existing floor structure is capable of supporting the additional loading.

Options for installing a floating floor

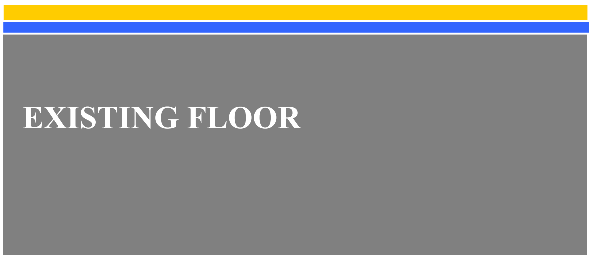


OPTION A – Raft Floors

22mm Chipboard or floorboard decking laid on resilient battens: composed of dual density foam or fibres. Lay 25mm mineral wool quilt between battens not under. To achieve best performance install min. 5mm flanking strip between flooring edge and wall and skirting – see below.

OPTION B – Platform Floors

22mm chipboard or flooring boards resting 40mm rock wool batt insulation. To achieve best performance install flanking strip between flooring edge and wall / skirting - see below.

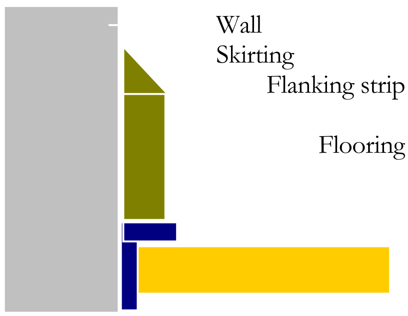


OPTION C – Shallow Deck Floors

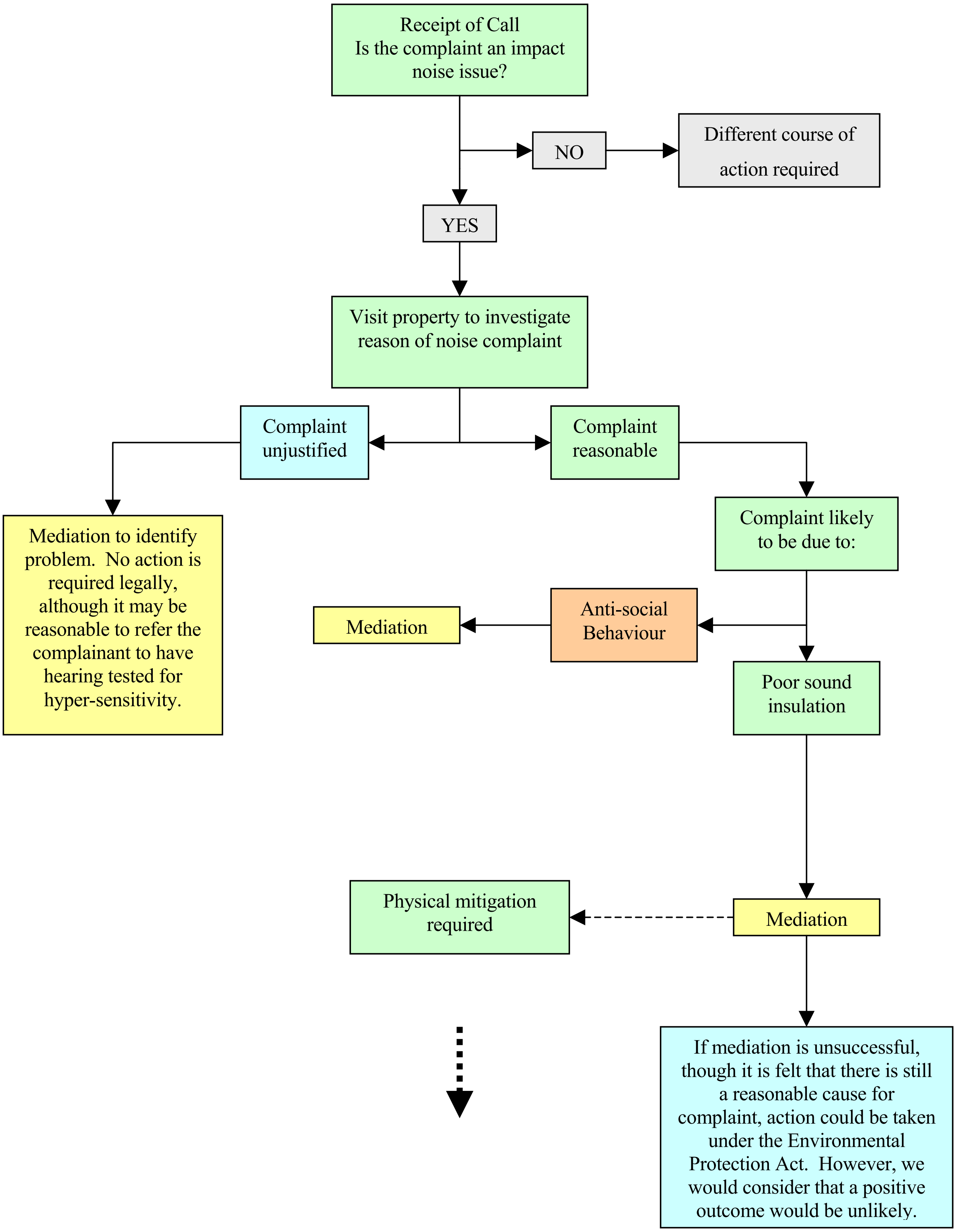
22mm chipboard pre-bonded to resilient layers composed of dual density foam or fibres. Do not use bead or extruded polystyrene. To achieve best performance install flanking strip between flooring edge and wall / skirting – see below.

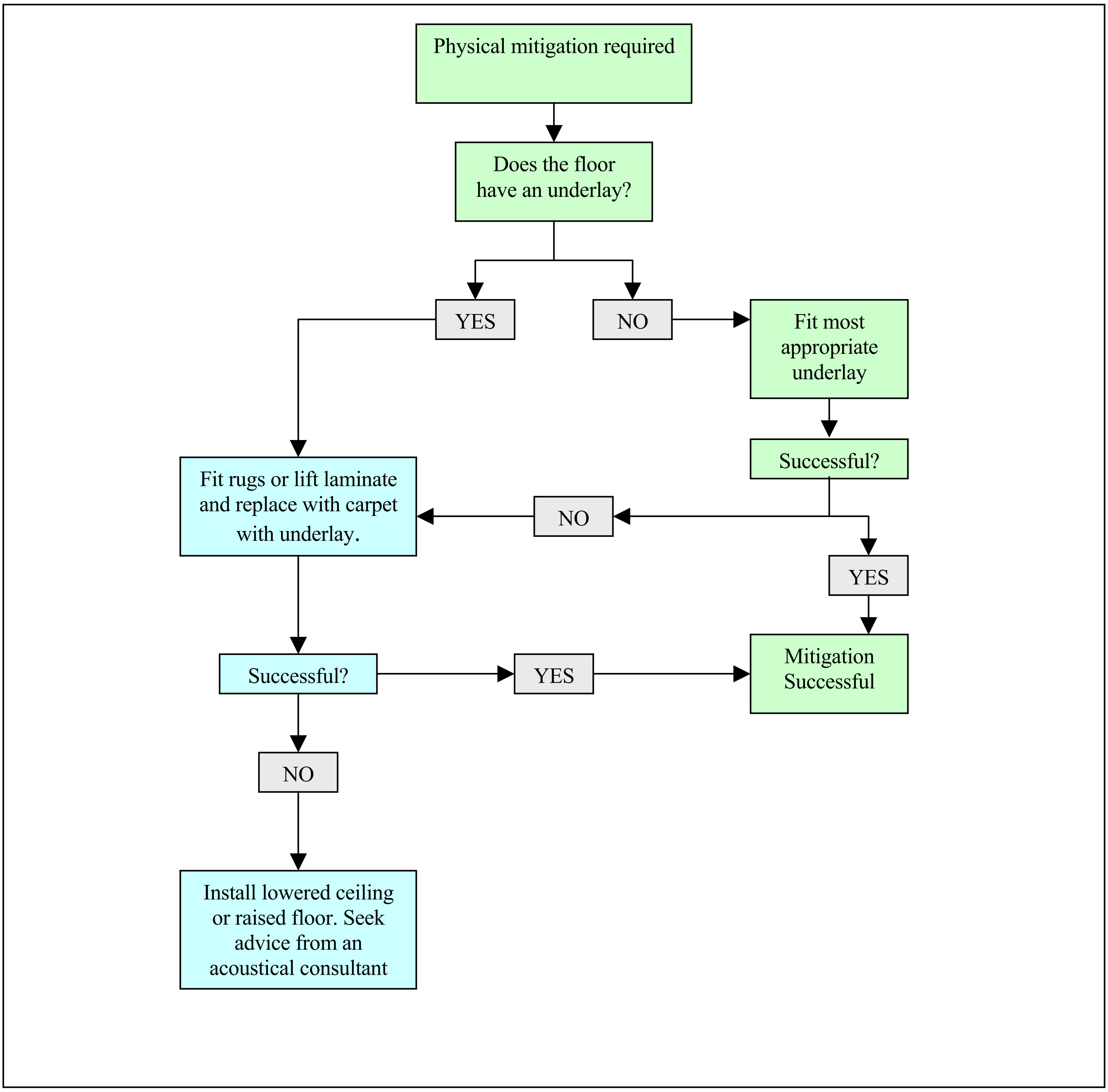
ADDITIONAL INFORMATION

e) Do not use bead or extruded polystyrene for resilient layers or flanking strips
f) Ensure all joints are well sealed
g) Ensure you install a flanking strip at all wall floor junctions.
h) For further info see www.pasm.org.uk



FLOWCHART FOR DEALING WITH IMPACT NOISE COMPLAINTS




Physical mitigation required
Does the floor have an underlay?
YES
NO
Fit most appropriate underlay
Successful?
Fit rugs or lift laminate and replace with carpet with underlay.
NO
YES
Successful?
YES
Mitigation Successful
NO
Install lowered ceiling or raised floor. Seek advice from an acoustical consultant

Chapter 9: Project Recommendations

9.1 INTRODUCTION

This chapter brings together the findings of the previous chapters in the form of recommendations for best practice in dealing with the issue of noise from hard floor finishes and provides recommendations on areas into which further research would be beneficial.

9.2 PUBLICATION OF A NON-TECHNICAL ADVICE LEAFLET

In order to raise public awareness of the issue of noise from hardwood floor finishes and potential solutions, we recommend publication of a simple non-technical guide for circulation within DIY shops and flooring retailers/suppliers, registered social landlords and Local Authorities.

The guide should aim to achieve the following:

- Highlighting of the problem with hard floor finishes. The guide will need to avoid being too negative towards the use of laminates and hardwoods, as this may give rise to problems in encouraging laminate retailers to stock the leaflet.

- Encouragement of the use of underlays, rugs and other mitigation measures where laminated and hardwood flooring is to be used.

- Provision of basic information for dealing with problems, which might occur.

- Recommendations on mitigation and mediation, providing contact details where appropriate.

Example of the potential guidance leaflet content is included in Appendices A and B of this report.

9.3 PUBLICATION OF A NON-TECHNICAL GUIDANCE DOCUMENT

Given that it has been established through the survey, in Chapter 5, that a significant number of people are experiencing problems with noise from hard floor finishes, we would recommend that a detailed guide for noise control from laminated and hardwood flooring be published. The guide should be made available to all Local Authority Housing and Environmental Health Departments and to registered social landlords.

The guidance document should aim to achieve the following:

- Provision of background details on the nature of the problem and the research that has been carried out.
- Identification of typical floor constructions, which give rise to problems.
- Discouragement of the use of laminated and hardwood floor surfaces on floor constructions, which are likely to give rise to problems, such as lightweight timber floors without any resilient layer.
- Encouragement of the use of underlays, rugs and other mitigation measures where laminated and hardwood flooring is to be used.
- Provision of best practice advice on pre-emptive measures that can be undertaken to reduce the rate of noise complaints including advice on the use of tenancy clauses and deeds of sale.

- Provision of detailed information for investigating and dealing with problems which occur, including recommendations on mitigation and mediation measures, together with contact details where appropriate.

An example of the potential content of a guidance document is included in Appendices A and B of this report.

9.4 INVESTIGATION OF MANUFACTURERS' CLAIMS

It is common to find statements in laminate and underlay manufacturers' product literature, which claim that the product will provide significant acoustic benefits. Typical examples of such claims are:

- *"20 dB sound reduction"*
- *"26 dB noise reduction and 19 dB impact reduction"*
- *"Reduces sound by up to 50%"*
- *"81 dB Impact Noise"*
- *"ΔLw 21 dB and reduction of noise in the room of up to 6dB"*

It should be clear to anyone with a basic understanding of building acoustics that these claims are, at best, misleading, but in most cases quite meaningless. The only claims that appear to have some credence are those that refer to ΔLw, as this is likely to have been taken from an actual laboratory test result. However, as identified in Chapter 7, improvements of this order are only to have been achieved on concrete floors without a resilient screed. It is also likely that some of these claims are for the product on its own and not with a hard floor surface on top of it. Indeed, none of the underlay claims relate to the actual increase in performance provided by the underlay with board above compared to the board alone.

9.5 IDENTIFY A STANDARD METHOD OF DISPLAYING PRODUCT PERFORMANCE

In light of the above, we recommend that a standard method of labelling underlay and related products with details of acoustic performance be produced. We further recommend that this should clearly identify the impact improvement that the product is likely to achieve when placed under a hard floor surface, specifying separate results for concrete and timber structural floors.

9.6 FORMATION OF A WORKING GROUP TO DEAL SPECIFICALLY WITH NOISE FROM HARD FLOOR FINISHES

We recommend that consideration be given to the creation of a Code of Practice by a working party of all interested parties such as the flooring industry, registered landlords, local authorities etc. The Code of Practice would provide direction for effective assessment of impact noise complaints.

9.7 SPECIFIC RECORDING OF NOISE FROM FOOTFALL BY ENVIRONMENTAL HEALTH OFFICERS

We recommend that environmental health departments adopt the practice of recording complaints specifically relating to footfall or impact noise. This will provide greater clarity as to the extent of the problem and the annual increase in complaints made by the public.

9.8 REGULAR REVIEW OF CASE LAW

There is currently limited case law specifically setting precedents with regard to nuisance and hard flooring, however it is likely that given the number of residents now reporting problems, that cases will come to Court in the near future. We would therefore recommend that a regular review of new case law be carried out.

9.9 DISCUSSION WITH FLOORING MANUFACTURERS

It is recommended that discussions be held with flooring manufacturers to encourage the adoption of resilient underlay to be pre-bonded as standard within the factory prior to distribution and sale. This is currently only found on a few high cost products but does have a number of positive benefits for users as outlined in Chapter 8.

9.10 AREAS OF FURTHER RESEARCH

Research into the performance of modern floor structures.

As identified in Chapter 7, the use of high performance constructions should reduce the rate of complaints in future as these constructions become more common. It is, however, as yet unknown how the subjective and objective performance of various high performance structures are affected by the installation of a hard floor surface and, in particular, the removal of a soft finish to be replaced by a hard finish. Since residents of flats with high performance floors generally enjoy the added privacy that such constructions provide, the replacement of carpets with hardwood flooring is likely to cause a nuisance, even although the physical sound insulation remains above average. In other words the relationship between perceived nuisance and the resulting level of sound insulation needs to be established.

We would therefore recommend that further research be conducted into the impact performance of the current high performance floors. The project would involve conducting a series of impact tests in actual dwellings with and without hardwood floor finishes and carrying out a corresponding attitude survey to record the response of residents in the lower flats.

New Code of Practice to deal specifically with noise from hard floor finishes

Given the findings of the review of the current legal position, we recommend that consideration be given to the creation of a Code of Practice by a working party of all interested parties such as the flooring industry, registered landlords, local authorities etc. The Code of Practice would provide direction for effective assessment of impact noise complaints in the instances where the occupiers of the upper floor properties are not behaving unreasonably, as unreasonable behaviour could be controlled under the Anti-Social Behaviour Act. It is recommended that the Code of Practice include a simple procedure for identifying whether or not the normal activities of the upper residents are giving rise to unacceptable noise levels in the lower property, which could be prejudicial to health.

As reported, the crux of the issue is the juxtaposition between the rights of the lower property occupants to quiet enjoyment of their home against the rights of occupants in the upper storey to live in a reasonable manner unhindered by statutory control.

In order to facilitate and support such a guide, it would be necessary to conduct a research project to identify the level of impact noise, which the average person would find unacceptable. This would require to be carried out under controlled laboratory conditions, during which a survey group would be exposed to different levels and types of impact noise and asked to comment on the relative degree of nuisance.

Research into improved underlay performance

It is debatable whether it is for Defra to commission research into the physical mitigation measures as this is typically the domain of product manufacturers. However, as reported in Chapter 7, the use of resilient layers incorporating sandwich materials including heavily dampened layers, such as metallic alloys, may provide significantly enhanced mitigation over that currently available on the market. It is entirely possible that increased guidance will create a market for these more costly solutions, which currently does not exist in the current legislative climate.