INTER-TENANCY SOUND CONTROL
(A suppliers perspective)

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SUMMARY

The New Zealand Building Code requires a Sound Transmission Class and Impact Insulation Class of STC 55 and IIC 55 between habitable spaces in multi-unit residential buildings. A 5-point performance reduction is deemed acceptable on site. Winstone Wallboards, New Zealand's largest supplier of gypsum plasterboard, has developed, tested and published an extensive range of Gib® inter-tenancy sound control systems. This paper describes development work and experiences with actual installations and on-site testing. Details for wall and floor/ceiling junctions are discussed.

1. THE NEW ZEALAND BUILDING CODE

In 1992 the performance-based New Zealand Building Code (NZBC) [1] introduced requirements for noise control between permanent occupancies. NZBC Clause G6 'Airborne and Impact Sound' has the following provisions;

- The objective is to safeguard people from illness or loss of amenity as a result of undue noise being transmitted between abutting occupancies.
- The functional requirement for building elements is that they are constructed to prevent undue noise transmission from other occupancies or common spaces, to habitable spaces of household units.
- This requires a performance of Sound Transmission Class (STC) 55 for walls, floors and ceilings, and Impact Insulation Class (IIC) of 55 for floors.

Household units are defined as a home or residence of not more than one household, and do not include transient accommodation. A habitable space within a household unit includes living spaces where people spend time frequently and for extended periods, such as a lounge, bedroom, or study. Spaces such as a bathroom, laundry, or hallway, are excluded. The definition of a building element includes any attached or penetrating services.

Verification method G6/VM1 states that the STC performance of building elements may be verified in accordance with ASTM E336 [2] (laboratory) and ASTM E413 [3] (field). The IIC performance is verified using ISO 140:Part VII [4] (laboratory) and ASTM E 989 [5] (field). G6/VM1 states that field test results shall be within 5dB of the performance requirement. The market generally considers STC50 and IIC50 site tests acceptable for compliance with the NZBC. However, the higher level mandatory requirements of NZBC Clause G6 do not mention the 5dB on-site variation, nor the acceptability of STC50 and IIC50 field tests.

2. GIB® INTERTENANCY NOISE CONTROL

Winstone Wallboards Limited is New Zealand's sole manufacturer and largest supplier of gypsum plasterboard and accessory products marketed under the brand name Gib®.

2.1 Gib® plasterboard products

Although standard Gib® plasterboard (9.5 mm and 12.5 mm) is the highest volume product, modified performance boards have been developed and are targeted at specific applications. These products are colour coded for easy identification and to assist the design, specification and building control process. Examples are;

- Gib® Fyreline (red) for fire rated applications
- Gib® Braceline (blue) for structural bracing
- Gib® Aqualine (green) for wet areas
- Gib® Toughline (grey) for high impact areas
- Gib® Noiseline (white) for noise control

The performance of different products is enhanced by modification of the paper facings and gypsum plaster core. 9.5 mm Gib® Noiseline was introduced in 1998 for noise control applications and is a high-density glass-fibre reinforced Gib® plasterboard with a high quality white face paper.

2.2 Gib® performance systems

Gib® performance plasterboards form an integral part of Gib® performance wall, floor and ceiling systems. The first collection 'Gib® Board Sound Control Systems' [6] was published in 1992 and contains timber and steel framed wall and floor/ceiling systems with STC ratings ranging from 34 to 59. In addition to specifications, construction details and performance ratings, Section 6 of the publication gives guidance notes and explains the general principles of sound control and how to avoid common flanking problems.

In 1994 'Gib® Inter-tenancy Sound Control Systems' [7] was released, containing only systems with at least STC55 and IIC55 performances. These systems were aimed at the growing market for inner city apartment developments and inter-tenancy applications requiring compliance with NZBC Clause G6.

Ongoing systems development, the introduction of Gib® Noiseline, a need to tighten specifications, and a market demand for increased economies, all resulted in the publication of 'Gib® Inter-Tenancy Noise Control Systems, 1998' [8] replacing the 1994 version. Tables 1 and 2 give an overview of the number of Gib® inter-tenancy noise control systems. 'FRR' indicates the systems Fire Resistance Rating in minutes.

frame	timber frame		steel frame	
option	double stud	resilient rail	double stud	resilient rail
FRR (mins)	30 – (2) 60 – (3) 90 – (1)	60 – (1) 90 – (1)	30 – (2) 60 – (2) 90 – (1)	60 – (1) 90 – (1)
Total#	(6)	(2)	(5)	(2)

Table 1 - Gib® Inter-Tenancy Wall Systems

frame	Timber or steel	
option	clip and batten	Suspension
FRR (mins)	60 – (1)	30 – (1) 60 – (2)
Total#	(1)	(3)

Table 2 - Gib Inter-Tenancy Floor/Ceiling Systems

In addition to these published Gib® inter-tenancy noise control systems, Gib® can offer specific design options using Sound Insulation Prediction software 'Insul4.2' [9] developed by acoustic consultants Marshall Day Acoustics. 'Insu4.2' is ideally suited to framed construction and predicts the STC performance of both wall and floor/ceiling systems. Although ongoing fine-tuning and monitoring is taking place, as the test data-base is growing, 'Insul4.2' generally gives good agreement (within 1-2 STC points) with laboratory test results.

In order to achieve adequate levels of noise control with framed construction, a number of important design principles apply;

- provide 'disconnection' by means of double or staggered frames, or resilient mounting of linings
- add mass by installing multiple linings and/or selecting high density linings
- increase the cavity depth
- add cavity noise control insulation

Disconnection is most important and without it adding mass or increasing the cavity depth will only result in relatively minor improvements, resulting in in-efficient use of materials. Adding cavity insulation is important, but generally improves performance by no more than 3-4 dB points.

2.3 Gib® Solutions

As a logical next step Gib® is currently positioning itself as a solutions provider, by developing market partnerships and integrating products and systems technologies to create a total building envelope solution that meets owners needs and expectations. 'Gib® Noise Control for Homes', 'Gib® Healthy Home Solutions', and 'Gib® Interior Solutions' were introduced during 1997/98, targeted mainly at the homeowner. In 1999 these solutions will be integrated into a simplified 'Gib® Living Solutions Guide' offering performances such as noise control for bedrooms ('quiet zones'), moisture protection in bathrooms ('dry zones'), impact resistance for hallways ('tough zones'), superior finish for formal areas ('feature zones').

In parallel to solutions developments for the single unit housing market, Gib® is developing integrated solutions packages for commercial buildings, including multi-unit residential construction. These solution packages will address performance aspects such as fire safety, moisture control, impact resistance, interior finish and designing for noise control. The noise control module is expected to give guidance on how to avoid annoying noise reverberations within occupied spaces, and proper detailing to avoid flanking and sound transmission between units.

3.0 CONSTRUCTION DETAILS

Although an extensive database exists of laboratory tests on wall and floor/ceiling systems, field test information on completed buildings is limited. Achieving a desired STC rating for a single element in the laboratory is relatively simple compared to performance of completed structures in the field. Complicating factors include;

- preferred architectural details (departures from tested system specifications)
- preferred practical details and workmanship (departures from specified details)
- the inter-action between elements (wall and floor/ceilings junctions)

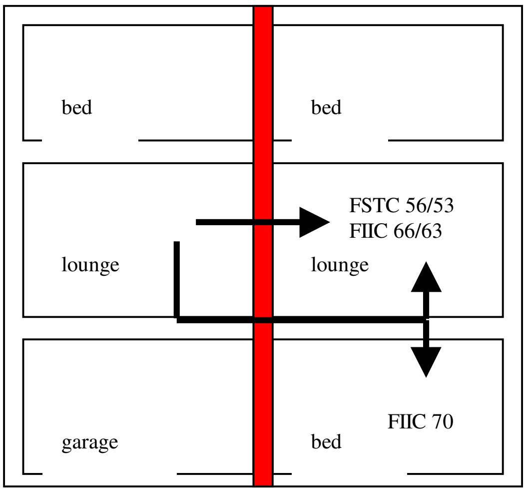
- structure related flanking paths (e.g., connections)
- airborne flanking paths (e.g., doors and windows, cracks, voids)
- services and penetrations
- substitution of materials

In New Zealand, multi-unit apartment buildings have to be designed to meet all performance requirements of the NZBC which include structure and fire safety. Conflicts often exist between detailing for fire safety and structural stability (solid blocking and connections), and noise control (cavities and disconnection).

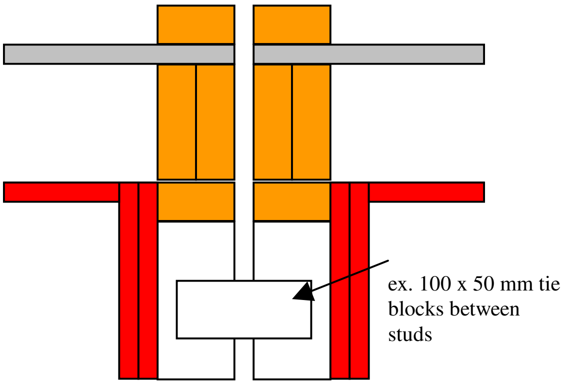
The following case studies give an insight into current practice and a comparison between laboratory and field test results. Due to the confidential nature of the test results, the sites have not been identified in detail.

3.1 Christchurch Apartments (I)

This is a three storey apartment building with units separated vertically by means of a double timber framed sound control wall. Platform construction was used.



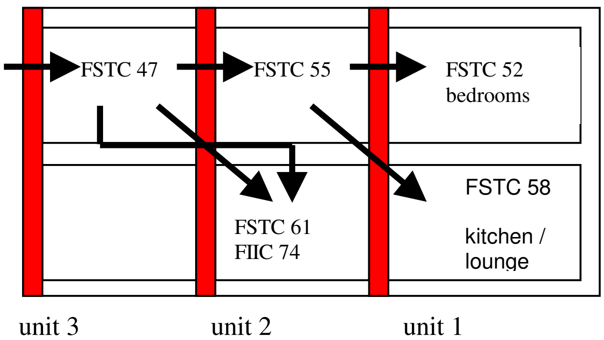
The inter-tenancy sound control wall system consists of two ex. 100 x 50 mm timber frames separated by 50 mm. Two layers of 9.5 mm Gib® Fyreline were installed to each side of the wall and R1.8 glass fibre cavity insulation. This Gib® system GBT(L)A 60 has a published laboratory STC 57. The ceiling consisted of a single layer of standard 9.5 mm Gib® plasterboard on timber joists. At the time of testing no carpet or underlay had yet been placed on the particle board floor. A schematic wall to floor/ceiling detail is given below.



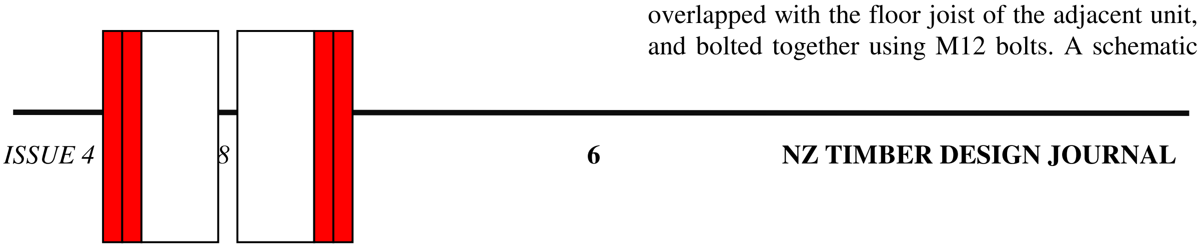
Structural tie blocks were used in some locations. Testing between apartments with tie blocks gave field results between the lounge areas of FSTC 53 (-3dB) and FIIC 63. Without tie blocks these results were FSTC 56 (-1dB) and FIIC 66. Testing between a lounge and downstairs bedroom was only carried out where tie blocks were present and gave FIIC 70.

3.2 Christchurch Apartments (II)

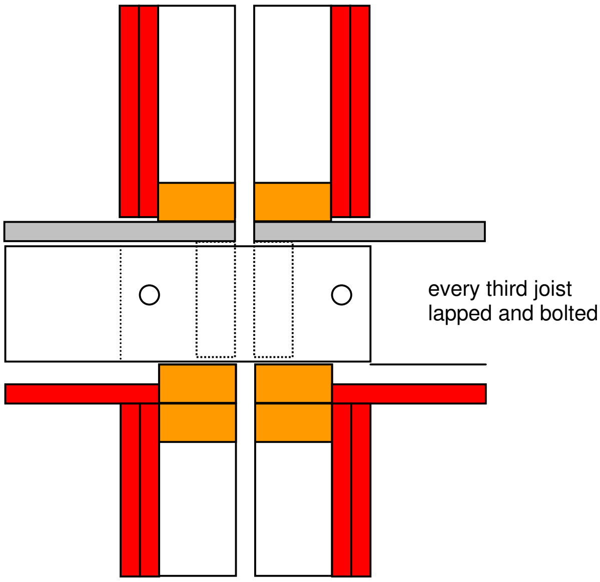
A two storey building with units separated vertically by means of double timber framed sound control walls. Platform construction was used.



The inter-tenancy sound control wall system consists of two ex. 100 x 50 mm timber frames separated by 50 mm. Two layers of 9.5 mm Gib® Fyreline were installed to each side of the wall and R1.8 glass fibre cavity insulation. This Gib® system GBT(L)A 60 has a published laboratory performance of STC 57. The ceiling consisted of a single layer of standard 12.5 mm Gib® plasterboard on a metal clip and batten system. At the time of testing, carpet and underlay was in place over the particle board floor. To provide structural connection, every third floor joist was overlapped with the floor joist of the adjacent unit, and bolted together using M12 bolts. A schematic



wall to floor/ceiling detail is given below.

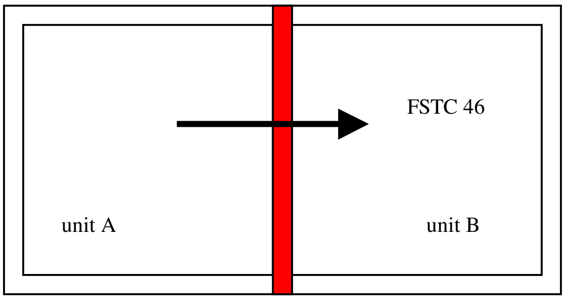


Despite the structural connection between joists, testing between bedrooms gave field results FSTC 55 (-2dB), FSTC 52 (-5dB) and FSTC 47 (-10dB). The results measured diagonally between bedrooms and the kitchen / lounge areas were FSTC 58 (+1dB) and FSTC61 (+4dB) and FIIC 74.

No further investigation was carried into the low FSTC 47 measurement. However, it is likely that flanking occurred due to wall penetrations and detailing at the wall to roof/ceiling junction.

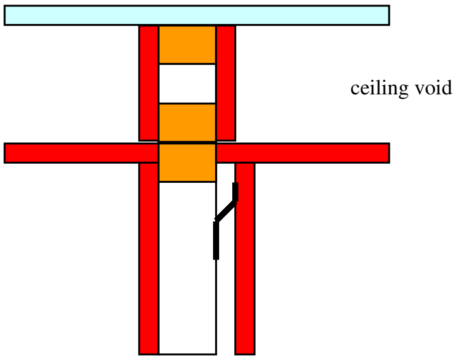
3.3 Christchurch Retirement Complex

This is a single storey complex on a concrete slab. Units are separated by means of a single timber stud and resilient rail sound control wall.



The inter-tenancy sound control wall system consists of a single ex. 100 x 50 mm timber frame with a resilient rail to one side and R1.8 glass fibre cavity insulation. The wall was lined on both sides with 2 layers of 12.5 mm Gib® Fyreline. This Gib® System GBT(L)A 90r has a published laboratory performance of STC 55.

The ceiling lining consisted of a single layer of 12.5 mm Gib® Fyreline on timber framing and a ceiling void separation was included consisting of a single layer of 12.5 mm Gib® Fyreline on each side of a ex. 100 x 50 mm timber frame. A schematic wall to ceiling detail is given below.



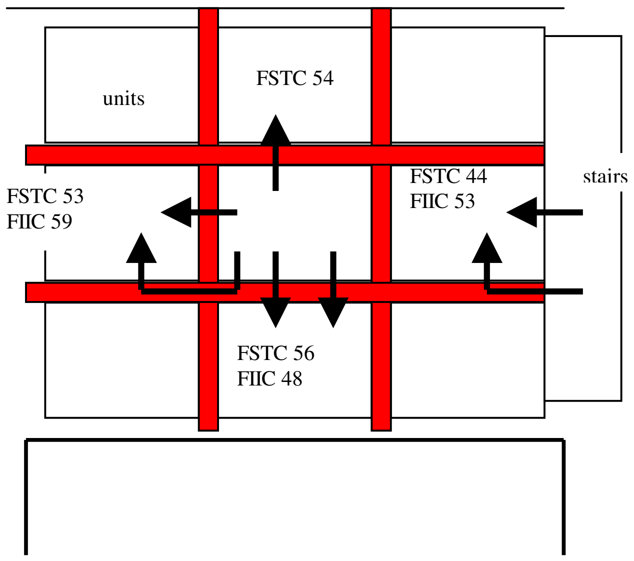
Field testing recorded FSTC 46 (-9dB) between units. Five switch boxes (some back to back) and an intercom unit penetrated the wall. The last item appeared to be a significant airborne flanking path. The wall to ceiling detail was also identified as a structure borne flanking path. Fixing the ceiling lining on a resilient clip and batten system would have eliminated this flanking path.

The units had carpet on underlay on the concrete floors. Transmitted sound levels were so low that FIIC could not be measured.

3.4 Wellington Apartments

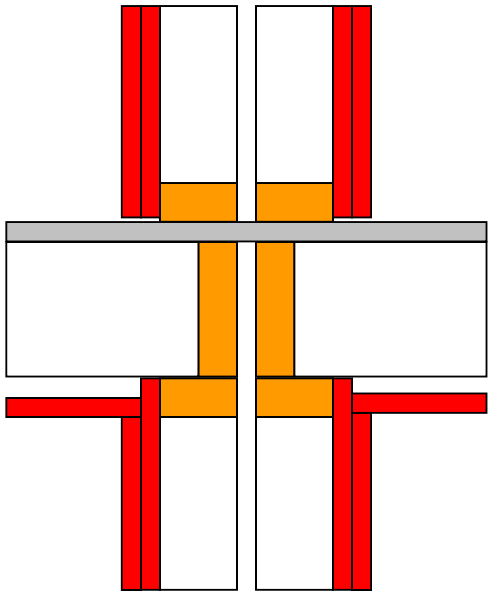
This is a three storey timber framed multi-unit apartment building on a concrete car-park basement. Platform type construction was used throughout. On the same level, each apartment was separated from adjacent apartments by means of a double stud inter-tenancy wall. Between levels a sound control floor/ceiling comprising a clip and batten system on timber joists and multiple layers of Gib® plasterboard provided separation.

roofing



The inter-tenancy walls consist of double ex. 100 x 50 mm timber frames separated by 50 mm. R 1.6 polyester blanket was placed in the cavity. The walls are lined each side with a layer of 12.5 mm Gib® Fyreline over 9.5 mm Gib® Fyreline. No test data exists for this construction, but acoustic consultants Marshall Day Acoustics estimated the laboratory performance as STC 60.
The wall between the stairwell and the apartments consists of a single ex. 150 x 50 mm frame lined with a single layer of 12.5 mm Gib® Fyreline on each side and with R 1.6 polyester cavity insulation. The estimated laboratory performance was STC 42.
The inter-tenancy floor/ceiling construction consisted of continuous 20 mm particle board on ex. 250 x 50 mm joists with a R 1.6 polyester blanket. The ceiling lining was fixed to a metal clip and batten system and consisted of 12.5 mm Gib® Fyreline (exposed) over 9.5 mm Gib® Fyreline. Carpet and underlay was used in most areas and standard vinyl flooring in the bathroom and kitchen. The estimated laboratory performance was STC 55, IIC 74 (carpet) and IIC 48 (vinyl).

A schematic wall to floor/ceiling detail is given below.



Field testing recorded FSTC 53 (-6dB) between units horizontally. Vertically the field test results were FSTC 54 (-1dB) for the unit above the noise source and FSTC 56 (+1dB) for the unit below the source. The stairwell adjacent to units had been reported by occupants as a problem area and recorded FSTC 44 (+2dB). This highlights the need to carefully consider and design separation between common and habitable areas at the design stage.
Field impact testing recorded FIIC 53 between adjacent apartments. FIIC 48 was recorded between the kitchen (vinyl) and the unit below. Even though FIIC 53 was achieved between the stairs and the adjacent unit, the footfall noise was clearly audible inside the living room.
In this complex, the noise of slamming doors was measured at approximately 45-50dB in the bedrooms and living rooms of units below the source.

3.5 Auckland Apartments

A Gib® sound control floor/ceiling system similar to GBDFC 60b has been installed in a substantial multi-unit apartment development. Gib® system GBDFC 60b consists of particle board flooring, timber joists, R 1.8 glass fibre cavity insulation, a resilient metal clip and batten system, and a ceiling lining consisting of two layers of 12.5 mm Gib® Fyreline. The laboratory performance is STC 55.
Occupants complained about the noise transmission between apartments and field tests of

the floor/ceiling system revealed a site performance of FSTC 44 (-11dB).
Further investigation established that the following substitutions had occurred.

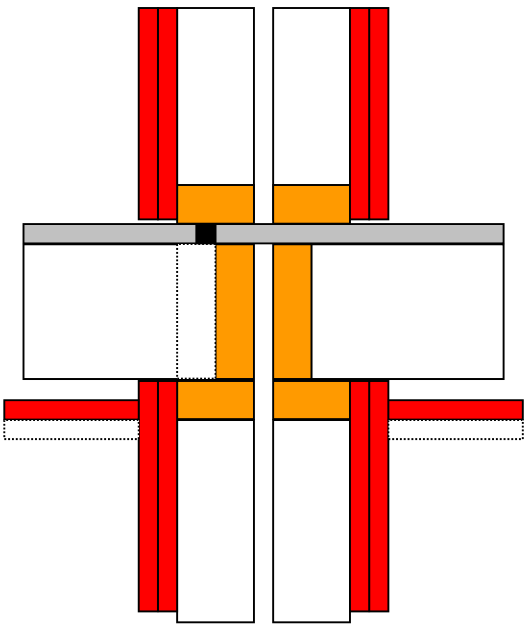
- the cavity insulation was of a different type than specified
- the resilient clip and batten system was of a different brand than specified

The unacceptable drop in performance was mainly attributed to the substitution of an untested metal clip and batten system for the specified and tested brand.
The costs of rectification have been substantial. In this case all parties managed the claims process extremely sensibly. However, further significant damage can easily be done to important industry alliances and partnerships.
This study highlights the need for suppliers to accurately specify tested systems, and for specifiers and contractors to closely follow the published specifications, including all component brands.

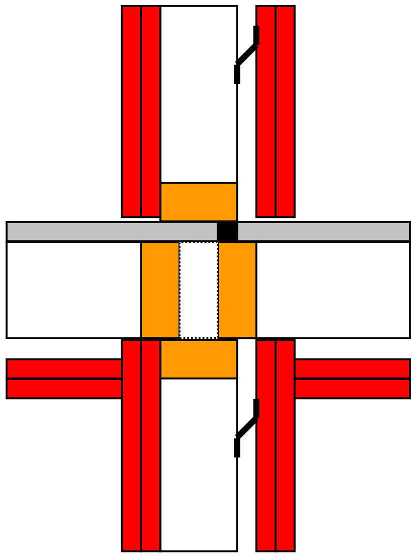
3.6 Miscellaneous Details

The following schematic details have been derived from the case studies described above. They have themselves not been site tested, but apply the principles that gave satisfactory results.

The first detail is suitable for the common scenario of a double frame inter-tenancy wall requiring structural connection at floor level. The particle board flooring is carried through the cavity, but cut and filled with an acoustic sealant under the bottom plate on one side of the assembly.
The ceiling linings are fixed on a resilient metal clip and batten system. If vertical separation between tenancies is also required then a full Gib® sound control floor/ceiling system must be installed.



The second detail is for a single frame and resilient rail inter-tenancy wall requiring structural connection at floor level. Again the particle board is carried through the cavity, and cut and filled with an acoustic sealant on one side of the assembly.
The ceiling linings are fixed on a resilient metal clip and batten system. If vertical separation between tenancies is also required, then a full Gib® sound control floor/ceiling system must be installed.



4.0 PLUMBING SERVICES

The two most common forms of plumbing services noise complained about in apartment buildings are from fresh water and waste water plumbing. Good building design and layout, and minor noise control treatment is often sufficient to minimise problems.
Flushing toilets and water draining from sinks can produce sound levels in excess of 40dB in the unit below, when pipes run through floor/ceiling cavities. Waste-masters can generate noise levels up to 40dB in a lower unit.
Marshall Day Acoustics report 'Plumbing services noise control' [10] describes simple noise control techniques for plumbing services in framed multi-unit apartment buildings. The main findings are summarised below.

4.1 Fresh Water Noise Control

- Locate taps and other plumbing appliances away from inter-tenancy walls
- Do not attach pipes directly to inter-tenancy walls or floors
- Use resilient attachments wherever possible. These could include proprietary pipe clips, and fibre-glass or foam wrapping through oversize

holes in framing

- If appliances are attached to vanity or sink bench units, try to minimise any rigid contact between the unit and the inter-tenancy wall
- Use polybutylene pipe (or other soft material) in preference to copper or even PVC. If not practicable, then ensure that there is at least 150 mm of flexible connection (e.g., a short length of polybutylene pipe) between the appliance and the first rigid connection to the building structure
- Keep the mains water pressure as low as possible

4.2 Waste Water Noise Control

- Design pipe runs to be as straight as possible. This is particularly important for vertical drops. Do not use any more bends than absolutely necessary
- Wrap pipes with at least 4kg/m2 barrier wrap over at least 12 mm soft foam or fibrous material for at least 500 mm each side of a bend, where these pass over the ceiling of another tenancy. Ensure that the ceiling cavity has sound absorbent material over the entire ceiling
- At least two layers of 12.5 mm Gib® plasterboard should be used for all ceilings and bulkheads containing plumbing services. The cavity should be reasonably well filled with sound absorbent material, or pipes could be wrapped individually ensuring no contact between the pipe and any part of the framing
- Avoid rigid contact between waste pipes and the building structure. Pipe clips should preferably be attached around the pipe wrap material rather than directly around the pipe
- Where pipes pass over noise sensitive areas, use heavy pipe material in preference to lighter materials

5.0 DISCUSSION AND CONCLUSIONS

- This paper is by no means exhaustive. It describes the development and laboratory testing of a range of Gib® inter-tenancy noise control systems, and a (limited) number field test results for multi-storey, multi-unit apartment buildings. For Gib® sound control systems the field tests generally agree reasonably well with laboratory results for STC and IIC ratings.
- However, significant reduction in performance can be expected when heavy structural connections create structure-borne flanking paths. Some details with limited structural connections have been tested and performed within the -5dB variation deemed acceptable for site testing.
- The other common reason for poor site test results is airborne flanking. This can be internal, through penetrations, cracks, doors and windows. The wall to ceiling junction is often inadequately designed, causing noise control problems that are expensive to rectify. Airborne flanking can also be along the external façade through doors and windows of adjacent units.
- Common areas such as corridors and stairwells must be separated from habitable spaces and this needs to be addressed at the design stage. Footfall on stairs was identified in one project as a noise problem. The NZBC requirements for the IIC performance of stairs are unclear. However, designers are advised to isolate stairs and stair stringers from wall framing of an adjacent apartment unit.
- Sound control systems tested and specified by manufacturers must be closely followed during the design and construction process. Substitution of materials can have costly consequences. As shown in one example, even seemingly minor alterations can result in major reductions in STC and IIC performance.
- Appliances and plumbing services can create significant noise nuisance problems to occupants in apartment buildings. However, consideration at the building design stage and some simple isolation measures, can significantly reduce the risk of complaints.

6.0 NOMENCLATURE

NZBC	-	New Zealand Building Code
FRR	-	Fire Resistance Rating
STC	-	Sound Transmission class
IIC	-	Impact Insulation Class
FSTC	-	Field Sound Transmission Class
FIIC	-	Field Impact Insulation Class

7.0 REFERENCES

1. Building Industry Authority, The New Zealand Building Code Handbook and Approved Documents, Standards New Zealand, Wellington, 1992
2. ASTM E 336:1984, Method for measurement for airborne sound insulation in buildings, American Society for Testing and Materials, 1984
3. ASTM E 413:1987, Classification for rating sound insulation, American Society for Testing and Materials, 1987
4. ISO 140/VII:1978, Field measurements of impact sound insulation of floors, International Standards Organisation, 1978
5. ASTM E 989:1984, Classification for determination of impact insulation class (IIC), American Society for Testing and Materials, 1984
6. Gib® Board Sound Control Systems, Winstone Wallboards Limited, 1992
7. Gib® Inter-tenancy Sound Control Systems Supplement 1, Winstone Wallboards Limited, 1994 (superseded)
8. Gib® Inter-tenancy Noise Control Systems, Winstone Wallboards Limited, 1998
9. 'Insul4.2' Sound Insulation Prediction, Version 4.2, Marshall Day Acoustics, 1997
10. Wassilieff, C, Plumbing Services Noise Control, report to Winstone Wallboards Limited by Marshall day Acoustics, 1998