Field Floor Impact Noise South-East Queensland (Australia)

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ABSTRACT

Floor impact noise is a significant inter-tenancy issue in high rise buildings. This paper, based upon over 10 years practical experience, provides an understanding of field floor impact insulation issues and discusses floor impact noise from hard flooring surfaces as it impacts into lower apartments, based on different floor finishes, type of underlay, thickness of concrete slab and ceiling construction. The standard test procedures and typical compliance limits are discussed with the analysis separated into two sections; the base building concrete slab (with and without ceiling) and different type of floor finishes with acoustic underlay. The ISO Standard methods used to assess floor impact insulation are discussed with a case study showing the performance of different floor systems (acoustic underlay samples) and different ceiling treatments. The paper concludes with a discussion of the implications of such noise for Body Corporate's and provides advice on ways in which they can mediate on floor impact noise matters.

Keywords: Floor Impact, Insulation I-INCE Classification of Subjects Number(s): 51.5

1. INTRODUCTION

Increasing people in Australia are now living in high rise buildings where noise and privacy between units is an important issue. People are now also moving away from traditional carpet flooring to hard floor covers such as tile, timber and vinyl. A change from a soft floor covering (carpet) to hard a flooring often creates an adverse noise impact to adjacent and lower residences. Floor impact insulation materials and/ or ceiling construction elements become important components in the acoustic treatment to minimise this noise in lower apartments.

The impact test procedures from the relevant International Standards (ISO) are used as a baseline to obtain comparable results. This paper looks into the field testing procedures from the ISO standards to obtain a weighted, standardized, impact sound pressure level ($L'_{nT,w}$) and provides a general comment on the relationship between $L'_{nT,w}$ and American Standard (ASTM) Field Impact Insulation Class (FIIC).

Based on over 10 years of experience in conducting hundreds of tests on different floor finishes, acoustic underlays, concrete slabs and ceiling constructions, this papers provides a basis to discuss the general performance from different construction materials.

2. FLOOR IMPACT STANDARDS

Australia currently adopts the standards (ISO) ISO140-7 "Field measurements of impact sound insulation of floors" and ISO 717-2 "Impact Sound Insulation" (AS1276-1). These standards provide field test procedures and procedures for evaluating single number quantities to determine a impact sound insulation rating. The ISO Standards were adopted by Building Code of Australia (BCA) approximately 10 years ago. Queensland BCA did not start applying the standards till 2009.

2.1 Test Methodology

Under ISO 140-7, the equipment/instruments required for the test are a standard tapping machine and a class 0 or 1 sound level meter. For a reference impact source an ISO 140 standard tapping machine is placed in at least four positions on the floor under test (source room). The tapping machine should be at least 0.5m away from the floor edges. After the tapping has started, measurements should begin when the noise level becomes steady. The measurements in the receiving

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room are made in one –third octave bands between 100 and 3150 Hz. For a sample test the test sample (floor-ceiling assembly) is installed in the source room floor, which is above the receiving room.

A standard tapping machine, which has five equally spaced hammers, typically lifted by a can shaft rotating at 120rpm (20 taps per second), is placed on the test surface.

The standard offers two microphones placement options or methodologies, one fixed and one moving. For the fixed microphone option a minimum of four fixed microphone positions should be used and measurement of at least four tapping positions undertaken. Using the moving microphone option, the minimum number of measurements is four. For each of the measured positions for the fixed microphone, the average measurement time must be at least 6s. As for the moving microphone, the minimum average time is 30s.

The next step is to measure the receiving room reverberation time and from this calculate the equivalent sound absorption area in the room. At least six locations are measured with the results arithmetically averaged.

Measurements of the background noise level are made to validate that the test data is not affected by extraneous noise. If the background and tapping signals are within 6dB to 10dB, the standard allows for corrections to the recorded level.

The field test results are expressed in weighted normalised and weighted standardised impact sound pressure level $L'_{n,w}$ and $L'_{nT,w}$ respectively. The single number quantity for impact values are calculated from one-third-octave bands measurements (refer to Section 2.2 below).

The Standard also provides a list of information that must be submitted in the test report.

2.2 Evaluation Procedure

The ISO 717-2 Standard provides the procedure for evaluating single number quantities for the impact sound insulation rating. The values obtained from the methodologies of ISO 140-7 are compared with reference values for each one-third octave band frequencies measured between 100Hz and 3.15kHz. A reference curve is compared with the measured curve until the sum of the unfavourable deviations, measured levels higher than the reference levels, is not more than 32dB.

3. IMPACT PERFORMANCES

The test results in the following section are taken from field tests. The major of these tests were conducted in South-East Queensland. Due to the time limitations, only a small quantity of data was used.

3.1 Concrete Slab

The most common concrete floor slab thickness in South-East Queensland is between 180 and 220mm. Figure 1 presents the field impact rating of different slab thickness from various building sites. For a typical 180mm thick slab, the $L'_{nT,w}$ ranges between 68 and 76. For a typical 200mm thick slab, the $L'_{nT,w}$ ranges between 65 and 69. The results are just the concrete slab without a suspended, daub or furring channel fixed plasterboard ceiling.

It is readily understood that the thickness of the slab will affect the impact rating, however there are other factors that will also change the final result, including concrete density, pre and post tensioning (or stress), building structures (beam, columns, and joints).

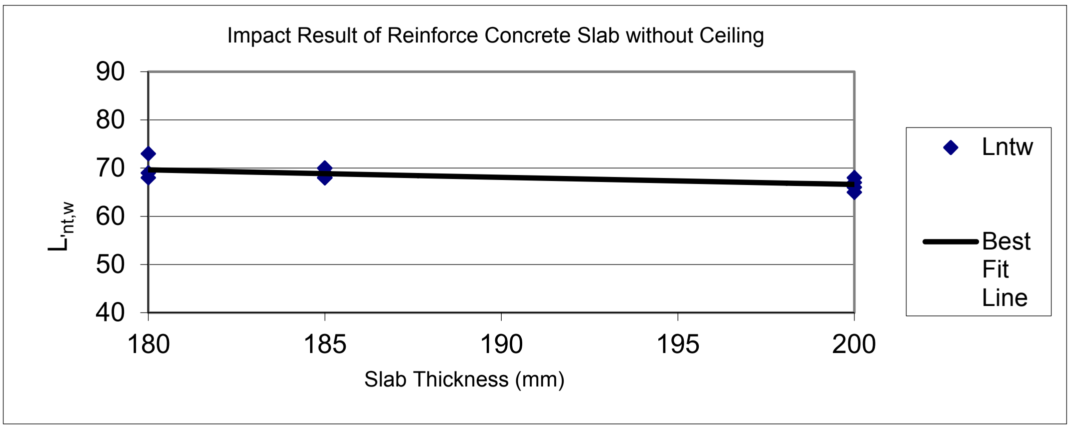

Figure 1 – $L'_{nT,w}$ V Slab Thickness without Ceiling

3.2 Suspended Ceiling

Installing a suspended plasterboard ceiling under the concrete slab increases the overall impact rating. Figure 2 presents the field impact rating of different slabs with a suspended plasterboard ceiling from various building sites. For a typical 180mm thick slab with a suspended ceiling, the $L'_{nT,w}$ ranges between 62 and 72. For a typical 200mm thick slab with a suspended ceiling, the $L'_{nT,w}$ ranges between 58 and 66.

The results in Figure 2 are more spread out compared with the results from Figure 1, due to different ceiling constructions i.e. ceiling cavity thickness, with or without insulation, with or without resilient mounts and number of plasterboard layers. All these ceiling constructions differences will contribute to the final impact rating of the system.

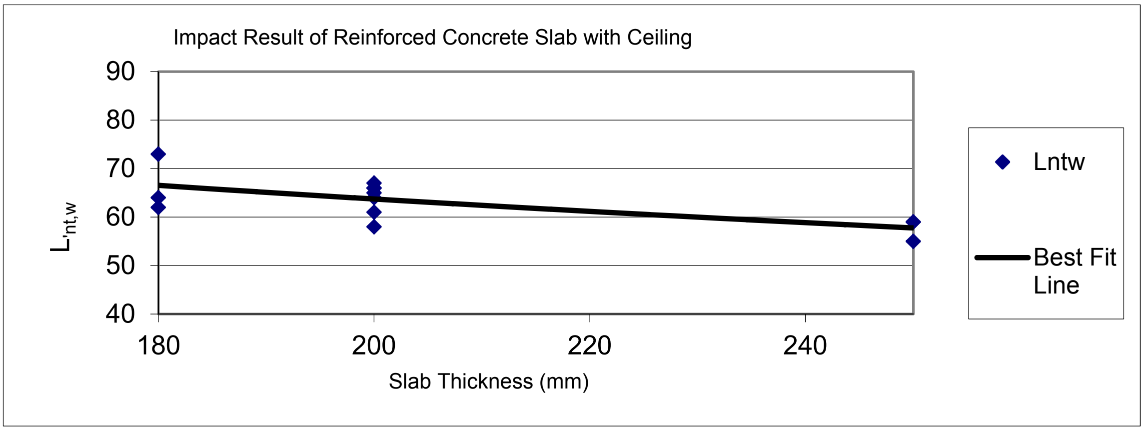

Figure 2 – $L'_{nT,w}$ V Slab Thickness with Ceiling

3.3 Floor Covering

There are many types of floor covering which, with regards to impact isolation performance can be classified into two main categories. First is the soft covering and second is the hard floor covering.

3.3.1 Soft Floor Covering

Soft floor covering is carpet, with or without an underlay. The thickness and softness, i.e. resilience, of the carpet varies. One type can be a thin carpet tiles without underlay. This is typically design for installed in commercial offices or schools, not generally in residential situations. Another type is a thick pile carpet with thick underlay. This is floor covering is often used on residential floors. Generally the impact performance of a thin carpet tile or old & worn carpet should an $L'_{nT,w} > 40$ with a thick carpet with underlay $L'_{nT,w} > 30$.

There are two potential problems, for testing the carpet. First problem is that the impact noise from the tapping machine is too low to readily measure in a field situation. A very low ambient noise is required for measuring impact insulation noise from carpet. Second problem is the dropping height of the tapping machine hammers. In the ISO 140-7 Standard, Annex A "ensures the correct falling height of 40mm". For the extremely soft carpet, it is difficult to confirm the tapping machine to give the correct drop hammer height of 40mm. Adjustment of the tapping machine with pads under the support of the machine may be required.

3.3.2 Hard Floor Covering

Hard floor coverings are typically ceramic or stone tiles, timber, engineer timber, any type of wood products, vinyl and any type of rubber or PVC products. Timber and tiles are the two most common. To data no clear distinction between ceramic, porcelain and marble tile has been observed. The floor impact insulation of a ceramic tiled floor without acoustic underlay, direct stick to the concrete slab generally provide zero (0) to two (2) point improvement from the slab result. It is considered that the tile without underlay is similar to the concrete slab rating.

When comparing between the construction of timber and tiled flooring and its impact insulation performance, a general comments are as follows. There are two (2) ways to install timber flooring, glued or floating and for tile glue is used. The impact insulation rating of a floating timber floor has better performance than the glued timber flooring. The timber flooring has better impact insulation performance than tiled floor, even on tiles with high performing acoustic underlay.

The physical characteristic (hardness) of vinyl, rubber or PVC flooring varies. Some vinyl products have less elasticity and harder than others. Due to the product variation, some people claimed that vinyl floor is a soft floor covering. The tapping machine will be able to generate impact noise through all types of vinyl floor coverings. The typical acoustic performance of a 5mm thick vinyl plank loosely laid without underlay will be between that of the tiled and timber systems.

3.3.3 Summary

The majority of the floor covering (soft and hard covering) can be tested with an ISO 140 tapping machine. A limitation when testing the softer material or high performing system, is that the generated noise will be reasonably low and therefore requires very low ambient noise, to have a valid test. Figure 3 presents the resent test results and shows the performance of a typical 180mm concrete slab without suspended ceiling.

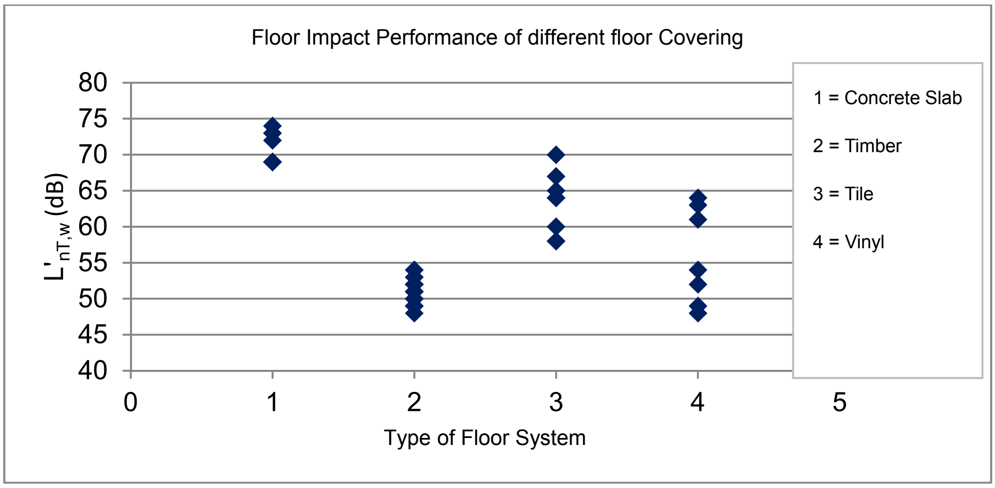

Figure 3 – $L'_{nT,w}$ Performance with different types of floor covering

The overall floor impact insulation performance varies from carpet as providing the best insulation, to thin carpet tiles, timber, vinyl with ceramic tiles providing the lowest insulation.

3.4 Acoustic Underlay

There are many proprietary acoustic underlay products on the market, which can be installed between the floor finishes and concrete slab. These products range between single layer systems to multi layers system. The comments below are based on the tested data presented in Figure 3. When the product is applied to tiles, a typical improvement should be from 5 to 15 points for an average 5mm underlay. The typical improvements for the timber flooring with floating situation are from 15 to 22 points. For vinyl flooring (thickness ranges from 3mm to 9mm, glued or loosely lay), when the underlay is applied, the system provides ranges from 8 to 21 points improvement.

The overall $L'_{nT,w}$ result will depended on type of acoustic underlay products with different thickness, type of bonding adhesives, type of floor finishing and type of ceiling under the source room.

4. CASE STUDY

Through Palmer Acoustics I have had the opportunity to carry out a wide range of floor impact insulation tests. Many of these buildings were aiming for 5 Star rating. IN our assessments we advise clients to use Association of Australian Acoustical Consultant (AAAC) "*Guideline for Apartment and Townhouse Acoustic Rating*" (re: www.aaac.org.au).

On our of our projects early in the construction stage, a developer constructed two identical test rooms (one above each other). The façades were fully closable, to minimise flanking. Test samples were installed in the source room (upper room). A tiled floor with five different underlay samples was tested under three (3) ceiling conditions: concrete (no suspended ceiling), with insulation and one (1) layer of 13mm plaster board ceiling, with two (2) layers of 13mm plasterboard ceiling and with and without openings for a light fitting. The source room was identical to the lower receiving room. The concrete slab was 190mm thick with suspended 13mm thick plasterboard ceiling. The air-gap in the ceiling void is 220mm and void fill with 50mm fibreglass insulations. The volume of receiving room was $56m^3$. The results are presented in Table 1 to Table 3.

Table 1 – Test results – Concrete ceiling (no suspended plasterboard ceiling)

Test details	$L'_{nT,w}$	C_I	FIIC
Bare concrete slab	69	-12	32
Sample 1 – 4mm	63	-8	44
Sample 2 – 6mm x 2	52	1	53
Sample 3 – 4.5mm	60	-6	44
Sample 4 – 10mm	64	-8	44
Sample 5 – 5mm	65	-10	42

Table 2 – Test results – 1 layer of 13mm suspended plasterboard ceiling

Test details	$L'_{nT,w}$	C_I	FIIC
Bare concrete slab	55	-11	46
Sample 1 – 4mm	50	-7	57
Sample 2 – 6mm x 2	44	-2	63
Sample 3 – 4.5mm	49	-6	57
Sample 4 – 10mm	50	-7	58
Sample 5 – 5mm	51	-8	55

Table 3 – Test results – 2 layers of 13mm suspended plasterboard ceiling

Test details	$L'_{nT,w}$	C_I	FIIC
Bare concrete slab	54	-10	48
Sample 1 – 4mm	49	-7	59
Sample 2 – 6mm x 2	43	-1	64
Sample 3 – 4.5mm	46	-5	60
Sample 4 – 10mm	48	-7	60
Sample 5 – 5mm	49	-8	58

From this case study, the $L'_{nT,w}$ results shows that concrete slab with 1 layer of ceiling provided 14 points improvement over a bare concrete ceiling. There is only one (1) point improvement between a single layer of 13mm plasterboard and 2 layer of plasterboard ceiling. When comparing the improvement of samples to concrete slab, it ranged between 4 to 17 points for Table 1 and ranged between 4 and 11 points for Table 2. For the high performing underlay with ceiling, the improvement of the samples gradually decreased its performance, as the whole floor ceiling system reached the maximum threshold. The points where the floor ceiling system begins to taper off are different between buildings.

It is often accepted that the sum of the $L'_{nT,w}$ and FIIC will be approximately 110 points. Each sample from Table 1 to Table 3, showed that the sum of the $L'_{nT,w}$ and FIIC gives between 104 to 108. When compared with the concrete slab, the sum of $L'_{nT,w}$ and FIIC gives between 100 to102 and this is lower than 110. From the previous experience, when the measured impact level follows closely to the reference curve, then the sum of $L'_{nT,w}$ and FIIC will be closer to 110. When the measured impact level deviate away from the reference curve, the sum of $L'_{nT,w}$ and FIIC will be up to 10 points or sometimes even up to 15 points less than 110.

To test the performance of the light fitting, penetrate through the two layers plasterboard ceiling system. Sample 3 was used as a reference to compare the results between open holes and with light fitting. The results were presented in Table 4.

Table 4 – Test results – Sample 3 – plasterboard ceiling with light fitting

Test details	$L'_{nT,w}$	C_I	FIIC
Ceiling with 90mm diameter opening hole	46	-5	60
Ceiling with 90mm round light	46	-5	60
Ceiling with 90mm square light	46	-4	60
Ceiling with 130mm square light	46	-4	60

From Table 4, the results show that all three light fittings did not degrade the acoustic performance of the ceiling system.

The graphical results of Table 1 to Table 3 are presented in Figure 4.

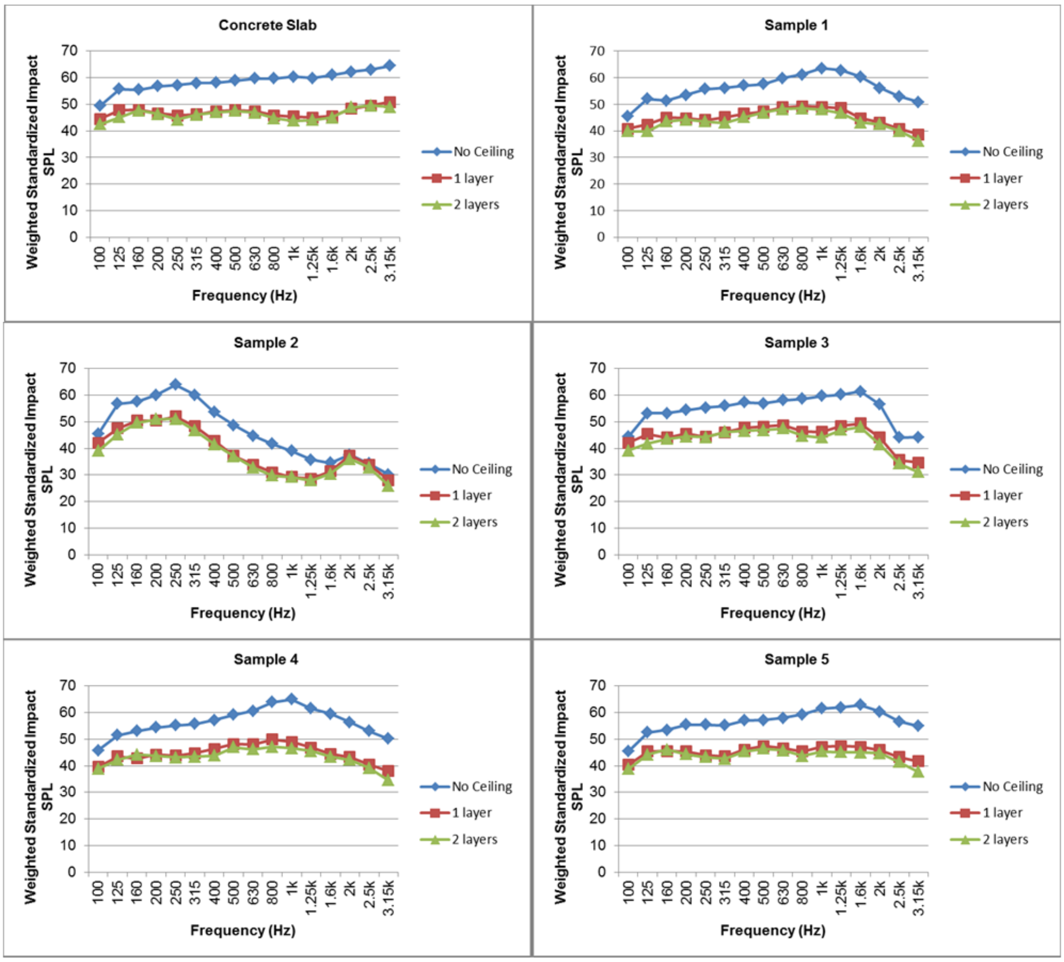

Figure 4 – One-third octave band floor insulation test results

5. DISCUSSION

Floor impact issues encountered over the past ten years.

<u>Discussion 1</u> – A common problem for floor impact is poor installation, typically at the perimeter. The floor when touching the wall or any skirting boards, becomes a flanking path to receiving room. The installer need to follow the product installation procedure. In many instances for both timber and tiled flooring, the results show performance lower than a test sample. It is important for the manufacturers to educate retailers, and from the retails to advice installers on the importance of this gap.

<u>Discussion 2</u> – On many apartment buildings in Queensland, floor impact insulation layers are not

installed in the wet areas including kitchens, bathrooms and laundries. As the design of an apartment becomes more compact, to save floor height, plasterboard ceilings are now installed exposing the bar concrete slab. The distance between the upper level wet areas to living area underneath is generally less than 500mm. This is a potential problem (depending on the living habits of the people on the upper level) for people below. We advise clients to apply an acoustic underlay on tiled floor areas, to minimise impact for kitchens, bathrooms, entries, hallways and laundries.

Discussion 3 – The C_I term when included in Building Code of Australia (BCA) impact rating ($L'_{nT,w}$ + Ci > 62) provides a very low level of acoustic amenity. When this term is added to the $L'_{nT,w}$ results, it increases the overall performance of the floor. It is our my experience that the C_I term should be dropped.

Discussion 4 – The current BCA minimum rating, compared to AAAC Star rating for floor impact insulation and airborne insulation are not consistent. The BCA rating for floor impact is a 2 1/2 Star rating, but for airborne noise is constructed to a 4 Star. The minimum BCA rating should have similar construction standard, i.e. either increase the floor impact standard or decrease the wall standard.

Discussion 5 – There are more and more body corporate by-laws that include hard floor insulating limits from FIIC to $L'_{nT,w}$ rating. To set a reasonable and achievable $L'_{nT,w}$ number for hard flooring, a body corporate committee should test the current floor impact insulation rating within the building. The test should include the existing kitchen tile, concrete slab and any other tile, timber and vinyl floor samples with type of acoustic underlays. These tests and advice should be provided by a qualified and experienced acoustic consultant (experienced in this field). It is recommended that multi-level residential buildings should have a minimum $L'_{nT,w}$ rating of 55. According to the AAAC, this is a 3 Star rating, which provides a reasonable level of amenity. Some Body Corporate's do not have any hard flooring rating in their by-laws, but some have extremely high criteria that cannot be achieved with any hard flooring.

Discussion 6 – Some apartment owner say that vinyl floor is soft flooring and therefore an impact test for hard flooring will not be applied. We considered that a vinyl flooring (according to its floor impact property) is closer to hard flooring than soft flooring but still need to be assessed. It is recommended to the Body Corporate's allow for vinyl flooring in their by-laws.

6. CONCLUSIONS

Acoustic amenity in densely populated areas, especially high rise apartments is important. An adequate floor-ceiling impact insulation treatment must be considered by builders and apartment owners who want to construct a multi-level residential apartments or change to a hard floor surface. In a normal situation carpet with underlay has the best floor impact insulation performance, next is the timber with underlay (not glued), then tile with underlay and vinyl floor can range between the timber and tile ratings.

To determine appropriate floor impact insulation performance criteria for a Body Corporate, tests should be carried out on existing floors in the building. To provide advice to the body corporate committee on reasonable and achievable hard flooring, tests should include the existing kitchen tile, the concrete slab and any other tile, timber and vinyl floor samples with underlays. These tests will provide an understanding of the current building impact isolation performance. All such testing and advice should be provided by a qualified and experienced acoustic consultant (experienced in this field).

Generally as a minimum $L'_{nT,w}$ of 55 should be applied to the multi-level residential building. This criterion is based on building without a suspended ceiling in living and bedroom areas. For a building that has ceiling over the living and bedroom spaces, the $L'_{nT,w}$ of 55 can be increased. Under the AAAC "*Guideline for Apartment and Townhouse Acoustic Rating*" an $L'_{nT,w}$ of 55 represents a 3 Star level of quality.

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