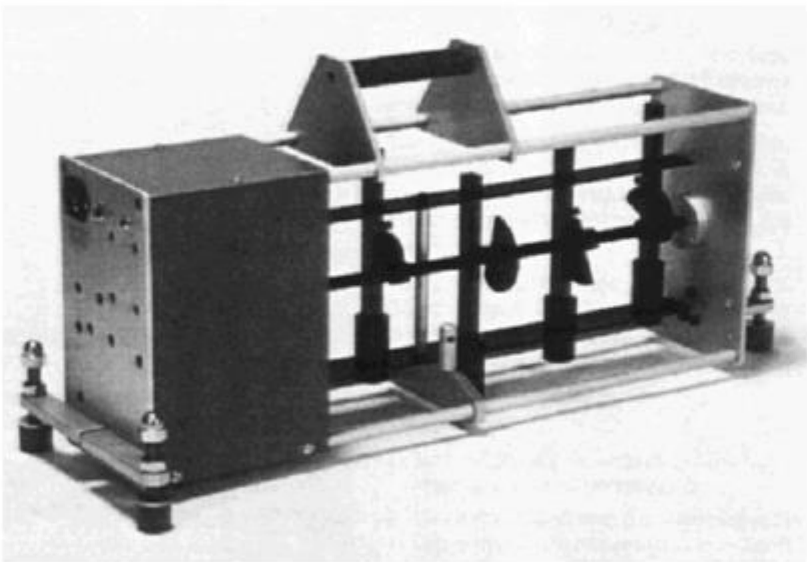
THE MANAGEMENT OF FLOOR IMPACT NOISE
TO MEET OR EXCEED
BUILDING CODE OF AUSTRALIA REQUIREMENTS



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1.0 INTRODUCTION

In 2010, Queensland adopted the Building Code of Australia acoustic requirements which now specify limits for the control of floor impact noise. The BCA provisions require for high rise residential dwellings that the field tested $L'_{n,Tw} + C_I$ of a floor have:

"An $L'_{nT,w} + C_I$ not more than 62 for floors separating dwellings and for floors separating dwellings from a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification."

The BCA specifies 4 options for "*Deemed-to-Satisfy*" systems, however none of these are systems that would normally be used for hard floor surfaces and cannot be applied directly to achieve a full "*Deemed-to-Satisfy*" solution. Instead they provide a reference to determine alternative systems with regard to the defined performance requirements. We do not believe that any system can be taken directly as a "D*eemed-to-Satisfy"* system due to the fact that the laboratory system and the field installed system will be physically and dynamically very different.

There are 4 assessment methods to arrive at a BCA compliant system:

a) Evidence that the system meets the Performance Requirements or *Deemed–to-Satisfy* provisions

b) Verification methods to show compliance with the Performance Requirements;

c) Comparison with the *Deemed-to-Satisfy* provisions

d) Expert Judgement

In all cases a determination is judged in relation to the performance requirement that the field tested $L'_{n,Tw} + C_I$ not exceed 62 or a laboratory tested $L'_{n,w} + C_I$ 62. In some cases an Expert Judgement is required to confirm that a specific system will be BCA compliant. In such cases it is normal that the Judgement will be supported by field tests to ISO 140 Part 7.

Note:

- $L'_{nT,w} + C_I$ is a standardised <u>corrected room noise level</u> in dB resulting from a tapping test and hence lower noise levels represent a better performance.

- The term to describe the impact sound insulation rating of a floor when tested on-site, is the weighted standardized impact sound pressure level ($L'_{nT,w}$) plus the spectrum adaptation term (C_I). $L'_{nT,w} + C_I$ is similar to the laboratory term $L'_{n,w} + C_I$. The "I" suffix represents "Impact" as a spectrum adaptation factor. These terms are in accordance with ISO 717 – 1996 Part 2 with the field tests are conducted in accordance with ISO 140 – 1998 Part 7 using a standardized tapping machine (see below Figure 1).

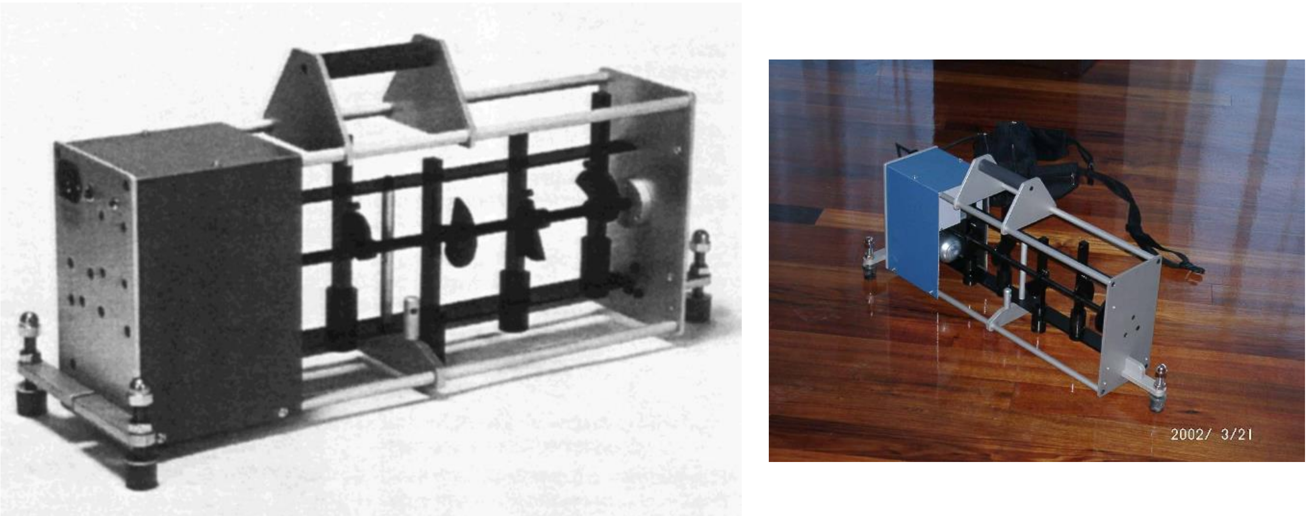


Figure 1. ISO 140 tapping machine

Under the BCA there is also an option to show compliance from laboratory testing to ISO 140 Part 6 (*Acoustics – Measurements of sound insulation in buildings and of building elements – Part 6 Laboratory measurements of impact sound insulation of floor)s*. Such an approved system can only apply if the ISO 140 Part 6 tested system was installed in a building that was physically and dynamically identical to the conditions under which the laboratory tests were conducted. The real test and outcome to confirm BCA compliance is a field test carried out in accordance with ISO 140 Part 7 (*Acoustics – Measurements of sound insulation in buildings and of building elements – Part 7 Field measurements of impact sound insulation of floors*) – re BCA Verification Methods FV 5.1 (b).

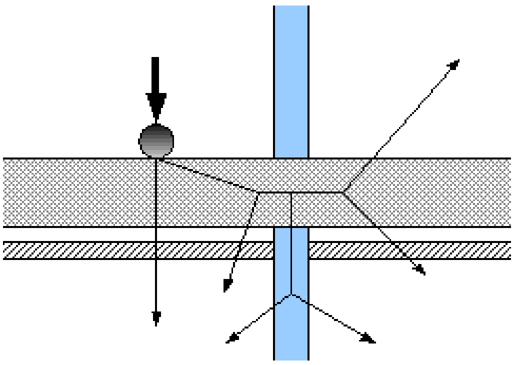


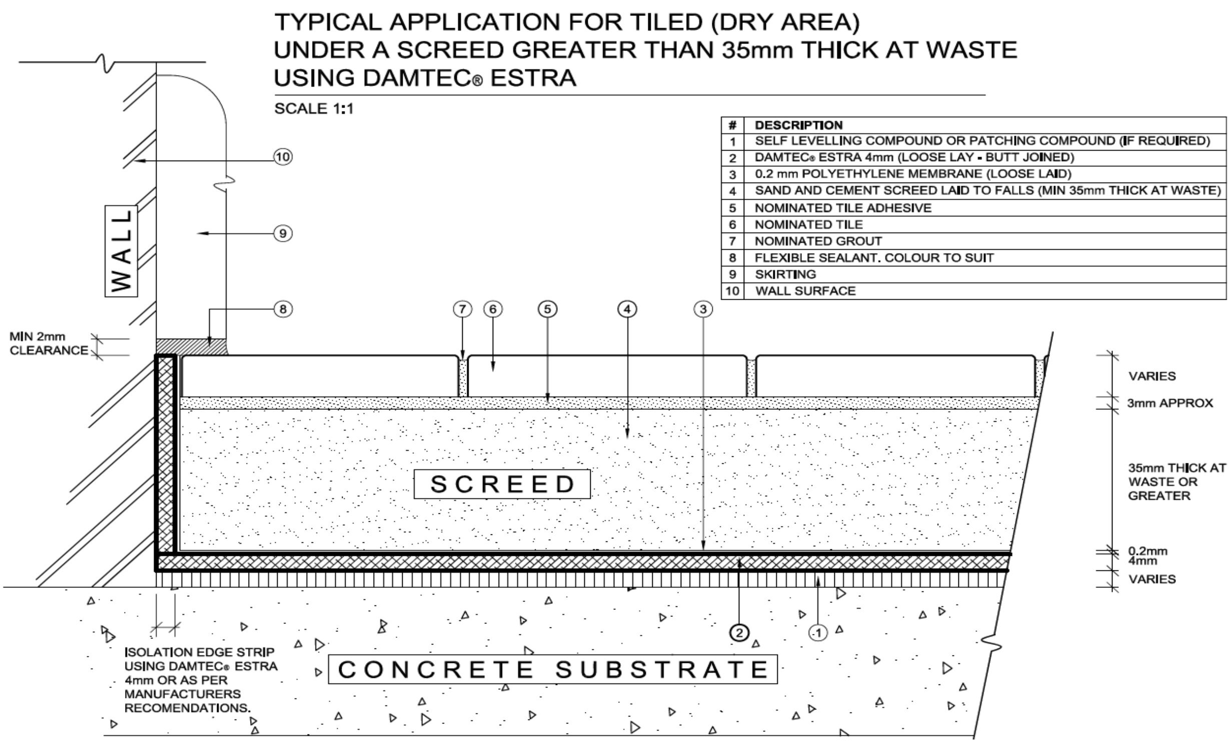
Figure 2: Floor impact transmission paths

- The spectrum adaptation term C_I is a term about which there is currently a lot of confusion. Apparently C_I is a term that shows the effect of the addition of carpet to a hard floor surface and this has little relevance to the BCA intentions regarding hard floor tests. The net effect of the $L'_{nT,w} + C_I$ is a <u>very poor level</u> of isolation such that a bare slab with a light weight ceiling under will meet BCA. This was never the intention of the new BCA and Palmer Acoustics understand that there is currently strong lobbying to have the criterion changed. It is our recommendation that clients as a minimum use a higher level of acoustic isolation (preferably LnTw 55 without the C_I correction).

- It should be understood that the net result of the BCA criterion limits, is that in a building that meets this code, every day impact events (eg a vacuum cleaner or chair moving across a floor) in an upper level areas can generate noise levels of around 50 to 60 dB(A) in lower spaces. This level of noise is very intrusive, particularly in low ambient noise level areas.

- The standardized tapping test and assessment procedures are very effective in quantifying performances for mid to high frequency events (1000 to 3000 Hz). Such events can be the dropping of items onto a floor or noises resulting from pulling chairs of furniture across floor. The assessment procedures do not work well on low frequency noises (100 and 500 Hz), e.g. foot fall or tapping of a balls on the floor. A floor can be very highly rated for impact isolation and yet these low frequency noses will still be clearly audible. In many real life situations the noise source is often a 7 to 9 year old boy.

Regardless of the fact that the impact isolation aspects of the BCA are currently inadequate, there are strong market expectations regarding floor impact isolation performance to the extent of affecting the buildings rated quality in the market. The market is a strong force pushing up building standards, and floor impact isolation is an important consideration in setting high standards. It is our experience that in high rise building disputes, the biggest issue of concern from occupants is impact noise from upper level units. These matters are now more and more being resolved through Body Corporate intervention or through legal processes in Courts of Law. They should wherever possible be resolved at the design stage by the application of appropriate building structures and treatments.



2.0 IMPACT INSULATION CRITERION

The commonly used criterion can be better understood in terms of the Association of Australian Acoustical Consultants (AAAC) Star rating system for floor surfaces (re www.aaac.org.au);

3. Intertenancy Activities		2 Star	3 Star	4 Star	5 Star	6 Star
(c) Impact Isolation of Floors						
between tenancies	$L_{nT,w} \leq$	65	55	50	45	40
between all other spaces & tenancies	$L_{nT,w} \leq$	65	55	50	45	40

These levels of isolation can be considered as follows:

ISO Rating	Star Rating	Approx. ASTM Rating	Perception
$L'_{nT,w}$ 70	No rating	FIIC 40	All floor impacts clearly audible (e.g. dropping comb on floor)
$L'_{nT,w}$ 65	2 Star	FIIC 45	Footsteps on tiled or parquetry floors clearly audible below
$L'_{nT,w}$ 60	2 ½ Star	FIIC 50	Footsteps on tiled or parquetry floors audible below;
$L'_{nT,w}$ 55	3 Star	FIIC 55	Footsteps on tiled or parquetry floors audible below
$L'_{nT,w}$ 50	4 Star	FIIC 60	Footsteps on tiled or parquetry floors barely audible below
$L'_{nT,w}$ 45	5 Star	FIIC 65	Footsteps on tiled or parquetry floors normally inaudible below
$L'_{nT,w}$ 40	6 Star	FIIC 65	Footsteps on tiled or parquetry floors near inaudible below

Note: Field impact Isolation class (FIIC) is the old ASTM standard descriptor used to define floor impact performance ratings. In Australia this term has now be superseded by the ISO standard terms, which are currently being adopted across Australia. It is advisable to now think in terms of the ISO terms $L'_{nT,w} + C_I$ and $L'_{n,w}$ (see above and enclosed glossary of terms).

There is an industry relationship that considers that the FIIC and $L'_{nTw,}$ when added should give 110. The relationship, is only very approximate and cannot be used as a reliable guide.

The achievement of impact isolation of less than $L'_{nT,w}$ 60 is not an easy task and requires careful consideration of all the building elements involved.

3.0 FLOOR IMPACT INSULATION REALITIES AND OPTIONS

It is currently not possible by using empirical means to predict floor impact isolation levels. There are suppliers of floor impact isolation systems who quote that there product will provide a specific level of isolation. This data has to be seen with scepticism, as the reality is that levels of impact isolation are both unpredictable and inconsistent. Often the data used is from the result of tests on floor ceiling systems of which the highlighted product is only one component. Frequently a high performance system is chosen for the tests, such as a 250mm thick slab with suspended ceiling under. A better measure of performance is the difference between the bare slab test and the test with the hard surface and impact isolation layer installed.

The following factors all come into the final levels of overall performance:

- Slab thickness. Has an effect of reducing noise by approximately 9 dB per doubling of mass.
- Whether the slab is pre or post tensioned. This can have a significant effect in the ability of a slab to re-radiate impact noise to lower areas.
- The density and composition of the concrete floor.
- The location of beams, columns and shear walls.
- The locations and types of interior wall and structural supports.
- The use of curtain wall systems. These can create flanking paths which can significantly reduce the overall level of acoustic isolation achieved (both air-borne and structure-borne).
- Any floor levelling topping systems applied. These can be air-rated concrete, which in some cases are in themselves a reasonably effective impact isolation treatment.
- The absence of gaps between tiles and adjacent building structure. Where tiles directly abut adjacent structures impact noise can easily by-pass the impact isolation layer with a significant reduction on overall performance. It is recommended that a minimum 5mm gap occur between the tiles and adjacent walls or structure. This gap is filled with a resilient sealant.

It can be found that in the same building on different locations or on different levels that the levels of floor impact isolation can change appreciably. When testing on the same floor in different locations we have variations of up to 10 dB between different locations. This is one of the reasons that the ISO 140 standard tapping test requires testing in a minimum of 5 different locations with the results averaged. To achieve a reasonable level of predictability it is our advice that floors be tested during construction and that proposed products be field tested on site to determine there site specific performance. Typically such tests would be carried out on a minimum 1.2m x 1.2m sample. Such results give a reasonably close indication of the overall performance compared to performance when all the floor area has been laid.

Generally impact isolation systems are applied to concrete floor slabs. Where structural timber floors are used the issues become more complex with there being more difficulty in achieving medium to high performance. This is due to the higher deflections of the base floor slab and hence the ease through which floor vibrations can be excited and noise transmitted.

It is of interest to note that the floor performance is directly related to the noise levels audible in the source room. Extensive field-testing has shown that a floor that performs badly is "quiet" in the source room. However a floor that performs well is "noisy" in the source room. This can be noted on timber floating floors where the floor sounds "tinny" or "rattly" to walk on. Such floors generally transmit low levels of noise and have high levels of impact isolation.

From our experience with floor impact isolation we find that prediction is not easy. By applying standard vibration isolation theory it would be reasonable to assume that by using thicker impact isolation layers (with more deflection under load) that more isolation would be achieved. This is not always the case and it is found that constrained layer dampening theory can be better applied. Under this theory better isolation is achieved by increasing the thickness of the isolation material and using thin stiff constrained layers in the isolation material to restrict horizontal shear forces

To provide floor impact isolation treatments there are a number of options/systems that can be selected depending upon the performance levels required.

3.1 Bare Concrete Slab

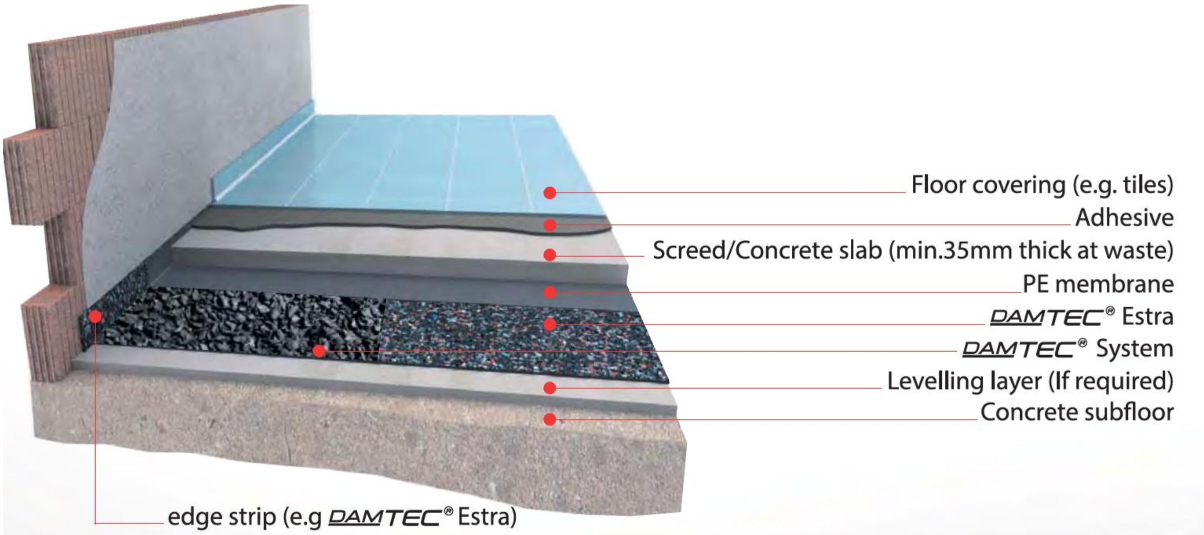
Extensive field testing has shown that a 200mm concrete slab will provide an isolation of close to $L'_{n,Tw}$ 70, which represents a high level of sound transmission and low level of acoustic amenity. The characteristics of the floor and locations of structural supports and walls will define the final level of performance.

3.2 Suspended Ceiling under Slab

It is our experience that a standard 64mm channel with 13mm plasterboard ceiling under a slab will add close to 5 dB extra performance to floor/ceiling impact performance. With fibreglass in the void (close to 18 kg/m^3) this could rise by an extra 3 units. With a resiliently supported ceiling (3mm static deflection)of 2 layers of 13mm plasterboard with 100mm air gap and 75mm fibreglass in the void, overall improvements in performance of around 10 units could be expected.

3.3 Impact Insulation layer under tiles

What appears to be the most cost-effective means of reducing impact noise is to install an impact isolation layer under the hard floor surface.



These are generally a proprietary product located under tiles, stone or timber floor systems. On tiled floors such products should provide at-least a 15 unit improvement in isolation with isolation of up to 25 units possible. The impact systems can be a rolled out resilient element (1mm to 15mm thick), a screeded wet system (typically 5 to 10mm), or a solid board system laid out across the floor (approx. 10mm thick).

Issues of cost, build-ability and weight, coupled with acoustic performance, often decide the product that will be used. Impact Isolation systems in Queensland are available from:

- Damtec Australasia, direct stick system. Costa Varsos Ph 0411 116 114
- Regupol Australia (roll out sheet systems) Nick Anderson Ph 0411 866 461, Peter Wilson 0418 751 979
- Construction Chemicals (wet screed system) Ph (07) 3271 2944
- Architectural & Structural Adhesives (ASA) (wet screed system) Max Bowden Ph (07) 32657355
- Chemind Construction Products Eral Dettrick Ph (07) 3255 5755
- ABA Building Products (wet screed system) Colin Morrow, Graeme Robb Ph (07) 3881 3188
- Embelton (rolled out ImpactaMat) Bob Hunt Ph (07) 3359 7100
- Sika Australia (timber flooring system) Denis Gray Ph (07) 3868 1911
- Creative Surfaces – AcoustcMat Ph 1300 765 723 or 0434077077

3.4 Impact isolation layer under timber floors (ie parquetry or similar floor systems)

On timber floor systems higher levels of isolation are possible, with treatments as simple as using a polyurethane adhesive for the floor, in some cases being able to provide 30 dB in floor impact improvement (ie $L'_{nT,w}$ levels close to 45). The same proprietary impact isolation systems applied to tiled floors are also used under timber floors.

3.5 Impact isolation layer plus ceiling tiles

The combination of a proprietary impact isolation system under tiles coupled with a resiliently isolation ceiling under can give overall levels of isolation in the range $L'_{nT,w}$ 50 to 55. The heavier the ceiling and greater the static deflection of the ceiling isolation hanger the greater the level of acoustic isolation.

3.6 Full floating floor Systems

The highest levels of impact isolation are achieved by creating a fully floating concrete slab on top of the building concrete slab floor. Such a floating slab would be 100mm concrete supported on spring isolation mounts (typically 15mm deflection) or neoprene pads provide close to 6mm static deflection. These floors can provide level of impact isolation down to $L'_{nT,w}$ 35.

3.7 Carpet

Carpet floor coverings are the most effective and economical floor impact isolation system. A heavy pile carpet on top of a thick underlay can be expected to provide isolation close to $L'_{n,Tw}$ 40. In Queensland many people prefer to have hard floors for purposes of cleanliness and the sense of coolness. For such reasons carpet is not a preferred floor covering and hence we must have treatments available to manage noise from hard floor surfaces.

Generally any impact isolation assessment will take consideration of all of the issues 3.1 to 3.7 raised above with the most suitable systems and treatments selected for the application.

4.0 DISCUSSION

From our work over the at least 25 years in high rise buildings we are becoming increasingly aware of the reality that noise is a function of living in high rise building. To expect to live in a high rise building and not experience noise is simply not realistic. However the issue is the level of noise. There are ways and means by which impact noise can be significantly reduced, but these have limitations with regard to:

- Cost – many developers/builders do not wish to pay the cost to upgrade floor and ceiling systems to achieve reasonable level of impact isolation.

- Height limitations – impact isolation systems can raise floor heights from 1mm to 150 mm depending upon the performance required. Many typical systems will be close to 10mm thick. This can create issues with floor levels and the relative heights where tiled floors meet carpeted floors.

On many projects we have worked on it is argued that floor impact isolation systems need not be applied due to the fact that the only hard areas are entries, bathrooms and kitchens, which have close to a 400mm deep bulkhead ceiling under. Whist this argument partially applies to bathrooms the problem arises for kitchen and entry areas where impact noises in these areas easily travels across the slab into the ceiling of adjacent living or bedroom areas. For this reason impact isolation treatments are important for entry, kitchen and bathroom areas.

In Queensland to maximize building and floor to ceiling heights, many projects do not have ceilings in living areas. The lack of a ceiling is a significant factor in reducing the overall level of acoustic isolation. Where medium to high levels of floor impact isolation is required ceilings should be applied to lower occupied areas.

5.0 CONCLUSION

The management of floor impact isolation is a complex issue requiring extensive consideration particularly at the design stage. Without such consideration impact noise can be a serious issue for occupants affecting both amenity for occupants and the perceived quality of the building. It is our recommendation that any residential development be constructed with a minimum $L'_{nT,w}$ isolation of 55 (ie 3 Star) to provide a reasonable level of acoustic amenity. Such a floor would likely include a minimum 190mm slab, an impact isolation layer under a tiled area, and a suspended ceiling for lower areas. For quality developments a higher level of acoustic isolation is appropriate.

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APPENDIX A

GLOSSARY

IMPACT MEASUREMENT AND ASSESSMENT DESCRIPTORS

- $L_{Aeq,T}$ – **Time average A-weighted sound pressure level is the average energy equivalent level of the A Weighted sound over a period "T".**

- L_{Aeq} – **Equivalent Continuous Noise Level. The noise level in dB(A) which if present for the entire measurement period would produce the same sound energy to be received as was actually received as a result of a signal which varied with time. Normally abbreviated to "L_{eq}" or "L_{Aeq}", often followed by a specification of the time period (such as 1 hour or 8 hours) indicating the period of time to which the measured value has been normalized;**

- $L'_{n,w}$ – **Weighted Normalized impact sound pressure level; a measurement of impact sound transmission between rooms. Lower values denote better performance. The single figure measure is derived by adapting a standard response curve to measured 1/3 octave band sound pressure level measurements. Measured results are adjusted based upon 10m2 of absorption in the receiving room. This descriptor is normally derived from a laboratory test**

- $L'_{nT,w}$ –**Weighted Standardised impact sound pressure level; a field measurement of impact sound transmission between rooms. Lower values denote better performance. The single figure measure is derived by adapting a standard response curve to measured 1/3 octave band sound pressure levels. Measured results are adjusted based upon a reverberation time of 0.5 sec in the receiving room. This descriptor is normally derived from a field test.**

- C_I – **A spectrum adaptation term compensating for the effect of floor coverings when applied to bare floors under test. The usually negative value, in decibels, is added to the single-number quantity, L'_{nw} or L'_{nTw}.**

- *Field Impact Insulation Class (FIIC)* – **a single-number rating derived from measured values of normalized one-third octave band impact sound pressure levels in accordance with Eq 4 and the reference contours in Classification E 989. It provides an estimate of the sound insulating performance of a floor-ceiling assembly and associated support structures under tapping machine excitation.**

- *Impact Insulation Class (IIC)* – **This classification covers the determination of a single-figure rating that can be used for comparing floor-ceiling assemblies for general building design purposes.**

- *Impact Sound Pressure Level* – **the average sound pressure level in a specified frequency band produced in the receiving room by the operation of the standard tapping machine on the floor assembly, averaged over each of the specified machine positions.**

- *Normalized Impact Sound Pressure Level* – **the impact sound pressure level normalized to reference absorption of 10 metric sabins (108 sabins).**

- *Receiving Room* – **a room below the floor specimen under test in which the impact sound pressure levels are measured.**

- *Source Room* – **the room containing the tapping machine.**

STANDARDS

- *ISO 140 – 6*
  Acoustics – Measurement of sound Insulation in buildings and of building elements – Part 6: Laboratory measurements of impact sound insulation of floors

- *ISO 140 – 7*
  Acoustics – Measurement of sound Insulation in buildings and of building elements – Part 7: Field measurements of impact sound insulation of floors

- *ISO 717 – 2*
  Acoustics – Rating of sound insulation in building and of building elements – Part 2: Impact sound insulation

- *ASTM Classification E 1007 – 97*
  Standard Test Method for Field Measurement of Tapping Machine Impact Sound Transmission Through Floor-Ceiling Assemblies and Associated Support Structures

- *ASTM Classification E 989 – 89*
  Standard Classification for Determination of Impact Insulation Class (IIC)