FACT SHEET

Sound Impact Properties of Precast Concrete

By Peter Knowland and Paul Uno

Introduction

National Precaster (May 2006) addressed the air-borne sound properties of precast concrete i.e. the transmission and insulation of air borne sound from outside noise sources to interior environments, where precast cladding and glazing were the predominant building materials used in construction.

This paper will look at the role which precast concrete plays in controlling the effect of impact sounds on concrete. The criteria is quite different to that used in air borne sounds and therefore must be analysed separately in accordance with standard procedures, documented guidelines and Australian Codes.

Structure Borne Sounds

This refers to sound which either impacts on or vibrates directly on the structure and then travels through it.

Such sounds are typically experienced by people in units or offices, where one person's ceiling is the other person's floor.

In the case of floors, examples of this type of noise include footsteps from people walking on floors above, scraping chairs on floors, furniture being moved, vibrating clothes dryers, washing machines and dishwashers. This is especially worse when those people above are running rather than walking (as the impact sounds are usually louder and more frequent) on their floors and in particular if those floors are bare, rather than covered with a soft resilient material such as carpet with rubber underlay. In the case of walls, impact sounds could include people merely closing cupboards and drawers in wall-units attached firmly or butting up to walls. Other structure-borne sounds in floors and walls are often due to water hammer (i.e. fluctuating pressure waves in pipes) that often cause the energy to be released via the fixings of those pipes to walls and floors.

Impact sounds are also experienced in an industrial environment – examples include vibrating machinery, service pipes and dropped objects such as tools. In this case it is always preferable to provide damping materials (such as rubber pads and soft

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mountings) in order to minimize the transfer of energy from the vibrating machine or pipe into the structure and therefore reduce the structure-borne impact sounds. The solution however may not always be this simple, as the noise source path may be obscure.

Construction materials or forms of construction that provide good air borne sound insulation may not necessarily provide good insulation against impact sounds. This is especially the case where 'higher mass' is a key parameter in limiting the transfer of air borne noise from one wall (or floor) surface to the other side. This parameter has an influence with concrete floors as a thick concrete floor may transmit less impact sound, but overall this is a very complex situation as the span of the floor can be a significant factor as well as the energy stored within the floor as is the case with prestressed floors. The law of diminishing returns comes into effect so constructing a thicker more massive concrete wall may not afford any extra noticeable benefit when impact sounds are the key issues.

In the case of impact sounds, one of the key considerations is 'separation'. 'Separation' refers to providing a soft or resilient material between two layers with few rigid connections tying the construction together (thus the preference for floating floors and air gaps between panels).

Floating and Non-Floating Floors
Many forms of precast flooring elements are available in the marketplace for residential, industrial and commercial applications (such as hollowcore, beam and infill systems and solid pre-stressed and reinforced slabs *). Examples of these types of precast element are shown below. The methods by which these panels may be improved to deal with structure borne sound is addressed later in this paper. https://www.nationalprecast.com.au/sites/default/files/user-content/

Beam and infill system

Solid reinforced slab (sacrificial formwork)

Hollowcore flooring

** For more information on flooring systems go to www.npcaa.com.au/html/PRODUCTS-Flooring.html and www.npcaa.com.au/html/RESOURCES-Flooring.html. For specific product information and suppliers go to www.npcaa.com.au/html/Precaster_ProductGuide/GuideTo.html.*

Floating Floors

As mentioned in the previous section, one method of reducing the effects of impact noise from hard surfaced floors (e.g. tiled concrete) is to provide a floating floor. A floating floor is a load-bearing slab that is supported by a structural floor, but is isolated from it by resilient and sound absorbing support materials such as rubber (see Figure 9.17 from Precast Concrete Handbook Ch.9). The floating slab is more effective if it is relatively heavy (50mm to 100 mm thick) and does not contact the building structure (thus the need to caulk and seal air gaps). If penetrations such as pipes and ducts are necessary in the slab, the penetration must not form a rigid connection between the slab and the walls. The floating floor system has the potential ability to provide a high order of sound impact isolation.

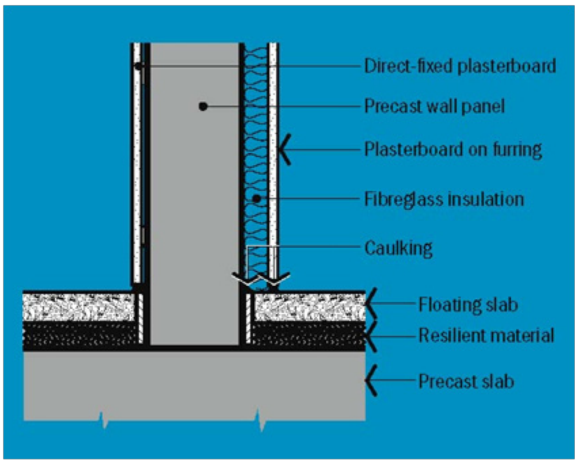


Fig. 9.17 - Floating Floors and Plasterboard either Direct-Fixed or on Furring Channels Attenuate Direct and Flanking Transmission of Airborne and Impact sound.

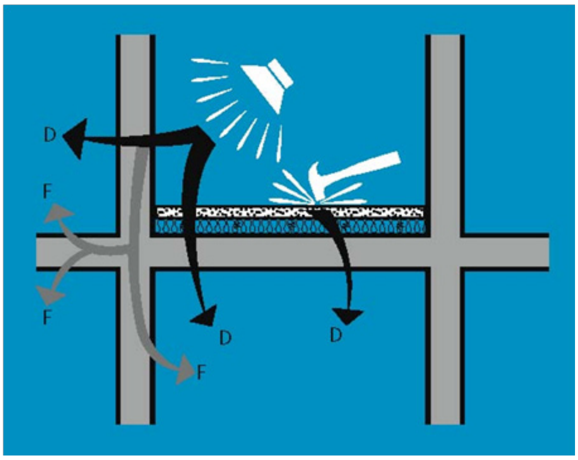


Fig. 911 - A Resiliently-Suspended Ceiling in a Concrete Building Reduced Direct Sound but not Flanking Sound.

A further improvement can be obtained using a resiliently supported ceiling with insulated ceiling space (as shown in Figure 9.11 from Precast Concrete Handbook). The improvement obviously depends on the method of support, the cavity depth, the weight of the ceiling/floor, and the amount of sound absorbing material in the cavity. The ceiling has to be a continuous sheet (not individually suspended tiles). This type of insulation also provides noise protection to the upper room, from noises generated in the room containing the suspended ceiling – thus minimising complaints from neighbours.

Non-Floating Floors

If a floating floor is not an option then the best method of insulating the floor against impact sound is to provide soft resilient floor coverings. Any hard surfaced material, whether it be polished concrete or tiled concrete will produce a low impact sound insulation. The quantification of this will be covered later in the paper.

The best option is to cover the hard floor with quality carpet and a rubber or hairfelt underlay. This system laid on a reasonably thick floor, say 200mm, provides a very high degree of impact isolation that is difficult to better by other systems.

Modern living has become excited with hard floor finishes such as stone, tiles or timber boarding. These floor covering systems applied without some form of resilient layer to separate them from the concrete slab provides an unsatisfactory performance in terms of impact sound isolation. Acoustic consultants are being kept in business by ever increasing matters dealt in either the courts or tribunals where people have unthinkingly ripped up the carpet and replaced it with a hard floor finish.

There are resilient layers that can be installed between these various hard floor finishes and the concrete floor. These can provide a reasonable degree of impact isolation but in the end rarely approach the performance of a high quality carpet and underlay.

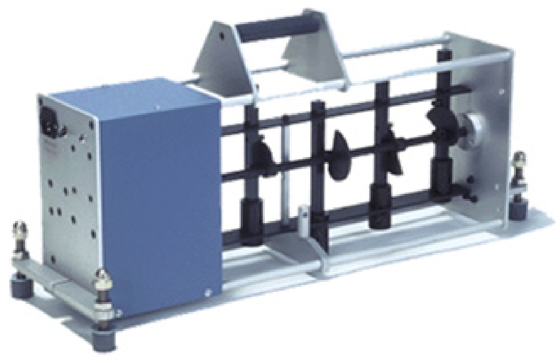
A system that can also be used is thick rugs or non-chloride based magnesite type floor corking. In the early 1960's and late 1970's magnesite (a combination of calcinated magnesite, talc, ground silica and sawdust all mixed together with a solution of magnesium chloride) was a very common intermediary material between the carpet and the concrete however in subsequent years due to time and humidity, the chlorides diffused into the concrete below causing rusting of top layer reinforcing and delamination of concrete surfaces.

Impact Noise Measurement and Test Standards

As mentioned earlier and in the May 2006 edition of National Precaster, the test methods adopted for air borne sounds (such as STC, Rw etc) do not apply to impact testing (although up to recent times, the earlier requirements for impact did necessitate a higher Rw value – around 55 dB – than those required for air borne sounds).

The key test criteria for impact sound in structures for many years in Australia and the World was the Impact Insulation Class (IIC) method. This method involved the use of a

standardised tapping machine (see photo), whereby the unit would be placed on the floor (or sometimes even the wall via a plate and support structure although this system has been demonstrated to be highly inaccurate) and then turned on. Five rubber-tipped steel hammers – each weighing 0.5kg – would drop from a height of 40mm and impact the surface in question at an operating frequency of 10 Hz (i.e. each of the five hammers in series at two impacts per second). This conformed to the following overseas Standards – ISO140, EN 20140, ASTM E492.



Since this was the governing system for impact testing in Australia up to 2004, many manufacturers have been slow to update their product datasheets and still quote IIC values for their tested building products. Due to the fact that the Precast Concrete Handbook was released in 2002, it too quotes the impact capacity of precast hollowcore panels in terms of IIC values (see figure 9.16). This information was based on a 1974 paper by the Portland Cement Association [3], which itself was based on work by Beranek & Newman in 1963 for the American Federal Housing Authority.

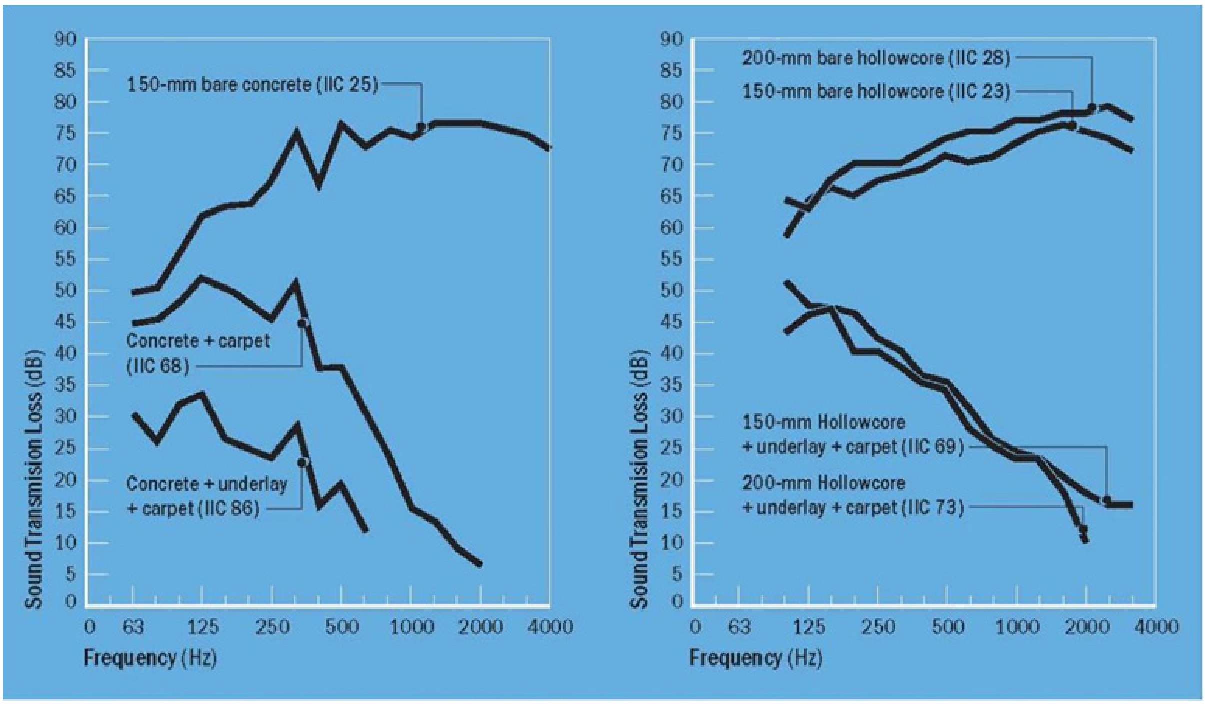


Fig. 9.16 - Tapping machine data for a 150mm concrete floor, tested bare, with a carpet, and with a carpet and foam underlay. Similar date is shown for 150 and 200mm Hollowcore floors (after PCI 9.11).

The Association of Australian Acoustical Consultants released a document in 2002 titled “Acoustical Star Rating for Apartments and Townhouses” (now version 9.4 May 2005) whereby the IIC impact rating system was replaced with a new system called the ‘Weighted Standardised Impact Sound Pressure Level L NT, W (see extract on page 4). This document is also in accordance with ISO140-7 and rated in accordance with ISO 717.2. It is also now quoted in the Building Code of Australia (BCA). The Association of Australian Acoustical Consultants released a document in 2002 titled “Acoustical Star Rating for Apartments and Townhouses” (now version 9.4 May 2005) whereby the IIC impact rating system was replaced with a new system called the ‘Weighted Standardised Impact Sound Pressure Level L NT, W (see extract on page 4). This document is also in accordance with ISO140-7 and rated in accordance with ISO 717.2. It is also now quoted in the Building Code of Australia (BCA).

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3. Intertenancy Activities
2 Star 3 Star 4 Star 5 Star 6 Star

This system works in reverse to the IIC system in that the better the impact isolation, the lower the L NT,W (obviously the lower the values of L NT,W, the better the star rating for the unit or townhouse in question). Fortunately the AAAC have provided a means of relating the older IIC values to the new L NT,W values, so that designers can compare building product datasheets quoting the older IIC ratings for the various building products (e.g. precast concrete flooring panels). The relationship can approximately be expressed as

$$L_{NT,W} = 110 - IIC$$

Since this system relates directly to sound pressure levels rather than a difference between impact levels and a reference IIC contour line, the smaller the L NT,W (i.e. the smaller the sound pressure levels) the better the impact rating of the unit being tested.

Example: referring to Figure 9.16, the 200 mm bare hollowcore panel had an IIC of 28 whilst the same panel with underlay and carpet had an IIC of 73. In the new rating system this translates to L NT,W of 82 vs 37 for bare vs carpet with underlay, thus the lower the L NT,W value the lower is the impact noise issue.

A good example of how product manufacturers have adopted this system in with the previous system can be seen in the tables above.

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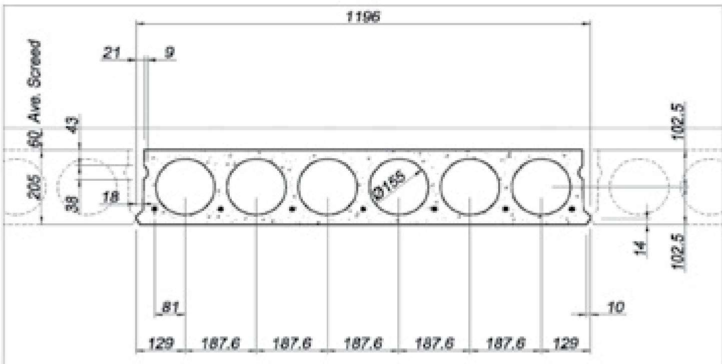
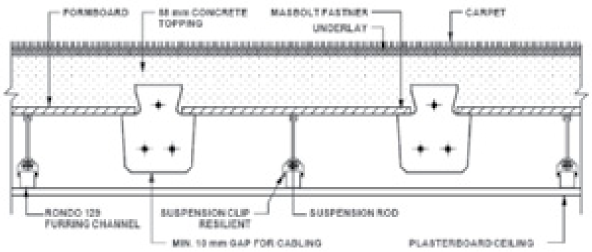
Typical Hollowcore Sound Insulation Systems



Component	Details of Options	Floor Code	R_w (STC)	IIC (Impact Insulation)	L_{NTW} (Impact Insulation)
Hollow Core	205 Hollow Core Plus 60mm Structural Screed	**HCC**	**58**	**28**	**82**
	Plus: Parquetry Flooring	**HCC + P**	**53**	**53**	**57**
	Plus: Parquetry Flooring + Soft FibreBoard	**HCC + P + SF**	**-**	**57**	**53**
	Plus: Carpet	**HCC + C**	**-**	**54**	**56**



Rw (STC) 59 IIc 70+

Figure 6.4.2e: Sound Insulation System 3

TYPICAL ULTRAFLOOR SOUND INSULATION SYSTEMS		Basic Floor	SOFT Floor Surface			HARD Floor Surface					
Component	Details of Options	1	2	3	4	5	6	7	8	9	10
Ultrafloor	Standard (min 86mm thick)	Y	Y	Y	Y						
	Set-Down (min 65mm thick)	Y				Y	Y	Y	Y	Y	Y
Floor Covering	Carpet with underlay		Y	Y	Y						
	Tiled onto screed + resilient layer					Y	Y	Y			
	Tiled onto floating floor + insulation fill								Y	Y	Y
Ceiling	Standard-mounted plasterboard		Y			Y			Y		
	Resilient-mounted plasterboard			Y			Y			Y	
	Resilient-mounted + plasterboard + insulation fill				Y			Y			Y
Sound Insulation Ratings	Rw (STC)	53	67	59	65	57	59	65	59	61	65+
	IIC (Impact Insulation)	30	70+	70+	75+	63	62	65	65	67	73
	L_{nTw} (Impact Insulation)	80	40-	40-	35-	50	48	36	35	33	40

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The overall acoustic appraisal with respect to air borne sound insulation as well as impact insulation can thus be represented in tabular form similar to the following table which is reproduced from the Ultrafloor technical manual.

ULTRAFLOOR SYSTEM	RW	IIC
Basic Ultrafloor system with standard plasterboard ceil	53	45
Carpet with underlay added to basic floor and standard ceiling	57	70
Carpet with undelay + resilient-mounted ceiling with insulation fill	65	75
TIled over resilient layer with standard plasterboard ceiling	57	60
Tiled over floating floor with insulation fill + standard plaster-board ceiling	59	65
Tiled over resilient layer with resilient-mounted ceiling Δ	59	62
Tiled over floating floor with insulation fill + resilient-mounted ceiing Δ	61	67

Summary

In conclusion, it can be seen that building inhabitants today are not only concerned about noise intrusion into their living space from air borne noise sources such as neighbours' speech and music, they are also concerned about impact from structure borne sounds such as neighbour physical movements and their appliance vibrations.

To counteract these effects, practical building elements such as precast concrete floors and walls need to have insulated barriers attached to them to limit the energy transfer from one side of the panel to the other. These barriers should be in the form of soft, resilient coverings with no stiff connectors to structural elements. In this way the precast panels can provide effective and practical structural advantages such as load bearing capacity as well as the equally important parameters associated with noise control

in the form of resistance to air borne sound transmittance and minimisation of the effects of impact sound transference.

References:

(1) Precast Concrete Handbook, Sept 2002
(2) Acoustical Star Rating for Apartments and Townhouses, Association of Australian Acoustical Consultants, version 9.4, May 2005
(3) "Acoustics of Concrete in Buildings", Portland Cement Association, 1974, Frank A. Randall Jr
(4) Ultrafloor Technical Manual, Sept 2002
(5) "Concrete in Energy Efficient Design & Noise Control"