FACT SHEET

Acoustic Properties of Precast Concrete

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In today's cities people are living closer and closer together primarily due to urban consolidation. The need to utilise services and infrastructure, to be close to work, and to be close to entertainment is of high priority.

Medium density living in modern architect-designed glass and concrete structures is very much in demand, and thus it becomes the task of the designer to ensure the building inhabitants have a comfortable living standard. Precast concrete structural walling and flooring systems are becoming an integral part of this construction process of multi-unit buildings. Knowledge of the acoustic properties of such forms of construction is crucial to ensure quality lifestyle living in these buildings.

Part of this process it to ensure that noise from people working and living above, below and outside of a dwelling, does not hinder one's lifestyle. Building designers need to understand the basic science of acoustics and noise control. The following information shows how precast concrete is not the problem, but rather, the solution when one is trying to limit noise intrusion.

Noise Levels & Measures

Noise values quoted in reports and technical datasheets most times will be a number approximately in the range of 40 to 100 with the letters dB after the number eg 70 dB. The dB stands for decibel (one tenth of a Bel) and is a logarithmic scale (similar to the Richter scale for earthquakes). Whilst noise levels can be outside this range, those values would tend to be in the extreme (eg values over 100 dB are extremely loud and often short in duration).

If however one sees values quoted in dB(A) then this scale relates to the sound measured in particular with its reference to the human ear. This scale has been "weighted" to correspond to the way the human ear hears sounds at corresponding loudness levels in each frequency. Road traffic noise levels are usually quoted in terms of dB(A) and the "difference" between outside and inside noise levels (due to barriers, windows, walls etc) is quoted as dB(A) reduction.

Sound Reduction Ratings – Wall & Floor Panels

Precast concrete floor and wall panels (as well as other materials eg glass) are tested both under laboratory conditions and on-site, to establish their acoustic ratings. This is basically to establish how efficient they are at reducing the transmission of noise from outside to inside environments. For example, measurements of noise levels taken near a busy highway and on the outside of a building wall may show that average noise levels are around 80 dB(A), yet when measured on the inside of that building only record 50 dB(A). The difference between the two levels is 30 dB(A), so an approximate noise reduction rating for that wall would be 30 dB(A).

Sound transmission loss of an acoustic barrier system was previously rated as Sound Transmission Class, a system derived from America. This system not only takes into account the difference between noise levels either side of a wall (or floor, or ceiling) but also the absorption capacity of the room itself eg a room lined with soft textured fabrics will record a lower noise level since many of the sound waves entering that room get absorbed by the soft materials. The formula that is normally quoted in this application is:

$$TL\ (dB) = L1 - L2 + 10 \log 10\ (S/A)$$

Where: L1 – L2 is the noise reduction or difference either side of the barrier (generally taken as internal)

S is the area of the dividing wall

A is the equivalent absorption area of the receiving room (determined from reverberation measurements).

In recent times the TL rating system has been changed to conform to the International Standards Organisation system of Weighted Sound Reduction Index Rw. This, in essence is similar to the previously used Sound Transmission Class system.

Both the rating systems and Sound Transmission Class were based on a speech related noise spectrum and in this regard are successful at determining required performance for the sound insulation required by a dividing barrier. In the case of the Sound Transmission Class, it's deficiency in the low frequency area was identified and there was an attempt to introduce Music Transmission Class to take this into account. In the case of the ISO Rw system it was recognised that it did not adequately insulate against external traffic noise and the correction factor Ctr was introduced to provide enhanced low frequency sound insulation.
Work done in the United Kingdom showed that using the Ctr factor also provided more appropriate sound insulation when dealing with modern home entertainment systems. The Ctr correction factor has been introduced into the Acoustic Provisions of the Building Code of Australia since 2004.

The Precast Concrete Handbook gives values for various common concrete wall arrangements (see Tables 1 and 2 – which are reproductions of Table 9.8 & Table 9.9 from the Precast Concrete Handbook-Sept 2002). Added to the Rw values are the spectrum adaptation terms Ctr.

When dealing with external noise intrusion, particularly traffic noise, there is a rule of thumb used in a number of Australian Standards that the effective dB(A) reduction equals the Rw rating minus 5. If the Ctr spectrum adaptation term is used the dB(A) reduction is likely to be closer to the Rw factored down by the Ctr rating.

In the case of external noise intrusion the external wall is usually a mixture of solid wall and windows and/or doors. The concrete panel has a typical Ctr value of -5 which is very good. If double glazed windows are used the Ctr value could be -10 for that component. It is therefore necessary to examine the composite sound transmission loss of the solid wall area together with all the components that make up that wall, in order to determine the Ctr value for the composite construction.

Performance of 150mm precast panels

A 150 mm thick precast concrete panel is an interesting situation in respect to compliance with the Building Code of Australia. The typical laboratory performance of a 150 thick precast wall is Rw 54 and the Ctr is -5 giving an overall rating of Rw + Ctr equalling 49 dB. Technically this does not comply with the BCA, which requires 50 dB and there has been experience with some certifiers that will not approve a 150 precast concrete wall as complying with the BCA 2004 onwards acoustic provisions.

This would be fine if people lived in acoustic laboratories, but they do not, they live in real apartments. There are some walls that perform well in an acoustic laboratory but do not perform well when installed. The acoustic laboratory has precise openings built to fine tolerances. This does not exist in the field.

There are other walls however that better accommodate site tolerances and experience has clearly demonstrated that precast panels lose very little performance between that tested in a laboratory and that measured in the field, assuming that the rest of the structure is up to the appropriate acoustic standard. What is more important is the field performance (designated as Dntw). The requirement of the current BCA is that the installed performance including Ctr should exceed 45 dB. In this regard the precast element easily achieves this value with a field result in the range Dntw + Ctr equals 47 to 48 dB.

The acoustic laboratory measurement is essential and is the first starting point in acoustic design, however it is the installed result in the finished apartment or town house that is vital and will become the dominant factor in the future. As previously said, people do not live in acoustic laboratories, they live in apartments and it is there where the acoustic performance must be delivered.

Effect of Fixing Plasterboard

Whilst a 150 thick precast concrete panel has a Ctr value of -5, this value is made more negative if a plasterboard wall on furring channels is fixed to the precast wall, giving a less favourable result overall. The thinner the furring channel and the lighter the plasterboard, the more the Ctr factor is made negative. This should be watched carefully. When dealing with internal noise and furring channels are applied to both sides of the precast wall together with the use of 10mm plasterboard the effect of the two cladding systems is compounded in respect to Ctr. If it is necessary to provide cladding with airspace for the running of services then it is important that the plasterboard is either 16mm or 13mm sound rated, that the furring channels are no less than 28mm deep and that effective insulation is applied to both cavities.

It can be seen from Table 1 that a 150 mm precast concrete panel (which weighs 360 kg/m2) would provide at least 50 dB reduction of sound levels from outside to inside when exposed to road or rail traffic (or factory noise – refer to the Handbook for more detailed information).

Another simple rule of thumb that can be applied to materials to calculate their approximate transmission loss is the 'mass law' equation:

TL = 20 log 10 (mf) – B
Where: TL = transmission loss (dB)
m = surface mass (kg/m2)
f = frequency (Hz)
B = 48 dB (on average but can range from 45-53).

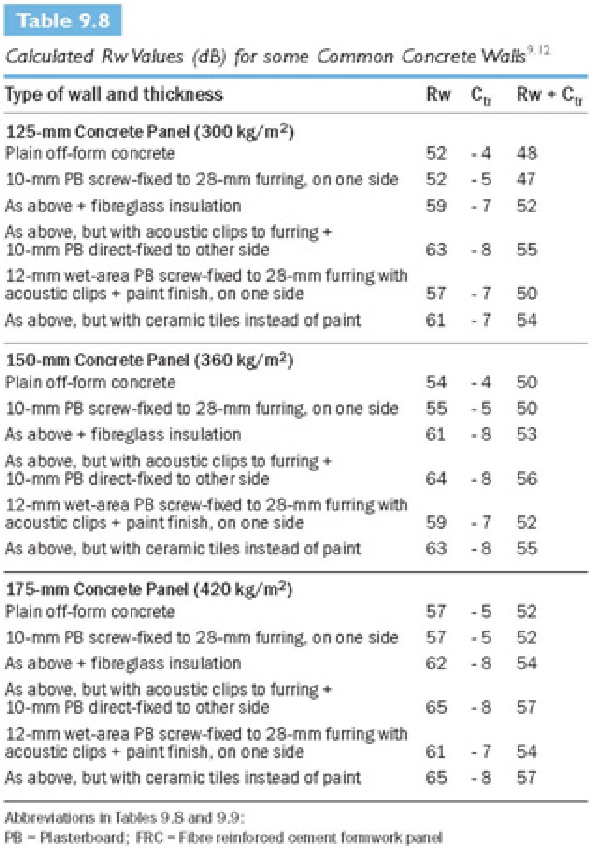


Table 9.8

Calculated Rw Values (dB) for some Common Concrete Walls[9.12]

Type of wall and thickness	Rw	C_{tr}	Rw + C_{tr}
125-mm Concrete Panel (300 kg/m^2)			
Plain off-form concrete	52	- 4	48
10-mm PB screw-fixed to 28-mm furring, on one side	52	- 5	47
As above + fibreglass insulation	59	- 7	52
As above, but with acoustic clips to furring + 10-mm PB direct-fixed to other side	63	- 8	55
12-mm wet-area PB screw-fixed to 28-mm furring with acoustic clips + paint finish, on one side	57	- 7	50
As above, but with ceramic tiles instead of paint	61	- 7	54
150-mm Concrete Panel (360 kg/m^2)			
Plain off-form concrete	54	- 4	50
10-mm PB screw-fixed to 28-mm furring, on one side	55	- 5	50
As above + fibreglass insulation	61	- 8	53
As above, but with acoustic clips to furring + 10-mm PB direct-fixed to other side	64	- 8	56
12-mm wet-area PB screw-fixed to 28-mm furring with acoustic clips + paint finish, on one side	59	- 7	52
As above, but with ceramic tiles instead of paint	63	- 8	55
175-mm Concrete Panel (420 kg/m^2)			
Plain off-form concrete	57	- 5	52
10-mm PB screw-fixed to 28-mm furring, on one side	57	- 5	52
As above + fibreglass insulation	62	- 8	54
As above, but with acoustic clips to furring + 10-mm PB direct-fixed to other side	65	- 8	57
12-mm wet-area PB screw-fixed to 28-mm furring with acoustic clips + paint finish, on one side	61	- 7	54
As above, but with ceramic tiles instead of paint	65	- 8	57

Abbreviations in Tables 9.8 and 9.9:
PB = Plasterboard; FRC = Fibre reinforced cement formwork panel

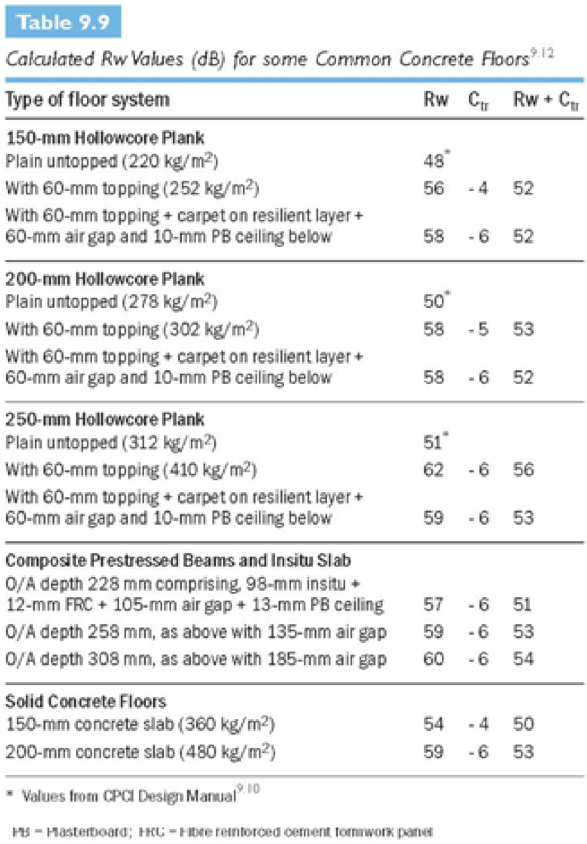


Table 9.9

Calculated Rw Values (dB) for some Common Concrete Floors[9.12]

Type of floor system	Rw	C_{tr}	Rw + C_{tr}
150-mm Hollowcore Plank			
Plain untopped (220 kg/m^2)	48*		
With 60-mm topping (252 kg/m^2)	56	- 4	52
With 60-mm topping + carpet on resilient layer + 60-mm air gap and 10-mm PB ceiling below	58	- 6	52
200-mm Hollowcore Plank			
Plain untopped (278 kg/m^2)	50*		
With 60-mm topping (302 kg/m^2)	58	- 5	53
With 60-mm topping + carpet on resilient layer + 60-mm air gap and 10-mm PB ceiling below	58	- 6	52
250-mm Hollowcore Plank			
Plain untopped (312 kg/m^2)	51*		
With 60-mm topping (410 kg/m^2)	62	- 6	56
With 60-mm topping + carpet on resilient layer + 60-mm air gap and 10-mm PB ceiling below	59	- 6	53
Composite Prestressed Beams and Insitu Slab			
O/A depth 228 mm comprising, 98-mm insitu + 12-mm FRC + 105-mm air gap + 13-mm PB ceiling	57	- 6	51
O/A depth 258 mm, as above with 135-mm air gap	59	- 6	53
O/A depth 308 mm, as above with 185-mm air gap	60	- 6	54
Solid Concrete Floors			
150-mm concrete slab (360 kg/m^2)	54	- 4	50
200-mm concrete slab (480 kg/m^2)	59	- 6	53

* Values from CPCI Design Manual[9.10]

PB = Plasterboard; FRC = Fibre reinforced cement formwork panel

Example: If one is interested in the TL value of a glass panel (density ~ 2700kg/m3) with thickness 6 mm at a frequency of 500 Hz (ie this frequency corresponds to the C above middle C on a piano) then the m value would be 0.006 x 2700 = 16.2 kg/m2, the mf value would be 16.2 x 500 = 8100 kg/m2.Hz and thus the TL would be 30 dB.

Weak Links

Whilst the information above gives the designer a good reference point to start with when trying to account for noise levels in buildings, much of this noise reduction can be forfeited if the so-called 'weak links' are not understood and accounted for when designing a structure.

(a) Flanking

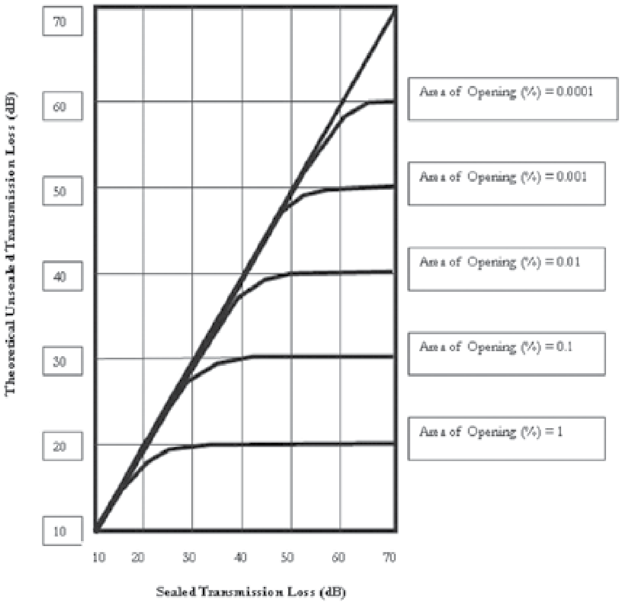
Noise entering a structure does not always follow a direct path from an outside noise source through the wall in question, to the person inside hearing the noise. Often the sound waves can enter from indirect paths such as through ceilings, service penetrations and joints. This being the case, a designer needs to reduce the noise levels from these flanking paths (eg providing separation materials between walls and/or ceilings; caulking perimeter walls –again refer to the Handbook for more detail).

(b) Openings, Holes & Cracks

Any concrete element will have its acoustic rating downgraded if openings, holes or cracks are left in the element after installation and during the life of the element. These openings provide an avenue for sound waves to penetrate directly through the panel. Figure I below (reproduced from an ABIC 1992 conference paper titled 'Acoustic & Thermal Advantages of Concrete' by Paul Uno) shows the reduction in sound level efficiency when openings of different sizes are present in panels. For example, if a panel has a sound transmission rating of 50 dB (when appropriately sealed) and an opening in that panel which only constitutes 0.01 % of the area of that panel (eg a 20mm diameter hole in a 2.4m x 1.2m panel), then the panel will now only have a 40 dB rating – well below most accepted ratings for building design.

Figure 1

Insualtion vs % Openings



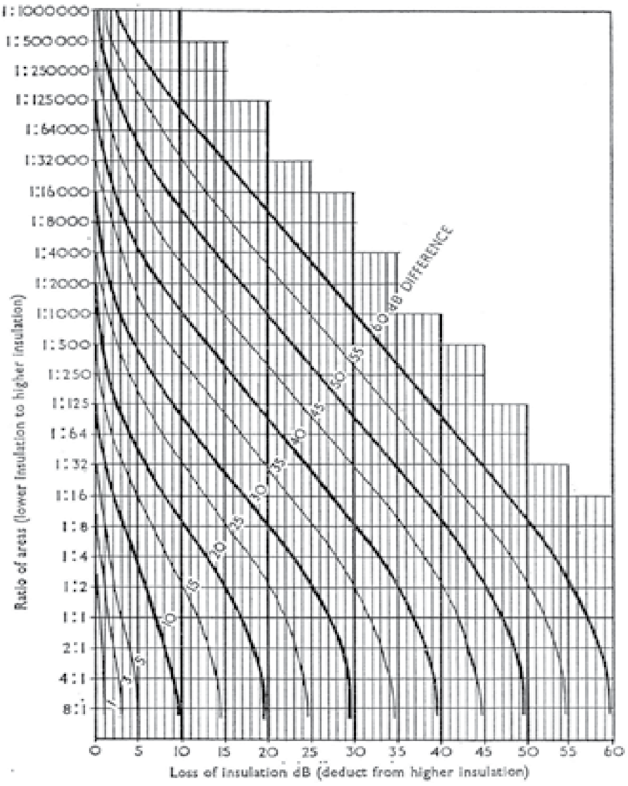
(c) Windows

Glazing is obviously a key part of any building envelope and as such the designer has to take into account the limitations of glass with respect to acoustic efficiency. The transmission loss of standard residential glass is around 25 dB and for 6mm commercial thickness glass it is around 30 dB. If one puts glazing into a precast concrete panel where the panel thickness is 150mm (TL = 50 dB) and the glazing is a single 6mm sheet (TL = 30 dB) then one cannot simply just average the two acoustic ratings as both values are logarithmic units. Whilst the mathematics is complicated for non-mathematicians, Chart A quantifies this 'composite grading' process.

From Chart A it can be seen that if the concrete panel is 6.0m x 2.4m and the glazing is 1.2 x .2m, then the ratio of the small panel to the large panel is (1.2 x 1.2 / 6.0 x 2.4 = 0.10 or 1: 10). The acoustic rating difference between panels is 20 dB so the 'loss of insulation' from the higher value is 9 dB which means the composite panel TL value is 41 dB.

If however, the panel contained a louvre panel for air-intake (which has no sound insulation) rather than the glass panel, then the sound level difference between the two panels would be 50 – 0 = 50 dB, and thus the composite partition TL value would be 10 dB (i.e. 50 dB minus 40 dB where the latter value corresponds to the x axis value from the chart for 50 dB difference and 1:10 ratio).

Chart A - Composite Walls Sound Insulation



Summary

In conclusion, when one is concerned about acoustic performance in building construction, precast concrete is seldom a concern as it has excellent sound transmission loss properties.

As well as performing well acoustically, aspects such as quality control, curing and crack elimination are issues which have been addressed during the manufacturing process.

This is sometimes not the case with concrete which is not factory-manufactured. For example, lack of vibration on site may result in incorrect element density, thus the mass of the panel is reduced leading to small TL (Rw) values. Cracks may occur due to lack of quality control on site (eg lack of curing, or incorrect protection procedures on site against adverse weather conditions), thus providing acoustic leakage paths and thus downgrading the overall sound rating of the building envelope.

Precast elements have very high sound transmission loss values (i.e sound reduction index values) and as such the designer needs to address the TL (Rw) values of other elements incorporated into the panel or building envelope to ensure the whole façade

or envelope is not compromised by other elements with lower TL (Rw)values.

References:

(1) Precast Concrete Handbook, Sept 2002

(2) "Acoustic & Thermal Advantages of Concrete" by Paul Uno, ABIC Conference 1992 p67-69

(3) "Concrete in Energy Efficient Design & Noise Control" by Paul Uno, TN62, CCAA, 1993

(4) "Acoustics Noise & Buildings", Humphreys & Cowell

(5) Peter Knowland & Associates (Acoustic Consulting Engineers)