RECENT CHANGES TO THE SOUND INSULATION PROVISIONS OF THE BUILDING CODE OF AUSTRALIA

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Abstract

This paper discusses the recent changes to the Building Code of Australia (BCA) sound insulation requirements. It outlines the main drivers for the changes and looks at the process used by the Australian Building Codes Board to develop the measures. It also outlines the extent of the changes and the different options for demonstrating compliance with the BCA.

Nomenclature

R_w	Weighted sound reduction index
C_I	Spectrum adaptation term
C_{tr}	Spectrum adaptation term
$L_{n,w}$	Weighted normalised impact sound pressure level
$D_{nT,w}$	Weighted standardised level difference
$L'_{nT,w}$	Weighted standardised impact sound pressure level

Introduction

The Building Code of Australia 2004 (BCA) [1] came into effect on 1 May 2004 and introduced new sound insulation requirements. The changes were a response to increasing evidence that the previous BCA sound insulation requirements were not meeting community expectations. The purpose of the requirements is to reduce sound transmission between attached dwellings and units and also between dwellings or units and other areas within the building. The requirements do not address external noise.

As part of developing the new measures, a number of documents were released for public consultation. The ABCB used comments received on those documents to assist with finalising the changes.

The scope of the changes included:

- increase in the level of airborne sound insulation for walls/floors separating dwellings/sole-occupancy units.
- introduction of impact sound insulation requirements for floors separating dwellings/sole-occupancy units.
- introduction of field testing as an option for verifying compliance of walls/floors.
- sound insulation requirements for services extended to cover water supply pipes, duct work and storm water pipes.

Queensland, Western Australia and the Northern Territory have not adopted the new requirements. The previous requirements continue to be applicable in these States/Territories.

Background

The Building Code of Australia

The BCA is produced and maintained by the Australian Building Codes Board (ABCB) on behalf of the Australian Government and each State and Territory Government. It is a performance based code, which sets out the level of performance that the building is to achieve. In most cases, it also gives a prescriptive solution (i.e. Deemed-to-Satisfy).

The BCA is prepared and written on the basis that it is the uniform set of technical provisions for the design and construction of buildings and other structures throughout Australia.

The BCA contains 2 volumes. Volume One covers Class 2 – 9 buildings, and Volume Two covers Class 1 and 10 buildings.

Each State and Territory has its own building control legislation that references the BCA as the technical standard that specifies the requirements for the design and construction of buildings. The State or Territory legislation is generally administrative and does not contain technical requirements.

The building control authority within each State and Territory determines the application of the BCA within its jurisdiction. The manner of application and administrative arrangements differ between the States and Territories due to recognition of local influences.

The States and Territories may also vary the technical provisions of the BCA. These variations are included in the BCA as State and Territory Appendices and are given legal effect by the relevant State or Territory building control legislation.

Because of these differences between the States and Territories, there are different criteria or 'triggers' for how the BCA applies to buildings. Essentially the BCA applies to -

- All new buildings.
- New building work in existing buildings, such as additions and alterations.
- Existing buildings that are to be used for a purpose different from that for which they

were originally designed (often referred to as a "change of use").

BCA Sound Insulation Provisions

The BCA sound insulation provisions apply to Class 2, 3 and 9c buildings. The requirements also apply to attached Class 1 buildings. Generally a Class 1 building is a single dwelling, such as a detached house or an attached house (i.e. townhouse, terrace house, etc.). Class 1 buildings also include smaller type buildings where unrelated persons live, such as boarding houses, hostels and guest houses. A Class 2 building is a building such as an apartment building or block of flats. Class 3 building covers buildings, such as hotels, motels larger type boarding houses and aged care buildings where low levels of care are provided. A Class 9c building is an aged care building where levels of care ranging from low to high are provided.

There have recently been concerns with the BCA sound insulation requirements, particularly with Class 1a and 2 buildings where people may have made a major investment to purchase or may have entered a long term lease. Once they are in residence, they may find the sound insulation to be below expectation.

It could be argued that with commercial short-term accommodation such as hotels, motels and tourist hostels, there is some degree of self-regulation by the market. Further, food preparation and clothes washing areas are less likely within a Class 3 building unit.

There has also been a dramatic increase in recent years in the number of people living in both low and high rise apartments and in attached Class 1a houses such as townhouses. This is particularly the case in major cities and other large population centres throughout Australia. In addition, many commercial buildings in major cities have been converted into residential accommodation.

Associated with this increase in higher density residential living has been a corresponding increase in the number of complaints being received from the building occupants about the high sound levels being transmitted through adjoining floors and walls. There have also been some complaints about sound coming from service pipes and duct work.

According to information provided by the Home Unit Owners Association, investigations by members of the Australian Association of Acoustical Consultants and recent media attention, complaints and litigation are on the increase. Where fault has been found, it has generally resulted in high rectification costs. In other instances, it has not been possible to resolve the dispute because the provisions of the BCA had been achieved even though the owner is of the view that the sound penetration is unacceptably high.

Some of the sound passing through adjoining walls and floors can be attributed to inferior practices and poor quality workmanship. However, there is strong evidence that the principal reasons for the complaints were that the insulation levels specified in the BCA were no longer relevant to current lifestyles and modern appliances.

It should be noted that the BCA sets minimum acceptable standards and that the building industry may provide higher levels by using better performing systems. However, the latter is only likely to occur in more prestigious developments where greater attention may be paid to sound insulation design or where there may be high quality control during construction.

The BCA provisions have received considerable criticism in the press over recent years and many Councils, particularly in NSW, have imposed higher standards. A number of Councils in Sydney have adopted criteria considerably more demanding than that of the BCA.

In other developed countries, building control authorities had already adopted higher minimum levels than those that were required by the BCA.

ABCB Sound Insulation Project

Due to the concerns raised about the BCA sound insulation provisions, the ABCB undertook a review of the requirements applicable to Class 1, 2 and 3 buildings. The requirements for Class 9c aged care buildings were not considered. The conclusion of the review was that the BCA sound insulation requirements were not meeting community expectations and that the provisions needed to be amended.

The review and development of the changes were conducted in consultation with peak professional and industry organisations. The ABCB's Building Codes Committee (BCC) also had significant input into the development of the provisions. The BCC is the ABCB's peak technical advisory body and has responsibility for providing technical advice on reforming, maintaining and upgrading the technical content of Australia's building codes and standards. The BCC's membership includes representatives of the Australian Government, State and Territory Government agencies responsible for building regulatory matters along with members of industry.

As part of the development of the sound insulation requirements, proposals to amend the provisions were released for public comment on three separate occasions. A Regulation Document (RD) was released in January 2001, a combined RD and Regulatory Impact Statement (RIS) was released in May 2001 and an amended RD/RIS in February 2002. A final RD/RIS was released in April 2004. All of these documents are available from the ABCB web-site (www.abcb.gov.au).

The Office of Regulation Review has written to the Board stating its satisfaction with the April 2004 RIS methodology.

Over 80 submissions were received on the February 2002 RD/RIS. In April 2002, the ABCB held a forum with key stakeholders to identify and resolve the key issues. The forum was attended by 49 people representing the range of views expressed in the submissions.

Significant outcomes from the forum included:

- Agreement that a change to the BCA provisions were warranted.

- General support for the levels of sound insulation proposed in the February 2002 RD/RIS.
- Identification of technical matters to be resolved before amending the BCA.
- An identified need for an industry-developed (ABCB coordinated) guideline to assist in achieving compliance with the BCA.

The ABCB also undertook to consult with industry when developing the BCA Deemed-to-Satisfy methods. The Deemed-to-Satisfy methods are contained in Specification F5.2 of Volume One and Table 3.8.6.2 of Volume Two, and are wall/floor systems that have been tested in the laboratory in accordance with the relevant standards, and meet the BCA sound insulation requirements.

Scope of Changes

The changes affected the BCA sound insulation requirements applicable to Class 1, 2 and 3 buildings. The following explains the changes in general terms.

Addition of Spectrum Adaptation Factor

Spectrum adaptation factors are commonly used to compensate for the fact that certain kinds of sounds are more readily transmitted through insulating materials than others. ISO 717-1 [2], which is reproduced as AS/NZS 1276.1 [3], sets out testing methodologies for the sound insulation properties of building elements and incorporates these factors and explains their use.

Under the previous BCA requirements for airborne sound insulation, the weighted sound reduction index (R_w) of a building element was the only consideration. On advice from industry, the adaptation factor C_{tr} has now been introduced for most building elements which require an airborne sound insulation rating. The only exception is a wall which separates a dwelling from a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification.

Therefore, both the C_{tr} factor and the R_w of the building element need to be considered in most cases.

The C_{tr} factor takes into account lower frequency level sounds, and was chosen in large part in recognition of the problem of the high bass frequency outputs of modern home theatre systems and music reproduction equipment.

Adopting C_{tr} is also likely to minimise inconsistencies between laboratory test results and on-site test results.

C_{tr} is a negative number which means that the $R_w + C_{tr}$ of a building element will be less than the R_w of the building element. For example a wall system may have an R_w of 55 but would have an $R_w + C_{tr}$ of 50 if the C_{tr} value was -5.

The C_{tr} for a building element varies according to the insulating material employed. For example a 90 mm brick cavity wall has a C_{tr} value of around -6, as does a wall constructed of 150 mm core-filled concrete blocks. By contrast, a double cavity masonry/plasterboard wall has a C_{tr} of around -12.

Increase in Levels of Airborne Sound Insulation

The previous BCA Deemed-to-Satisfy Provisions for airborne sound insulation were:

- R_w not less than 45 for walls between dwellings and between dwellings and other parts of the building; and
- R_w not less than 50 for walls between a bathroom, sanitary compartment, laundry or kitchen in one dwelling and a habitable room (other than a kitchen) in an adjoining dwelling; and
- R_w not less than 45 for floors between dwellings.

There has been some confusion about whether the above requirements were for what should be achieved in the laboratory or what should be achieved on-site. The new BCA Deemed-to-Satisfy Provisions increase the levels of airborne sound insulation and now make it clear that the Deemed-to-Satisfy Provisions apply to wall/floor systems that are tested in the laboratory. For airborne sound insulation the new requirements are:

- $R_w + C_{tr}$ not less than 50 for walls between dwellings; and
- R_w not less than 50 for walls separating a dwelling from a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification; and
- $R_w + C_{tr}$ not less than 50 for floors between dwellings and between dwellings and a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification (i.e. retail, office area, etc.).

The scope of the provisions for airborne sound insulation have been extended slightly as the requirements now apply to floors which separate a dwelling from a plant room, lift shaft, stairway, public corridor, public lobby or the like. Also, the requirements now apply to a wall or floor which separates a dwelling from parts of a different classification.

Quantification of Floor Impact Sound Insulation Ratings

The previous BCA sound insulation Performance Requirements for floors made reference to floors providing insulation against impact generated sound. However, unlike the requirements for walls, there was no corresponding Deemed-to-Satisfy Provision to establish compliance.

The ABCB received advice from various sources that the Deemed-to-Satisfy Provisions in this area were inadequate as they did not provide guidance as to what was required to meet the Performance Requirement. Anecdotal evidence suggested that complaints were

being received, particularly in relation to wet areas or uncarpeted living areas that are above sleeping areas.

Consequently, the Deemed-to-Satisfy Provisions have introduced impact sound insulation requirements for floors. The terms to describe the impact sound insulation of the floor is the weighted normalised impact sound pressure level ($L_{n,w}$) plus the spectrum adaptation term (C_I). The lower the $L_{n,w} + C_I$ of the floor, the better the performance of the floor in terms of impact sound insulation.

The new BCA Deemed-to-Satisfy Provisions require the $L_{n,w} + C_I$ of a floor to be determined by testing in the laboratory. The impact sound insulation requirements for floors are:

- $L_{n,w} + C_I$ 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.

Increase in Impact Requirements for Walls

The previous BCA Deemed-to-Satisfy Provisions required walls separating a bathroom, sanitary compartment, laundry or kitchen in one dwelling from a habitable room (other than a kitchen) in an adjoining dwelling, to provide a satisfactory level of insulation against impact sound. The options for compliance were for the wall to:

- be in accordance with Table F5.5. Table F5.5 listed 3 wall systems which were deemed to have satisfactory level of resistance to impact sound; or
- for other than masonry, be 2 or more separate leaves without rigid mechanical connection except at the periphery; or
- be no less resistant to the transmission of impact sound when tested in accordance with Specification F5.5 than a wall listed in Table F5.5.

The impact sound insulation requirements for walls have changed slightly. The application of the requirements has not changed, however walls which require impact sound insulation must now be of discontinuous construction. For the purpose of the BCA, discontinuous construction means a wall having a minimum 20 mm cavity between two separate leaves, with no mechanical linkage between the leaves except at the periphery. For masonry wall systems, resilient wall ties are not considered to be mechanical linkage.

Wall systems using staggered studs on common plates are not considered to be discontinuous construction.

Provision of On-site Testing

The previous BCA Deemed-to-Satisfy Provisions did not include requirements for on-site testing of building elements. The changes now provide a means of verifying compliance on-site. This is one way of verifying a performance approach (Alternative Solution). An Alternative Solution must be assessed according to one or more of the Assessment Methods as defined in the BCA. These Assessment Methods are:

- Documentary Evidence as described in Clause A2.2 of the BCA.
- Verification Methods
- Expert Judgement
- Comparison to Deemed-to-Satisfy Provisions

The on-site testing requirements appear as Verification Methods FV5.1 and FV5.2 in Volume One and Verification Method V2.4.6 in Volume Two. For Class 2 and 3 buildings, FV5.1 relates to floors and has requirements for both airborne and impact sound insulation while FV5.2 covers requirements for walls and only considers airborne sound insulation. For Class 1 buildings, Verification Method V2.4.6, like FV5.2, covers requirements for walls and only considers airborne sound insulation.

There is no Verification Method for verifying the impact sound insulation performance of walls on-site as there is not currently an accepted test method available. Therefore, where a wall requires impact sound insulation, the wall can be discontinuous construction. Alternatively, if appropriate an Alternative Solution could be developed using one of the Assessment Methods outlined above i.e. expert judgement, comparison to the Deemed-to-Satisfy Provisions, etc.

The terms to describe the airborne sound insulation rating of a building element when tested on-site, is the weighted standardised level difference ($D_{nT,w}$) plus the spectrum adaptation term (C_{tr}). $D_{nT,w}$ is similar to R_w, whilst the purpose of C_{tr} is explained previously in this paper. The higher the $D_{nT,w} + C_{tr}$ of a building element, the better the performance of the building element in terms of airborne sound insulation.

For building elements tested on-site, the airborne sound insulation requirements are as follows:

- $D_{nT,w} + C_{tr}$ not less than 45 for walls between dwellings; and
- $D_{nT,w}$ not less than 45 for walls separating a dwelling from a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification; and
- $D_{nT,w} + C_{tr}$ not less than 45 for floors between dwellings and between dwellings and a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification.

It should be noted that the level of airborne sound insulation that the wall needs to achieve on-site, is less than that required for a building element tested in the laboratory. The lower requirement for elements tested on-site reflects the fact that on-site airborne sound insulation performance is generally less than laboratory tested samples due to the penetration of pipes, doors, and possibly less than exact standards of workmanship.

There are also "flanking sound" considerations. Flanking sounds are where noise is able to pass through an element via wall/floor junctions, cross walls or service penetrations. Thus, the on-site testing requirement has been set with the objective of ensuring that the stringency of this requirement is, as near as possible, equal to that of the laboratory testing requirement. The differential proposed between laboratory and on-site testing standards, accords with advice from the acoustics industry. In this context it can be noted that the USA International Building Code also has a 5-unit concession for on-site testing.

The terms to describe the impact sound insulation rating of a floor when tested on-site, is the weighted standardised 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 $L_{n,w} + C_I$ (see Quantification of Floor Impact Sound Insulation Ratings). For floors tested on-site, the impact sound insulation requirements are as follows:

- $L'_{nT,w} + C_I$ 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.

Doors

The new provisions have introduced requirements for dwelling entry doors where the entry door adjoins an enclosed common area within the building, e. g. hallway, and stairway. If a door assembly is located in a wall that separates a sole-occupancy unit from a stairway, public corridor or the like, the door assembly must achieve a certain level of airborne sound insulation. For a door assembly tested in the laboratory, this level of sound insulation is R_w not less than 30, and for a door assembly tested on-site the level of airborne sound insulation is $D_{nT,w}$ not less than 25. For a door assembly located in a wall that separates 2 dwellings, the door assembly must meet the requirements prescribed for the wall, i.e. $R_w + C_{tr}$ not less than 50 or $D_{nT,w} + C_{tr}$ not less than 45.

Services

The BCA Performance Requirements for sound insulation previously specified that the required sound insulation of walls and floors must not be compromised by the incorporation or penetration of a pipe or other service element. The BCA Deemed-to-Satisfy Provisions had some requirements to deal with piping, but these requirements only dealt with soil and waste pipes.

The changes have extended the Deemed-to-Satisfy Provisions so that they also cover water supply pipes, duct work and storm water pipes. The level of acoustic performance that water supply pipes, duct work and storm water pipes must meet are as per the requirements for soil and waste pipes. The requirements for soil, waste, water supply pipes and duct work apply only where these elements pass through more than one dwelling. The requirements for storm water pipes apply to any pipe that passes through a dwelling in a Class 2 or 3 building.

Deemed-to-Satisfy Methods

The Deemed-to-Satisfy Provisions in Volume One of the BCA and the acceptable construction practice in Volume Two had tables listing the R_w for some common forms of construction. The tables were included in the BCA to give practitioners details of some forms of construction that meet the sound insulation requirements. Therefore practitioners using the prescriptive (Deemed-to-Satisfy) BCA requirements had the option of using a system listed in these tables, or using a system that had been tested in the laboratory in accordance with the appropriate test.

In light of the changes, these tables have been updated to list wall and floor systems which comply with the new requirements.

Case Study

Due to the proposed changes there are a number of methods to determine compliance with the proposed BCA sound insulation Performance Requirements. For example, any one of the following ways could achieve compliance for a new apartment building:

Option 1 – Prescriptive Approach – Deemed-to-Satisfy Provisions

The developer could use a prescriptive approach and comply with the BCA Deemed-to-Satisfy Provisions. As an apartment building is typically a Class 2 building, the building would need to comply with the sound insulation provisions of Volume One. The developer would need to install wall/floor systems that achieve the levels set out below:

- Walls between apartments would require an $R_w + C_{tr}$ not less than 50 when tested in the laboratory.
- Walls between an apartment and a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification would, require an R_w not less than 50 when tested in the laboratory.
- Door assemblies located in a wall between an apartment and a stairway, public corridor, public lobby or the like, would require an R_w not less than 30 when tested in the laboratory.
- Walls between a bathroom, sanitary compartment, laundry or kitchen in one apartment, and a habitable room (other than a kitchen) in an adjoining apartment would need to be discontinuous construction.
- Floors between apartments and between an apartment and another part of the building

would require a $R_w + C_{tr}$ not less than 50 and a $L_{n,w} + C_I$ not more than 62, when tested in the laboratory.

The developer could use-

- wall/floor systems that have been verified by laboratory testing as achieving the above levels; or
- wall/floor systems described in the BCA that meet the above levels.

Option 2 – Performance Approach – Verification Methods

The developer could use a performance approach, where compliance is to be checked using the Verification Methods. The Verification Methods relevant to a Class 2 building are FV5.1 and FV5.2. The Verification Methods require the following:

- Walls between apartments would require a $D_{nT,w} + C_{tr}$ not less than 45 when tested on-site.
- Walls between an apartment and plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification, would require a $D_{nT,w}$ not less than 45 when tested on-site.
- Door assemblies located in a wall between an apartment and a stairway, public corridor, public lobby or the like, would require a $D_{nT,w}$ not less than 25 when tested on-site.
- Floors between apartments and between an apartment and another part of the building, would require a $D_{nT,w} + C_{tr}$ not less than 45 and an $L'_{nT,w} + C_I$ not more than 62 when tested on-site.

There is no Verification Method for satisfying the Performance Requirement FP5.2(b). This requirement requires a wall separating a bathroom, sanitary compartment, laundry or kitchen in one apartment from a habitable room (other than a kitchen) in an adjoining apartment to have resistance to impact generated sound.

The options for compliance for walls in this situation would be to comply with the Deemed-to-Satisfy Provisions (i.e. discontinuous construction) or develop an Alternative Solution using one of the Assessment Methods outlined in the BCA, i.e. expert judgement, comparison to Deemed-to-Satisfy, etc.

Option 3 – Performance Approach – Checking of Compliance

The developer could use a performance approach where compliance is checked using:

- Documentary Evidence as described in A2.2 of the BCA; or
- Expert Judgement; or
- Comparison to Deemed-to-Satisfy Provisions.

An example of Documentary Evidence would be the use of a wall or floor system which has a Certificate of Accreditation or Certificate of Conformity. A Certificate of Accreditation is a certificate issued by a State or Territory accreditation authority stating that the properties and performance of a building material, or method of construction or design, fulfill specific requirements of the BCA. A Certificate of Conformity is similar to a Certificate of Accreditation however, it can only be issued by the ABCB.

An example of Expert Judgement would be the use of a wall or floor system that meets the sound insulation Performance Requirements as determined by an appropriately qualified and experienced person.

An example of comparison with the Deemed-to-Satisfy Provisions could be the use of a test method that is not referenced by the BCA. If it is demonstrated that the test method is suitable for the particular application, a Deemed-to-Satisfy wall or floor system could be tested, followed by testing of a system that the developer wishes to use. If testing the wall or floor system shows that the system is no less resistant to sound than the Deemed-to-Satisfy system, it could be deemed that the system is comparable and therefore meets the Performance Requirement.

Conclusions

The changes to the BCA sound insulation provisions are significant and will contribute to the BCA sound insulation requirements better meeting community expectations. The new measures have generally increased the levels of sound insulation, introduced impact requirements for floors, extended the scope of the requirements for services and introduced the option of on-site testing to verify compliance.

References

[1] Australian Building Codes Board, “Building Code of Australia 2004”

[2] International Organization for Standardization ISO717.1–1996. Acoustics – Rating of sound insulation in buildings and of building elements Part 1: Airborne sound insulation.

[3] Standards Australia AS/NZS1276.1-1999. Acoustics – Rating of sound insulation in buildings and of building elements Part 1: Airborne sound insulation.