Fire resistance and acoustic properties

Fire resistance and acoustic properties

Fire resistance levels are specified in the Building Code of Australia (BCA). This system provides an accurate method of predicting the ability of a wall to maintain its strength in a fire and to resist the spread of the fire.

The fire resistance level (FRL) specifies the fire resistance periods (FRP) for structural adequacy, integrity and insulation. These components can be defined as:

- **Structural Adequacy -** The ability of a wall to continue to perform its structural function.
- **Integrity -** The ability of a wall to maintain its continuity and prevent the passage of flames and hot gases through cracks in the wall.
- **Insulation -** The ability of a wall to provide sufficient insulation, such that the side of the wall away from the fire does not exceed a predefined rise in temperature.

The fire resistance level is expressed in minutes and lists the three components in the same order as they are given above. For example, an FRL of 90/90/90 means a minimum fire resistance period of 90 minutes each for structural adequacy, integrity and insulation. FRL's can be determined from Australian Standard AS 3700 (Masonry Structures) or by testing in accordance with AS 1530.4.

The fire resistance level of a wall depends not only on the thickness of the wall but also on its height, length and boundary conditions (i.e. how it is connected to other building elements). For this reason, it is impossible to give a FRL for a particular brick.

STRUCTURAL ADEQUACY

The fire resistance period for structural adequacy is specific to the wall type and its boundary support conditions. The CBPI publication, Design Manual 5, Fire Resistance Levels for Clay Brick Walls provides charts for determining the

structural adequacy of common wall types. The manual allows designers to assess the fire resistance level for a specific wall type and enables the FRP for structural adequacy to be directly read from a series of charts.

INTEGRITY

The fire resistance level for integrity is the lesser of the values achieved for structural adequacy and insulation. That is, the required fire resistance for integrity is met if the level is met for structural adequacy and insulation.

INSULATION

The fire resistance level for insulation is determined by the material thickness of the wall, as shown in the table below:

The material thickness is a function of the type of masonry unit. Masonry units are classified as:

Material thickness (mm)	60	90	110	130	160	180
Fire resistance period for insulation (mins)	30	60	90	120	180	240

Solid or cored units
If they have voids with a volume of less than 30%. This classification includes units with frogs. The material thickness for a solid or cored unit is the actual thickness of the units in the wall. For example, a 110mm solid or cored brick will give a 90 minutes fire resistance period for insulation, using the table above.

Hollow units
If they have voids with a volume greater than 30% The material thickness of a hollow unit is calculated as the net volume of the units divided by the area of the exposed unit. For example, the equivalent material thickness of a brick of dimensions 230mm x 119mm x 110mm containing 35% coring can be calculated as below:

Net volume = 230 x 119 x 110
x (100-35)% = 1956955mm3

Area of exposed vertical face of the unit = 230 x 119
= 27370mm2

Equivalent material thickness = 1956955 / 27370 = 71.5mm

Therefore, the corresponding fire resistance period for insulation is 30 minutes (from the table above). In contrast, a solid or cored unit of the same size has the much higher value of 90 minutes.In addition, the type of wall impacts on the material thickness. For a single leaf wall the material thickness is based upon the type of unit used, as described previously. The material thickness for a cavity wall is equal to the sum of the material thicknesses of the separate leaves.

For example, the FRP for insulation for a cavity wall built with 90mm solid or cored bricks will be 240 minutes as the material thickness is 2 x 90mm = 180mm. Whereas, a single leaf of 90mm solid or cored bricks has a FRP of 60 minutes.

Note: the FRP is 240 minutes for materials with thicknesses over 180mm.

CHASING AND RECESSES

Chasing and recesses can affect the fire resistance periods for a wall. Refer to the CBPI Manual 5, Fire Resistance Levels for Clay Brick Walls for further details on when chasing and recesses must be considered.

ACOUSTIC PROPERTIES

Sound Transmission Measurements
The Building Code of Australia (BCA) requires that building elements have certain levels of insulation from airborne noise and impact sound. The weighted sound reduction index (Rw) describes the acoustic performance of a construction system. It is a single number quantity for the airborne sound insulation rating of building elements. As the acoustic performance of a material or construction improves, the higher the Rw value will be.

Rw ratings are determined by laboratory tests of a specimen of the construction system. The specimen is fixed within a frame to form the wall between two test chambers. A high noise level is generated in one room and the difference in sound level between the source room and the receiver room represents the transmission loss through the test specimen. The measurements are conducted over a range of sound frequencies. The Rw rating is then determined by comparing the results with reference curves.

Corection Factor	Type of Noise Source
C	Living activities (talking, music, radio, TV) Railway traffic at high speeds Highway road traffic (>80km/h) Jet aircraft at short distance High and medium frequency factory noise
C_{tr}	Urban road traffic Railway traffic at low speeds Propeller driven aircraft Jet aircraft at large distance Low and medium frequency factory noise

Correction factors (C and C_{tr}) can be added to Rw to take into account the characteristics of particular sound spectra and indicate the performance drop of the wall in the corresponding sound frequency range. The factor C relates to mainly mid to high frequency noise, whilst Ctr relates to lower to medium frequency noise. Some typical noises have been grouped by their corresponding correction factor in the table (left).

The weighted sound reduction index is quoted as $R_w(C,C_{tr})$, where C and C_{tr} are correction factors representing different noise sources. As an example, if a wall is measured as R_w 54(-1,-4) the value of the index when the lower frequency correction factor (C_{tr}) is applied is:

$R_w + C_{tr} = 54 + (-4)\ R_w + C_{tr} = 50.$

In practice, any small gaps and cracks which permit even minor air leakage will provide a means for sound transmission, leading to lower field performance. This degradation should be recognized and an appropriate allowance made when selecting a tested system to achieve a particular Rw rating when installed.

The sound transmission class (STC) was the method that was used previously to measure acoustic performance. The requirements of the BCA have changed to comply with international regulations and Rw is now used. The STC was based on different criteria and did not include any correction factors.

BUILDING CODE OF AUSTRALIA REQUIREMENTS

The noise levels received from adjoining premises are dependant upon the level and type of noise generated and the acoustic performance of the construction between the two dwellings. The BCA requires that the R_w and $R_w + C_{tr}$ should be determined in accordance with AS/NZS 1276.1 using results from laboratory measurements.

The Building Code of Australia (BCA) classifications for acoustic performance are categorized based on the building type.

Class 1 buildings include single dwellings that do not have another dwelling above or below it, such as a stand-alone house or a row of townhouses. Class 2 buildings include buildings that contain two or more sole-occupancy units, such as an apartment unit. Class 3 buildings include residential buildings that contain a number of unrelated persons, such as a guest house or the residential part of a school, hotel, etc. Aged care buildings are classified as Class 9c.

The BCA should be referred to for more detail on these and other classifications.

REQUIREMENTS FOR NEW SOUTH WALES, VICTORIA, SOUTH AUSTRALIA, TASMANIA, WESTERN AUSTRALIA

Note: These requirements came into effect from the 1st of May, 2004, except for Western Australia where they came into effect from the 1st of May, 2005.

Common walls separating Class 1 buildings are required to have an $R_w + C_{tr}$ of not less than 50. In addition, the construction must be discontinuous, if the wall separates a habitable room (living room, dining room, bedroom, study and the like) from a wet room (kitchen, bathroom, sanitary compartment or laundry). Discontinuous construction requires:

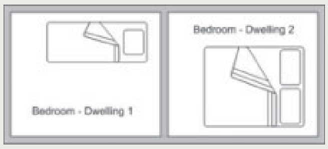
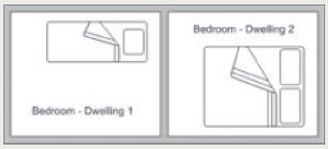
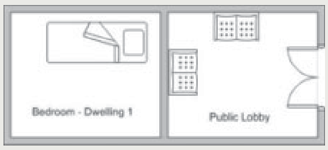
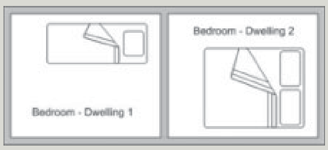
- A minimum 20mm cavity between two separate leaves
- If required, in masonry walls resilient wall ties such as those provided by Matrix Industries should be used, and
- No mechanical linkage if the leaves are not masonry.

Walls in Class 2 or 3 buildings that separate sole-occupancy units must have an $R_w + C_{tr}$ of not less than 50. In addition, if the wall separates a habitable room in one sole-occupancy unit from a wet room in another sole-occupancy unit the construction must be discontinuous. The BCA also requires that walls in Class 2 or 3 buildings that separate a sole-occupancy unit from a plant room, lift shaft, stairway, public corridor, public lobby or the like must have an R_w of not less than 50. If the wall separates the sole-occupancy unit from a plant room or a lift shaft, the construction must be discontinuous.

In Class 9c buildings, walls separating sole-occupancy units must have an R_w of not less than 45. Walls separating a sole- occupancy unit in a Class 9c building from a kitchen, bathroom (not including an associated ensuite), laundry, plant room or utilities room must have an Rw of not less than 45. In addition, walls separating a sole-occupancy unit from a laundry or a kitchen must have satisfactory impact sound resistance. A summary of the BCA's requirements is given below.

Note: Impact sound insulation is determined by laboratory testing. A 'tapping machine' is set to operate on a horizontal steel plate which rests against the test specimen. The sound transmission through the wall is then measured and normalized using a reference equivalent absorption area. Adequate impact sound insulation is achieved if the performance of the test specimen is equivalent to, or better than, the performance of deemed-to-satisfy construction under the same test conditions.

In addition, the BCA requires that soil and waste pipes in a Class 1, 2 or 3 building must have a minimum R_w of 40 if adjacent to a habitable room (but not the kitchen). Or, a minimum Rw of 25 if the pipes are adjacent to a kitchen, bathroom, laundry or the like.

Building Class	Construction	Requirement
Class 1	Habitable - Habitable 	$Rw + C_{tr} \geq 50$
Class 1	Habitable - Wet 	$Rw + C_{tr} \geq 50$ With discontinuous construction
Class 2 or 3	Habitable - Habitable 	$Rw + C_{tr} \geq 50$
Class 2 or 3	Habitable - Wet 	$Rw + C_{tr} \geq 50$ With discontinuous construction
Class 2 or 3	Sole-Occupancy - Public Area 	$Rw \geq 50$ With discontinuous construction (if lift shaft or plant room)
Class 9c	Sole Occupancy Unity - Sole Occupancy Unit 	$Rw \geq 45$
Class 9c	Sole Occupancy - Wet 	$Rw \geq 45$ With satisfactory impact resistance (refer to note) if laundry or kitchen.

REQUIREMENTS FOR QUEENSLAND AND THE NORTHERN TERRITORY

Common walls separating Class 1 buildings in the Northern Territory or Queensland are required to have an R_w of not less than 45 if the rooms separated are habitable. Whilst, a separating wall between a habitable room and a wet room is required to have an R_w of not less than 50, with satisfactory impact resistance.

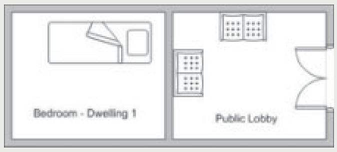
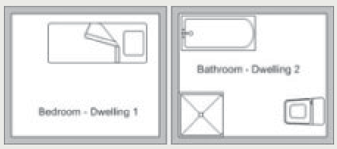
Walls in Class 2 or 3 buildings in the Northern Territory or in Queensland, that separate sole-occupancy units must have an R_w of not less than 45. If the wall separates a habitable room in one sole-occupancy unit from a wet room in another sole-occupancy unit the construction must have an Rw of not less than 50, with satisfactory impact resistance. The BCA also requires that walls in Class 2 or 3 buildings that separate a sole-occupancy unit from a plant room, lift shaft, stairway, public corridor, public lobby or the like must have an Rw of not less than 45.

Walls separating sole-occupancy units in Class 9c buildings in the Northern Territory or Queensland, must have an R_w of not less than 45. Walls separating a sole-occupancy unit in a Class 9c building from a kitchen, bathroom (not including an associated ensuite), laundry, plant room or utilities room must have an R_w of not less than 45. In addition, walls separating a sole-occupancy unit from a laundry or kitchen must have satisfactory impact sound resistance.

A summary of the requirements for the Northern Territory and Queensland is given below.

Note: Impact sound insulation is determined by laboratory testing. A 'tapping machine' is set to operate on a horizontal steel plate which rests against the test specimen. The sound transmission through the wall is then measured and normalized using a reference equivalent absorption area. Adequate impact sound insulation is achieved if the performance of the test specimen is equivalent to, or better than, the performance of a cavity brick construction of two leaves of 90mm bricks under the same test conditions.

In addition, the BCA requires that soil and waste pipes in a Class 1, 2 or 3 building must have a minimum R_w of 45 if adjacent to a habitable room (other than the kitchen). Or, a minimum Rw of 30 if the pipes are adjacent to a kitchen, bathroom, laundry or the like.

Building Class	Construction	Requirement
Class 1, 2 or 3	Habitable - Habitable 	Rw ≥ 45
Class 1, 2 or 3		Rw ≥ 50 With satisfactory impact resistance (refer to note)
Class 2 or 3		Rw ≥ 45
Class 9c		Rw ≥ 45
Class 9c		Rw ≥ 45 With satisfactory impact resistance (refer to note) if laundry or kitchen.

ACHIEVING THE REQUIRED ACOUSTIC PERFORMANCE

The performance requirement of the BCA can be satisfied by:

- Building a deemed-to-satisfy wall as specified in the BCA
- Demonstrating compliance by laboratory testing of an exact construction, or
- Demonstrating compliance by performing field testing

The Rw figures presented in the following examples of deemed to satisfy walls are the lowest bound results. Further details of these walls can be found in the BCA. Walls built of specific clay bricks may have better performance, as indicated by the manufacturer from individual tests.

It is important to recognize that bricks from different manufacturers and manufactured in different plants give different results. To allow for these differences Austral BricksTM tests each state's products separately.

As such, the results provided by Austral Bricks are specific only to the state in which they were tested and are not transferrable to products manufactured outside that state or to another company's products.

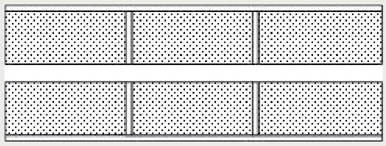
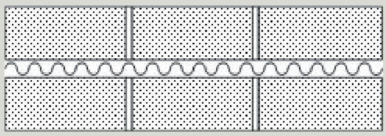
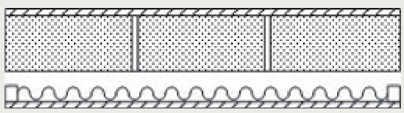
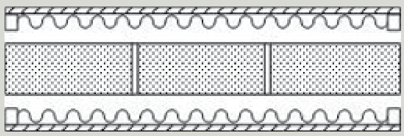
Direct fixing of plasterboard to single skin masonry walls reduces the acoustic performance of the walls. Plasterboard needs to be fixed on resilient mounted furring channels or on a separated stud wall on one side of the wall, to avoid deterioration of the R_w rating.

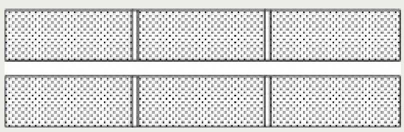
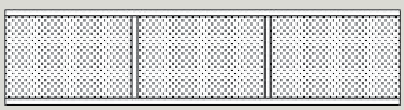
Rendering one or both sides of a wall increases the R_w rating primarily because the render seals the fine pores in the brickwork and eliminates partially filled mortar joints. In addition, a layer of 13mm render increases the mass of thewall thereby increasing the acoustic performance.

The application of a layer of 13mm render to one side of the wall is predicted to give an increase of 1 in the overall R_w rating of the construction. In a CSIRO technical study, the tested performance was much better than this prediction, which indicates that factors other than just the mass of the structure play a part in the effect of applying a surface finish to a wall.

Once one side of a wall has been rendered, little acoustic benefit will be gained by rendering the other side. This is largely due to the fact that the relative increase in the mass is small compared to the overall mass of the structure and also because the initial benefit of sealing the pores of the brickwork has already been largely achieved by the first layer of render.

For highly porous masonry wall constructions, sealing one side with an application of a cement-based paint will also result in a noticeable increase in acoustic performance.

BCA Deemed-To-Satisfy Examples of Rw + Ctr ≥ 50	
	**Cavity Brickwork** 2 leaves of 110mm clay brick masonry with a 50mm cavity and 13mm render on both sides
	**Cavity Brickwork** 2 leaves of 110mm clay brick masonry with a 50mm cavity and 50mm glass wool or polyester insulation in the cavity
	**Single leaf 110mm Brickwork** Plasterboard directly fixed to one side with a separating stud (70 x 35mm timber stud or 64mm steel stud) at 600 centres spaced 20mm from wall with insulation and plasterboard fixed to the other side
	**Single leaf 110mm Brickwork** Plasterboard directly fixed to one side with a separating stud (70 x 35mm timber stud or 64mm steel stud) at 600 centres spaced 20mm from wall with insulation and plasterboard fixed to the other side

BCA Deemed-To-Satisfy Examples of Rw ≥ 50	
	**Cavity Brickwork** 2 leaves of 90mm clay brick masonry with a 40mm cavity
	**Single Leaf of 150mm Brickwork** With 13mm cement render on each face

CONSTRUCTION DETAILS TO ACHIEVE MAXIMUM PERFORMANCE

For a wall to achieve its optimum acoustic performance, the construction must be solid without gaps through which air, and therefore sound, can pass. Masonry units must be laid with all joints filled solid including those between the masonry and any adjoining construction. Flanking transmission (through unfilled joints and gaps) is the major reason so many wall constructions fail to achieve their tested performance when in the field. Even a very small penetration will dramatically reduce the insulation performance of a wall. This is one reason why it is beneficial

to finish masonry wall construction with render, or a cement-based paint. The render or paint acts as a sealant for the porous masonry and also fills any weaknesses in the mortar joints.

Another common sound path occurs at wall junctions such as at floor or ceiling level and also at the intersection with another wall. Larger voids should be solidly backfilled with mortar. However, where this is difficult to carry out successfully, an expanding foam sealant which is non-shrinking, durable and has a long life span, can be injected into the gap.

To maximize the acoustic performance of a masonry wall, it is important to avoid the following:

- gaps and cracks through which sound can pass
- gaps around service penetrations
- poorly sealed doorways
- back-to-back power outlets and cupboards
- chasing for services

Contact Austral's Technical Department for acoustic performance results and for any further information.