Acoustic benefits of 'solid' construction

Cement and Concrete Association of Australia

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Introduction

When people purchase units, apartments or flats, the furthest thing from their minds is probably the issue of acoustics. Display units and houses do not have noisy neighbours with loud steroes, TVs and parties. It's not until they move in and are faced with these everyday living issues that the importance of acoustics within units and – more importantly – acoustic insulation from their neighbours, becomes obvious. Increasingly, owners are demanding better acoustic performance of the separating walls and floors, to allow them to sleep, rest and engage in normal domestic activities in what they consider to be satisfactory conditions.

Solid walling systems such as concrete and concrete and clay masonry effectively provide this important acoustic insulation. Innovative new systems can economically achieve ratings of 60 to 65 dB, enabling the most stringent requirements to be met.

Solid construction options such as concrete and concrete and clay masonry perform well in insulating against airborne sounds due to their mass.

This data sheet summarises the acoustic requirements for walls and floors in medium density residential buildings and outlines the ways that solid construction methods can easily and cost effectively meet them.

Transmission of Sound

Sound Sources Two types of sound sources can produce the noise (or unwanted sounds) heard in an adjacent dwelling: *airborne sources* such as speech, musical instruments and loudspeakers and *impact sources* such as footsteps, furniture moving and some appliances.

Airborne Sounds Airborne sounds consist of successive pressure waves or vibrations, which are transmitted through the surrounding air. They can not travel through walls or floors, but set up vibrations in them. The vibration of these elements causes the air on the other side to vibrate, and it is these new airborne vibrations that transmit the sound.

The more mass contained in the wall or floor, the harder it is to set up vibrations in it, and hence the harder it is to transfer sound from one side to the other.

Solid construction options such as concrete and concrete and clay masonry perform well in comparison with other building materials in insulating against airborne sounds due to their mass.

Alternative low-mass walling systems generally rely on a combination of providing some mass in the wall via the lining (usually two layers), and some form of insulation in a cavity to absorb the energy from the sound waves. These multi-layered systems rely on the effective jointing of numerous layers of composite materials (including the insulation), to ensure that there are no gaps that sound can pass through or 'penetrate'. Even small gaps the size of power points or unfilled joints can be enough to significantly affect the overall performance.

Solid construction methods make it easier to ensure that the required acoustic performance of the as-built wall will be achieved.

Other factors such as the fixity at the edges of the walls and floors also affects the ease with which vibrations can be set up, and the natural frequency at which the element will vibrate.

Solid walling and flooring options generally provide good fixity at connections to further reduce sound transmission.

Impact Sounds With these sounds, the impact causes vibrations directly in the wall or floor element. Vibrations from impact tend to spread out over the entire element plus other elements connected to it. The vibration of the elements set up vibrations in the adjacent air, and it is these new airborne vibrations which transmit the sound.

Direct and Indirect Transmission The flow of sound energy through walls and floors can be by either direct or indirect (flanking) transmission. Direct transmission is when sound is transmitted directly from one side of a wall or floor to the other side. Indirect transmission is where the path of the sound energy is via another element attached to the wall or floor, or some other pathway. For example, vibrations in a wall setting a floor vibrating, or through some form of air gap, say in the ceiling space. Often, walls may have an adequate sound rating, but noises are transmitted through the ceiling of one apartment, over the top of the wall via the air space, and then back down through the ceiling into the next apartment.

Canadian research has shown that in some situations a wall with an STC rating of 66 (see *Measurement of Sound* below), provided an effective sound insulation of only STC 48. This was due to the indirect sound transmission path in the continuous lightweight subfloor, which provided much less resistance than the direct path through the wall.

Solid construction methods have traditionally provided both the mass and simple connection details to limit indirect transmission of noise.

This highlights the importance of getting the wall/floor/ ceiling combinations right as well as the connection details.

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Measurement of Sound

Sound Transmission Class (STC) All building elements (walls, floor/ceiling assemblies, doors, windows and so on) have some ability to reduce the airborne sound that is transmitted from one side of the element to the other. This is known as the sound transmission loss.

The STC rating is a measure of the amount of transmission loss that occurs through an element, expressed in decibels. An STC rating of 45 (STC 45) means that the element reduces the sound passing through it by a level of 45 dB.

Decibels (dB) Sound pressure levels are usually expressed in decibels (dB). One decibel is the smallest change in sound pressure level or intensity (loudness) detectable by the human ear.

'A' Weighted STC Values To establish the STC rating, the element is tested for sounds at various frequencies. The 'A' weighted decibel value – dB(A) – factors the transmission loss results for the frequencies that the human ear responds to the most. The frequencies and factors are determined from testing people's responses to different frequency sounds. It is a means of correlating objective laboratory measurements, with people's subjective assessments of noise at different frequencies.

Because dB(A) values take into account people's attitudes towards the nuisance value of sounds, they are generally used for setting limits on ambient noise levels.

In terms of the acoustic insulation offered by building elements, dB(A) values are generally higher than dB values, and thus tend to indicate a better performance for a given walling or flooring system.

While some manufacturers may give STC values in dB(A) units, the Building Code of Australia's performance criteria still refer to the unweighted dB measurement.

Impact Insulation Class (IIC) Although the adopted measure of impact sound insulation overseas is the Impact Insulation Class (IIC), the Building Code of Australia (BCA) assesses compliance by comparison with deemed-to-satisfy forms of construction. If the impact sound transmitted is less than that transmitted by one of these standard brick or concrete masonry walls, then the walling system is also deemed-to-satisfy the performance requirements.

Building Code of Australia

Requirements For medium density housing having sole occupancy units either next to or above/below each other the BCA specifies the required acoustic performance of the separating walls and floors, to allow the occupants to sleep, rest and engage in normal domestic activities in satisfactory conditions.

The requirements quoted are those in the BCA, 1996, including amendment 4 – January 1999.

The BCA requires a minimum STC rating of 45 for the following walls:

- A wall separating sole-occupancy units
- A wall between a sole-occupancy unit and a plant room, lift shaft, stairway, public corridor, hallway or similar
- Separation between a soil or waste pipe serving more than one unit, and a habitable room (not a kitchen where an STC 30 rating applies) in any one unit.

The STC rating is increased to 50 and the requirement for impact sound insulation added for walls separating a bathroom, sanitary compartment, laundry or kitchen in one unit from a habitable room (other than a kitchen) in an adjoining unit.

For all floors separating sole-occupancy units, an STC rating of 45 plus impact sound insulation applies.

Appendix A outlines various methods of complying with these requirements.

Sound Levels

To understand the levels of noise that partitions are designed to reduce, it is important to know how a decibel rating relates to various sound levels. **Table 1** *(shown on next page)* lists the decibel values for some common sound sources.

Ambient Noise Levels

Australian Standard AS 2107—1987 *Acoustics – Recommended design sound levels and reverberation times for building interiors* contains recommended ambient sound levels for different areas of occupancy in buildings. **Table 2** lists the values for some residential buildings. The use of dB(A) units implies that a subjective judgement has been included in the setting of the values.

It can be seen that the Standard recommends that ambient sound levels up to 30 dB(A) are satisfactory in a bedroom. From **Table 1** this corresponds to the noise from an average home or a quiet conversation.

Table 1 Sound pressure levels

Sound pressure level (dB)	**Description**	**Examples**
0	Threshold of hearing	Acoustical test room
10	Very faint	Normal breathing
20	Quiet	Whisper at 1 m Quiet room
30		Average home Soft radio Quiet conversation
40	Normal	Quiet radio/office Motor car
50	Noisy	Average conversation
60		Average radio/office
70	Loud	Busy street Argument
80		Noisy Office Vacuum cleaner Door slamming
90	Very loud	Printing plant Inside city bus
100		Loud car horn at 6 m Wood saw at 1 m

Table 2 Recommended design sound levels in inner-suburban private houses *Extracted from Table 1 in AS 2107*

	Recommended design sound levels dB(A)	
Activity	Satisfactory	Maximum
Recreation areas	35	40
Sleeping areas	30	35
Work areas	35	40

Buyer's Expectations

Complaints about being able to hear neighbours is often not related to substandard workmanship, but an expectation of how much noise the wall should be stopping in order to provide a comfortable living environment for the occupants.

With an STC 45 wall (BCA requirement), the noise from a busy street or argument (70 dB, see **Table 1**), will be clearly audible, but at a reduced level of 25 dB. This is still lower than the satisfactory ambient noise level given in AS 2107, see **Table 2**.

Whether this 25 dB level or up to the 35 to 40 dB(A) levels allowed in the Standard are acceptable to the owner if the source is from a neighbour is another issue. Further, as no control generally exists over the noise that neighbours can make, loud televisions and stereos could easily exceed the satisfactory levels.

The increasing number of complaints over noise issues, indicates that the BCA's minimum 45 dB requirement for acoustic insulation does not reflect people's expectations of how much noise (if any) they should be able to hear from their neighbours in order to provide a comfortable living environment.

Increased STC ratings introduced overseas reflect the importance that people place on acoustic insulation to provide them with a comfortable living environment within medium and high density developments.

Solid options can cost effectively provide performance well above the minimum STC 45 rating required by the BCA, providing reduced ambient noise levels and a greater level of comfort for the occupants.

Industry Response

Some Local Councils in Australia are already setting higher STC ratings than the BCA nominates, due to the increasing number of complaints.

Developers are also offering STC ratings greater than the minimum, to improve the quality of the product, and match the performance to the prestige image that is often marketed. Promoting lifestyle issues such as peace, quiet and relaxation can influence people's expectations. Providing higher STC ratings can avoid complaints and provide a marketing edge to boost sales.

Many cost effective new systems have been developed to meet the challenges of providing increased STC ratings.

Generally, single-element walls and floors of solid construction can provide STC ratings up to about 55. Examples include 150-mm-thick concrete or concrete masonry (with all cores grouted).

In New Zealand, the Building Code's deemed-to-satisfy solution for an STC of 55 (walls and floors) is 150 mm of concrete with a mass of 400 kg/m^2 (ie concrete density of 2670 kg/m^3). While this density is slightly higher than the normal 2400 kg/m^3 used in Australia, test results in the USA give STC results of 57 for a 150-mm-thick wall made of concrete with densities equal to our normal-weight concrete.

As most precast concrete residential development within Australia uses 150-mm-thick panels, superior STC ratings are being achieved with this solid construction method.

To achieve a level of 60 dB, either a composite wall system or double wall is usually used. Composite systems involve a solid material 'core' with a separate stud wall (12- to 15-mm cavity) on one or both sides. These are similar to double-wall solutions but use a lightweight option for the second wall. The lightweight half of the wall normally incorporates insulation as well. These systems not only offer excellent acoustic performance, but can pay for themselves by overcoming building tolerance problems and allowing a good finish to be rapidly installed. Details can be obtained from CSR, CSR Hebel and Boral.

STC ratings of 65 have been achieved (verified by field testing) in some recent digital theatre complexes by using a solid double-wall system. Walls consisted of 200-mm-thick tilt-up panels for the structural strength, a 50-mm cavity and a 100-mm-thick CSR Hebel wall.

Solid construction for walls and floors is typically allowing acoustic performance in excess of the minimum requirements to be achieved, and providing quality developments at an acceptable cost.

Solid construction is typically allowing acoustic performance well above the minimum to be achieved, and providing quality developments at an acceptable cost.

Quality Issues

With tilt-up (site cast concrete panels), precast (factory cast concrete panels), plus other insitu or composite concrete options, it is easy to ensure that mass requirements are achieved by simply controlling the thickness of the wall or floor. With concrete panels, gaps around the edges must be adequately grouted or sealed with an acoustic rated sealant.

The manufacturer's installation requirements for items such as precast floors should be followed to ensure topping thicknesses, joints and ceiling details are appropriate.

For concrete and clay masonry construction, the important issues are ensuring that the density of the masonry units used is the same as those that the acoustic test results are based on, and that all joints are filled during laying, including those at the edges of the wall. Masonry units should be laid frog up so that all bed joints can be filled. This will ensure that the mass is achieved and air paths within the wall are avoided. Acoustic sealants also provide an effective way to seal gaps at the top and ends of the wall.

Where chasing of party walls is required, it is important to ensure that the rebate formed is completely filled to maintain the required minimum mass of the wall and avoid air gaps.

Designers need to detail requirements within the specification to provide a simple, easy solution to acoustic insulation. Framed structures with infill walls are an example of how simple detailing around the edges to allow an effective joint to be provided, can avoid future problems and complaints.

With lightweight walling systems, close inspection during construction needs to be maintained to ensure that all materials, densities and thicknesses conform with the relevant acoustic test reports. Also that the various layers within the system are each correctly installed to the manufacturer's specification, and that no gaps are left as work proceeds. These factors complicate the achievement of ratings, especially when the locations of power points, light switches and services are considered.

Only a minimum number of precautions are necessary to ensure predictable, good performance with concrete and concrete and clay masonry walling systems. Materials are consistent and less reliance is placed on workmanship than with lightweight composite walling systems.

Meeting acoustics requirements with solid concrete options is straightforward, cost effective, and much simpler in terms of quality control to achieve.

Summary

Concrete and concrete products such as masonry can economically provide acoustic performance well above the minimum standards required. STC ratings up to 55 can be easily and cost effectively achieved with various single-element solid walling options. Higher ratings can be obtained using various double-wall systems.

The mass of solid systems makes them excellent barriers to the transmission of airborne sounds, and various lining board systems can economically provide more than adequate insulation against impact sounds.

Quality can be assured by paying attention to a few basic detailing and construction issues.

Solid construction not only provides a simple cost effective way of achieving good acoustic performance, but it satisfies many other building requirements at the same time. Its mass also allows a reduction in the energy requirements to heat and cool, protection against fire, loadbearing capacity to support the building and strength and security for the owner.

With all these benefits available from solid construction, consider the many advantages for your next project.

Appendix A

Compliance with the BCA Requirements

The BCA contains various solutions to satisfy the performance requirements. They are referred to as deemed-to-satisfy solutions. Other performance-based solutions are also possible provided that compliance with the BCA requirements can be demonstrated.

Walls with STC 45 Rating The factors that most influence the STC of a particular form of construction are:

- Its mass
- The acoustic absorbency of its surfaces
- How it abuts or is connected to adjoining building elements.

Of these factors, mass is generally the most important and this is provided by solid construction. The Building Code of Australia's deemed-to-satisfy options generally relate to the overall mass of the materials. **Figure A1** indicates the relationship between mass and STC for concrete masonry walls.

For walls, **Table A1** lists some deemed-to-satisfy precast and insitu concrete solutions from the BCA. Concrete walls in the range of 100 to 125 mm thick with a mass not less than 250 to 275 kg/m^2 are deemed-to-satisfy solutions.

Concrete masonry walling can be in a variety of thicknesses and types, but with a minimum mass of about 160 kg/m^2, an STC 45 rating can be achieved. **Table A2** lists some of the performance-based options that comply.

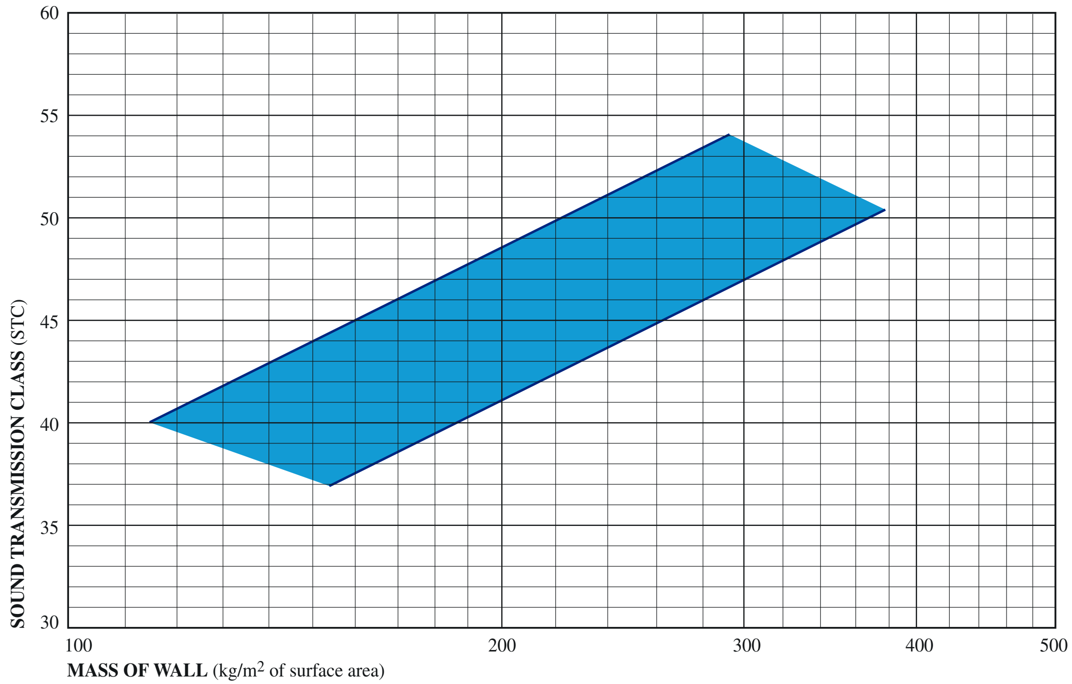

Figure A1 Relationship of STC and mass for bare masonry walls

From CMAA and Standards Australia *Design of Concrete Masonry Buildings* SAA HB 124—1999

Individual manufacturers should be contacted for details of their products and systems for achieving varying levels of acoustic and impact insulation and associated test reports.

AAC walls come in either block or panel types, with various thicknesses, surface coatings and wall systems available. Ratings up to about STC 60 can be economically achieved by using a combination of a central AAC wall with studs, plasterboard and insulation added to one or both sides. Systems offering impact insulation ratings of STC 53 to 57 are also available. Some walls, which achieve the minimum STC 45 rating, have been included in **Table A2**. Manufacturers should be contacted to discuss their full range of options to determine the most suitable and economical for a particular application.

Table A1 Deemed-to-satisfy walling options from the BCA (STC 45)

a] Precast concrete 100 mm thick without joints.

b] Insitu concrete 125 mm thick with a density not less than 2200 kg/m^3 (normal weight).

c] Insitu concrete 100 mm thick with a density not less than 2500 kg/m^3 (heavy weight).

d] Concrete brickwork 110 mm thick with a mass not less than 195 kg/m^2.

e] Clay brickwork 230 mm thick (one or more leaves) with a mass not less than 290 kg/m^2.

f] Clay brickwork 110 mm thick (minimum mass of 180 kg/m^2) plus 13-mm render on one side.

Table A2 Performance-based walling systems complying with STC 45 rating

a] Concrete lightweight brickwork 110 mm thick with 13-mm render both sides and wall mass of 160 kg/m^3 (STC 46).

b] Concrete dense hollow blocks 140 mm thick with wall mass of 253 kg/m^3 (STC 50).

c] CSR Hebel Powerpanel 75 mm thick with 10-mm Gyprock direct fixed one side and 25-mm cavity plus 51-mm metal stud frame and 10-mm Gyprock other side (STC 45 + impact).

d] CSR Hebel blocks 100 mm thick with a density not less than 650 kg/m^3 and 15-mm cement render plus 2.5-mm plaster to both sides.

e] 150-mm hollowcore panel with sealed joints.

Walls with STC 50 Rating plus Impact Where an STC rating of 50 is required with impact reduction, the BCA does give some concrete and clay masonry solutions. However, no deemed-to-satisfy options for single-element walls such as 150-mm-thick concrete panels are given.

This is because while the density of solid construction products like concrete and masonry make them excellent barriers to airborne sound, it also makes them good transmitters of impact sound.

With solid walling, if rooms require impact sound insulation, the usual solution is to install one of the standard acoustic impact systems readily available from most major lining-board manufacturers. These low-cost and easy-to-install systems involve standard wall-lining boards (soft layer to absorb the impact) mounted on furring channels. The furring channels are fixed to the wall with standard clips incorporating some form of resilient rubber mounting to further reduce the vibration transmitted to the wall. See **Figures A2 and A3** for typical details.

CONCRETE data

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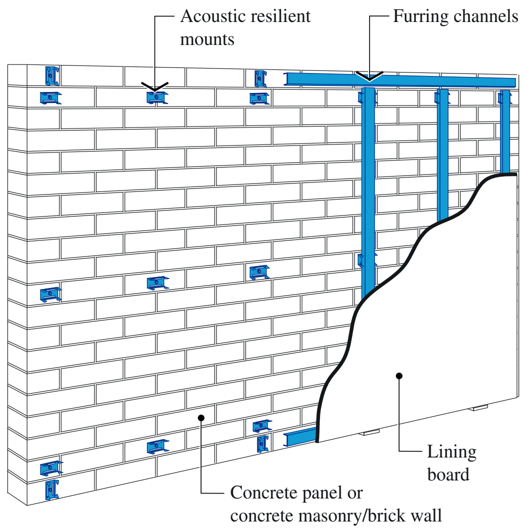

Figure A2 Acoustic impact system

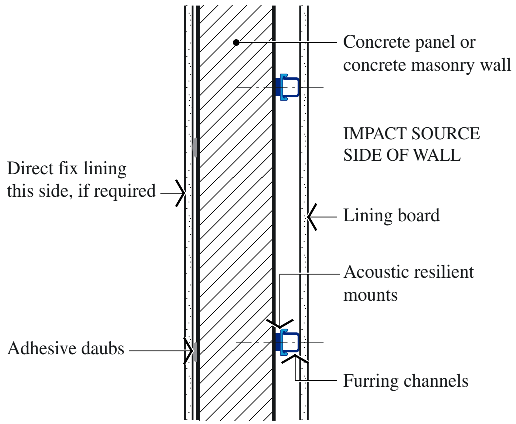

Figure A3 Cross section of acoustic wall system

Generally the lining is provided on the impact source side of the wall and is required only for the rooms outlined in the BCA (see earlier section on *Building Code of Australia*).

Home units are often designed to avoid the impact requirement for walls, thereby maximising the acoustic benefits offered by solid construction.

Table A3 lists examples of the performance-based walling systems from major suppliers that meet the acoustic and impact requirements of the BCA. Manufacturers should be contacted for a complete list of walling options and information regarding the installation of these systems.

Floors with STC 45 Rating plus Impact For floors, deemed-to-satisfy solutions in the BCA involve concrete slabs 100 to 125 mm thick, with masses of not less than 250 to 275 kg/m^2, see **Table A4**. Other performance-based systems are listed in **Table A5**.

The impact rating is normally achieved by the provision of some form of resilient material on the surface. Usually, this is carpet on a resilient underlay. Resilient flooring finishes such as rubber and vinyl tend not to be as effective.

If large areas of polished concrete, tiles, or parquetry/timber finishes are specified, a separate topping on resilient rubber mounts, or an insulated ceiling below the slab would be required to achieve the impact noise requirement. A marginal increase in the ceiling height may be advisable in order to allow for the installation of a resilient floor or an insulated ceiling should the option of replacing carpet with tiles or other timber/polished concrete finishes exist.

Meeting acoustics requirements with solid concrete options is straightforward, cost effective (only one element required), and much simpler in terms of quality control to achieve, contrasted with other building materials.

Table A3 Examples of performance-based solid walling systems complying with minimum STC 50 rating plus impact

a] 110-mm concrete masonry wall (Rippa-Bloks). 10-mm CSR Gyprock fixed to furring channels on resilient mounts one side, and 10-mm CSR Gyprock direct fixed other side.

b] 90-mm concrete masonry wall. 13-mm Boral Plasterboard direct fixed one side, and same fixed to 28-mm furring channels (with insulation) attached to wall with Acoustic Impact Clips on the other side.

c] 140-mm concrete masonry wall (Solo Wall).
10-mm Boral Plasterboard direct fixed one side and same fixed to 28-mm furring channels attached to wall with Acoustic Impact Clips on the other side.

d] 100-mm CSR Hebel Sonoblok wall. 10-mm CSR Gyprock fixed to furring channels with 45-mm Bradford Rockwool Partition Batts between on one side, and
10-mm CSR Gyprock direct fixed other side.

e] CSR Hebel Powerpanel 75 mm thick with 10-mm Gyprock direct fixed one side and 25-mm cavity plus 51-mm metal stud frame, Bradford S4 Polyester insulation and 10-mm Gyprock other side.

f] 150-mm-thick concrete panel/wall with mass of 360 kg/m^2. 10-mm Boral Plasterboard direct fixed one side and
10-mm Boral Plasterboard on 28-mm furring channels fixed with Acoustic Impact Clips on the other side.

Table A4 Deemed-to-satisfy flooring options from the BCA (STC 45)

a] Insitu concrete slab 125 mm thick with density not less than 2200 kg/m^3.

b] Insitu concrete slab 100 mm thick with density not less than 2500 kg/m^3.

c] Precast concrete slab 100 mm thick and without joints.

Table A5 Examples of performance-based flooring systems complying with STC 45 rating

a] Ultrafloor precast concrete system.
Minimum 130R beam system.
Note: 150R system gives STC 53 without ceiling.

b] Hollowcore prestressed concrete planks.
Minimum 150-mm-thick hollow core plank untopped with grouted joints.

c] Transfloor insitu concrete formwork system. Minimum 50-mm-thick precast panel combined with minimum 65-mm-thick topping over the polystyrene void formers.

Concrete and concrete products such as masonry can economically provide acoustic performance well above the minimum standards required.