

## TECHNICAL NOTE #38

### Built-in soundproofing with clay masonry walls

Noise is not only irritating, it can contribute to reduced physical and mental performance.

The density of ceramic clay brick provides an inherent resistance to the passage of airborne sound. It attenuates low-frequency noise from outside, and isolates and protects against impact sounds inside the building from footsteps, plumbing or

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## EXECUTIVE SUMMARY

Few things irritate us more than exposure to excessive noise. It is hard enough to concentrate with the distractions of nearby cell phones and loud conversations, without adding noise from other rooms or outside.

Research shows that noise can contribute to cardiovascular disease, high blood pressure, headaches, hormonal changes, sleep disturbance as well as reduced physical and mental performance. On the other hand, in an acoustically "comfortable" environment, in addition to listening to what we want, we focus better and feel calmer.

Creating acoustically comfortable environments is core to home theatres, hospitality and entertainment venues and sports stadia. Home and business property owners take noise into account out of self-interest. But in learning environments funded by public sector – where excessive noise is inevitable – sound insulation takes a back seat to cost and speed of construction.

Noise in classrooms directly influences the teaching-learning relationship. Keeping pupils attentive and focused in a "one-to-many" instruction environment is already difficult. An inability to hear clearly interferes with concentration, reduces memory and knowledge retention and makes empathetic student-teacher communication difficult.

According to the World Health Organization, the safe level of noise in a classroom cannot exceed 35 decibels. From there, the ability to learn is impaired. In France, a study found that with every 10-decibel increase in classroom noise, students' language and math scores decreased by 5.5 points.

In a 2019 research study of 30 public high schools in Spain (IES) it was found that physical features of the built environment had a profound effect on pupil performance discipline and behaviour as well as teacher health and conduct. Acoustical comfort is achieved if the teacher can easily be heard without having to raise their voice, and pupils found it easy to concentrate.

Improving classroom acoustics is therefore critical to a proper teaching-learning process. The gains affect students as well as educators, who won't need to exceed their voices' limits. Architects play a big role in this throughout the project.



*Figure 1: The University of Mpumalanga. Dense clay brick masonry resists the transmission of airborne sound waves. Due to these natural acoustic properties, pupils and teachers are not subjected to excessive noise transmitted from adjoining buildings or classrooms. Photo courtesy of Federale Stene.*



## HOW ARE SOUND LEVELS ASSESSED?

Many construction materials suppliers are quick to advertise generic statements about “good sound insulation” and “amazing noise reduction”. New types of insulation, foams and retrofit panels are regularly introduced to deal with the problem.

In the interests of truth and the long term sanity of building users and residents, it is critical that architects, contractors and property owners can judge the underlying research and performance characteristics for themselves.

The sound insulation of a building or structure is expressed as a **reduction factor in decibels (dB)**. The decibel is considered to be the smallest change the human ear can detect. Every increase of 10 dB (say from 40 dB to 50 dB) represents a 10-fold increase in volume as dB is a logarithmic scale.

130dB+	Jet plane take-off, machine gun, riveting.	Even a short exposure can cause hearing loss and permanent tinnitus.
100-120dB	Hard rock band, thunder, siren at 50m.	Threshold of pain.
80-100dB	Pneumatic jackhammer, unmuffled truck, power lawnmower,	Threshold of discomfort
60-80dB	Noisy office or home, average factory, average street noise	Intolerable for phone calls, difficult for conversations.
40-60dB	Average office or home, quiet street	Difficult for phone calls. Loud speech can be heard intermittently.
< 40 dB	Private office, quiet home, library.	Positive effect on focus and performance.

Sound is not just an objective measurement, but also an subjective and individual experience.

- In a home or office, a person trying to read, work or sleep, will perceive outside sounds as louder and more disruptive.
- Children have sharper hearing, and are also particularly sensitive to high-pitched noises.
- Scholars trying to concentrate may be far more aware of noise from outside than their teachers.

The experience of auditory comfort also depends on ambient sounds in the room. A space that is occupied (especially in a school) will have an ambient level of noise which helps to reduce cross-over sound from the adjoining classrooms or playground.



## HOW ARE CONSTRUCTION MATERIALS MEASURED AND RATED

### AIRBORNE NOISE

The noise performance of a building system is called the **Weighted Sound Reduction Index (Rw)**. The higher the **Rw** the better the system is at isolating airborne noise. Airborne noise comes from common sound sources such as voices, TVs and traffic.

The greater the mass of the wall or floor, the more difficult it is to set up vibrations in it, and hence more difficult to transfer sound from one side to the other. Brick walls perform well in reducing the transmission of airborne sounds due to their mass.

**Rw** ratings are determined by laboratory tests and compared against reference curves. 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. Measurements are conducted over frequencies between 100 Hz and 4000 Hz.



*Figure 2: Nelson Mandela University Business School was the first building in the education or public sector to achieve a "4 Green Star design rating" by the GBCSA. Photo courtesy of Algoa Brick.*

### IMPACT NOISE

When the building shell itself is impacted, noise travels easily via walls, floors and concrete slabs. Examples are heavy footsteps (particularly on bare timber or tile floors), banging doors, scraping furniture, air-conditioning and plumbing. Multi-unit residential buildings with shared walls are particularly susceptible to this type of noise.

**C** and **Ctr** are correction factors used to modify the measured sound insulation, and they take into account mid- to high-frequency and low-frequency noise.

To take Impact sound correction measurements, a standard 'tapping machine' set on a horizontal steel plate rests against the test wall. The sound transmission through the wall is then measured. The test specimen is compared against the performance of a cavity brick construction of two leaves of 90mm bricks.

The weighted sound reduction index is commonly denoted in the format **Rw (C, Ctr)**. As an example, if a wall is measured as 56 **Rw** (clay brick cavity wall), and has an Impact Correction factor of -5, the corrected value is :

$$Rw + Ctr = 56 + (-5) = 51$$



## SOUND TRANSMISSION FOR CLAY BRICK MASONRY

In their research report "Measurements of Sound Transmission Loss in Masonry" William Siekman of Riverbank Acoustical Laboratories tested 15 clay brick wall types including face brick, single and double leaf walls, as well as walls with and without cavities and/or insulation.

They found that the average double-leaf plastered clay brick wall cuts over 50% of the noise from outside. Ambient noise of around 65db (moderate to loud) is reduced to less than 20db which is barely audible.

A double skin clay brick wall is therefore defined as a superior insulator even without any additional insulation material or installation costs. Because the brick has mass, it has the ability to inhibit sound penetration.

<b>Material: average density kg/m<sup>3</sup></b>	<b>Wall Depth mm</b>	<b>13mm plaster cement render - single side</b>	<b>13mm plaster cement render - second side</b>	<b>Insulation/ cladding required</b>
Single leaf clay brick: 2000 kg/m <sup>3</sup>	90-110	Y	Y	Y
Single leaf "maxi" clay brick: 2000 kg/m <sup>3</sup>	150	Y	Y	N
Double leaf clay brick with cavity: 2000 kg/m <sup>3</sup>	90+50+90	N	N	N
Engineering bricks: 2200 kg/m <sup>3</sup>	110	N	N	N
Calcium Silicate brick: 1850 kg/m <sup>3</sup>	140	Y	Y	N
Dense hollow concrete block: 2000 kg/m <sup>3</sup>	140	Y	N	N
Lightweight cement hollow brick: 1400 kg/m <sup>3</sup>	190	Y	Y	Y
Dense [poured] concrete: 2200 kg/m <sup>3</sup>	190	N	N	N
Aerated Lightweight [poured] concrete (AAC): 500-850 kg/m <sup>3</sup>	240+	N	N	Y



## BEST FOR ACOUSTIC COMFORT

Although requirements differ from country to country, exterior walls are considered to satisfy sound insulation requirements if the Weighted Sound reduction plus Impact resistance index is 50 or higher.

The density of ceramic clay brick provides an inherent resistance to the passage of airborne sound. It is a superior performer in attenuating low-frequency, airborne noise caused by building mechanical systems, elevators, amplified music, traffic and aircraft. Cavity masonry walls have the added benefit of isolating impact sounds.

Although some alternative systems may perform as well as masonry for frequencies in the speech range, these lower mass systems have difficulty insulating against low-frequency noise.



*Figure 3: The timeless elegance of face brick provides a fusion of old and new in the construction of the new boarding house at St David's Marist Inanda..  
Photo courtesy of Corobrik.*

The sound insulation characteristics of hollow bricks and blocks can be complex, due to the different size voids, and the placement of voids. In general, denser bricks perform better at blocking sound, and especially high-frequency sounds.

## WORST FOR ACOUSTIC COMFORT

A recent EU study confirmed in acoustic in-situ studies that aerated concrete (AAC) walls fail to comply with the standard requirements. A 240mm inter-dwelling with a typical density of 600 kg/m<sup>3</sup> achieved a  $R_w$  rating of less than 40. Sound reduction deficiency is significant and the recommended method to improve sound insulation between dwellings is to apply at least 2 layers of insulating mineral wool and gypsum-cardboard panels.

Masonry veneer (a base cement block wall of 90 mm with a facing of clay brick cladding) is also insufficient with a  $R_w$  rating of about 40 making them suitable only for interior walls unless they have additional insulation or plaster board.

In Canada, common "wooden stud" interior walls only have a  $R_w$  rating of about 25 (11 mm oriented strand board on 140 mm studs with a 406 mm spacing) and therefore require glass fibre thermal insulation in the cavity as well as 13 mm gypsum board on one surface layer.



## HOW DOES RENDERING/PLASTERING HELP ACOUSTIC PERFORMANCE

Another factor that influence how we perceive sound and the experience of acoustic comfort is **Reverberation**.

Reverberation is time taken for a sound to "fade away" in an enclosed area after the source of the sound has stopped. If the delay is greater than 0.6 seconds, people find it hard to distinguish between consonants.

The longer the reverberation time, the lower the comprehension ability. This means that speaking louder will not make a difference to clarity, and it will make the environment more confusing.



*Figure 4: The dynamic double-curved clay brick walls, arching timber beams and slatted bamboo ceiling work together to provide a sustainable building with enhanced acoustics at the Constantia Waldorf School. Photo courtesy of Corobrik.*

Reverberation, sound reflection and echoing increase when walling materials are smooth and glossy, rooms are large and there are fewer objects to break up the sound

Reduce reverberation by plastering and painting a wall (which also helps to fill any gaps in mortaring). Little acoustic benefit is gained by rendering the other side because the relative increase in density is small and any pore and gaps are already sealed by the first layer of render.

In addition, masonry walls provide a slightly textured surface that absorbs sound. Textured brick and face-brick are superior performers at reduce sound reflection and reverberation.

## IMPROVING ACOUSTIC PERFORMANCE AND REDUCING NOISE

Where air can pass, so too can sound. When masonry wall are finished with render, or paint, this seals the fine pores in the brickwork and also eliminates partially filled and unfilled mortar joints.

Doors and windows have lower acoustic performance than the walls, and leaving them open, however slightly, will allow noise to penetrate. Badly fitting doors or windows will considerably increase noise levels.

Joints between dissimilar construction materials may open up if there is building movement. It is important that the acoustic seal in joints accommodates building movement.

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. Expanding foam sealant which is non-shrinking can be injected into the gap.



Where pipes or ductwork penetrate a wall, the clearance between the pipe or duct wall and the structure should be equal to approximately 1% of the pipe diameter or smallest duct cross-sectional diameter. In the case of ductwork, this clearance should not exceed 25 mm.

Exterior environmental noise can be reduced by creating a barrier external brick wall between two properties as well as between the property and the road. Textured face-brick walls reduce reflected sound, are low maintenance and have an aesthetic appeal for the home owner, adjacent residents and pedestrians.

## INSULATION

Insulation placed between leafs of a double-leaf cavity wall or above a ceiling also plays a role in reducing sound transmission through the wall. Generally, thicker insulation will contribute to improved sound reduction although the cavity should not be bridged by the insulation.

Subject to fire rating requirements, the following are options for insulation:

- Rockwool pipe insulation: 13mm minimum wall thickness with a minimum density of 14 kg/m<sup>3</sup>.
- Bitumen impregnated polyurethane foam sealant compressed at least 50%
- Sponge rubber
- Fibreglass
- Finish off with a non-setting mastic or synthetic rubber sealant.
- Gaps between ductwork fire dampers and wall penetrations (25 mm maximum) should be packed with mineral wool and sealed.
- Where fire-rated masonry wall penetrations occur, a 1mm galvanised steel or copper sleeve should be grouted or cast into that penetration gap.

## PLASTERBOARD LINING

For single leaf walls a plasterboard lining on walls improves the sound insulation. Clipping a gypsum or plaster board to a low density cement brick wall can increase the STC rating by 12 to 15 points. Specific plasterboard products such as fire-rated or sound-rated plasterboard may increase the sound insulation of a walling system.

1. Seal gaps at the edge of the lining.
2. Air conditioning ducts may need to be baffled or lined internally with sound-absorbing material to prevent sound from travelling along them from one space to another.
3. Suspended ceilings of sound absorbing material are very effective when properly used. However they are often responsible for the transmission of noise through the ceiling spaces into adjacent rooms. This can be prevented by extending the walls up to the roof or by providing a sound resistance layer above the absorbing panels.





## INTERIOR NOISE AND MULTI-UNIT HOMES WITH COMMON WALLS

For interior walls, a weighted sound reduction index (Rw) of 45 is recommended.

Material: average density kg/m <sup>3</sup>	Wall Depth mm	13mm plaster cement render – single side	13mm plaster cement render – second side	Insulation/ cladding required
Single leaf clay brick: 2000 kg/m <sup>3</sup>	90-110	Y	Y	Y

In general, masonry – whether it is clay brick, cement brick, concrete block or stone - provides superior sound control compared with timber and solid structures made from poured concrete. Often the reinforcing steel required for cement structures “rings” with vibration throughout a large multi-story building.

Masonry possesses an inherent resistance to the passage of airborne sound, which makes it a superior performer in attenuating low-frequency, airborne noise caused by building mechanical systems, elevators, amplified music, traffic and aircraft. Although some alternative systems may perform as well as masonry for frequencies in the speech range, these lower mass systems have difficulty insulating against low-frequency noise.

Special attention must be given where a habitable room is situated next to a bathroom, kitchen or laundry in its own unit, or an adjoining unit. Soil and waste pipes which pass through the walls must be sound insulated when adjacent to a habitable living area.

Absorbent, porous materials in interior surfaces like ceilings, walls or floor coverings, and furnishings that scatter sound eliminate disturbing echoes and improving speech intelligibility.

Many older buildings are having to be retrofitted with sound insulation and acoustic panels at a huge cost. By applying the walling materials during construction, effective acoustics are “built-in to living, working and learning spaces.



*Figure 5: Zweletemba High School in the Western Cape makes extensive use of face brick. This provides an aesthetic, low maintenance finish as well as built in noise and heat insulation. Photo courtesy of Worcester Brick.*



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### **For further information:**

The Clay Brick Association of South Africa

Website: [www.claybrick.org](http://www.claybrick.org)



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