

2.4 Acoustic Performance

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Introduction

Acoustics is the science and technology which deals with sound in and around buildings. It studies the phenomena of sound reflection, absorption and insulation and applies this knowledge in noise control and the creation of rooms with special acoustic characteristics such as concert halls and theatres.

For the practitioner, sound insulation is probably the most usual criteria to be satisfied.

It is interesting to note that many lightweight systems set their goals on trying to upgrade their systems sound properties on the levels achieved by concrete masonry. Sound insulation characteristics of masonry walls have been taken for granted in the past. Relaxation in fire regulations has permitted the greater use of lightweight construction which has often been to the detriment of sound insulation values.

Each principal phenomena of sound, i.e. insulation, reflection and absorption, is studied in this Manual Section.

Summary – Sound Insulation Performance/Classification

At the moment the only restriction placed upon the designer with respect to sound attenuation is on building elements which are common between occupancies. Both the Sound Transmission Class of walls, floors and ceilings, and the Impact Insulation Class of floors shall be no less than 55, as specified in New Zealand Building Code G6.3.1 and G6.3.2.

Table 1 is included to give further recommended classifications of sound attenuation performances, with descriptions, STC values and comments and methods of compliance in masonry construction.

Table 1: Recommended classification of sound attenuation performance

Description	STC (Median)	Comment	Masonry Specification
Space divider	< 30 dB	Has little acoustic merit and is a space divider only.	
Acoustic separation	> 30 dB	Will provide acoustic separation between adjacent occupants but conversations may be heard if listened for. Adequate for many offices.	Any masonry construction
Acoustic privacy	> 40 dB	Will provide privacy. Conversations will only be heard if loud, or in very low background noise. Adequate for offices and those walls inside a house where a high rating may be called for, e.g. living and sleeping areas.	Solid filled 10 series Partially filled 15 series
Acoustic	> 50 dB	Domestic intertenancy, motel, hotel walls will require to be security of this standard.	Solid filled 15 series
Acoustic special	> 55 dB	NZ Building Code G6 Domestic intertenancy	Solid filled 20 series

Tests carried out at Auckland University in 1993 gave the following results for the STC for 20 series solid filled:

Wall Type	STC
20 Series masonry block wall, every third cell reinforced all cells grout filled	55
Same as case (b) but with both faces of the wall painted with acrylic paint	56

From these results it can be seen that the STC rating for walls can be achieved through the use of concrete masonry.

These results and further overseas regulations and practices are referred to in more depth later in the Acoustic Properties Section

General

Noise can be defined as all unwanted sounds. Whether sound is experienced as pleasant or as mere noise it is a very subjective thing. A few examples will make this clear. The owner of a sports car will be excited by the roar of his engine while bystanders are most likely disturbed and regard it as a form of environmental pollution. Playing one's favourite music loudly on the stereo can be a pleasant experience while the neighbour might regard that same volume of music as a nuisance. In general, one's own sound sounds good and that of somebody else's does not.

Our modern industrial society produces an ever increasing number of sound sources and at the same time we are growing towards denser housing forms. This results in a growing need for noise control. Since noise is now regarded as a form of environmental pollution it has become a public issue and subject to growing legislation.

Protection from noise (excessive sound) is not a luxury but a need. Some countries have bylaw legislation setting standards of acceptable sound insulation. These are outlined in the classification section to follow. Continuous exposure to high noise levels affects our psychological well-being. This is well understood in the world of industry where it was proved that the reduction of noise of more than 90 dB to acceptable lower levels led to higher productivity through better concentration resulting in more output, less accidents and more job satisfaction.

Concrete masonry blocks possess a combination of acoustical properties found in few other building materials. The open surface texture has good sound absorbing qualities while the mass of a block wall guarantees good sound insulation at the same time as the structural and fire resistant functions within the building are fulfilled.

The Nature of Sound

Sound can best be explained as pressure waves or vibrations, in the air or any other elastic material. Sound needs a medium in which to travel; sound is not transported in a vacuum. In air, sound travels with a speed of approximately 340 m/s (20°C).

Sound can be generated by any object that will vibrate rapidly. From this source sound travels equally in all directions. When a sound is generated in a room the sound waves are reflected after a few milliseconds by the walls, floor and ceiling. Shortly after, the room is filled with sound waves travelling in all directions.

Airborne Sound

Airborne sound is the term used to describe sound waves travelling through the air. It is sound caused by such things as speaking, music, machinery and traffic.

The most common airborne sounds in apartments are neighbours talking and traffic noise.

Airborne sound is measured in R_wdB, which is the difference in sound levels either side of a barrier, such as a building partition. The higher the R_wdB figure, the better the sound attenuation.

The airborne sound attenuating performance of a material or system is described by its sound transmission class (STC), which classifies its ability to resist airborne sound transfer at the frequencies 125 Hz to 4000 Hz. The NZBC requires the STC of walls, floors and ceilings to be no less than 55.

However, the human ear can perceive frequencies as low as 50 Hz, which is below the frequencies considered for a building material or system's STC. Sounds at these frequencies, such as bass tones from deep voices or stereo systems, can be some of the most penetrating and disturbing.

The conventional rule for reducing airborne sound transmission is the mass law. This says that the heavier the structure, the less sound it will transmit (i.e. the more attenuation for airborne sound and sound at low frequencies). R'_w is the weighted apparent sound reduction index.

Impact Sound

Impact sound is the term used for sound waves that are generated on a partition and caused by such things as footsteps on the floor, hammering onto a wall, slammed doors and windows, or vibrating plant devices.

The most common impact sound in apartments is caused by people walking on the floor above a unit.

Impact sound is measured in Ln_wdB, which is the sound level transmitted below a floor from impact applied to the floor from above. The lower the Ln_wdB figure, the better the sound attenuation.

The impact sound attenuating performance of a material or system is described by its impact insulation class (IIC). IIC indicates the amount of impact noise isolation provided by a floor/ceiling assembly. The NZBC requires the IIC of floors to be no less than 55.

Impact sound can only be minimised by uncoupling the building elements. Therefore, to reduce the noise from people walking in the apartment above, it is necessary to separate the stepped-on surface from the structure.

Frequency

The human ear is a very sensitive instrument to register sound. The frequency of the sound waves is experienced as pitch and the amplitude of air pressure variation is experienced as the loudness of a sound.

The ear can detect sound with a frequency ranging between 20 Hz (low pitch) and 20,000 Hz (high pitch). Hz (Hertz) is the unit of frequency - previously known as cycles per second. The sensitivity of the ear is not the same over the whole frequency range. When human beings get older they slowly lose their ability to hear sounds with very high frequencies.

The highest sensitivity is found in the middle range. Most important is the range from 125 Hz to 4,000 Hz. This is essentially the range of frequencies important in building acoustics.

Doubling or halving the frequency is experienced as a difference of one octave. Most sounds encountered in daily life however are not pure sounds, i.e. they contain more than one frequency. They are a mixture of continuously changing composition and intensity.

Loudness

Sound waves can be described as compression waves travelling in a manner akin to the push-pull effect between wagons of a long train when starting and stopping.

The pressure difference between the compressed and decompressed parts of the wave has to pass a certain minimum pressure to become audible. This threshold varies according to frequencies.

Sound waves in fluids (e.g. air and water) are compression waves, and the passage of sound waves through air will cause variations in air pressure. In solids, sound waves may cause bending in shear or flexure.

Under favourable circumstances the human ear can detect airborne sounds with an rms (root means square) pressure variation of only 2×10^{-6} Pa, at 100 Hz. The sound intensity, i.e. rate of energy transfer per unit area (W/m^2) corresponding to this threshold pressure is 10^{-12} W/m^2 .

The intensity of these faint sounds is indeed very small, but for a short period, however, the ear can withstand sounds with a rms pressure of 200 Pa or an intensity of 100 W/m^2 without damage. Such a sound lies on the threshold of pain.

In the practical situation the rms pressure is not often used because it gives a scale which does not relate very well to how differences in sound intensity levels are experienced.

This led to the introduction of the "belscale" which is a logarithmic scale based on sound energy intensity (this is related to the square of the rms pressure). In the belscale a change of 1 B (bel) corresponds with a tenfold change in energy level, 2 B corresponds with a hundredfold change, 3 B with a thousand-fold change and so on. For practical reasons the bel (B) was subdivided in ten decibels (dB), thus creating the well-known term decibel.

A decibel is the smallest change in sound intensity detectable by the human ear. The decibel scale is a relative scale and in order to be practical a zero point had to be chosen. The average threshold of hearing was adopted for this purpose.

Table 2 (page 4) shows the decibel scale with the related rms pressures and energy intensity levels.

The scale is illustrated with examples and the subjective reaction to such sound levels.

Table 2: Decibel Scale

rms pressure in Pa	Energy intensity in W/m^2	Decibels (dB)		
200	100	140	Threshold of pain	Test stand jet engines on short distance
	10	130		Loud air-raid siren
20	1	120	Threshold of comfort	Machine gun on short distance
	10^{-1}	110		Wood working shop
2	10^{-2}	100		Loud car horn at 6 m
	10^{-3}	90	Very Loud	Printing plant
2×10^{-1}	10^{-4}	80		Orchestra fortissimo
	10^{-5}	70	Loud	Busy street
2×10^{-2}	10^{-6}	60		Average radio
	10^{-7}	50	Noisy	Average conversation
2×10^{-3}	10^{-8}	40	Normal	Quiet office
	10^{-9}	30		Soft radio
2×10^{-4}	10^{-10}	20	Quiet	Whisper at 1 m
	10^{-11}	10	Very faint	Silent garden
2×10^{-5}	10^{-12}	0	Threshold of hearing	Acoustical test room

Behaviour of Sound

Briefly summarised, sound is energy in the form of successive pressure waves transmitted through the air. As such it cannot pass through a solid obstacle such as a wall or a floor.

Most structures, however, are not fully airtight and sound travels easily through continuous pores, small holes and voids, cracks and joints.

Depending on the character of the surface texture, sound will be reflected and/or absorbed.

Dense smooth surfaces will reflect much of the striking sound while rough porous textures will absorb and dissipate much of it.

Part of the sound energy is transmitted by producing vibrations in the wall. In fact these vibrations are also sound waves but travelling through medium other than air.

After having been transmitted through the obstacle the vibrations regenerate sound waves in the air on the other side, but of lesser strength because of energy dissipated during transmission through the obstacle (**Figure 1**).

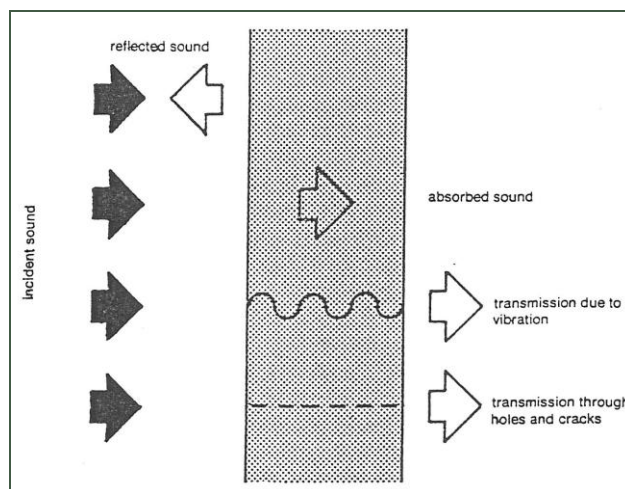


Figure 1: The behaviour of sound when striking a solid object

Sound Transmission

Speakers, singers, violinists and babies produce air-borne sound. They generate sound waves directly in the air. Upstairs neighbours walking on the floor, cellists, sanitary installations and wall mounted telephones produce air-borne sound and structure-borne sound. Vibrations are directly transferred to the structure.

To prevent these two types of sound passing through a wall or floor the same approach is followed for both, namely to try preventing the wall itself from vibrating as far as this is possible. This principle sound insulation is resolved in quite different ways, however, for the two types of sound.

To prevent the transmission of structure borne sound the best way is to absorb the vibration close to the source. Flexible mountings of sound emitting objects will absorb most of the vibrating energy and prevent it continuing into the structure. It must be noted that by proper design and detailing structure borne sound can be completely avoided in many cases.

The insulation of air-borne sound is achieved mainly by giving the wall or floor sufficient mass. The more mass the more energy is needed to vibrate this wall. According to the same physical law, more energy is required to vibrate the wall with a higher frequency. In theory the sound attenuation should rise by 6 dB every time the frequency doubles. In practice the sound attenuation graph follows the theoretical line only more or less (**Figure 2**). An important deficiency can be the resonance frequency of the wall itself.

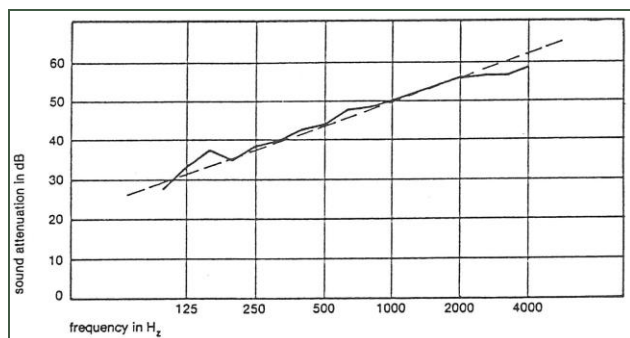


Figure 2: Sound transmission loss of 200mm concrete masonry wall, ungrouted, compared with 6 dB octave slope

The sound attenuation quality of a structure is expressed as Sound Transmission Class (STC) and is measured in dB's. This is derived from the attenuation figures measured in the different frequency ranges. The STC is a single figure rating based primarily on the relative importance of the different frequency ranges in achieving privacy of speech of sound.

Sound Attenuation of Concrete Masonry

Properly designed and constructed concrete masonry walls will provide good sound attenuation. A good sound insulating material requires properties

much the opposite of the ones for sound absorption, low porosity, high density and a close surface texture are needed.

Transmission loss increases with wall thickness (mass) and increases further by having air spaces discontinuities across the thickness of the wall, such as open cores and wall cavities. Wall ties as used in cavity walls can act as sound bridges and reduce much of the acoustic value of the cavity. Plastering and/or painting one or both faces of the wall increases the sound attenuation.

Figure 3 illustrates in graphical form the relationship of single leaf block walls with a certain mass per unit area and the expected STC value. Table 3 gives the mass per m^2 of commonly used wall construction in New Zealand. When plastered on both sides walls can gain as much as 50 kg/m^2 in mass which adds considerably to the STC.

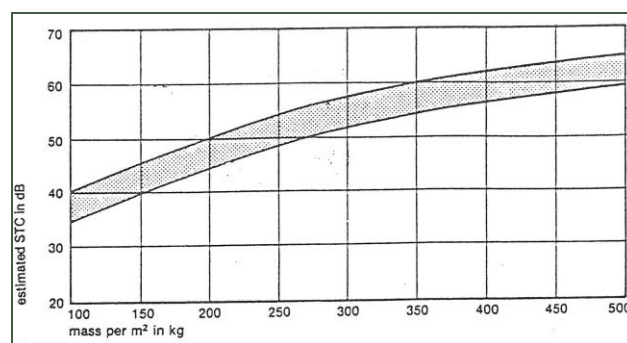


Figure 3: The relationship of estimated STC to the mass per m^2 of a single leaf concrete masonry wall

Full scale testing was commissioned through the University of Auckland in 1988 and 1993.

In the first series of tests, a 15 series wall was built, reinforced and grout filled to produce a partially filled wall which would be typical of structural requirements in Seismic Zone C. The test results from the report pages 1-3 "Transmission Loss of a Masonry Wall Construction" April 1988 are attached.

In the second series of tests carried out in 1993 a block wall was constructed of 20 series blocks, but this time it was completely grout filled. The test results from the report pages 1-9, "Transmission Loss Measurements of a Reinforced Solid Core Block Wall" November 1993, are also attached.

The test method utilised by the Applied Research Office at the Acoustics Centre is outlined on Pages 4-7 for the first series and pages 9-12 for the second series. These pages are not included but copies of the full report are available on request from the Cement and Concrete Association of New Zealand.

Construction of the test wall for series one (1988) is shown in **Figures 4 and 5**. The sound transmission coefficient based upon ASTM method of calculation was applied to the results obtained in Figure 1 of the attached report. The STC rating obtained for this wall construction was 42 but was close to achieving a 43 level. Bearing in mind, many masonry walls will be painted and the texture of the surface the test shows clearly that the predicted values of STC based on international results for masonry as shown in Figure 3 are substantiated for New Zealand materials. This is borne out in the second series of tests carried out in 1993. The wall was tested in both unpainted and painted conditions. The unpainted wall had a STC of 55 and the painted wall had a STC of 56 (see the attached results).

The summarised STC values for different masonry walls are set out in Table 1.

As far as ungrouted parts of the wall are concerned, the sound attenuation is very dependent on the workmanship of the block layer. A small gap in a mortar joint can cause a serious sound leak. When placing a closure block, especially, it is important to make a tight perpendicular joint. In cases where acoustical performance is of great importance, as in intertenancy walls, it is recommended to fill the space between the frogs on each side of a closure block with mortar. Plastering of the wall will give an extra safeguard against leaks and also adds mass.

Table 3 shows the result of acoustic tests on masonry walls of New Zealand made blocks. Although the test programme was limited they give a good indication of the sound attenuation qualities of concrete masonry. The STC values for the two single leaf walls conform very well with Figure 3 (estimated STC values). It must be noted that the test walls had none of their cores grouted. In the

practical situation at least some cores are reinforced and subsequently grouted. This increases the wall mass but fills voids and will have an influence on the STC. Another point is the relative concentration of mass and its influence on the STC values. For these reasons it was decided to carry out the acoustic testing at Auckland University as described earlier.

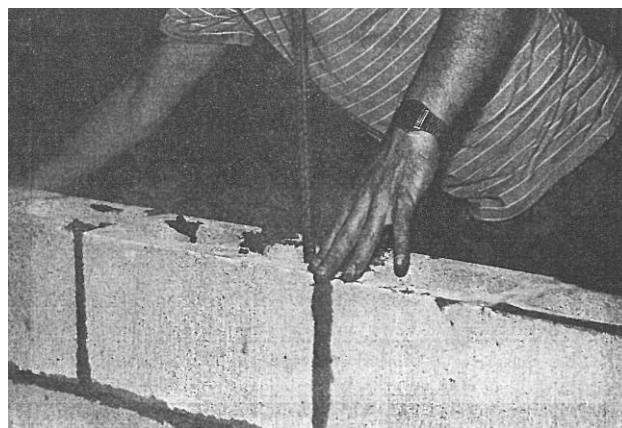


Figure 4: Laying up 15.05 units with reinforcing steel spaced at 800 mm centres

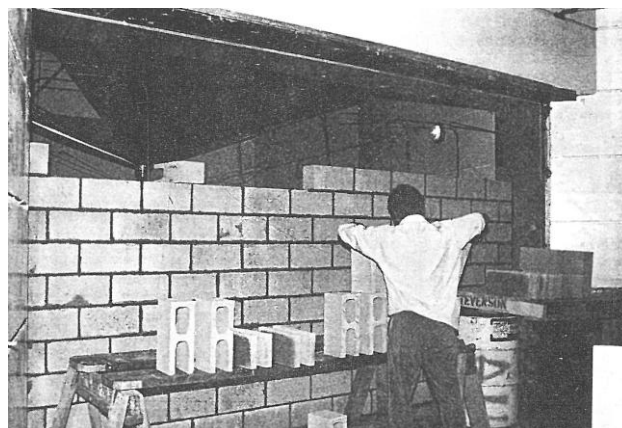


Figure 5: General view of wall under construction

Table 3: Sound transmission class of concrete hollow masonry in dB's as tested by BRANZ

STC (Median)	Wall Description
45	100 mm concrete block only
50	200 mm concrete block only
55	200 mm hollow concrete block + 50 mm cavity filled with R9 fibreglass + 100 mm concrete block + 13 mm Gib-board over timber furring
50	200 mm hollow concrete block + 50 mm cavity filled with R9 fibreglass + 100 mm concrete block

Classification in New Zealand Building Code G6

Many countries have standards and building codes covering sound attenuation of walls and floors in different situations and different types of buildings.

Released in July 1992, the new New Zealand Building Code and Approved Documents (NZBC) includes a section on airborne and impact sound. As with all other sections of the new code, it is in five main parts. The first three, the objective, the functional requirement, and the performance, are given below. The other two parts are the verification method, which is to be used in the case of specific design, and the acceptable solutions, which have been proven to meet the criteria and may be used without any specific design or testing. The first three main parts are as follows:

Objective

G6.1 The objective of this provision is to safeguard people from illness or loss of *amenity* as a result of undue noise being transmitted between abutting occupancies.

Functional Requirement

G6.2 *Building elements* which are common between occupancies, shall be constructed to prevent undue noise transmission from other occupancies or common spaces, to the *habitable spaces of household units*.

Performance

G6.3.1 *The Sound Transmission Class (STC) of walls, floors and ceilings, shall be no less than 55.*

G6.3.2 *The Impact Insulation Class (IIC) of floors shall be no less than 55.*

The verification method of the code states that any field tests carried out with respect to airborne sound insulation or impact sound insulation shall be within 5 dB of the performance requirement.

The acceptable solution states that sound transmission through building elements shall be minimised. To do this several options are listed.

Figure 6 is a schematic presentation showing the building elements which require noise control between separately occupied habitable spaces.

Whilst the New Zealand Code has some of the toughest compliance levels in the world, only a few situations are covered. Comparing the NZBC with other overseas regulations and practices clearly show these differences.

Typical overseas regulations and practices are summarised for some of the more common situations. However designers are advised to consult the primary reference sources to ensure a full understanding of their application.

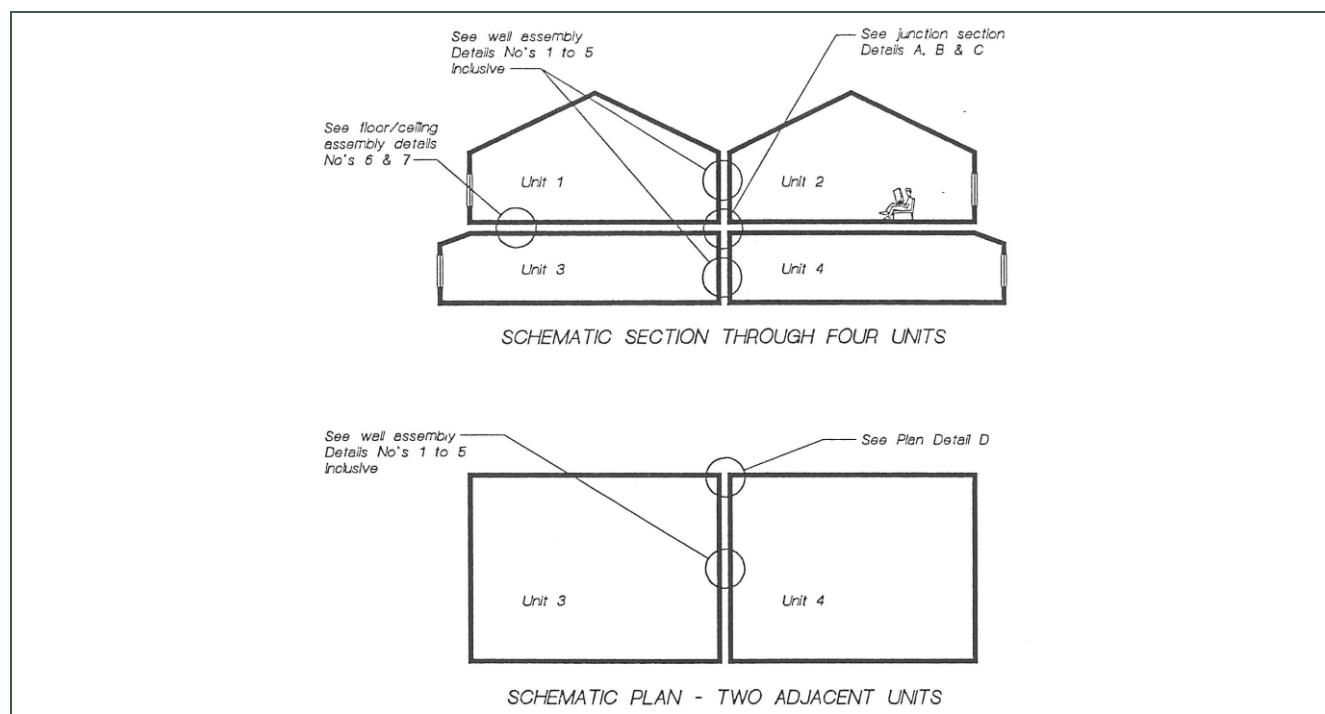


Figure 6: Location of building elements requiring noise control. Note - references refer to NZBC Section G6 which is the source of this figure.

Documents referred to are:

- BS 8233:1999 (UK) Code of Practice for Sound Insulation and Noise Reduction for Buildings.
- Sound Control for Homes, CIRIA Report 114, 1986.
- AS 2107:1987 (Australia) Acoustics - Recommended Design Sound Levels and Reverberation times for Building Interiors.

It is pertinent to refer first to CIRIA Report 114 because this gives:

- a summary of sound attenuation requirements
- a list of typical complying constructions
- a well-documented calculation method for dealing with external noise reduction through the building envelope.

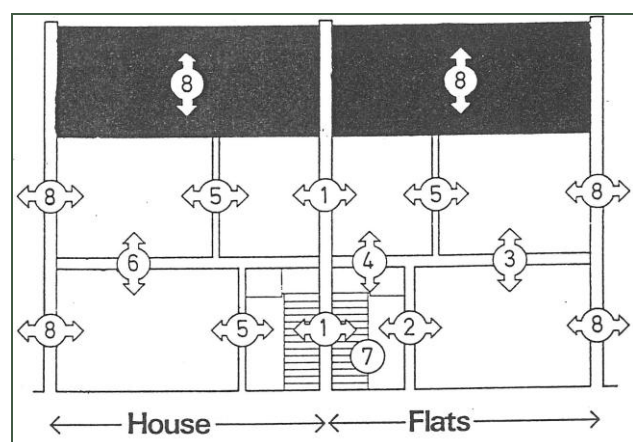


Figure 7: Typical construction separations taken from CIRIA Report 114.

Walls and Floors Covered by the New Zealand Building Code 1992

- Wall 1 Separating wall between dwellings.
Minimum sound insulation 55 dB.
- Wall 2 Separating wall in communal lobby.
Minimum sound insulation 55 dB.
- Floor 3 Separating floor between dwellings.
Minimum airborne sound insulation 55 dB.
Minimum impact sound insulation 55 dB.
- Floor 4 Take as 3.

For Walls 5 through 8 there are no requirements or recommendations.

Walls and Floors covered by UK Building Regulations 1985.

- Wall 1 Separating wall between dwellings.
Minimum sound insulation 52 dB.
- Wall 2 Separating wall in communal lobby.
Minimum sound insulation as for 1.
- Floor 3 Separating floor between dwellings.
Minimum airborne sound insulation 51 dB.
Minimum impact sound insulation 62 dB.
- Floor 4 Take as 3 but could relax impact sound requirement.

Walls and Floors not covered by Building Regulations. Suggested Standards.

- Wall 5 Partition wall quiet 46 dB.
Partition wall general 38 dB.
- Floor 6 Partition floor
Above a quiet room airborne 46 dB.
Above a quiet room impact 68 dB.
Below a quiet room airborne 46 dB.
Below a quiet room impact 38 dB.
- Area 7 References are made to special consideration for sound absorption surfaces.

Building Envelope 8

Building Envelope 8 is now discussed in more detail.

Designing the sound insulation of the building envelope requires the following information.

1. External noise level
2. Maximum design sound level inside the dwelling.
3. Surface area of the relevant portion of the building.
4. Sound absorption of receiving room.

The CIRIA Report 114 advises that a simplified approach can be used for housing. Items 3-4 can be ignored and a simplified external noise spectrum used.

When masonry walls are used it becomes only necessary to consider the detailing and construction of windows, doors, etc. Walls built of lightweight materials have a lower sound insulation value than masonry walls at low frequencies. Since road traffic noise peaks at low frequencies it follows that light

weight construction is not as an efficient insulator as masonry.

The difference is very noticeable to residents changing from a traditional timber weatherboard house to a masonry house. Where traffic or external noise is likely to be a problem, the first step is to use concrete masonry walls as a first option followed by veneer construction. Then attention must be paid to the detailing of windows. A single glazed window has a dB rating of 24 when viewed against traffic noise (masonry typically 47, timber typically 34-39). Double glazing with 100 mm gap between panes produces 37 dB.

Typically a masonry wall with 20% openings, single glazed, would have rating of 32 dB against traffic noise. With double glazing as described a rating of 43 dB.

A working document, CIRIA Report 114, is very useful for planning and designing for noise control for domestic construction.

While domestic structures are also included in AS 2107 and BS 8233, these documents include wide ranging advice on insulation levels.

Important areas for using masonry are seen in education buildings where a recommended minimum sound reduction between classrooms is 45 dB (BS 8233). Note this can be achieved with 150 series all cells filled.

Where special rooms require low intrusion of external noise, such as libraries, the barrier wall is best served by masonry construction since usually a 45 dB level is required. For offices where privacy is required the sound insulation level should be a minimum of 45 dB (BS 8233). AS 2107 recommends slightly lower values, 35-40 and 40-45 respectively.

From this section it can be seen that not only is there attention paid to between dwelling noise transmittance, but also there is some attention paid to external noise. Hence, the designer of a structure which is to be built in New Zealand may be wise to take noise attenuation from external sources into account.

Sound Absorption

The application of sound absorbing materials is one of the most important tools with which the acoustic designer can influence the acoustic character of a room or hall. It leads to greater economy, of course, if the absorbing material is also a structural material. Concrete block is one of the few building materials which combines acoustic and structural qualities.

Sound absorbing materials are commonly used to quieten noisy rooms such as airport lounges, hotel bars, open plan offices and manufacturing plants. These materials are also used to adjust the reverberation time (echo characteristics) of auditoria, theatres or concert halls. By applying the right degree of absorption satisfactory clarity and volume of sound is achieved for the type of performance for which the room is designed. In rooms designed for speech the potential for generating echo needs control as this will interfere with understanding. Not all reflected sound is undesirable. A room in which all sound generated is immediately absorbed can be unpleasant and could be called acoustically dead.

The sound absorbing qualities of concrete blocks depend on their surface texture. This is determined by the texture of the aggregates and the mix design. Also the frequency spectrum of the incident sound plays a role because there is a relationship between the wave length of the absorbed sound and pore dimensions. Rough and open surface textures generally absorb sound well, while smooth dense surfaces such as a plastered wall reflect much of the sound.

Absorbent surfaces allow the pressure waves to enter the pores in which they are reflected many times and become widely dispersed. The rough surface of the pore walls causes resistance to the airflow and the sound energy is transferred in to heat. The highest absorption is attained with concrete units using lightweight aggregates or with dense aggregates with an open surface structure and high internal porosity such as no fines concrete. For special acoustical applications custom designed surface shapes can add considerably to the absorption.

Masonry units and walls can be custom designed to achieve desired sound absorption properties. Examples of such special design are reported in the Concrete Masonry Association of Australia's publication "Concrete Masonry for Acoustic Control", MAPR 9 and "Tuning Concrete Masonry for Transformer Enclosures" MAPR 21. In both these cases, cavity walls were used incorporating an inner leaf of sound absorbing masonry and an outer leaf of sound attenuating material. The functions of sound absorption and sound attenuation were thus combined in a single structure.

It is believed that sound absorbing materials add to the acoustical insulation of a wall or floor by damping the coupling air space particularly in framed constructions. This is certainly true for materials which have absorbent qualities and sufficient mass, such as concrete block.

Sound absorbing qualities can be compared by means of absorption coefficients which are

measured at bands within the audible spectrum. The average value over the spectrum for a material is known as its Noise Reduction Coefficient (NRC). Such coefficients range from 0.03 (3%) for hard plaster to 0.8 (80%) for special absorbent materials. The sound absorption coefficient is derived as a proportion of an open window, assumed to be 1 (100%) because there is no reflection at all - which equals total absorption.

Any material with an NRC of 0.15 or higher is considered useful for sound control. According to **Figure 8**, the NRC of concrete block walls ranges from 0.06 to 0.68 (untreated). This places the majority of blocks in the category of useful for sound control.

The table in **Figure 8** (page 10) is based on international data because absorption figures for the full range of New Zealand produced blocks are not yet available. It is likely that they will differ from plant to plant since each plant uses different aggregates and different mix designs. **Figure 8** supplies some guidance for general cases but in special situations, tests should be carried out on the actual materials used.

A typical comparison illustrates the potential role of masonry in a sound absorption role. Consider a room 4 m square, ceiling height 2.4 with 2 m² glazing, 1.5 m² timber door, walls built in light weight (1,850 kg/m³) masonry.

	m ²	Absorption Coefficient			
Concrete ceiling	16.00	x	0.04	=	0.64
Masonry walls (38.40 - 3.50)	34.90		0.40	=	13.96
Door	1.50		0.06	=	0.09
Glazing	2.00		0.02	=	0.04
Carpet floor	16.00		0.45	=	7.20
	70.40			=	21.93
Average NRC =	21.93 = 0.31				
	70.40				
Repeat but with timber panelling					
Concrete ceiling	16.00	x	0.04		0.64
Panelling	34.90		0.06		2.09
Door	1.50		0.06		0.09
Glazing	2.00		0.02		0.04
Carpeted Floor	16.00		0.45		7.20
	70.40				10.06
Average NRC =	10.06 = 0.14				
	70.40				

For noise reduction comfort the sound absorption for a typical room as a whole should be between 0.2 and 0.5.

Rooms with special requirements for music, singing and speaking need a careful balance of reflection and absorption which may on occasions be obtained by different decorative wall treatments on masonry walls.

Unrendered and unpainted concrete masonry absorbs more sound than surface treated walls. Paint applied by brushing tends to seal the outer pores, reducing sound entry and dissipation, although light spray painting reduces sound absorption only marginally. This painting does of course increase sound insulation. A point explained in the earlier part of the acoustic section.

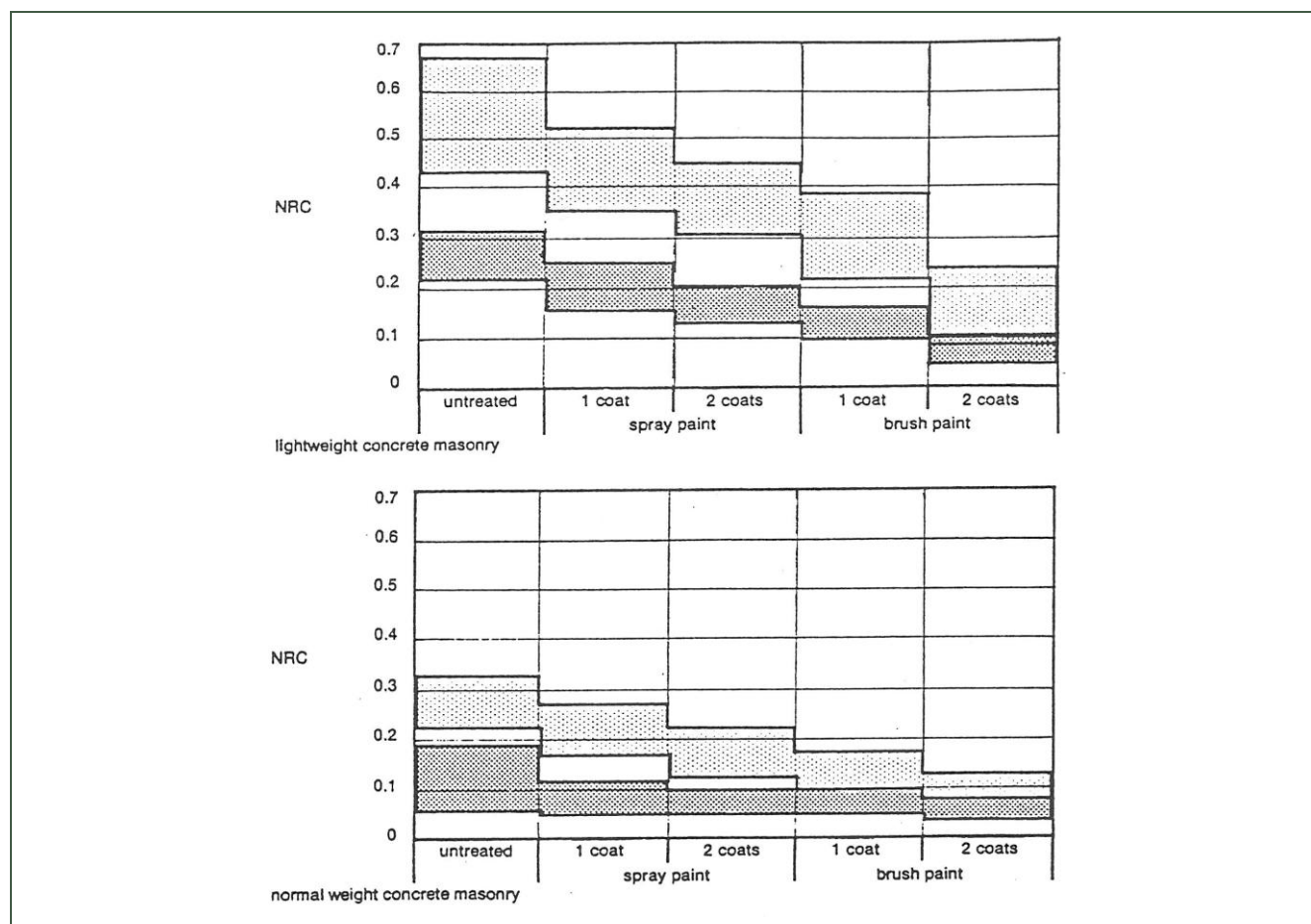


Figure 8: Sound absorption of concrete masonry expressed as Estimated Noise Reduction Coefficient (NRC). (This information is based on a large number of tests carried out in the USA by the PCA and the NCMA)

References

- Rodgers, M F. Sound attenuation of concrete masonry walls. New Zealand Engineering, 31 (3); pp. 78-82 (Mar 1976).
- The quiet comfortable house. Concrete Masonry Association of Australia, 1985.
- Concrete masonry for acoustic control. Concrete Masonry Association of Australia, Project Review MAPR 90, 1972.
- Tuning concrete masonry for transformer enclosures. Concrete Masonry Association of Australia, Project Review MAPR 21, 1974.
- Sound absorption of concrete masonry walls. Washington, D.C., Expanded Shale Clay and Slate Institute, 1965. (Lightweight concrete information sheet No.9 revised 1-65).
- Sound transmission loss through concrete masonry walls. Washington, D.C.; Expanded Shale Clay and Slate Institute 1965.
- (Lightweight concrete information sheet No.8 revised 1-65).
- Gage, Michael & Tom Kirkbride. Design in blockwork. London, Architectural Press. 3rd enlarged edition, 1980.
- Acoustics of concrete in buildings. Skokie, Ill. Portland Cement Association, 1982. IS 159T.
- Sound control for multi-unit housing. San Francisco, Portland Cement Association, n.d.
- Australian Standard 1475; Part 1 - 1977. Amdnt.1, Sep 1983; Amdnt.2, Oct 1986. SAA Blockwork code. Part 1 - unreinforced blockwork (Appendix D).
- Portland Cement Association. Concrete masonry handbook for architects, engineers, builders. Skokie, Ill., The Author. Rev. Ed. 1985.
- Litvin, Albert and Harold W Belliston. Sound transmission loss through concrete and concrete masonry walls. American Concrete

- Institute Journal, 75 (12); pp 641-646. (Dec. 1978).
13. Northwood, T D and D W Monk. Sound transmission loss of masonry walls: Twelve-inch lightweight concrete blocks with various surface finishes. Ottawa, National Research Council of Canada, Division of Building Research, 1974, (NRCC DBR, Building Research Note No.90.)
 14. Northwood, T D and D W Monk. Sound transmission loss of masonry walls: Twelve-inch lightweight concrete blocks - comparison of latex and plaster sealers - Ottawa, National Research Council of Canada, Division of Building Research, 1974 (NRCC DBR, Building Research Note No. 93).
 15. Christie, N J R and Harold P Isaacs. Australian concrete masonry design and construction - volume 1. Concrete Masonry Association of Australia, 1977 (MA 102), Chapter 7, pp. (7.1-7.9).
 16. Code of Practice for Sound Insulation and Noise Reduction for Buildings. BS 8233:1999 (UK).
 17. Sound Control for Homes, CIRIA Report 114, 1986.
 18. Acoustics - Recommended Design Sound Levels and Reverberation Times for Building Interiors. AS 2107: 1987 (Australia).
 19. The New Zealand Building Code and Approved Documents, Approved Document G6 'Airborne and Impact Sound' - Building Industry Authority, 1992.
 4. Copeland, R E. Controlling sound with concrete masonry. Concrete Products, July 1965.
 5. A guide to selecting concrete masonry walls for noise reduction. McLean, Va., National Concrete Masonry Association, 1970.
 6. Estimating sound transmission class of concrete masonry. McLean, Va., National Concrete Masonry Association, 1967 (NCMA Tek 9).
 7. Noise control with concrete masonry in multi-family housing. McLean, Va., National Concrete Masonry Association. (1984?) (NCMA Tek 18A).
 8. Noise control with concrete masonry. McLean, Va., National Concrete Masonry Association, 1972 (NCMA Tek 39).
 9. Apartments - design for economy, noise control and fire safety. McLean, Va., National Concrete Masonry Association, 1973 (NCMA Tek 51).
 10. Concrete masonry blocks out noise in apartments, town houses and multiplex buildings. McLean, Va., National Concrete Masonry Association, n.d. (NCMA CM 226).
 11. Parkin, P H, H R Humphreys and J R Cowell. Acoustics, noise and buildings. 4th revised edition. 1979. London; Boston: Faber and Faber.
 12. New data of sound reduction with concrete masonry walls. National Concrete Masonry Association, 1978, 4 pp. NCMA Tek 69A.

Further Reading

1. Beranek Leo L. ed. Noise Reduction. Huntington, N.Y.; R E Krieger Pub. Co., 1980, c 1960.
2. Reprint of the edition published by McGraw-Hill.
3. Stanley, R C. Light and sound for engineers. UK., Hart, 1968.

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ARO/3012

88T02

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REPORT ON
TRANSMISSION LOSS OF A
MASONRY WALL CONSTRUCTION

Report prepared for: N. Z. Concrete Research Association
Private Bag
PORIRUA

Report prepared by: Acoustics Testing Service
School of Architecture
UNIVERSITY OF AUCKLAND

APPLIED RESEARCH OFFICE
UNIVERSITY OF AUCKLAND
PRIVATE BAG
AUCKLAND

APRIL 1988



MEASUREMENT: Transmission loss of a Masonry wall construction.

STANDARDS FOLLOWED ISO 140 parts 1, 2 and 3 and ISO 717 part 1.

PLACE OF MEASUREMENT: Reverberation chambers C and A,
Acoustics Research Centre,
University of Auckland.

DESCRIPTION OF SAMPLE AND INSTALLATION: The wall construction was built in the test opening between chambers C and A. Before construction a timber surround of 18 mm customwood was bolted over the gap between the chambers, of width 500 mm. The masonry wall was built on the chamber A side of the surround. The wall consisted of 13 courses of blockwork using 140 mm blocks ("15" series blocks). The wall was partially filled and reinforced using one D16 bar in the top and bottom course of the wall and 6 vertical D12 bars in every second column of blocks. (See figure 2).

RESULTS: These are shown in figure 1 and the accompanying table.

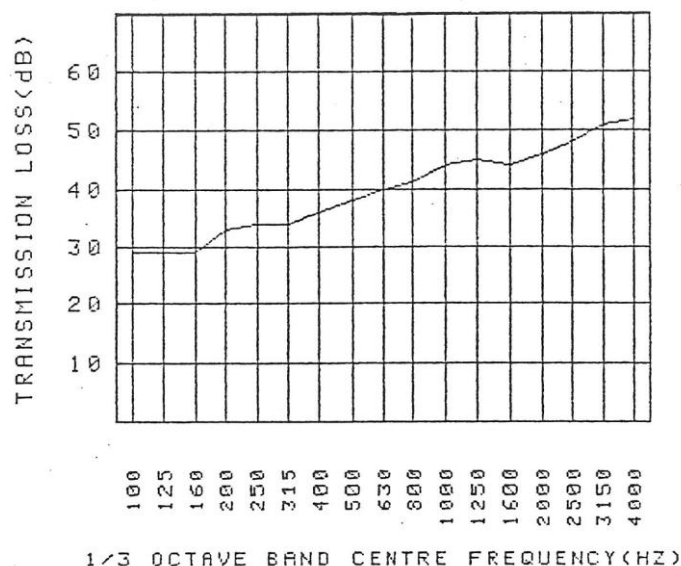

G. Dodd


M. Poletti

88T02

ACOUSTICS TESTING SERVICE
16-2-88

FIGURE 1: TRANSMISSION LOSS OF MASONRY WALL



1/3 OCTAVE CENTRE FREQUENCY (HZ)	TABLE 1 TRANSMISSION LOSS (dB)	STANDARD ERROR (dB)
100	29	1
125	29	1
160	29	1
200	33	1
250	34	<1
315	34	<1
400	36	<1
500	38	<1
630	40	<1
800	41	<1
1000	44	<1
1250	45	<1
1600	44	<1
2000	46	<1
2500	48	<1
3150	51	<1
4000	52	<1

SIC = 42

Rw = 42

WALL AREA = 12.341056 M²

RECEIVING ROOM = CHAMBER C VOLUME 209 M³ AREA 214 M²

METEOROLOGICAL CONDITIONS:

REVERBERATION MEASUREMENT = 24.5 DEGREES C 76.0 % RH 1000 MILLIBARS

LEVEL MEASUREMENT = 24.5 DEGREES C 76.0 % RH 1000 MILLIBARS

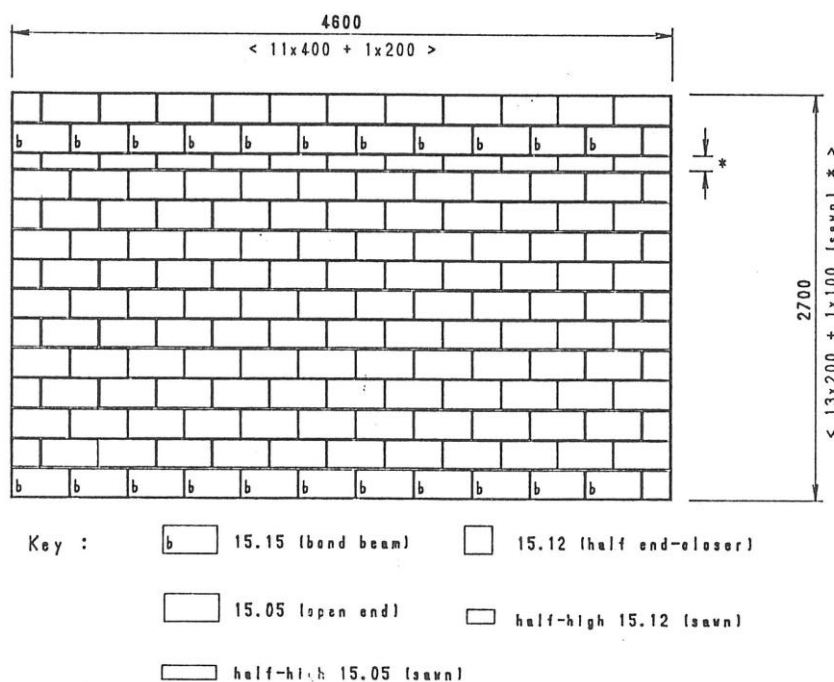
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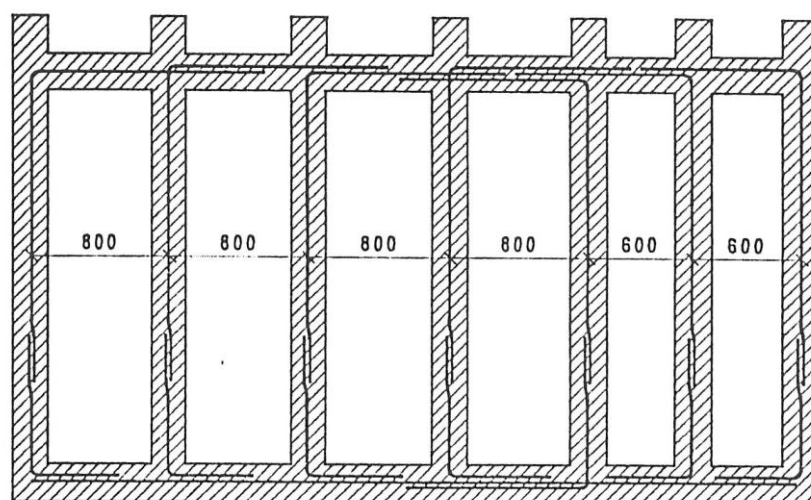
NZCMA ACOUSTICS TEST PROGRAMME (Feb. 1988)

15 SERIES WALL DETAILS

(a) Block Layout



(b) Grout/Reinforcement Profiles



All reinforcement Grade 275 MPa, D12

Grout proportioned to yield a standard compressive strength rating of between 17.5 - 20 MPa during the acoustic tests.

FIGURE 2

PROJECT T334

PAGE 1 OF 12

REF 5023.18

T334/ATS

TRANSMISSION LOSS MEASUREMENTS OF A REINFORCED SOLID CORE BLOCK WALL

Report prepared for: Cement & Concrete Association
P.O. Box 47-277
Ponsonby
Auckland

Report prepared by: Acoustics Testing Service
Department of Architecture
THE UNIVERSITY OF AUCKLAND

AUCKLAND UNISERVICES LTD
THE UNIVERSITY OF AUCKLAND
PRIVATE BAG 92019
AUCKLAND

November 1993

Dr G. Dodd
Mr J. Irons
Acoustics Testing Service



All tests reported
herein have been
performed in
accordance with the
laboratory's terms
of registration

REGISTERED TESTING LABORATORY No. 268

MEASUREMENT: Measurement by Laboratory Method of Transmission Loss of a reinforced solid core block wall.

STANDARDS FOLLOWED: ISO 140/III.1978
ASTM E413-87

PLACE OF MEASUREMENT: Reverberation Chambers A and C,
Acoustics Research Centre,
The University of Auckland.

INSTRUMENTATION:

EQUIPMENT	TYPE/SERIAL No.
Brüel & Kjær	

CHAMBER A EQUIPMENT

1" Microphone	4145/1503121
Preamplifier	2619/945922
Power Supply	2807/888602
Rotating Boom	3923/936497

CHAMBER B EQUIPMENT

1" Microphone	4145/1503121
Preamplifier	2619/945922
Power Supply	2807/888602
Rotating Boom	3923/936497

COMMON EQUIPMENT

Noise Generator	1027/882108
Noise Generator	1402/352500
Measuring Amplifier	2636/936030
Filter Set	1617/887800
Pistonphone	4220/1048366

MEASUREMENT SOFTWARE

"Reverb/SV2"	version 2.01
"Lread/SV2"	

NOTE: Where names are given in capitals in this report, they refer to proprietary products, which can be referred in appropriate product catalogues.

DESCRIPTION OF SAMPLES:

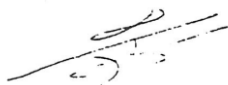
A TRI-BOARD collar was installed in the chamber C part of the test corridor between chambers A and C. This collar was made of 50 mm TRI-BOARD, and was bolted in place, then sealed to the structure of chamber C with USG ACOUSTICAL SEALANT, giving a sealed edge flush with the chamber (ref ATS/ I302). A further TRI-BOARD collar of 43 mm thickness was then fitted in the chamber A side of the test corridor, bridging the separation between the two chambers. The two collars were vibration isolated from each other by means of an intervening layer of SELLOTAPE 3507 rubber tape which also sealed the gap between them.

SAMPLE No.1:

On the collar in Chamber C, a concrete block wall was erected using type 20:16 blocks. The blocks were mortared with DRICON "TRADE" Mortar. The nominal weight of each block was 15 kg. The wall was constructed as a hollow core structure, with D12 reinforcing rods placed horizontally and vertically. When the wall was completed to within 60 mm of the top of the collar, grout was poured into the internal cavities, filling the existing structure to the top. To seal the wall, concrete capping slates were mortared and slipped into position on top of the blocks. See Drawings 1 and 2.

SAMPLE No. 2:

The wall described above was painted on each face with two coats of acrylic paint to seal the faces.

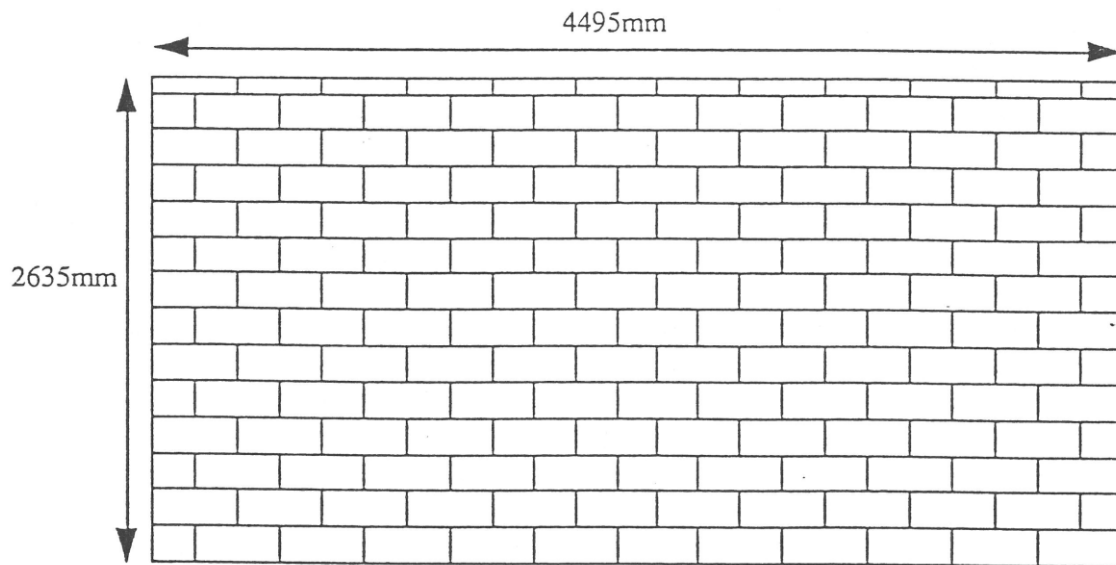


Mr J. Irons
Testing Officer

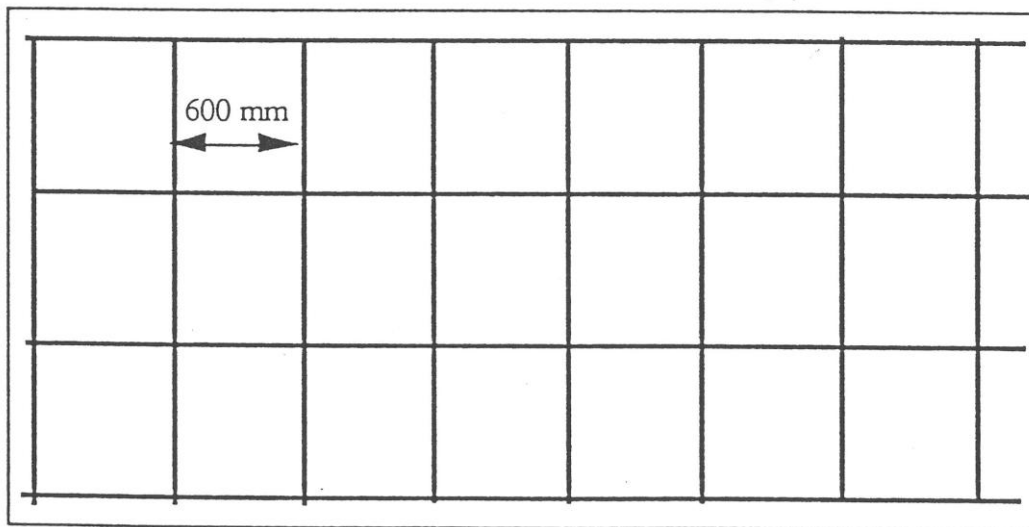


Dr G. Dodd
Head, ATS

DRAWING 1: BLOCK LAYOUT OF WALL



DRAWING 2: PLACEMENT OF D12 REINFORCING RODS IN WALL



DRAWING 3: SECTION OF WALL SHOWING BLOCK LAYOUT

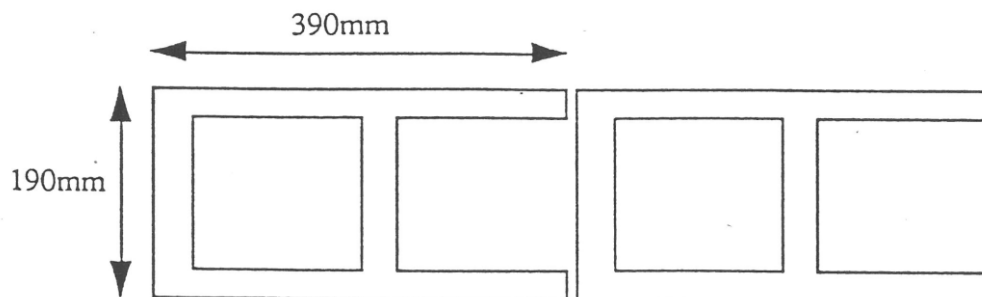


TABLE 1: Reverberation Times in Chamber A for bare block wall.

THIRD OCTAVE BAND CENTRE FREQUENCY (HZ)	R.T WITH SAMPLE (Seconds)	STANDARD ERROR
100	5.37	0.05
125	4.88	0.03
160	5.09	0.03
200	5.62	0.02
250	6.02	0.02
315	5.99	0.01
400	6.20	0.01
500	6.49	0.01
630	6.64	0.01
800	6.42	0.01
1000	5.99	0.04
1250	5.51	0.03
1600	5.02	0.02
2000	4.39	0.02
2500	3.85	0.02
3150	3.44	0.02
4000	2.98	0.01

METEOROLOGICAL CONDITIONS:

TEST ID	TEMPERATURE DEGREES C	RELATIVE HUMIDITY	ATMOSPHERIC PRESSURE (mB)
T334R01	20	90%	1011

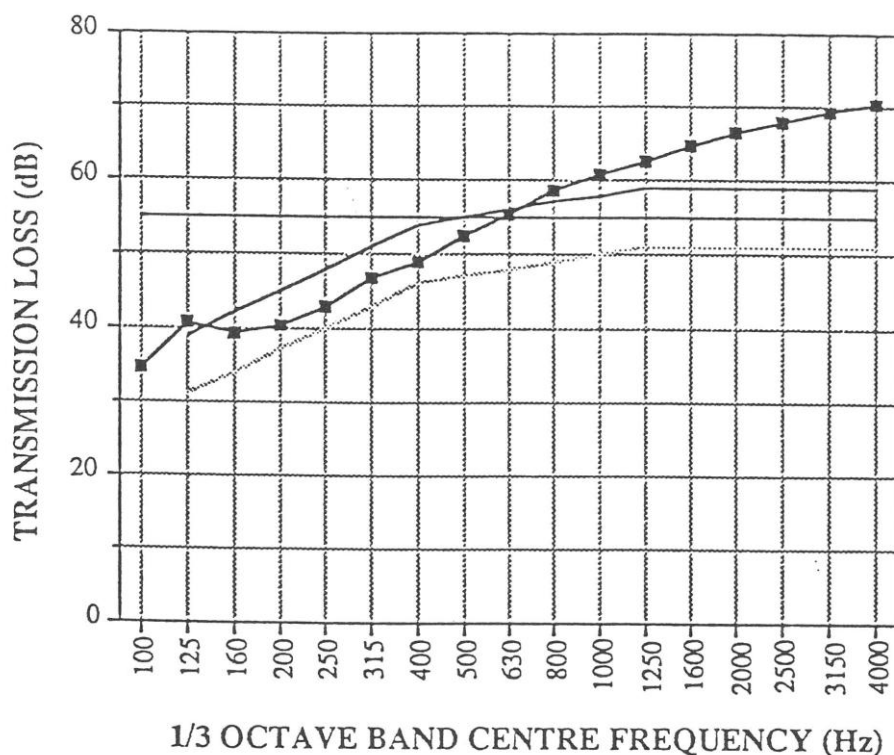
TABLE 2: Sound Pressure Levels measured for the determination of TL of bare block wall. Chamber C Source, Chamber A Receiving.

THIRD OCTAVE BAND CENTRE FREQUENCY (Hz)	LEVEL, (dB) SOURCE CHAMBER	STANDARD ERROR	LEVEL, (dB) RECEIVING CHAMBER	STANDARD ERROR
100	94.6	0.9	62.8	0.9
125	95.6	0.8	57.5	0.5
160	99.7	0.7	63.0	0.4
200	102.1	0.4	64.7	0.4
250	102.8	0.4	63.2	0.5
315	102.1	0.3	58.7	0.3
400	102.0	0.4	56.7	0.3
500	102.5	0.3	53.7	0.3
630	102.4	0.3	50.9	0.3
800	102.5	0.3	47.4	0.3
1000	101.1	0.3	43.7	0.3
1250	100.0	0.3	40.3	0.3
1600	98.6	0.3	36.7	0.3
2000	98.7	0.3	34.4	0.3
2500	98.2	0.3	31.8	0.3
3150	96.7	0.3	28.3	0.3
4000	97.2	0.4	27.0	0.2

METEOROLOGICAL CONDITIONS:

TEST ID	TEMPERATURE DEGREES C	RELATIVE HUMIDITY	ATMOSPHERIC PRESSURE (mB)
T334L01	20	90%	1010

GRAPH 1: Transmission Loss of Bare Block Wall



STC = 55
R_w = 55

TABLE 3: Transmission Loss of Bare Block Wall

THIRD OCTAVE BAND CENTRE FREQUENCY (Hz)	TRANSMISSION LOSS (dB)	STANDARD ERROR	DEVIATION BELOW RATED STC CURVE
100	35	1	-
125	41	1	0
160	39	1	3
200	40	1	5
250	43	1	5
315	47	1	4
400	49	1	5
500	52	1	3
630	55	1	1
800	59	1	0
1000	61	1	0
1250	63	1	0
1600	64	1	0
2000	66	1	0
2500	68	1	0
3150	69	1	0
4000	71	1	0

SAMPLE AREA = 11.84 m²
RECEIVING ROOM = CHAMBER A
VOLUME = 202 m³ AREA = 203.6 m²

Total Points Below
STC Curve = 26

Table 4: Reverberation Times in Chamber A for painted block wall

THIRD OCTAVE BAND CENTRE FREQUENCY (Hz)	R.T. WITH SAMPLE (Seconds)	STANDARD ERROR
100	5.78	0.04
125	4.92	0.03
160	5.25	0.03
200	5.88	0.02
250	6.49	0.01
315	6.39	0.01
400	6.73	0.01
500	7.25	0.01
630	7.46	0.01
800	7.28	0.01
1000	6.90	0.06
1250	6.29	0.05
1600	5.65	0.02
2000	4.90	0.02
2500	4.22	0.02
3150	3.72	0.02
4000	3.19	0.01

METEOROLOGICAL CONDITIONS:

TEST ID	TEMPERATURE DEGREES C	RELATIVE HUMIDITY	ATMOSPHERIC PRESSURE (mB)
T334R02	20	67%	1014

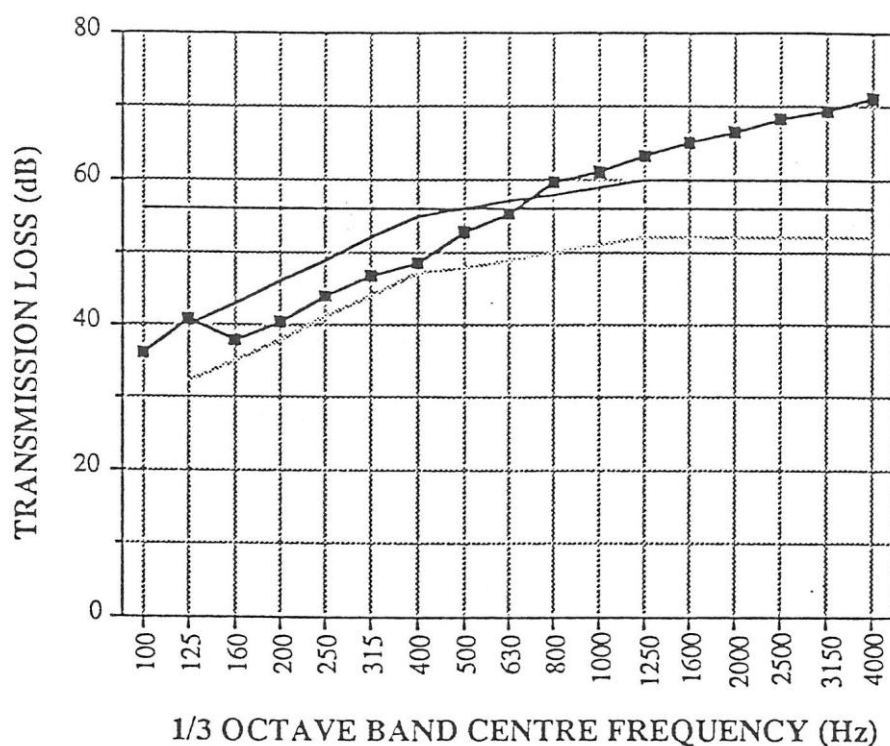
Table 5: Sound Pressure Levels measured for the determination of TL of painted block wall. Chamber C Source, Chamber A Receiving.

THIRD OCTAVE BAND CENTRE FREQUENCY (Hz)	LEVEL, (dB) SOURCE CHAMBER	STANDARD ERROR	LEVEL, (dB) RECEIVING CHAMBER	STANDARD ERROR
100	97.1	0.8	64.2	0.7
125	96.4	0.7	58.3	0.5
160	100.1	0.4	64.9	0.5
200	102.5	0.4	65.4	0.5
250	104.0	0.4	63.6	0.4
315	103.2	0.4	60.1	0.3
400	102.7	0.3	57.8	0.4
500	103.4	0.3	54.8	0.4
630	103.3	0.3	52.1	0.3
800	103.6	0.3	48.3	0.3
1000	102.1	0.3	44.8	0.3
1250	101.4	0.3	41.7	0.3
1600	99.6	0.3	37.7	0.3
2000	99.6	0.3	35.5	0.3
2500	99.1	0.4	32.7	0.3
3150	97.2	0.3	29.3	0.4
4000	97.3	0.4	26.8	0.2

METEOROLOGICAL CONDITIONS:

TEST ID	TEMPERATURE DEGREES C	RELATIVE HUMIDITY	ATMOSPHERIC PRESSURE (mB)
T334L02	19	66%	1013

Graph 2: Transmission Loss of Painted Block Wall.



STC = 56

R_w = 55

Table 6: Transmission Loss of Painted Block Wall.

THIRD OCTAVE BAND CENTRE FREQUENCY (Hz)	TRANSMISSION LOSS (dB)	STANDARD ERROR	DEVIATION BELOW RATED STC CURVE
125	41	1	0
160	38	1	5
200	40	1	6
250	44	1	5
315	47	1	5
400	49	1	6
500	53	1	3
630	55	<1	2
800	59	<1	0
1000	61	<1	0
1250	63	<1	0
1600	65	<1	0
2000	67	<1	0
2500	68	1	0
3150	69	1	0
4000	71	<1	0

SAMPLE AREA = 11.84 m²

RECEIVING ROOM = CHAMBER A

VOLUME = 202 m³ AREA = 203.6 m²

Total Points Below
STC Curve = 32