Proceedings of the Institute of Acoustics

A Discussion of Sound Insulation Values for a Variety of Auditorium Wall Constructions

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1. INTRODUCTION

The sound insulation of adjacent auditoria in multiplex cinemas is of critical importance to the operator. The auditoria should be sufficiently separated to enable quite different presentations to run simultaneously but construction should also be as simple and cost effective as possible.

The following paper presents on-site measured sound insulation results for a lightweight partition type and a masonry core type.

Commonly experienced problems are discussed and recommendations made for their avoidance.

2. CRITERIA

The criteria we recommend for sound separation between auditoria has been developed with an operator using digital sound systems. Comments had been received regarding noise break through in older cinemas that had been upgraded to a digital playback systems. Measurements on site during typical action films and trailers were used to assess the noise control requirements.

Based on these measurements, we recommend a sound insulation target of not less than R'w 65 dB, but also no less than the third octave band values given in figure 1.

3. WALL CONSTRUCTIONS

We have conducted extensive tests on two main wall types across a number of different geographic regions. These wall types are shown schematically in figures W1 and W2. The first type is a lightweight partition system typically used in the UK and Japan, our detail shows that all plasterboard should be equivalent to British Gypsum SoundBloc grade or plank and a similar proprietary system is distributed by Knauf. The second is a masonry core system normally used in Germany. In this system, a concrete core wall is used with a 2 layer plasterboard lining to one side. The studwork for the lining is braced using a minimum number of resilient ties from the core wall and mineral fibre quilt is located in the cavity.

4. REVERBERATION TREATMENT

Reverberation control is required within the auditoria to enhance the intelligibility of the dialogue and to render effects mixed in the soundtrack to be heard as intended. The aim of treatment is to control reverberation times and flutter echo whilst not creating a completely dead space that would be uncomfortable.

Mineral fibre batts are used as absorptive media behind stretched facing fabric. Treatment at seated head height is continuous and above this level, discrete mineral fibre batts are used arranged so that an exposed wall surface will always be opposite an absorptive panel. Again the emphasis is on simplicity and cost effectiveness, this limits the thickness of acoustic treatment that is typically used.

5. TEST PROCEDURE

Tests are conducted broadly in the manner recommended by BS EN ISO 140/4 Field measurements of airborne sound insulation between rooms. Deviations from the standard are mainly related to the loudspeaker system used. Omni-directional loudspeakers are quite simply incapable of generating sound levels high enough at all relevant frequencies to conduct meaningful sound reduction tests.

We use a distributed loudspeaker system, normally with 4 mid to high range loudspeaker cabinets and 1 sub-bass 'woofer'. The loudspeakers are stacked in two groups, one is positioned off centre at the front of the auditoria and one diagonally opposite about two thirds back. A remote controlled pink noise source is used, triggered from the sound level meter and the total power of the system is in the order of 5-6 kW.

Source room and receive room noise levels are measured at a minimum of 6 locations at about seated head height.

The reverberation time in the source room is measured with the sub woofer and one set of the mid/high speakers.

6. RESULTS

The results of the tests are presented on charts 1 to 4 as follows:

Chart 1 UK Plasterboard Partitions Wall Type 1, 25 Samples
Chart 2 Japanese Plasterboard Partitions Wall Type 1, 23 Samples
Chart 3 German Built Masonry Core Partitions With Fully Lined Concrete Core, 20 Samples
Chart 4 German Built Masonry Core Partitions With Plasterboard Panel Absorbers, 33 Samples

Each chart shows the arithmetic average R' values; the 2x standard deviation bands; and the measured maximum and minimum values in each third octave band.

7. DISCUSSION

7.1 Lightweight Construction

The results plotted on chart 1 for wall type 1 were measured in UK cinemas over four different sites and are collated from results measured across 25 partitions.

At each site there was a good level of site inspection during construction of the partitions with particular attention paid to the detailing at the head junction. Each auditorium had a front floating floor section and an upgraded ceiling protecting the lightweight roofs, which had no other acoustic treatment.

The arithmetic average value of R'w is 73 dB with a maximum value of 80 dB and a minimum value of 62 dB. 3 of the 25 partitions had R'w values under 65 dB and site observations note that these partitions suffered from weaknesses associated with escape doors opening into shared lobbies.

3 of the cinemas were built on-grade and one was on an upper floor. The upper floor cinema had a mixture of: 200mm equivalent solid thickness base slab with no resilient supports for the stadium seating slabs; and 140mm equivalent solid thickness base slab with resiliently supported lightweight timber decking stadia slabs.

2 of the measurements for auditoria with lightweight timber stadia slabs were affected by the lobbied escape doors referred to previously. The one adjacency with lightweight stadia on resilient pads and a 140mm base slab but with no shared escape door lobby achieved R'w 72 dB.

It is interesting to note the small deviation about the mean for the low frequency measurements, even down to 31.5 Hz, where the standard deviation is 3.5 dB.

The partitions measured in Japan have provided an aggregate performance in excess of the R'w target and also provide a low frequency performance in the order of our target. The overall performance is, however, lower than the performance for equivalent partitions measured in the UK. We believe the main reason for this difference is related to bracing between the plasterboard wall layers and structural flanking through an inherently lightweight shell structure.

The Japanese partitions were built off the base slab of the cinema shell, whereas the UK partitions were built off floating floors and stadium seating sections, providing very good separation between the outer leafs of the walls. By supporting the studwork off the base slab of the shell, a rigid link can be made between the plasterboard leafs. A resilient base channel assembly has been recommended to resolve this issue.

A second bracing issue is the form of lateral restraint used to achieve the partition heights required in cinemas. In the UK, the common method is to use back to back boxed studs to achieve heights over about 7.5 - 8m. In Japan, a horizontal beam is located within the wall and both sides of the studwork are tied back to the beam. Resilient connections to one side of the partition have been recommended to overcome this problem.

The lowest performing of the Japanese partitions had potentially rigid links at the cross-bracing beam and a question mark over whether the resilient base channel had been installed. The higher performing partitions had resilient connections to the cross-bracing beam and resiliently mounted base channels.

7.2 Masonry

The results plotted on chart 3 for wall type 2 were measured in German and Austrian cinemas over 4 different sites and are collated from results measured across 20 partitions. The results plotted on chart 4 for wall type 2 were measured in German cinemas over 6 different sites and are collated from results measured across 33 partitions.

The results have been split into two groups to illustrate a significant point.

In the older cinemas, the masonry core wall was fully covered with a layer of 100mm thick fabric covered mineral fibre as shown on figure W2, chart 3 presents the results of measurements made on these partitions. The cinemas are predominantly of massive concrete construction and there are few flanking issues. The arithmetic average value of R'w is 69 dB with a maximum value of 73 dB and a minimum value of 64 dB.

In more recent cinemas, the 100mm mineral fibre layer was reduced to 30mm to increase space and reduce cost. As described above, reverberation control is achieved by arranging discrete mineral fibre batts behind the fabric and with the reduced thickness of batt, we were concerned about the potential reduction in low frequency absorption. Discrete plasterboard sheets were fixed to 25mm battens act as panel absorbers where there had been exposed wall surface previously, also shown on figure W2.

The results obtained from a similar mix of cinemas to before are presented on chart 4. As can be seen, there is a general reduction in R' with a significant weakness at and around 250Hz. It has become apparent from investigations that the panel absorbers resonate at around this frequency leading to an apparently lower SRI when measured. The arithmetic average value of R'w is 63 dB with a maximum value of 69 dB and a minimum value of 59 dB.

Chart 5 presents results measured on 4 partitions that, whilst not having discrete panel absorbers, have a plasterboard liner on resilient bars leading to a similar airspace. The measured results show a weakness at the same frequency range as for the partition with panel absorbers.

8. POTENTIAL SOURCES OF WEAKNESS OR FAILURE

From the above measurements and our experience on site, we can make the following recommendations and comments.

8.1 Partition Separation

In order to achieve the highest performance from lightweight wall constructions, it is important that the external wall leafs are mechanically separated as much as possible. For this reason, cross bracing must be minimised and potential rigid links must be treated to ensure that the optimal wall performance is obtained.

8.2 Doors

Fire escape or exit doors are a potential source of weakness, particularly when opening to a shared lobby. In such situations, we have found that a minimum rating for the doors of Rw 45 dB is required to maintain the overall wall performance of R'w 65 dB.

Auditorium entrance doors are normally located at the end of an absorbent entrance corridor and R'w 65 dB between adjacent auditoria has been measured even with a single set of poorly sealed entrance doors on each auditorium. The requirement for sound insulation of the entrance doors is driven by the use of the area immediately outside.

8.3 Flanking Walls

It is important that lightweight building elements are not continuous between auditoria to reduce the possibility of noise flanking paths. The auditorium side of the projection room wall and screen wall should be broken on the partition line to achieve this discontinuity.

8.4 Roof

Care should be taken with lightweight roofs to ensure that they are not flanking paths.

Discontinuities can be introduced to the structure of the roof in the form of broken purlirfs and liner sheets or the roof structure can be protected by an auditorium ceiling upgraded with plasterboard.

The upgraded ceiling option has several additional advantages, including protection of the sensitive partition head junction and protection against unwanted rainfall generated noise. Rainfall generated noise is particularly a problem on standing seam roofs although less so on Sarnofil or Trocal type resilient membrane topped roofing systems.

8.5 Floors

Floors with an equivalent solid thickness of greater than or equal to 200mm (460 kg/m2) solid concrete can provide flanking control to R'w 65 dB and in the order of figure 1 when used in conjunction with floating front floor sections and stadium seating slabs without resilient supports. For thinner base slabs, resilient supports for the stadium seating slab are recommended. Base slabs of 300mm equivalent solid thickness (690 kg/m2) should not require floating front floor sections or resilient stadium seating supports.

8.6 Stadium Seating Steelwork Supports

There is a potential for the steelwork supporting stadium seating to allow flanking noise if directly connected between auditoria. We have found that acceptable separation is achieved if supporting beams are split by a column, that is no one beam spanning directly between two auditoria. All of the results presented in chart 1 had no greater separating mechanism than this, no neoprene grommets, brackets or sleeves were used at steelwork junctions.

8.7 Site Inspections

The most significant improvement in on-site measured sound insulation was achieved by increasing the frequency of site inspections during construction of the partitions. The most critical element in the construction of the partitions is the head junction where significant leakage can occur. The head junction often has purlins and steel beams passing through, all of which require close detailing for successful implementation.

The boards forming the penetrations should be cut as tightly as possible to the beam or purlin and non-setting acoustic mastic used to seal the joint. A pattresse or collar should then be used to finish the penetration detail.

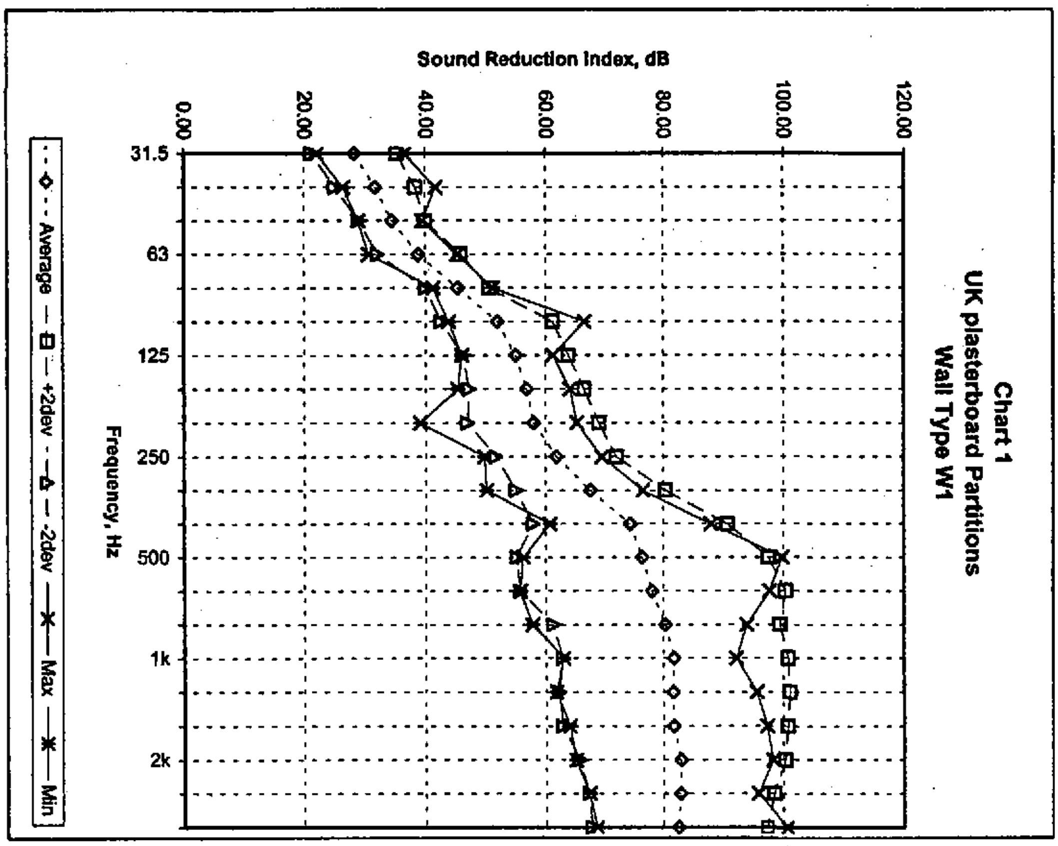


Chart 1
UK plasterboard Partitions
Wall Type W1
Sound Reduction Index, dB
0.00
20.00
40.00
60.00
80.00
100.00
120.00
Frequency, Hz
31.5
63
125
250
500
1k
2k
Average
+2dev
-2dev
Max
Min

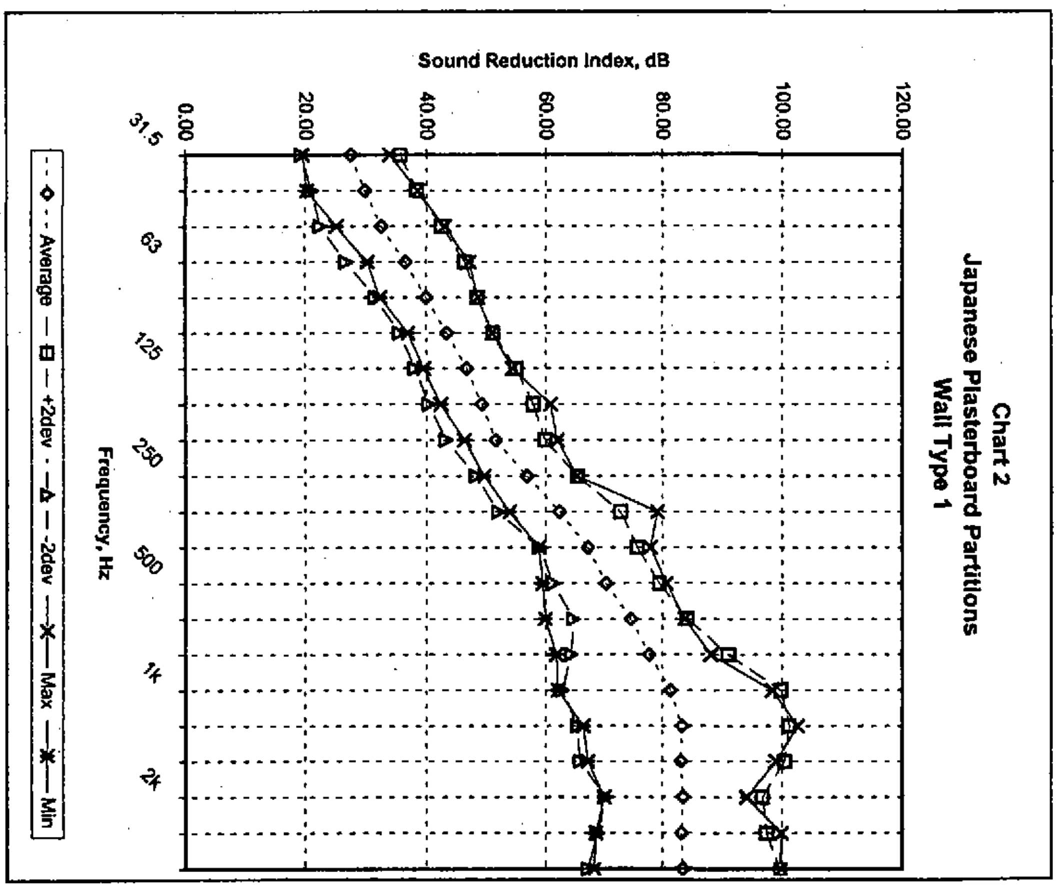


Chart 2
Japanese Plasterboard Partitions
Wall Type 1
Sound Reduction Index, dB
0.00
20.00
40.00
60.00
80.00
100.00
120.00
Frequency, Hz
31.5
63
125
250
500
1k
2k
Average
+2dev
-2dev
Max
Min

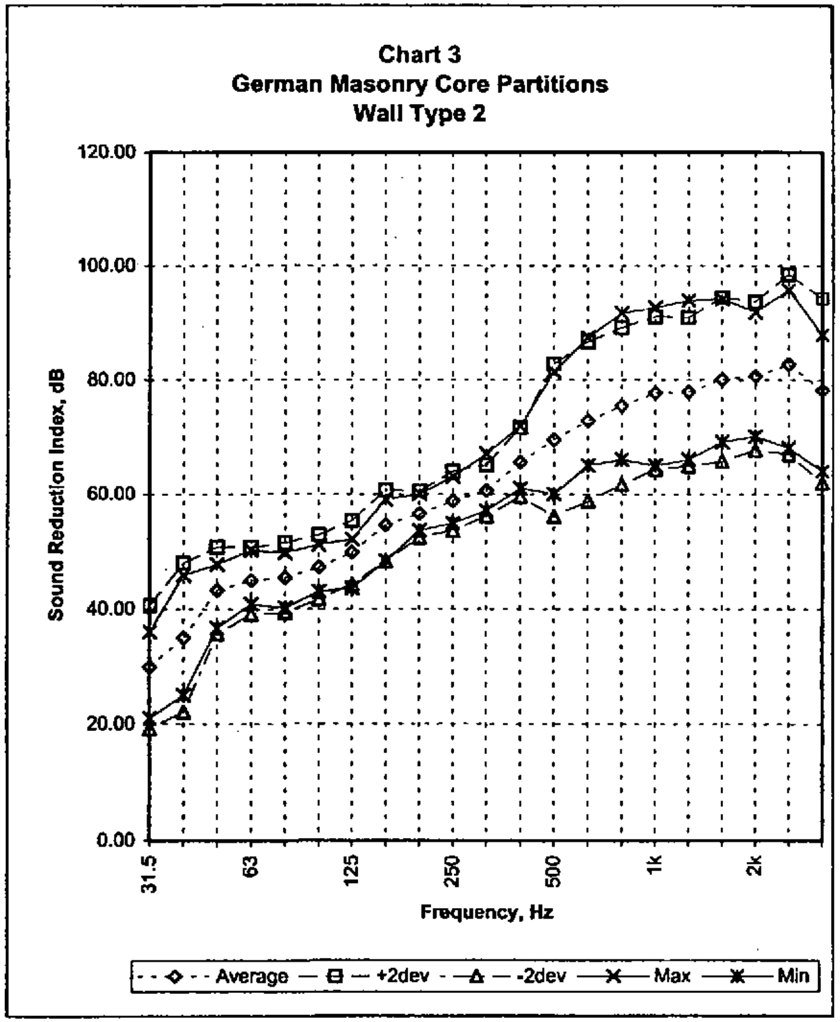


Chart 3
German Masonry Core Partitions
Wall Type 2
Sound Reduction Index, dB
120.00
100.00
80.00
60.00
40.00
20.00
0.00
31.5
63
125
250
500
1k
2k
Frequency, Hz
Average
+2dev
-2dev
Max
Min

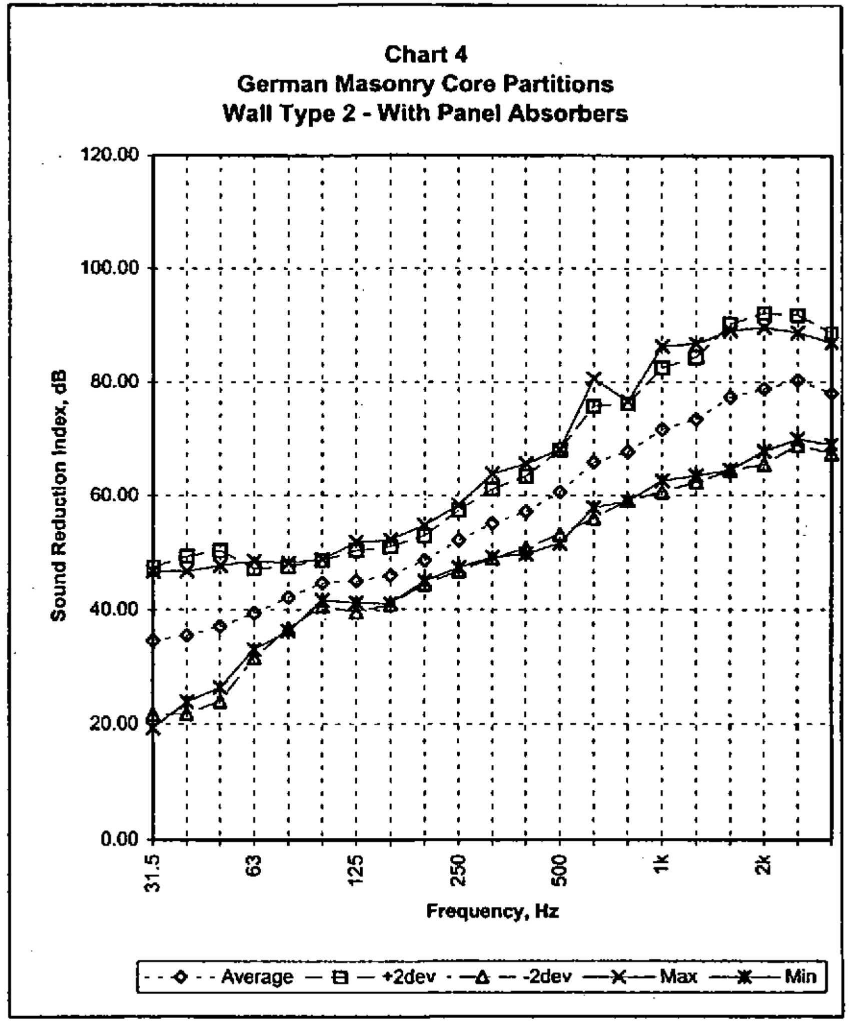


Chart 4
German Masonry Core Partitions
Wall Type 2 - With Panel Absorbers
Sound Reduction Index, dB
120.00
100.00
80.00
60.00
40.00
20.00
0.00
31.5
63
125
250
500
1k
2k
Frequency, Hz
Average
+2dev
-2dev
Max
Min

Chart 5
Masonry Core Partition
Wall Type 2 - With Continuous Plasterboard on Resilient Bars

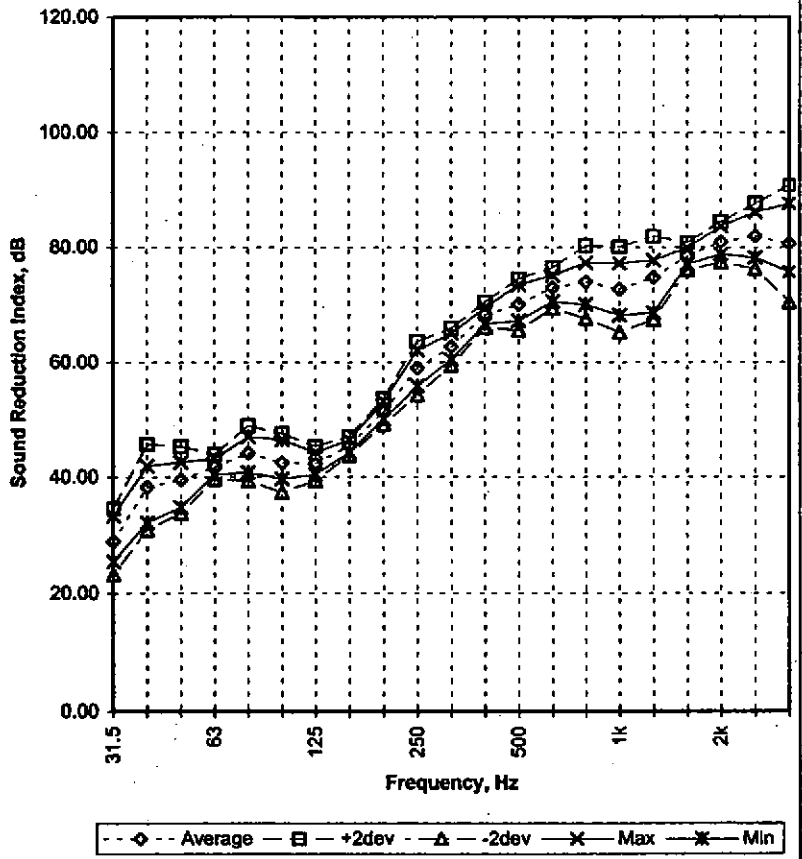
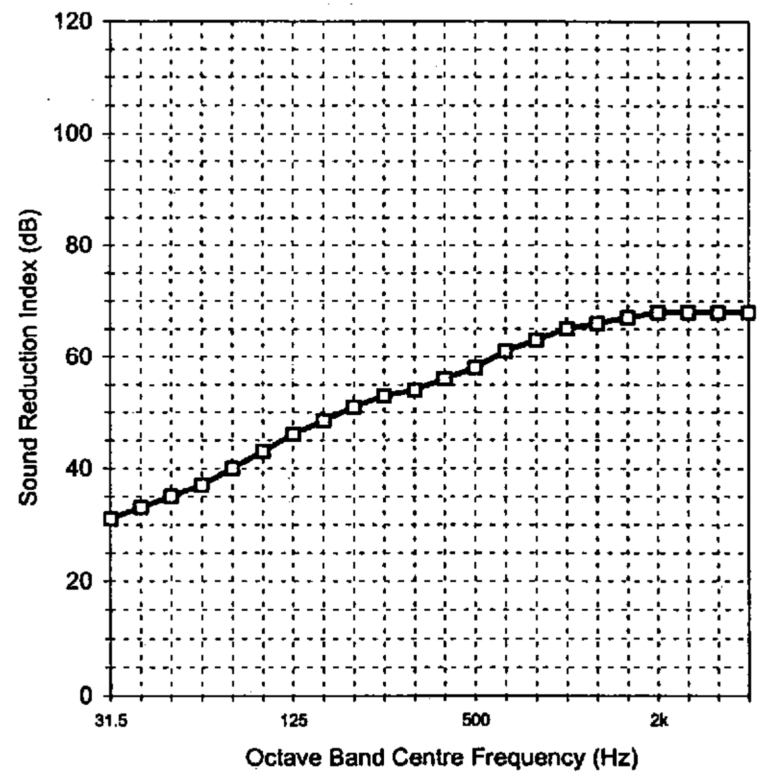
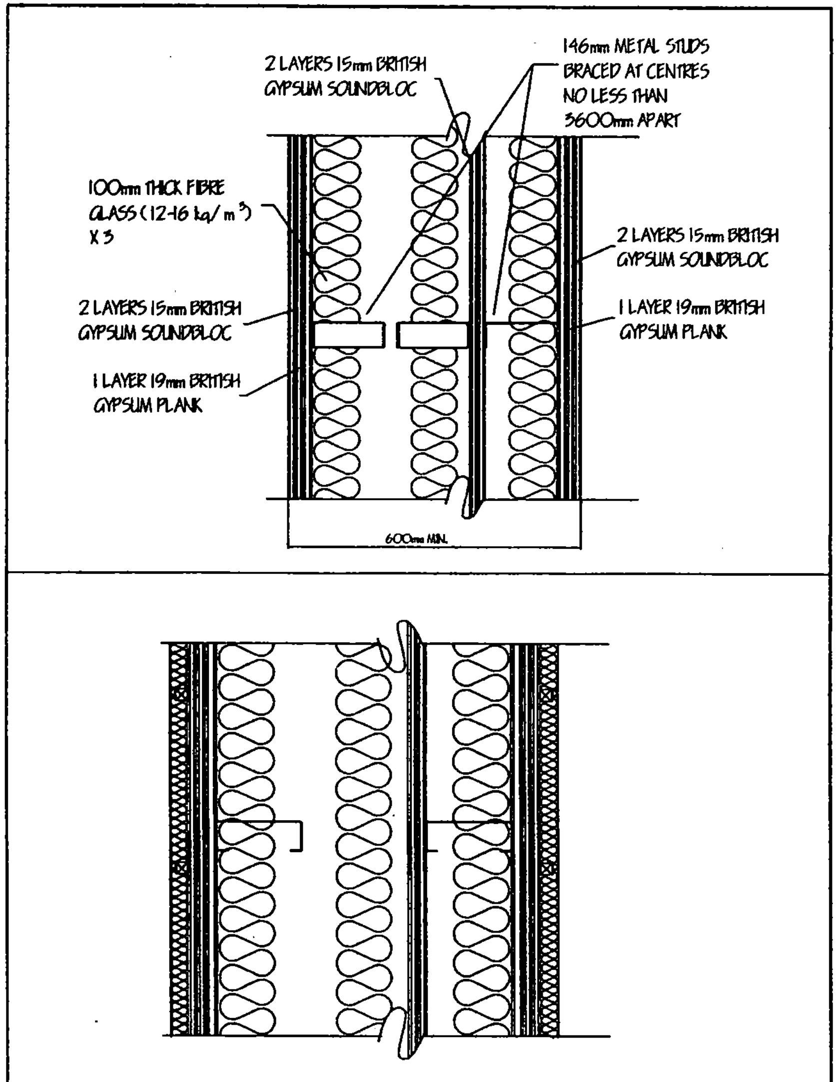


Figure 1
Sound Reduction Index
Between Auditoria in One Third Octave Bands





CONSULTANTS IN ACOUSTICS
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PLASTERBOARD WALL CONSTRUCTION
WITH REVERBERATION TREATMENT

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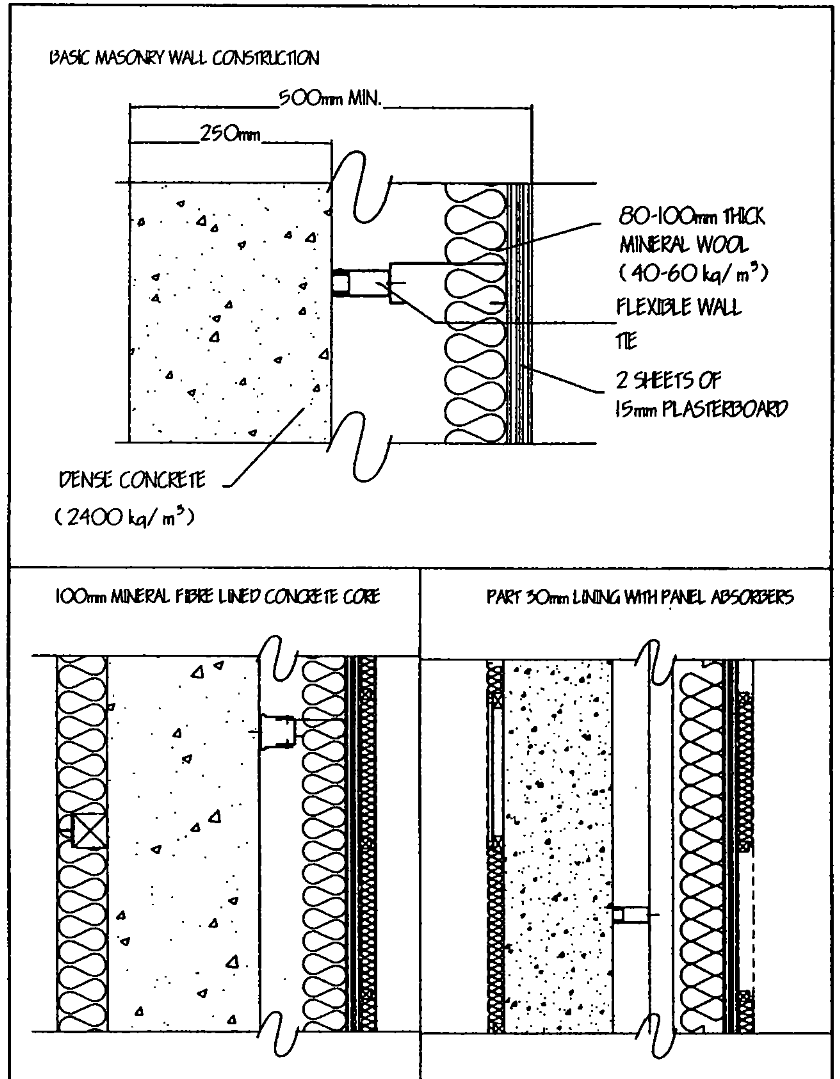

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MASONRY CORE WALL CONSTRUCTION
WITH DIFFERENT REVERBERATION TREATMENTS

IOA WORKSHOP	NTS	CAD	JAN 2000	W2

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