Design of walls and floors for good sound insulation

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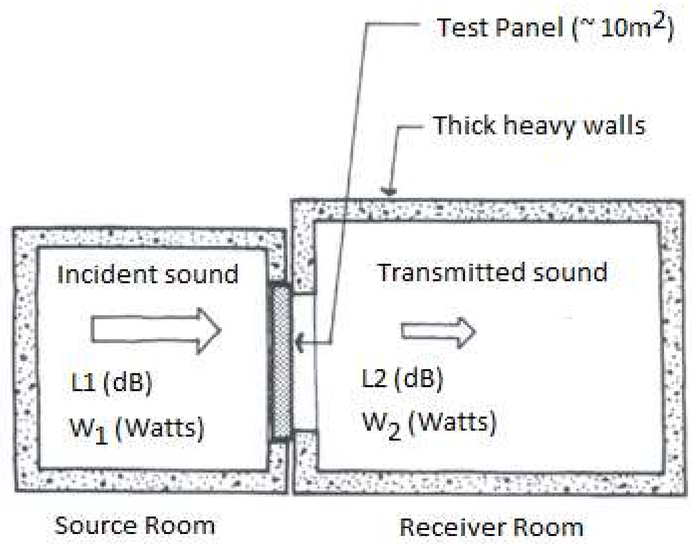
Measurement of Sound Insulation



- The measurement is made in a laboratory by constructing a wall between two specially isolated rooms. By isolating the rooms, sound only travels between the rooms via the test panel.

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Measurement and Calculation

- We measure the sound pressure on both sides of the wall, in 16 frequency bands between 100Hz and 3150 Hz.
- The results are plotted on a graph and a reference curve adjusted until the number of points below the graph is just less than 32 dB
- The value of the reference curve at 500 Hz is the weighted sound reduction index (Rw)

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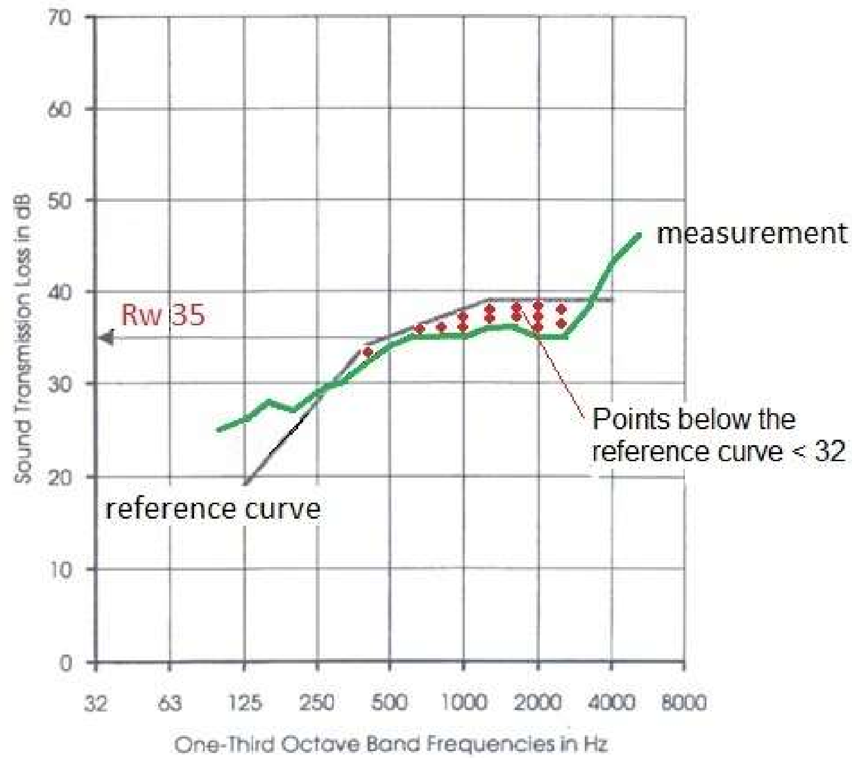
Calculation of Rw

(single number rating)



6 mm laminated glass sound transmission loss and Rw contour.

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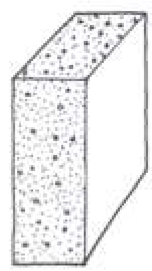
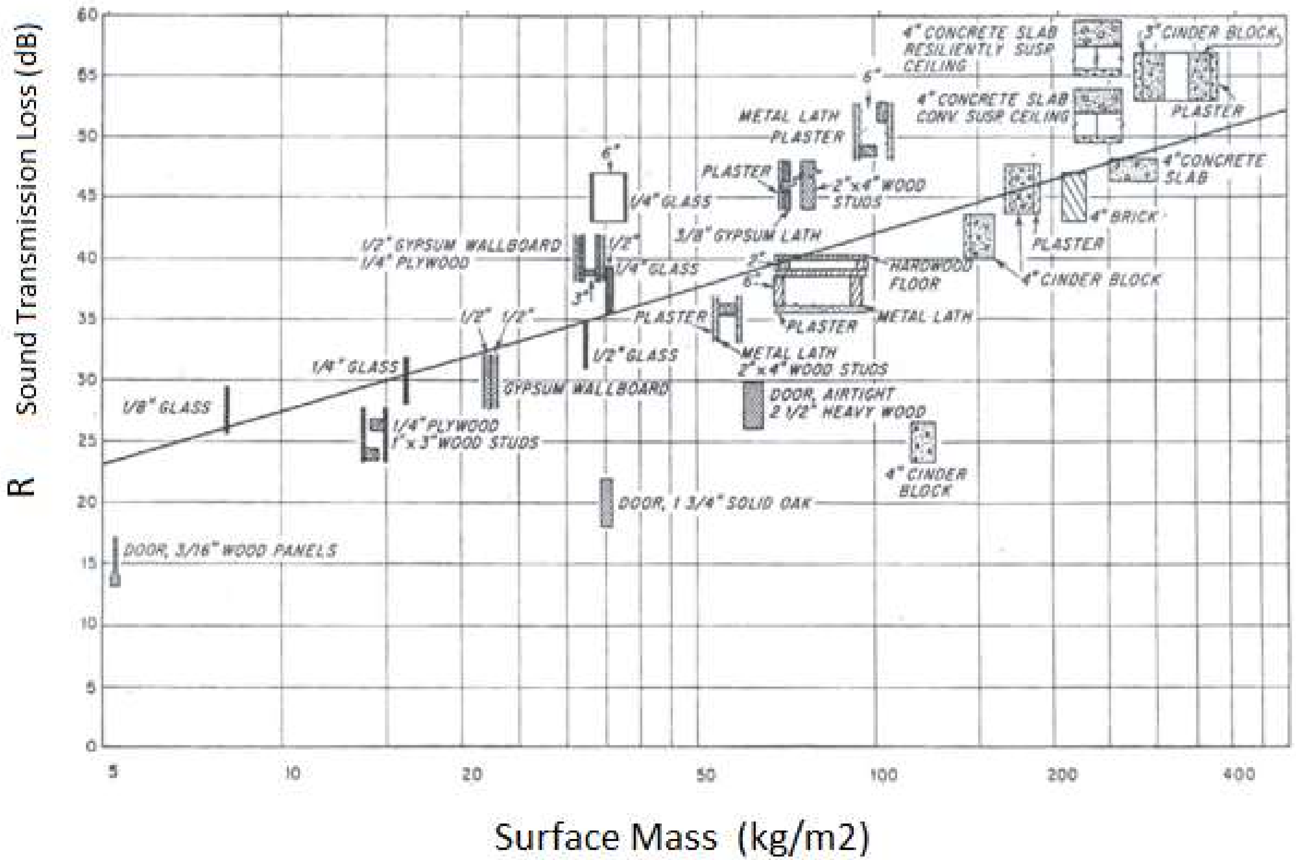
Engineering prediction methods

For single panels R is simply related to surface mass - *m*



surface mass - m (kg/m2)

Relation between surface mass and R



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Mass Law (single panel)

$$R = 20\log(mf) - 47$$

m is the surface mass (kg/m2)

f is the frequency (Hz)

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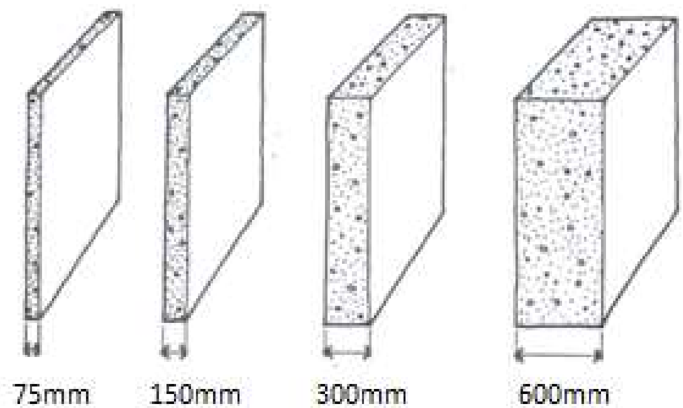
Mass Law (effect of mass)



Mass (kg/m2)	175	350	700	1400
STC/Rw	48	54	60	66
		+6 dB	+12 dB	+18 dB

R increases by 6 dB per doubling of surface mass

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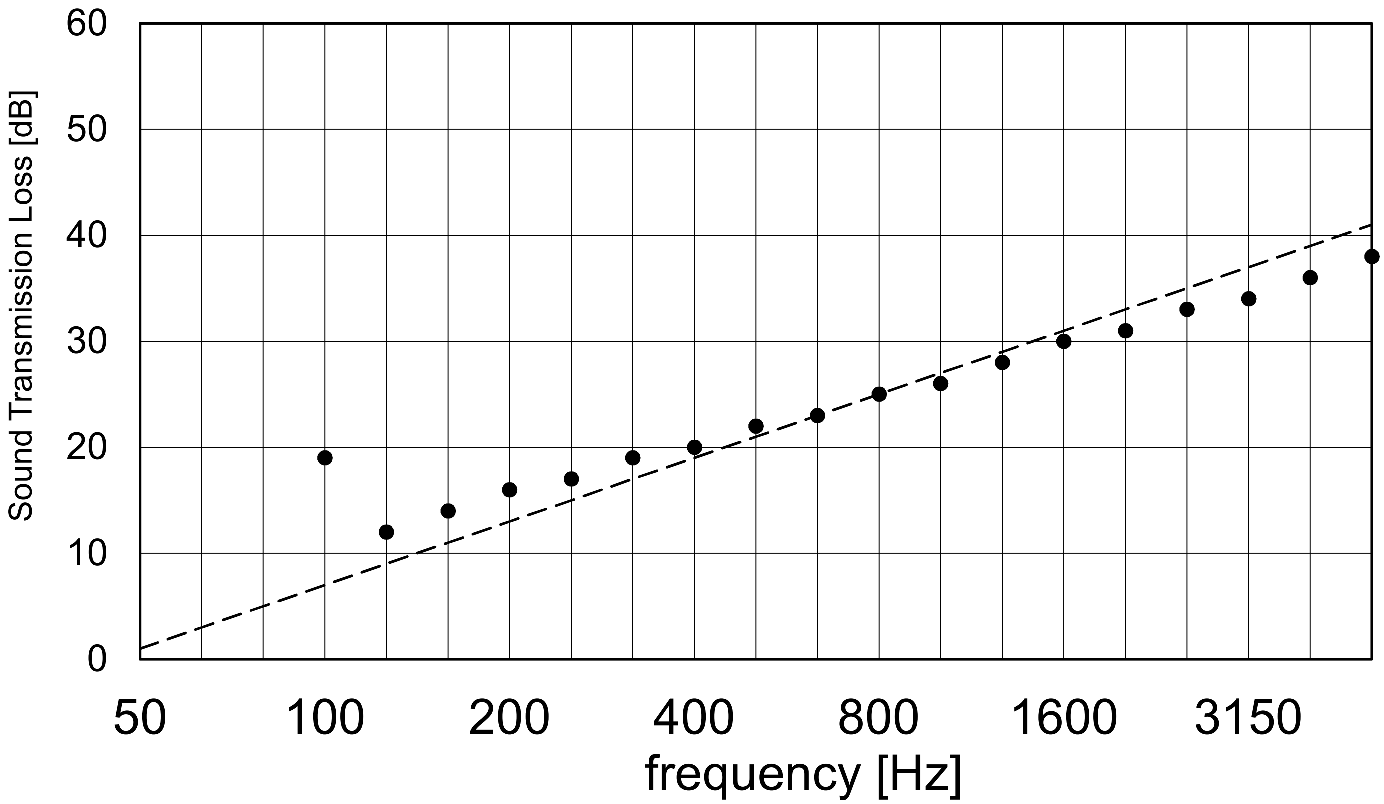
Mass Law (effect of frequency)



R increases by 6 dB per octave (doubling of frequency)

- • Heavy vinyl fabric (5kg/m2)
- - - - Mass law

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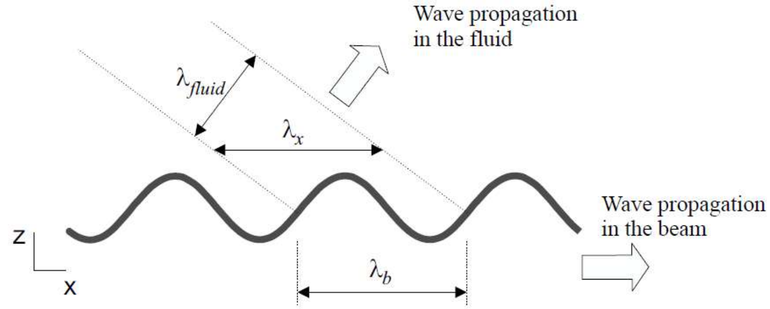
Bending Waves



- At low frequencies $\lambda_b > \lambda_x$ (sound radiation inefficient)
- At critical frequency $\lambda_b = \lambda_x$ (sound radiation efficient)
- At critical frequency the wavelength of the wave in the wall matches or coincides with the wavelength of the wave in the air.

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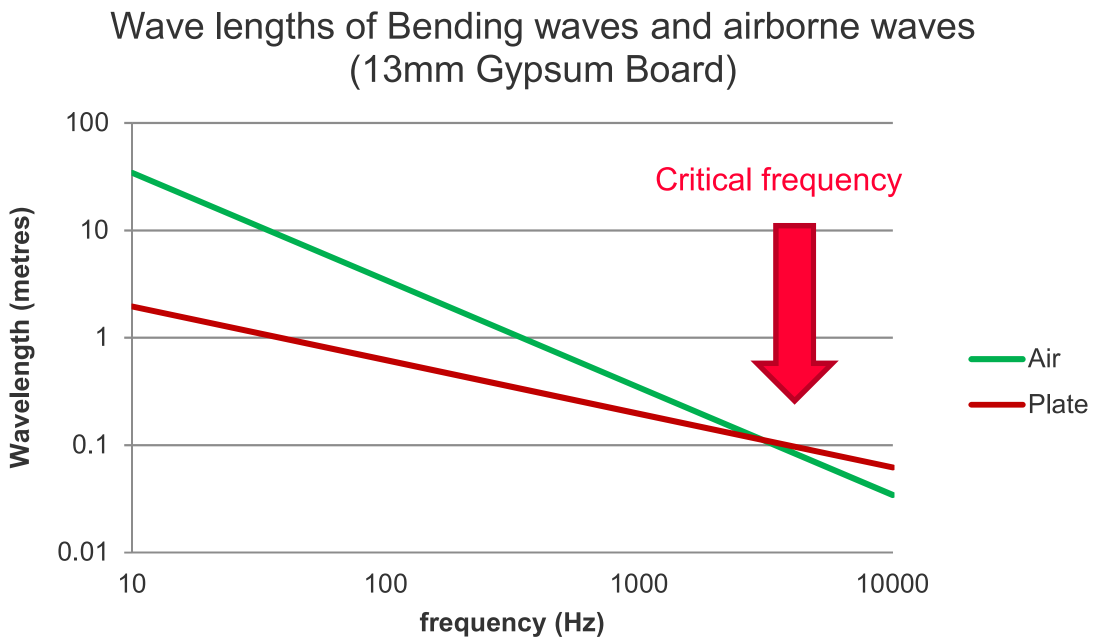
Wave length in Plate and in Air



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Mass Law (including bending waves)

Resonant transmission

$$R = 20\log(mf) - 10\log(2\eta f / \pi f_c) - 47$$

η - is the damping coefficient

f_c - is the critical frequency

$f_c m$ - is a constant for each material

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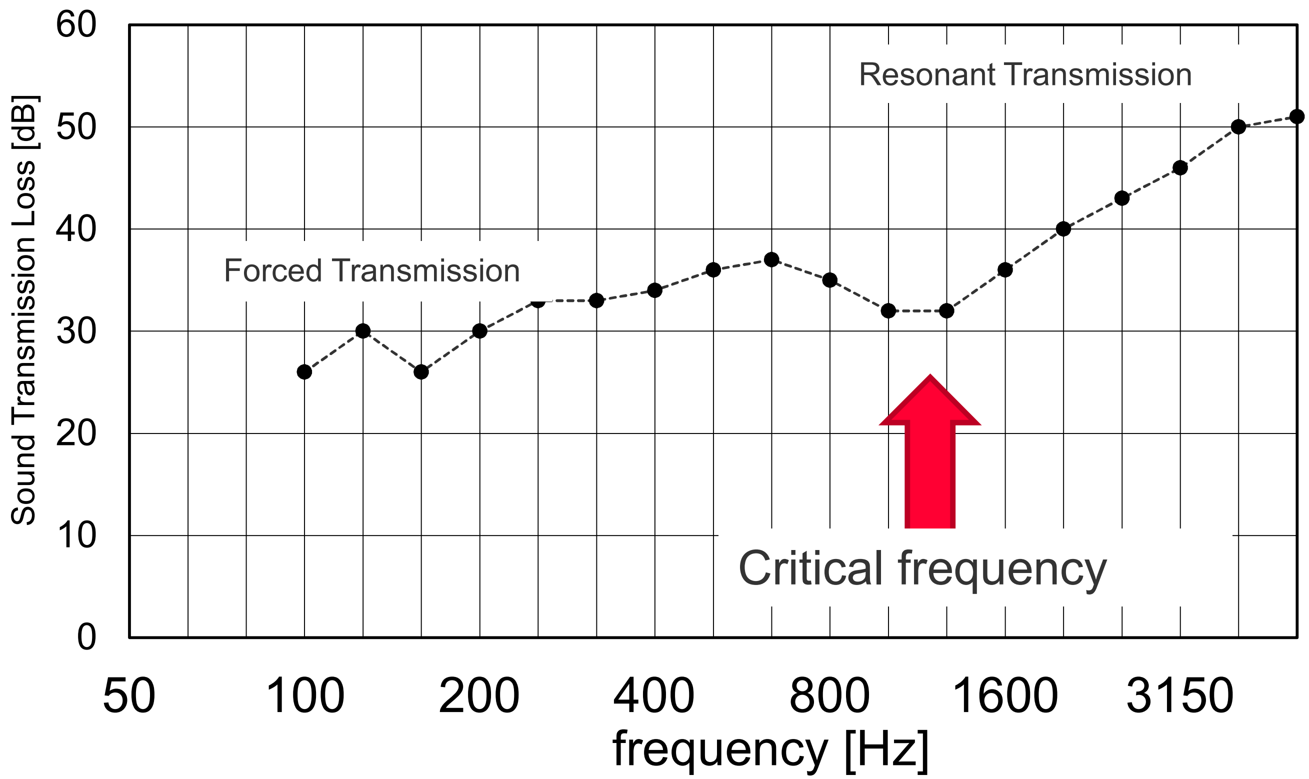
Effect of Bending Waves

(12 mm Glass)



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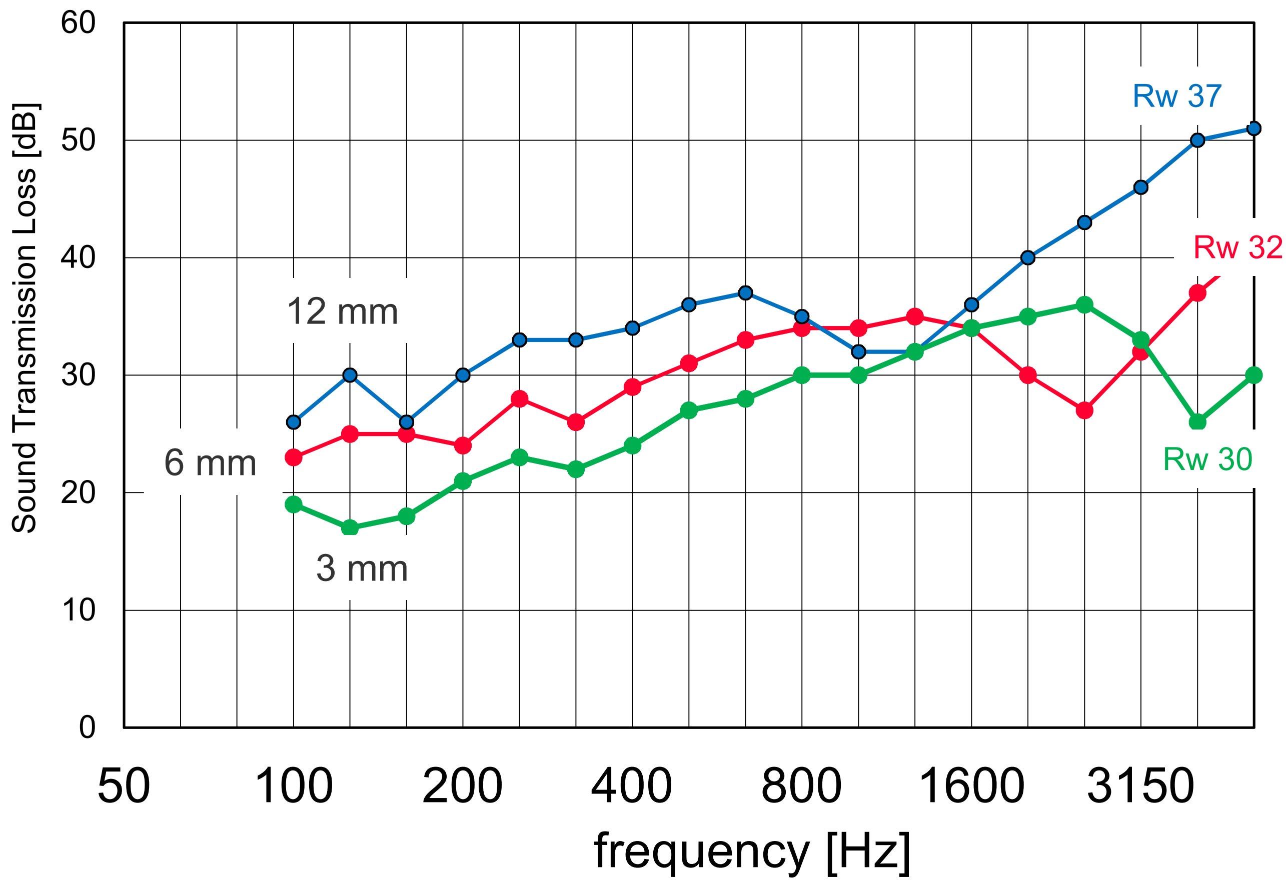
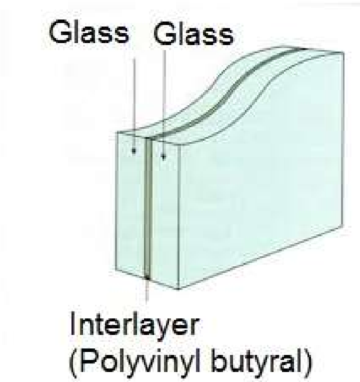
Effect of thickness

(Glass)

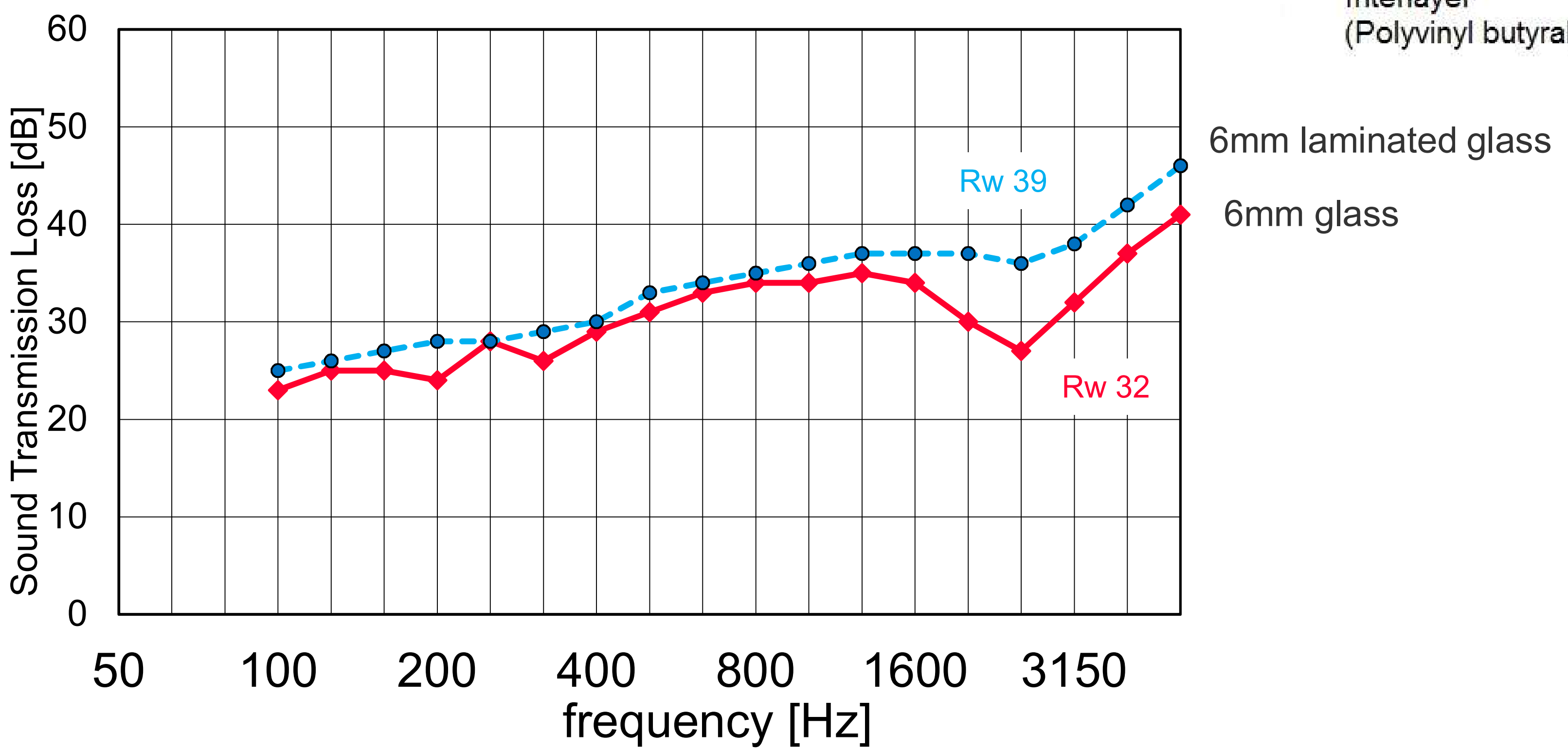


As glass thickness increases, low frequency R increases
But critical frequency decreases

Effect of damping



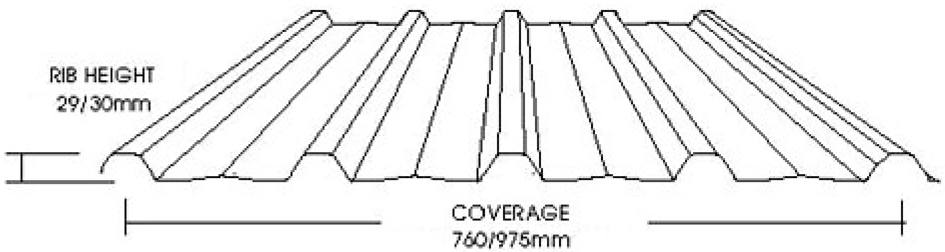
Laminated glass reduces the critical frequency dip



Orthotropic Panels

Thin metal panels are often rolled into trapezoidal profiles to increase the stiffness and hence spanning capacity

This is detrimental to their sound insulation because it lowers the critical frequency



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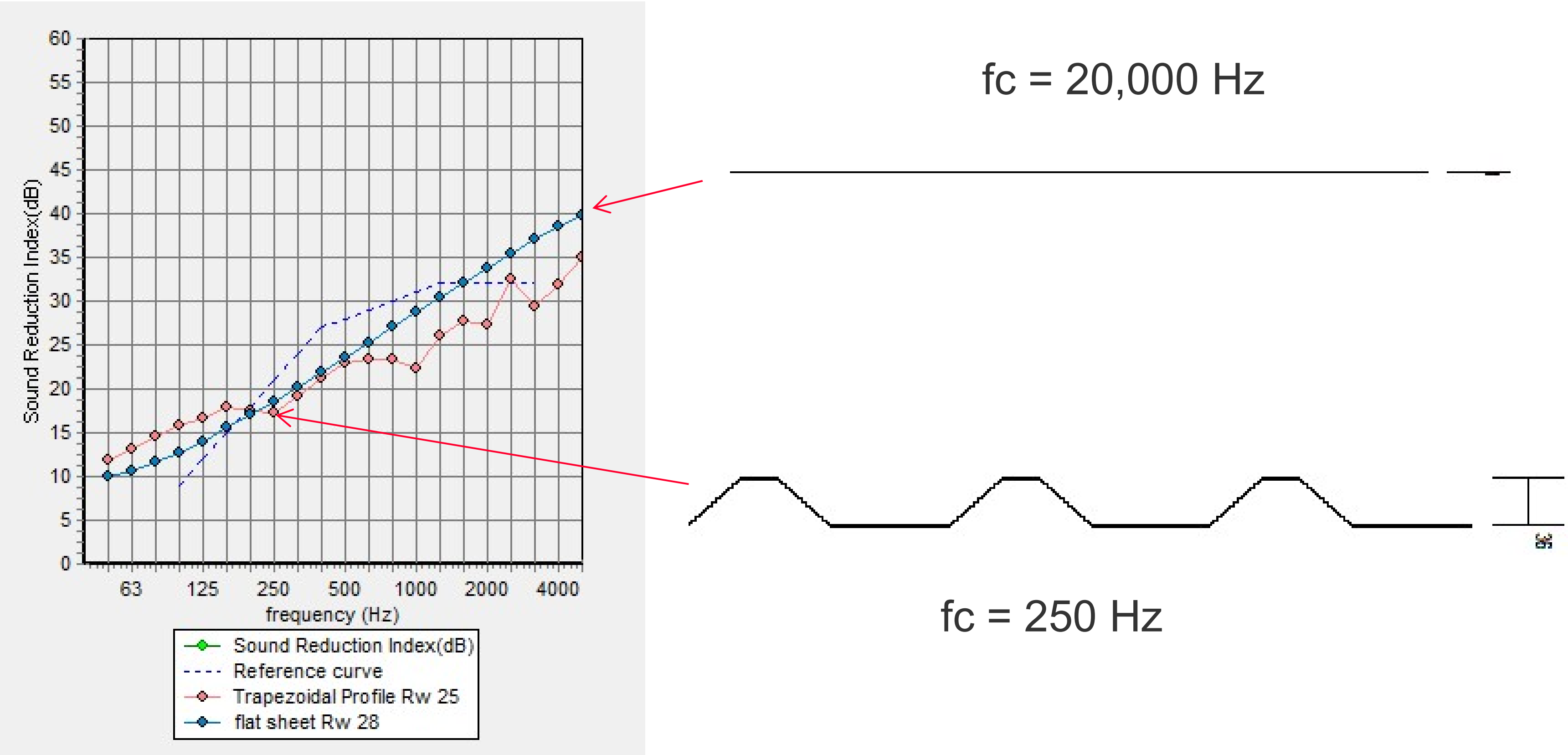
Orthotropic Panels



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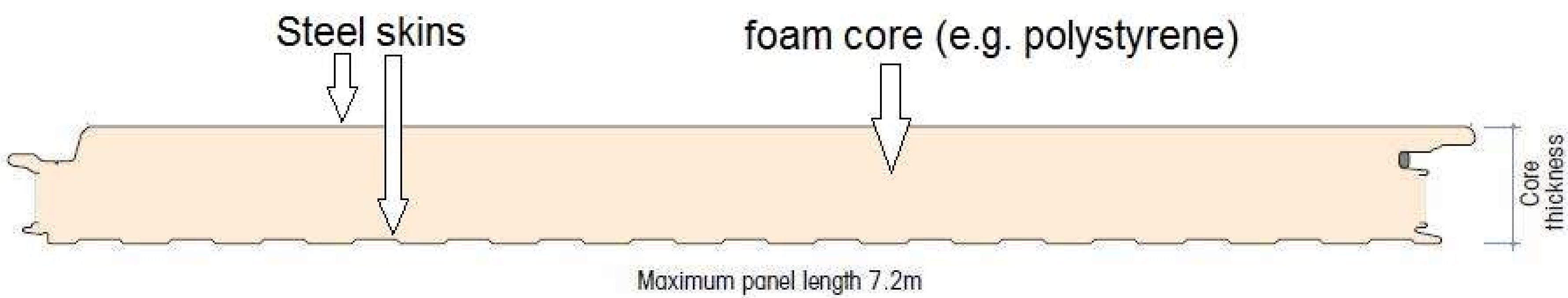
Foam Core Panels

- Thin metal skins with foam plastic core



Core thickness (mm)	45	60	70	80	100
Weighted sound reduction (Rw)	26	27	27	27	28

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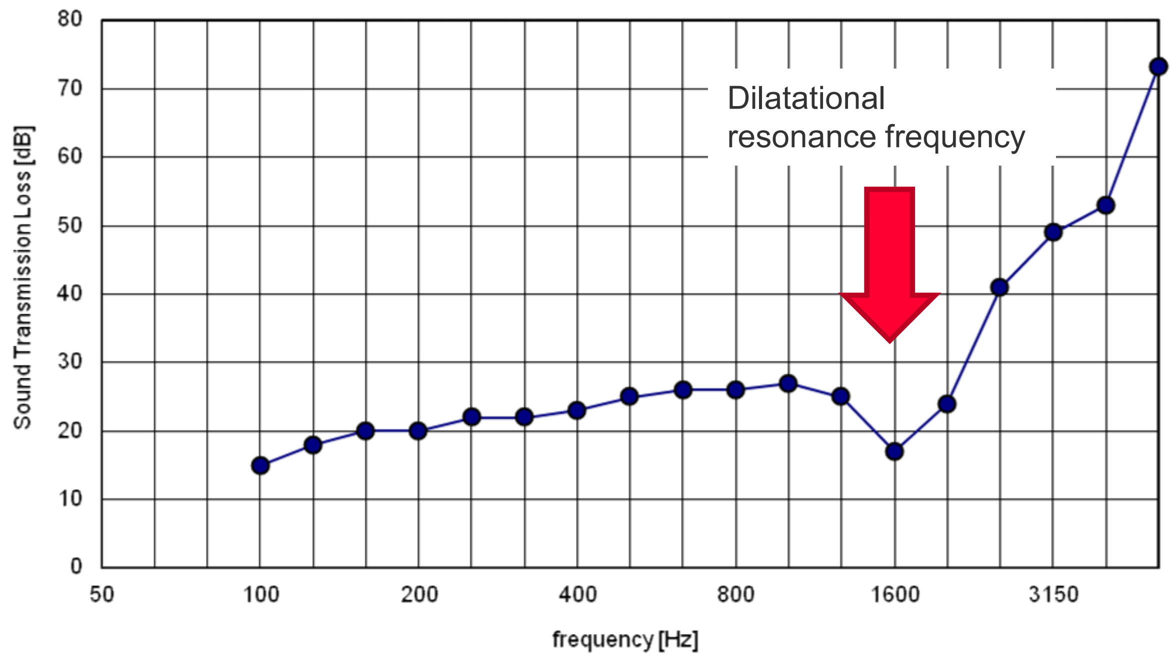
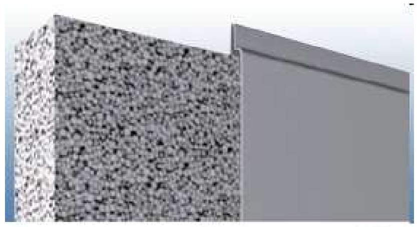
Sound Insulation Properties





XFLAMPANEL

75mm thick panel with 0.6mm steel skins Rw 26 dB

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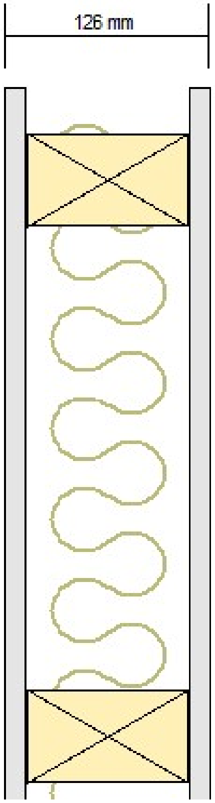
Double Panel Wall

- Two panels separated by an air gap



Double Panel prediction methods

Ideal Double Panels (London, Sharp)

$$R = 20\log(f(m_1 + m_2)) - 47 \qquad f < f_0$$

$$R = R_1 + R_2 + 20\log(fd) - 29 \qquad f_0 < f < f_l$$

$$R = R_1 + R_2 + 6 \qquad f > f_l$$

fo is the mass-air-mass resonance

fl is the knee frequency and is equal to (*55/d*) Hz

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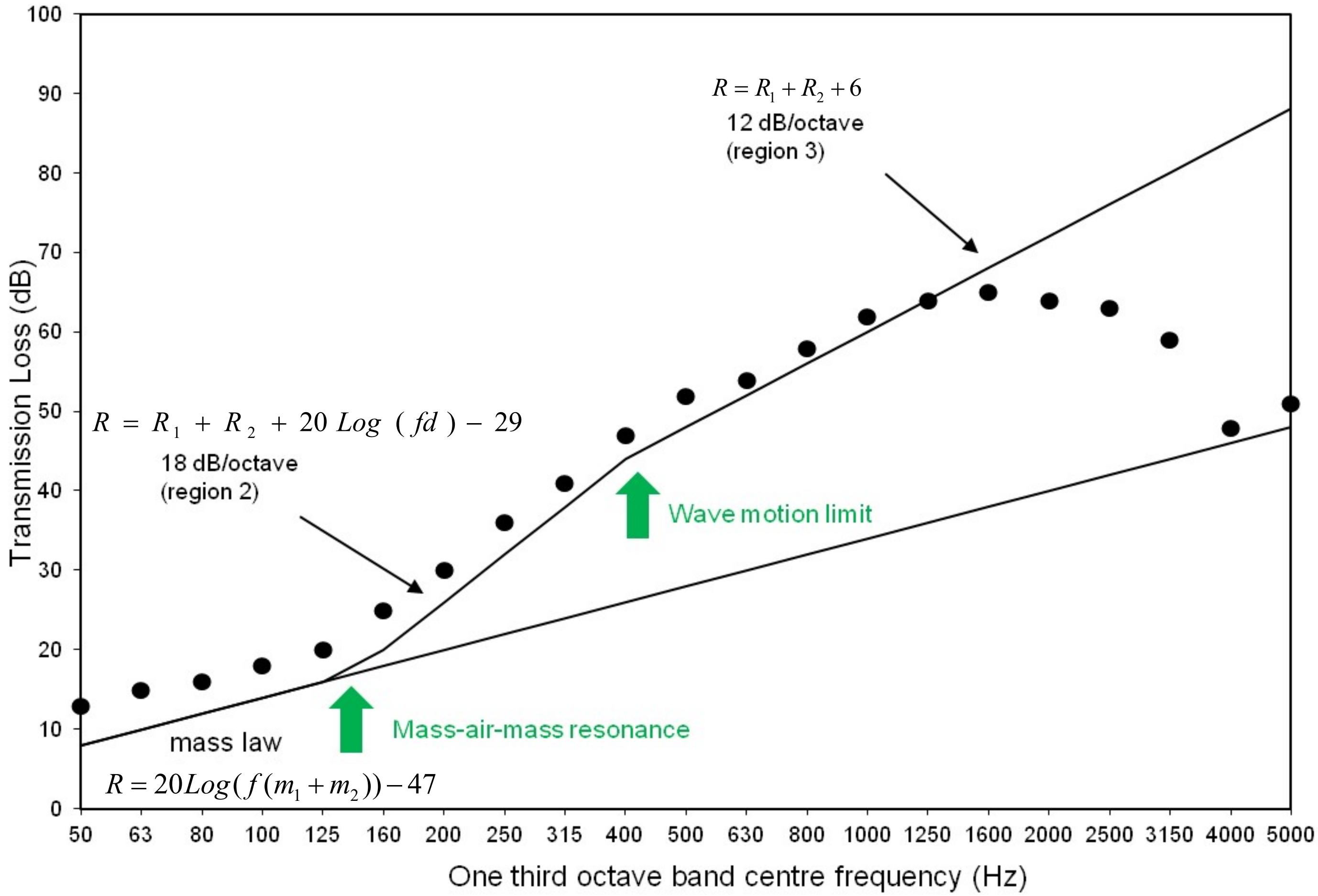
Double wall behaviour



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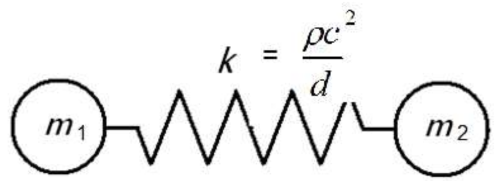
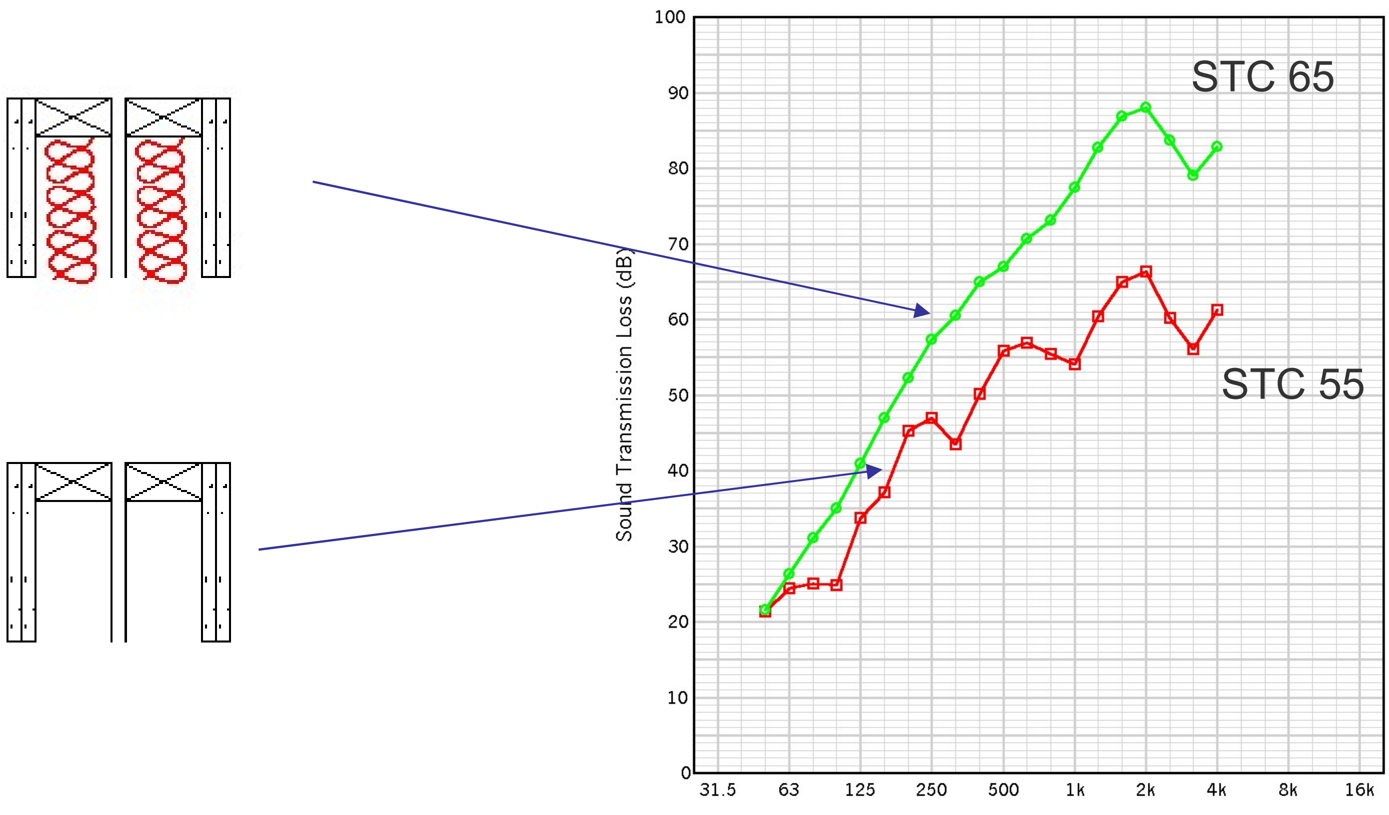
Mass-air-mass resonance



$$f_0 = \frac{1}{2\pi}\sqrt{\frac{\rho c^2}{d}\left(\frac{1}{m_1}+\frac{1}{m_2}\right)}$$

Effect of Cavity Absorption



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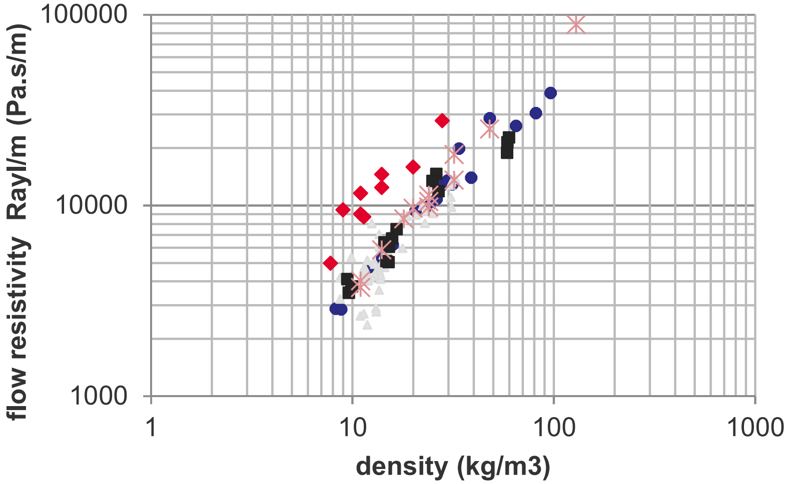
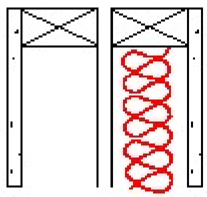
Flow resistivity

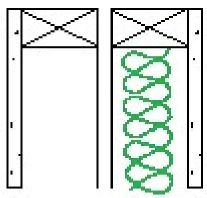
- Flow resistivity is a good predictor of acoustic absorption performance, the higher resistivity the better.
- Different types of absorber with same flow resistivity will have same acoustic performance



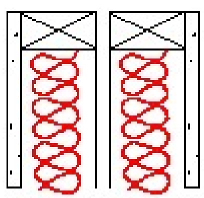
Effect of Flow resistivity (fibreglass)



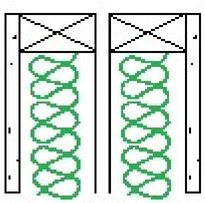
cavity infill 90mm 12kg/m3 (=4000 Rayl/m) **STC 56**



cavity infill 90mm 16kg/m3 (=8000 Rayl/m) **STC 58**

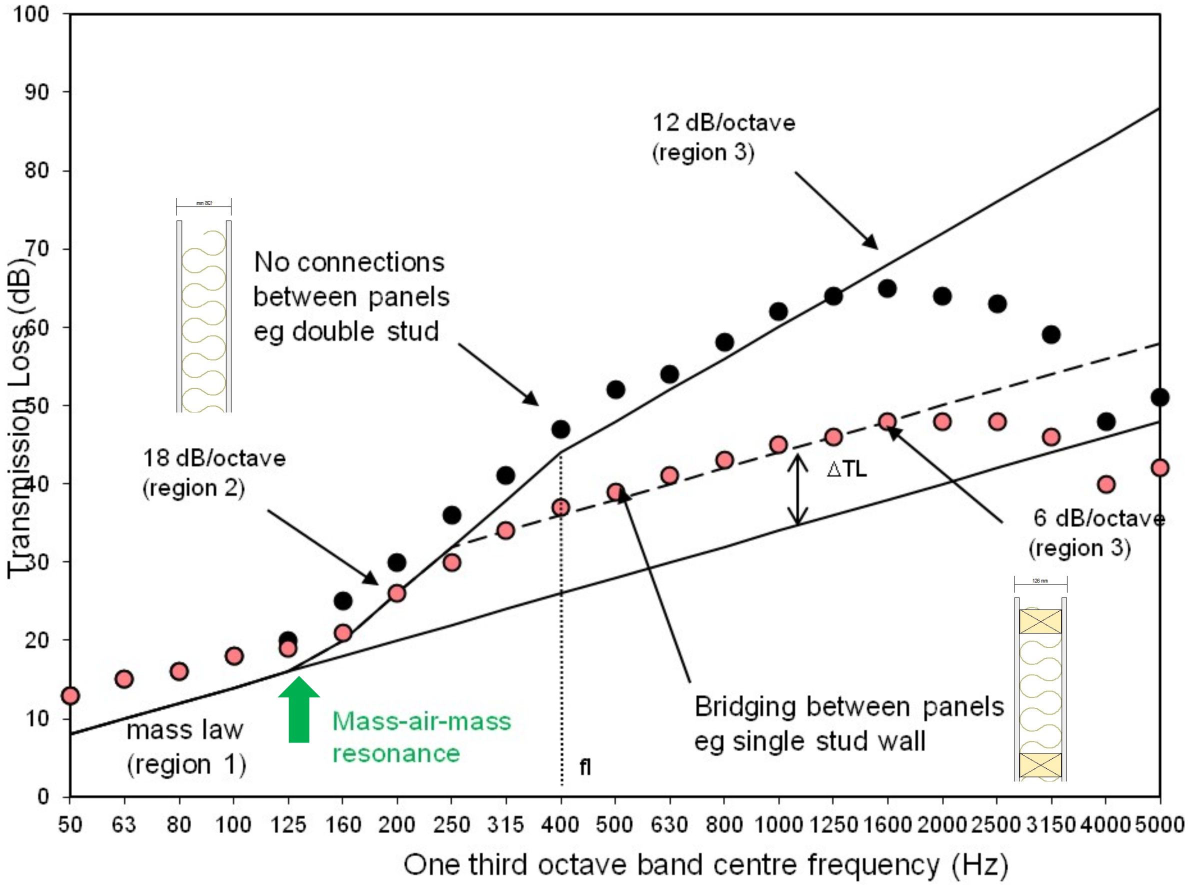


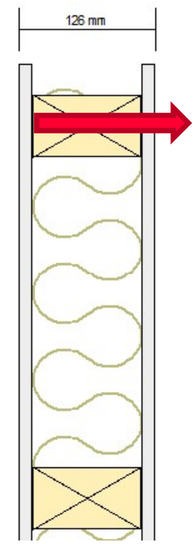
cavity infill 2x90mm 12kg/m3 (=4000 Rayl/m) **STC 59**



cavity infill 2x90mm 16kg/m3 (=8000 Rayl/m) **STC 61**

Effect of Connections





Sound energy is transferred by the solid stud connection

$$R = R_{1+2} + 10Log(b.f_c) + 20Log[m_1/(m_1 + m_2)] - 18$$

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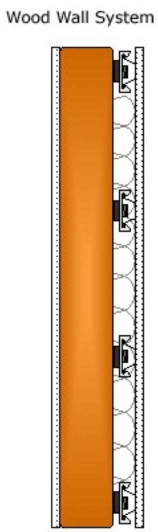
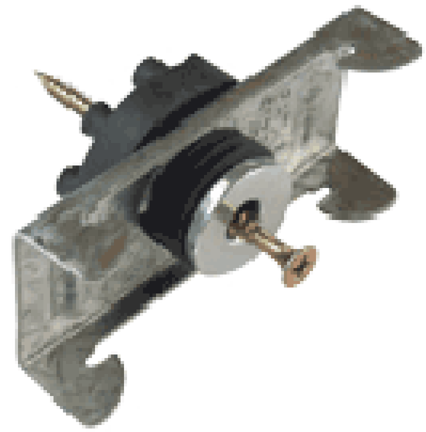
Methods of isolating wall linings

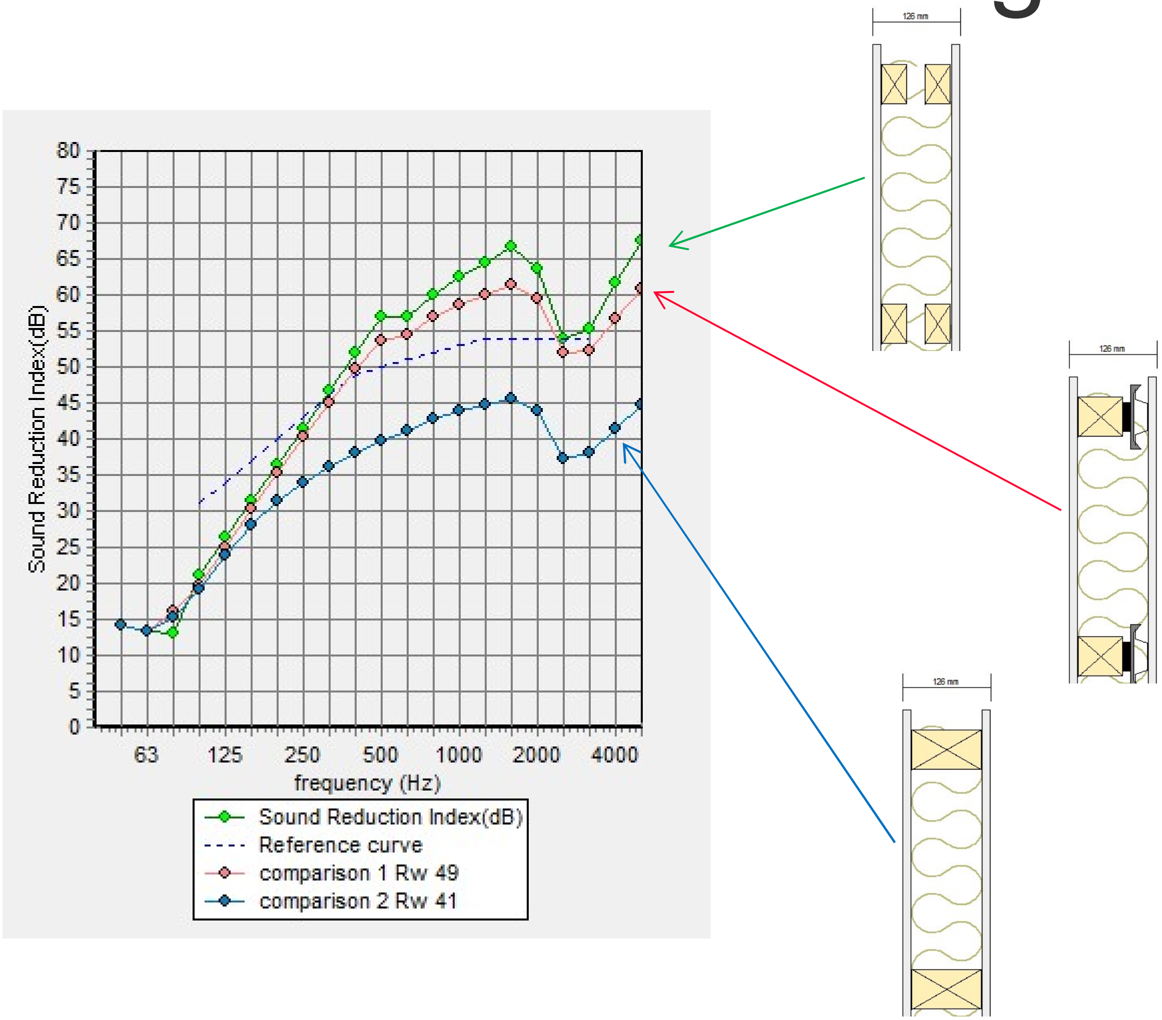




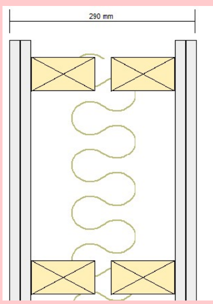
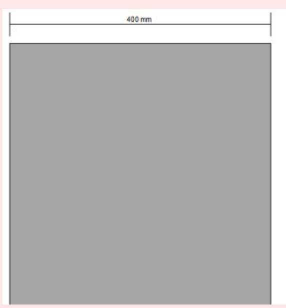
Resilient Sound Isolation Clip

Quietzone Acoustic Framing

Resilient fastenings of Linings



Comparison of single and double wall

	Description	Thickness (mm)	Mass (kg)	Rw (dB)
	2x16mm plasterboard on 2x100x50 studs	290	68 kg/m2	71
	400mm Solid concrete	400	900kg/m2	70

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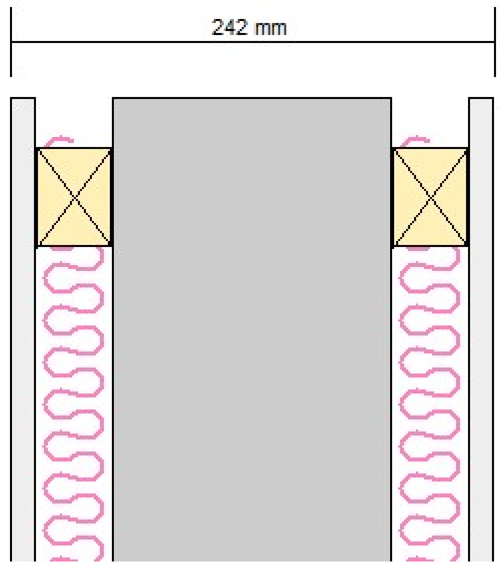
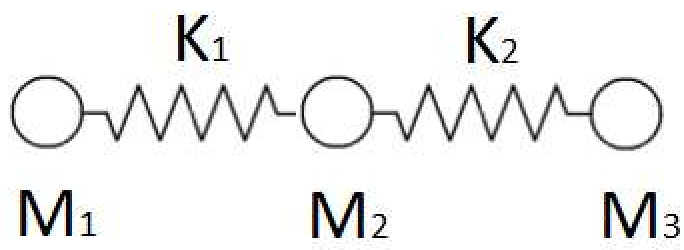
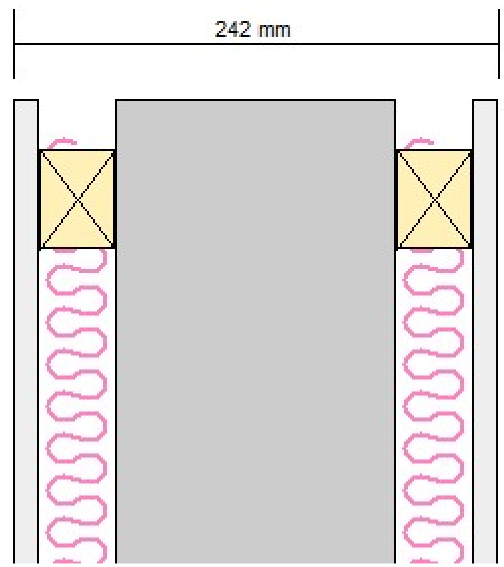
Triple Panel Constructions

- Three panels separated by two air gaps



Lumped Parameter Model





Lumped Parameter Model

f_0 = 73, 263 Hz

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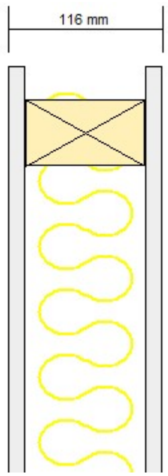
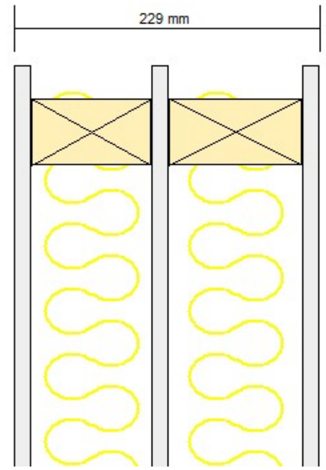
Resonant Frequencies

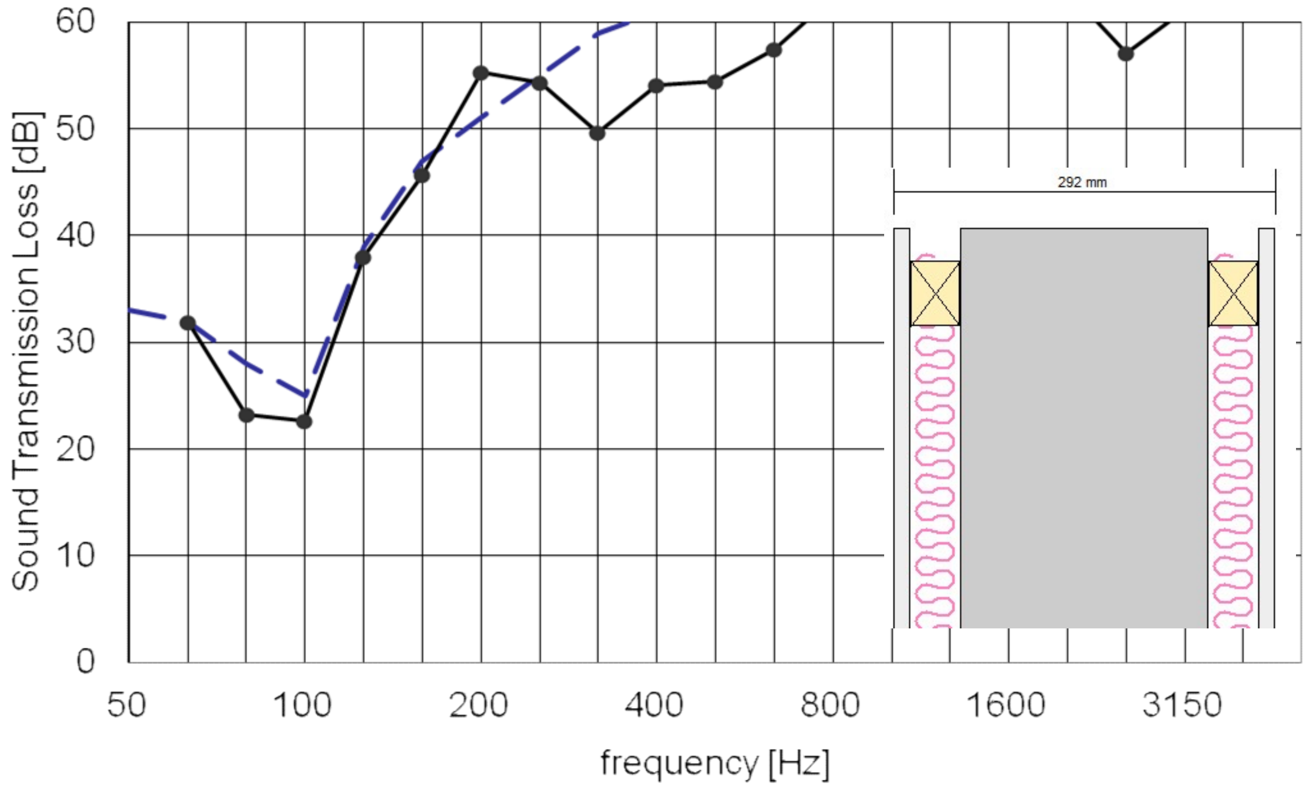




f_1 = 64 Hz

f_1 = 53, 92 Hz

Comparison of Model to Measurements



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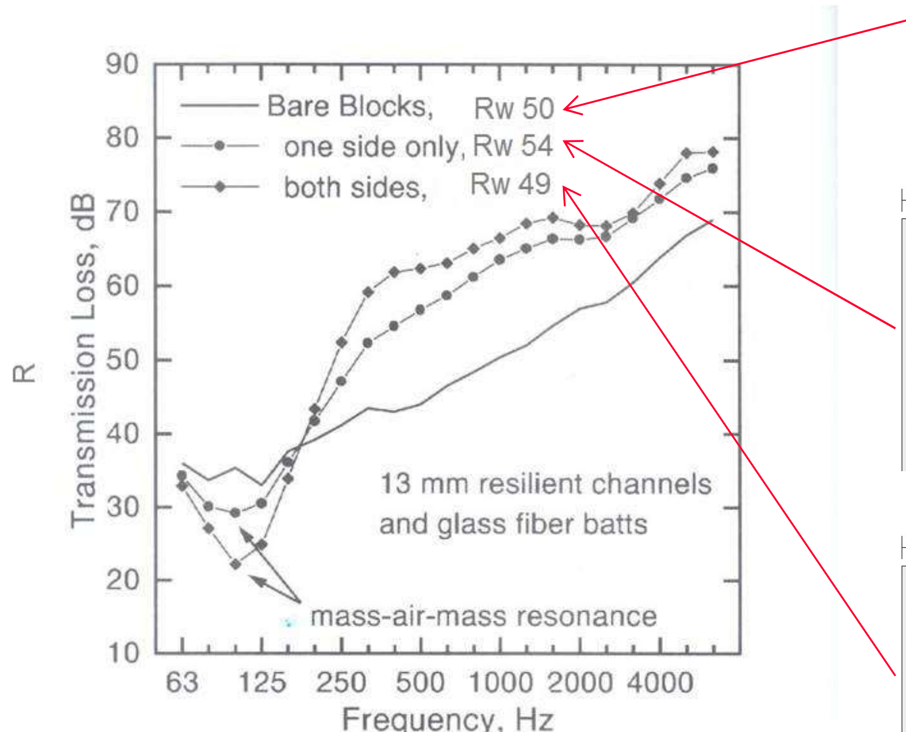
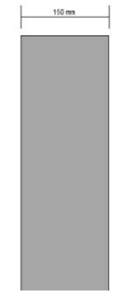
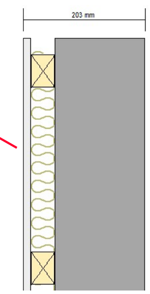
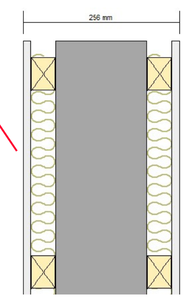
Masonry with attached lining

- A 150mm thick concrete wall which by itself will be Rw 50 can be less than Rw 50 if light gypsum board linings are fixed on both sides.
- The dip at the mass-air-mass resonance can reduce the Rw rating



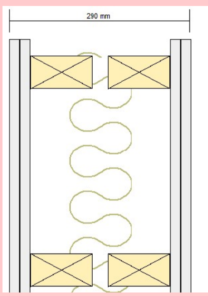
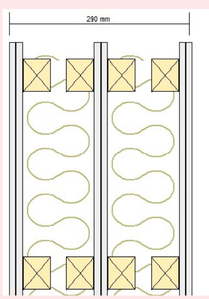




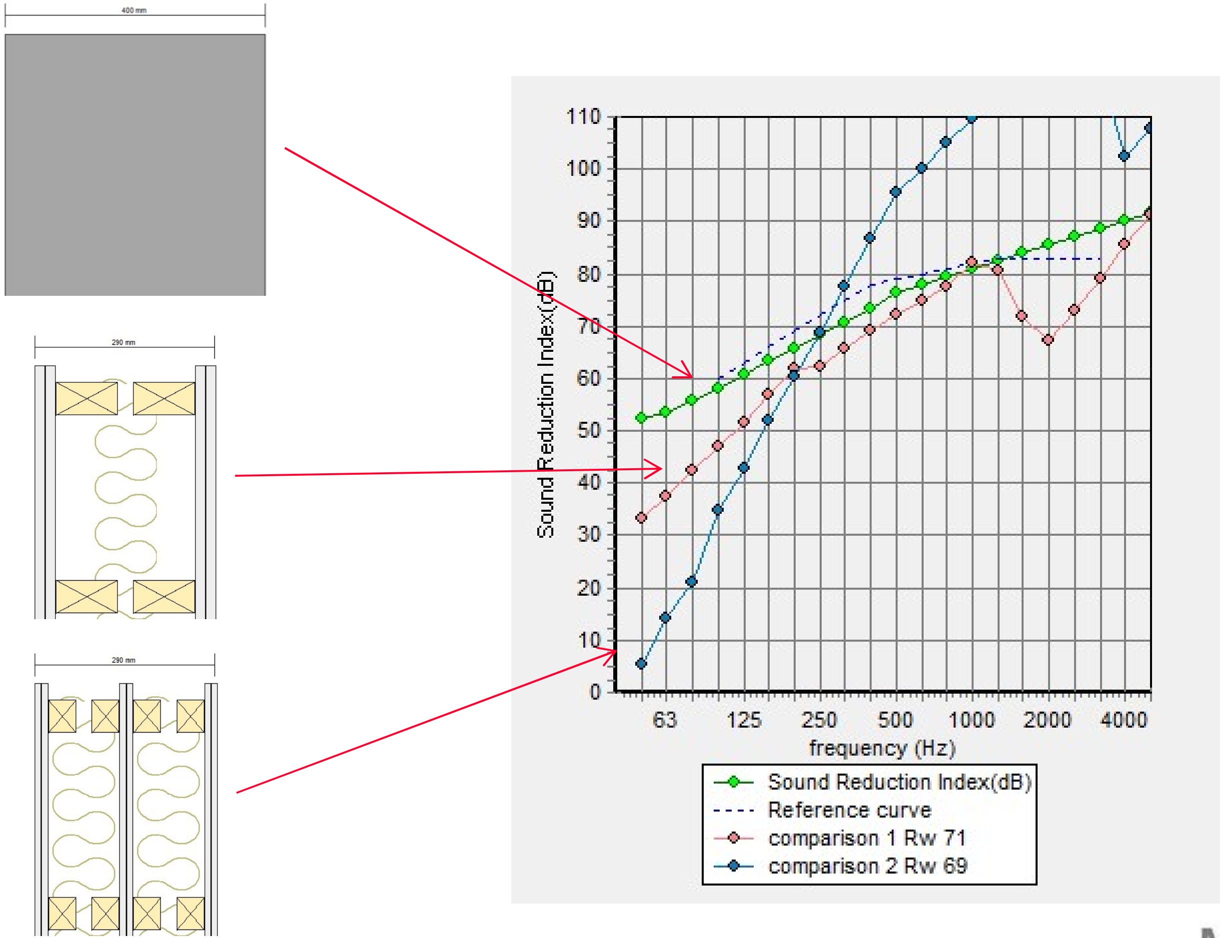


Sound transmission loss for a 190-mm concrete block wall with 16-mm gypsum board attached on 13-mm resilient metal channels to one side and to both sides of the wall with sound-absorbing material in the cavity.

Comparison of double and triple wall

	Description	Thickness (mm)	Mass (kg)	Rw (dB)
	2x16mm plasterboard on 2x100x50 studs	290	68 kg/m2	71
	2x10mm plasterboard on 100x50 studs	290	68kg/m2	69

Comparison of single double and triple panel walls



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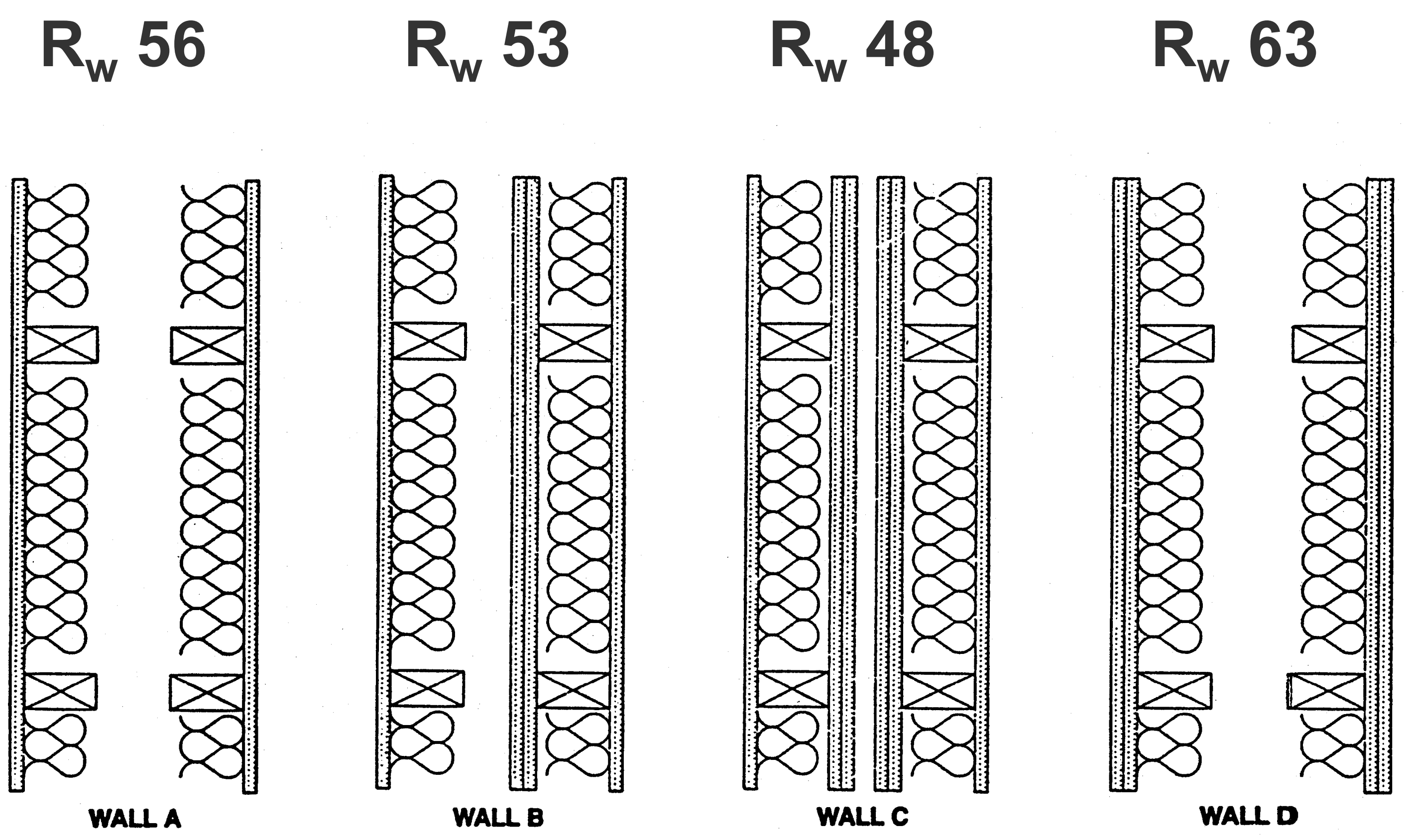
Cavity Walls



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Sound Insulation Requirements
(Residential)

Category	Airborne Insulation
High quality Apartments	Rw 65
Mid quality Apartments	Rw 60
Code Compliance Minimum performance	Rw 55

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Sound Insulation Requirements
(Education)

	Library /Study Room	Class-room	Multi-purpose Hall	Technology Room	Technology Room	Gymn-asium	Music Room
Technology Room	60	60	60	55	55	55	60
Gymnasium	60	60	60	55	55	55	60
Classroom	50	50	60	50	60	60	60
Multi-purpose Hall	60	60	60	55	60	60	60
Library/Study Room	45	50	60	50	60	60	60
Music Room	60	60	60	60	60	60	60

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Sound Insulation Requirements

(TV and Radio)

Required Rw

Group	#	NR	Room	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Radio	1	NR20	Music/Multipurpose Studio	70																				
Radio	2	NR15	Drama Studio	70	55																			
Radio	3	NR15	Talks/Continuity/News Studio	70	55	50																		
Radio	4	NR20	'Pop' Music Recording Studio	80	85	80	80																	
Radio	5	NR20	Studio Control (same prog. adjacent)	50	55	50	60	--																
Radio	6	NR20	Studio Control (other progs. adjacent)	70	60	55	70	--	45															
	7	NR30	Apparatus/Equipment Room	50	55	50	55	40	50	20														
	8	NR20	Quality Check/Listening Room	70	60	55	75	--	55	50	50													
Television	9	NR20	Dubbing Theatre/'Voice Over'/Narrator	70	60	55	75	--	55	50	55	55												
Television	10	NR20	General Purpose TV Studio	70	70	65	75	--	65	50	65	65	65											
Television	11	NR20	News/'Speech Only' TV Studio	70	55	50	75	--	55	50	55	55	65	50										
Television	12	NR20	TV Production/Vision/Lighting Control	--	--	--	--	--	50	30	55	--	45	50	20									
Television	13	NR20	TV Sound Control (Same prog. adjacent)	--	--	--	--	--	--	--	--	50	45	50	40	--								
Television	14	NR20	All TV Controls (other progs. adjacent)	70	60	55	75	--	55	40	55	--	50	55	--	--	55							
Television	15	–	Scenery Dock/Construction	70	65	60	55	60	60	50	60	60	60	60	60	60	--	--						
General	16	–	Building Exterior (via roof)	70	75	70	70	70	--	50	70	70	70	70	70	70	70	**	--					
General	17	–	Building Exterior (via walls)	65	70	65	65	65	--	45	65	65	65	65	65	65	65	**	--	--				
General	18	–	Mechanical Equipment/A.C. Plant Room	70	75	70	70	70	--	50	70	70	70	70	70	70	--	--	**	**	--			
General	19	–	Kitchen/Restaurant/Toilets/Corridor	60	65	60	60	60	--	40	60	60	60	60	60	60	--	50	**	**	50	--		
General	20	NR35	Office/Rest Area/Artistes Assembly	55	60	55	55	55	--	35	55	55	55	55	55	55	--	40	**	**	50	45	40	
General	21	–	Garage/Covered Access Road	80	85	80	80	80	--	60	80	80	80	80	80	80	--	--	--	--	**	50	55	--

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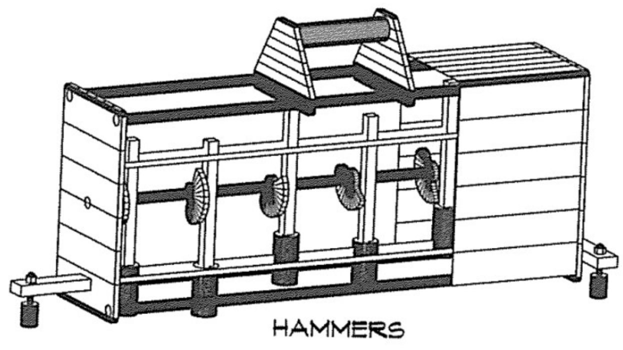
Impact Sound



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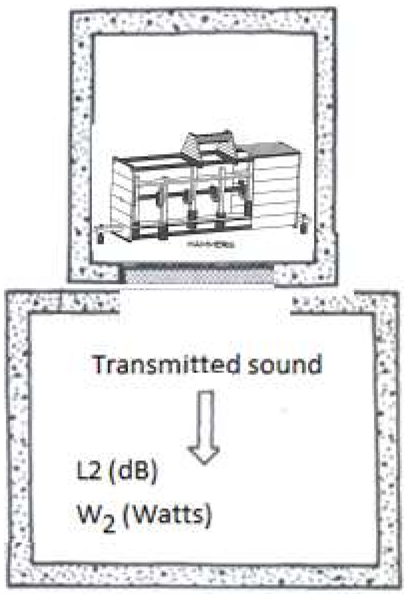
Measuring Impact Sound



Receiver Room

Australian Requirements

Conclusions

- Good sound insulation is very important in buildings
- Criteria can be established for each room in a building based on user comfort
- Walls and floors can be designed with simple engineering models to meet criteria
- Understanding the basic principles of sound transmission helps prevent bad buildings