Australia & New Zealand Acoustic Design Guide

Use of this Guide

Thank you for choosing to design with mass timber. XLam manufacture Cross Laminated Timber (CLT) from one hundred percent natural and renewable radiata pine. Each lamella and panel is unique, even with great care by XLam, slight deviations in grain pattern, knot location and colour will occur. By choosing to design in mass timber you are embracing the natural beauty of a renewable building material, its perfection is in its natural imperfection.

The information in this guide is based on testing methodology and certification owned by XLam. The information is provided for use in the design and specification of XLam manufactured Cross Laminated Timber (CLT) only. The guide is not intended as general information and guidance for all manufactured Cross Laminate Timber (CLT). The guide and information is specific to XLam CLT and no warranty is given to the suitability and application of the information to other manufacturers CLT.

Design Guide Description

This Acoustic Design Guide explains the principles of sound transmission between habitable spaces in buildings and how the required standards of insulation can be achieved in XLam construction. Specific wall and floor assemblies are based on extensive laboratory testing of XLam panels.

Application

This design guide has been prepared for use by suitably qualified construction professionals to assist in the design and specification of XLam panels. Products referred to in this document other than XLam panels are presented for information purposes only and due regard should be given to the relevant Australian and New Zealand Standards and other manufacturer literature. Advice on overall building design issues including, but not limited to: stability, loading, temporary stability during construction, fixings, waterproofing, fire engineering and overall acoustic performance are not covered by this guide and advice should be sought from suitably qualified professionals.

It is the responsibility of the user to ensure that the use of this Design Guide is appropriate and to exercise their own professional judgement when using the document. Full responsibility for the design and compliance with the Building Code of Australia (BCA) and the New Zealand Building Code (NZBC) and all relevant Australian and New Zealand Standards, rests with the design professional specifying the product. XLam will not accept any liability for the failure of any other elements of the building which cause a subsequent failure of an XLam product.

Updates and Version Control

This design guide is identified with a version number and date of issue. The latest issue is always on the XLam website. Access to the XLam design guides requires user registration for the purpose of disseminating updates. XLam will notify registered users of updates by email. It is the user's responsibility to ensure that the latest version is in use at all times.

Unless otherwise stipulated, the XLam design guides will be provided to registered users in electronic format. Bound hard copies can be made available by XLam on request.

Key Design Principles

The sound insulation of CLT building elements relies on appropriate design and construction detailing.

Compliant ratings can be effectively achieved by XLam wall and floor assemblies incorporating mass (CLT plus linings and overlays), de-coupled structure, resilient layers, air gaps, and absorbent insulation within cavities.

Designers must also detail construction to avoid 'flanking' sound transmission via alternative paths e.g. through air gaps, service ducts or adjoining elements which are common to two tenancies.

There are significant inter-dependencies between fire and acoustic solutions which require them to be considered together at an early stage.

BCA & NZBC Compliance Standards

Application of Standards

The NCC 2019, Volume 1 Section F5: Sound Transmission and Insulation, and the NZBC Clause G6: Airborne and Impact Sound, sets standards for building elements which prevent undue noise transmission to habitable spaces of household units from other occupancies or common spaces.

Building elements include structural and non-structural components such as fixtures, services, drains, permanent mechanical installations for access, glazing, partitions, ceilings, and temporary supports.

Habitable spaces are those used for activities normally associated with domestic living but exclude bathrooms, laundries, water closets, pantries, walk-in wardrobes, corridors, hallways, lobbies, clothes-drying rooms, or other spaces not occupied frequently or for extended periods.

Household units refer to any building, or part of a building, used solely or principally for residential purposes, and occupied exclusively by one household. Excluded from this are single family homes, hostels, boarding houses, and specialised accommodation such as aged care.

There are two sources for perceptible sound transmission through a wall or floor:

- Airborne sound such as speech and music
- Impact sound created through direct contact with the building structure, such as footsteps and door slams

Airborne and impact sound transmission through building elements are designated by separate decibel (dB) ratings.

Airborne Sound Transmission

R_w Rating (Australia), STC (New Zealand)

This performance rating provides an estimate in decibels of the overall airborne sound transmission loss of a wall or floor partition. The "Weighted Sound Reduction Index", R_w, is a measurement that determines the effectiveness of a building element's airborne insulation over a range of frequencies in a single number quantity. The R_w values measurement is correlated from room volume and reverberation time but does not consider sound flanking paths associated with in-situ installations. In New Zealand the Sound Transmission Class (STC) is the terminology used but while values may differ slightly to the R_w values the overall concept is the same.

The higher the R_w or STC the better performing the wall is overall.

C_{tr} Rating (Australia only)

The "Spectrum Adaptation Term", C_{tr}, is an airborne low frequency adjustment factor that quantifies the low frequency performance of the building element from sources like traffic, music, television etc. This is a way of "skewing" the overall assessment of a wall performance towards the lower, more commonly problematic, frequencies. C_{tr} figures are always negative numbers and most frequently are called up in combination as an R_w+C_{tr} value for certain wall types.

Typical minimum ratings for most common apartment buildings:

Australia:

R_w (walls between SOUs and corridors etc): more than 50dB

R_w + C_{tr} (intertenancy floors and walls): more than 50dB

New Zealand:

STC: more than 55dB

Structure-borne Sound Transmission

$L_{n,W}$ Rating (Australia), IIC Rating (New Zealand)

These ratings determine the sound performance of a wall or floor (though they typically only see specification for floors) and are related to physical impacts on those surfaces. It is a single number which measures effectiveness over a range of frequencies (from 100Hz to 3150Hz) and is expressed in decibels.

The two ratings work differently. $L_{n,w}$ – the lower the value, the better the performance. IIC – the higher the value, the better the performance.

Typical minimum ratings for most common apartment buildings:

Australia:

$L_{n,W}$ (floors only): less than 62dB

New Zealand:

IIC: more than 55dB

Field Testing

The sound ratings above are all based on laboratory testing, but field testing of mass timber assemblies is another route to show compliance with the relevant building codes. These are very effective measures as they account for the actual performance of the assembly, inclusive of flanking and construction quality, compared to the more idealised laboratory measurements. They are typically 5dB lower in performance than the laboratory ratings to take this into account.

Laboratory Rating	Equivalent Site Rating
R_w / R_w+C_{tr}	$D_{nT,w}$
$L_{n,w}$	$L_{nT,w}$
STC	FSTC
IIC	FIIC

NZBC Acceptable Solution

Acceptable Solution G6/AS1 1.01 requires that sound transmission through building elements shall be minimised by using one or more of the following construction techniques:

a) Physical separation of building elements comprising each face of any wall, floor or ceiling assembly which is common to two or more occupied spaces

b) Use of noise control building elements

c) Avoidance of rigid service connections (e.g. in plumbing) where the reticulation passes through noise control building elements separating different occupancies

d) Making the noise control installation airtight by sealing all joints between building elements, and around penetrations and service fittings.

Additional guidance notes include:

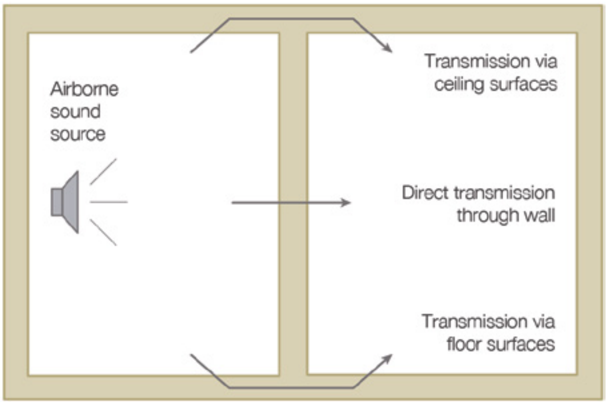
- Common walls should not be used for mounting fixtures and appliances which are likely to be a source of noise, e.g. telephones, TV sets, stereos, cupboards with doors, service switches
- Where the location of services in common walls and ceilings is unavoidable, they may require additional airborne and impact sound insulation in order that the building element achieves the required performance
- Airtightness of common partition elements is important, as an unsealed air space can in some circumstances amplify, rather than reduce sound

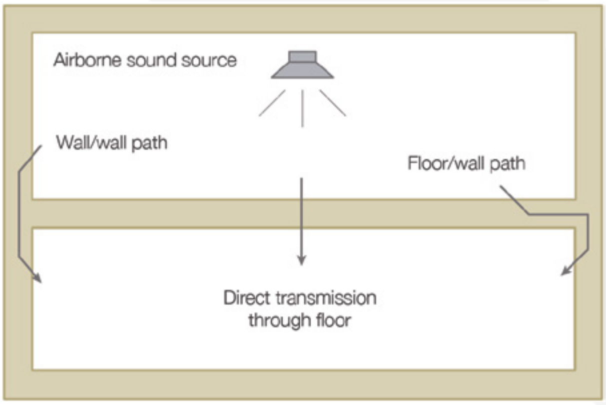
Flanking Sound

Sound transmission between two spaces in a building occurs not only through the separating floor and wall assemblies but also through the flanking building elements adjoining them at their edges (flanking transmission). The separating assembly and flanking elements are excited in the source space and transmit vibrations into the receiving space via coupled building elements.

Simply specifying a high-performance wall or floor assembly will therefore not guarantee a high acoustic performance. Flanking paths at the junctions therefore have to be taken into account in estimating the apparent sound insulation.

Flanking transmission can be minimised by careful consideration of design and construction details. As a general principle, it is wise to target a higher than code requirement for sound ratings to compensate for potential flanking effects.





Sound Sealants

Any air gaps in and around building elements are easy sound paths. An acoustic sealant should be used to fill all edge gaps between building components and cracks or voids around openings and penetrations.

Building Services

Flanking sound may find transmission pathways through assemblies such as electrical switches, light fittings, and plumbing systems. For this reason, building services should be avoided in dividing walls between habitable spaces. Acoustic ratings can be lower for non-habitable spaces such as bathrooms and laundries, however building services should still be given special acoustic consideration.

Discontinuous Construction

This is a concept specified for certain wall constructions in Australia and requires physical separation between two leaves of a wall between single occupancy units (SOU's) when back to back rooms are of certain usage types. This typically applies when bathrooms, kitchens or laundries in one unit back onto living areas or bedrooms in another.

Acoustic Ratings of Individual Panels

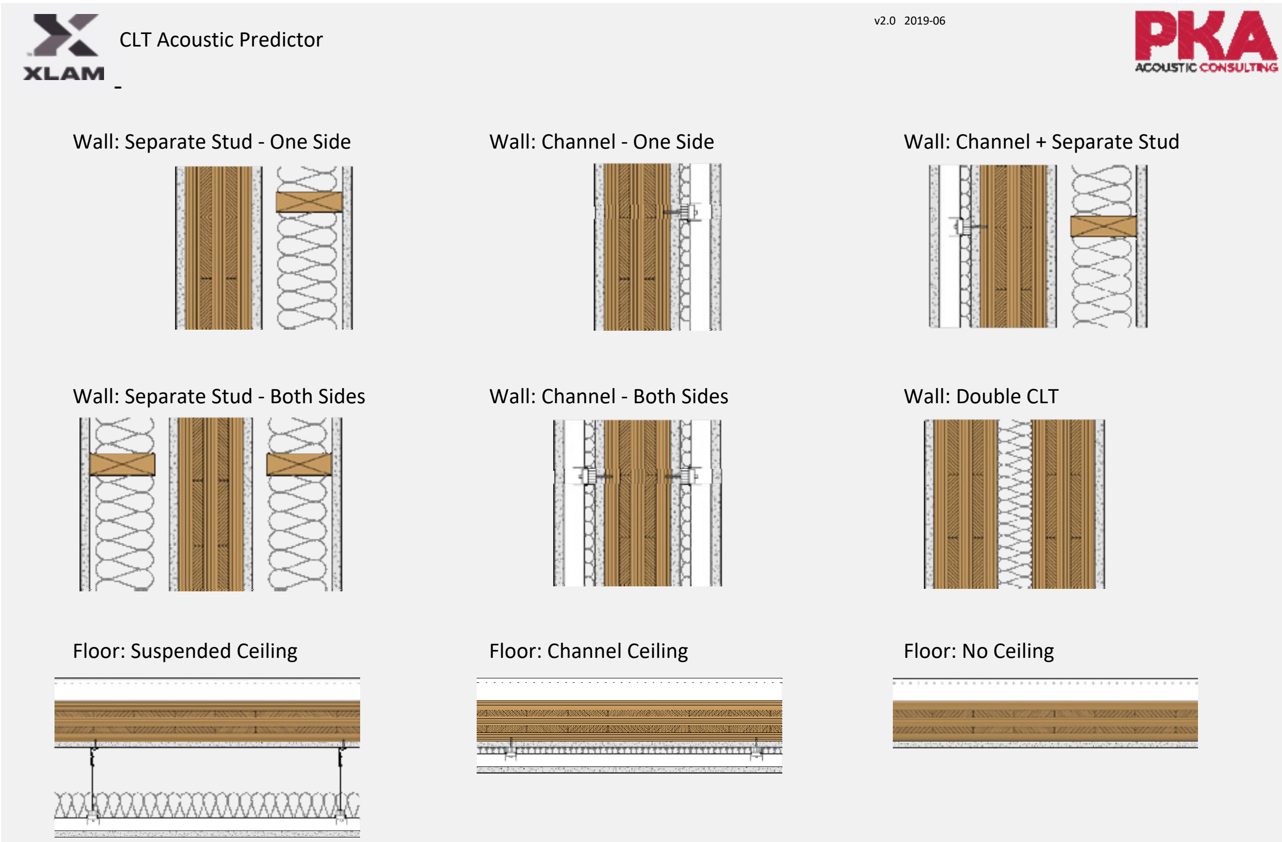
The table below gives the calculated airborne and impact sound insulation ratings for the entire range of XLam panels to give a comparison of the relative performance of each. It should be noted that to comply with building regulations on most commercial buildings a CLT panel on its own would not be sufficient but for domestic construction it gives some performance levels to consider in design.

Panel Type	Panel Reference	Thickness (mm)	min.Mass (kg/m²)	Airborne Sound Insulation				Impact Sound Insulation		
				R_w	C_{tr}	$R_w + C_{tr}$	STC	$L_{n,w}$	C_i	IIC
3 Layer	CL3/90	90	44	34	−3	31	34	92	−5	18
	CL3/100	100	49	34	−3	31	35	91	−5	19
	CL3/110	110	54	35	−3	32	35	90	−5	20
	CL3/120	120	59	36	−3	33	36	89	−5	21
	CL3/130	130	63	36	−3	33	36	89	−5	21
5 Layer	CL5/140	140	68	37	−3	34	37	88	−5	22
	CL5/155	155	75	38	−4	34	38	87	−5	23
	CL5/170	170	82	39	−4	35	39	86	−5	24
	CL5/190	190	92	40	−4	36	40	85	−5	25
	CL5/200	200	97	40	−4	36	40	85	−6	25
	CL5/220	220	107	41	−4	37	41	84	−5	26
7 Layer	CL7/240	240	116	42	−4	38	42	83	−5	27
	CL7/260	260	126	42	−4	38	42	83	−6	27
	CL7/270	270	131	43	−4	39	43	82	−5	28
	CL7/290	290	140	43	−4	39	43	82	−6	28
	CL7/310	310	150	44	−4	40	44	81	−6	29

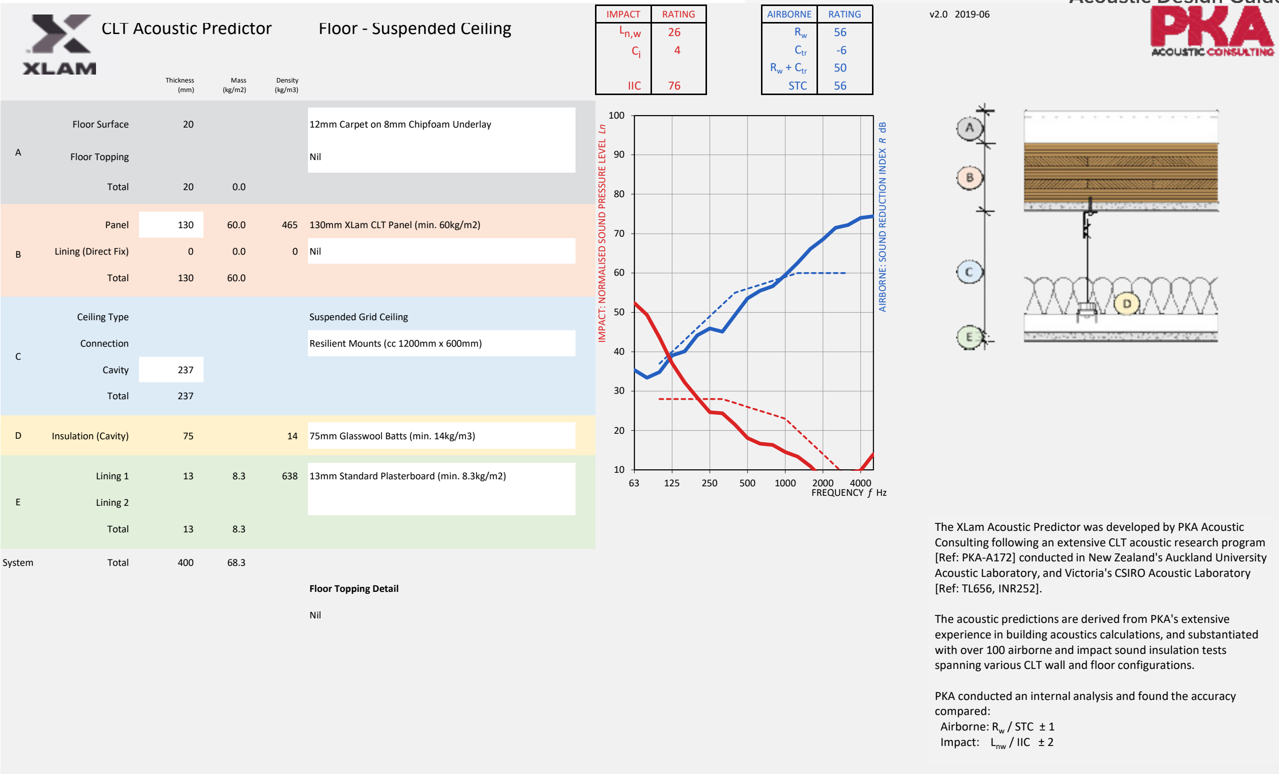
XLam Acoustic Predictor Software

XLam have invested significantly in the development of our own acoustic prediction software in collaboration with PKA Acoustic Consultants. It uses results from all the tests completed by XLam and allows variations to be quickly assessed for their acoustic performance for nine different wall/floor buildup typologies. It should be noted that the output only gives the rating for the wall or floor assembly and other issues like flanking should be considered as an overall part of the design process.

This is not currently available to the public but members of the XLam team are able to run example calculations for your project. For further information speak to your local XLam representative or email technical@XLam.com.au



Nine available buildups



Example interface and output

Acoustic Testing

Applicability to XLam CLT

The rapidly increasing demand for CLT within Australia & New Zealand highlighted the need for a comprehensive acoustic research programme which adopted testing methodology specific to meeting the BCA & NZBC requirements.

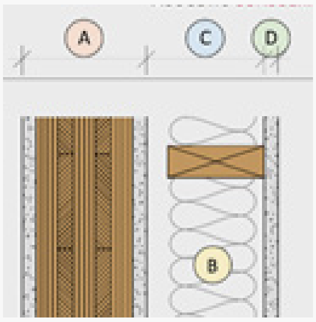
In 2016 the Timber Development Association, in conjunction with Forest and Wood Products Association of Australia, commissioned PKA Acoustic Consulting to complete a total of 107 separate airborne/impact tests on 66 different CLT wall and floor applications, both as bare panels and in combination with various lining and insulation systems. Testing was carried out at the University of Auckland Acoustic Laboratory, using XLam CLT panels. XLam also conducted further research in 2018 at CSIRO's laboratories in Melbourne to further explore the potential performance of CLT floors with exposed soffits. We found floor assemblies with both heavyweight screeds and lightweight batten and cradle type floors which would comply with code requirements, although they would both have cost/construction considerations. The test results, together with other project-based reporting commissioned by XLam from Arup and Marshall Day, substantiate the acoustic predictions included within this design guide.

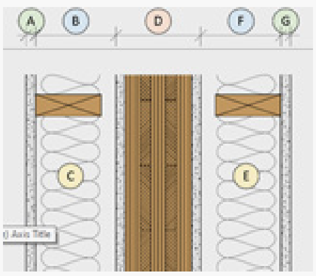
Deviations from Tested Assemblies

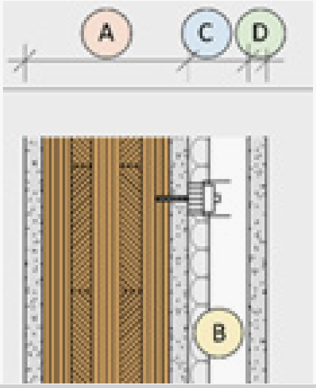
The performance ratings given in this chapter were derived using the materials shown in the acoustic assembly diagrams and detailed in the accompanying component descriptions. Any assembly deviations or material substitutions may affect the acoustic performance. Some variations may be required to meet non-acoustic considerations. Advice should be sought from a qualified acoustic consultant.

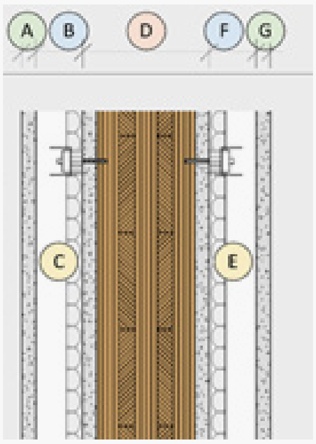
Tested Wall Assemblies

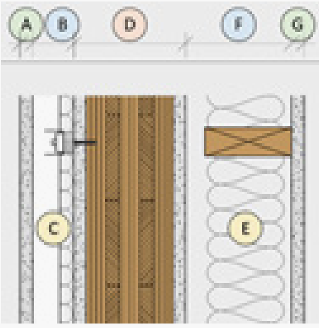
The following examples are presented based on the 2016 Auckland University test programme and represent some typical wall and floor build-ups common in both Australia and New Zealand. They are presented as examples for information only and may not comply with individual requirements in each country and these should be checked by the designer. XLam can be contacted for further information or can provide contact details for acoustic consultants experienced in mass timber construction.

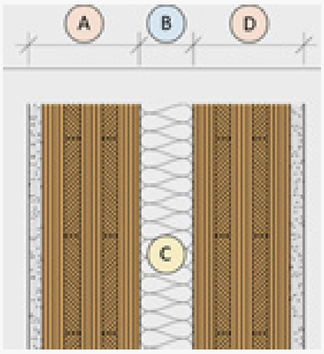
Walls	Components A to B	Thick mm	STC	R_w	$R_w + C_{tr}$
	16mm Fire Rated Plasterboard (min 12.4kg/ m2) 100mm XLam CLT Panel 16mm Fire Rated Plasterboard (min 12.4kg/m2) 20mm Air Gap 70mm Timber Studs 75mm Glasswool Batts (min 14kg/m2) 13mm Sound-rated Plasterboard (min 12.3/ kgm2)	235	58	58	50
Variation 1	155mm CLT panel	290	60	59	53

Walls	Components A to B	Thick mm	STC	R_w	$R_w + C_{tr}$
	13mm Standard Plasterboard (min 8.3/ kgm2) 70mm Timber Studs 50mm Glasswool Batts (min 14kg/m2) 20mm Air Gap 16mm Fire Rated Plasterboard (min 12.4kg/ m2) 100mm XLam CLT Panel 16mm Fire Rated Plasterboard (min 12.4kg/m2) 20mm Air Gap 70mm Timber Studs 50mm Glasswool Batts (min 14kg/m2) 13mm Standard Plasterboard (min 8.3/ kgm2)	338	66	64	52

Walls	Components A to B	Thick mm	STC	R_w	$R_w + C_{tr}$
	16mm Fire Rated Plasterboard (min 12.4kg/ m2) 100mm XLam CLT Panel 16mm Fire Rated Plasterboard (min 12.4kg/m2) Resilient Mounts (cc 1200 x 600mm) 50mm Top Hats 0.75 BMT (cc 600) 50mm Glasswool Batts (min 11kg/m2) 13mm Standard Plasterboard (min 8.3/ kgm2)	212	55	54	45
Variation 1	Change 13mm Standard Plasterboard (min 8.3/ kgm2) to 13mm Sound-rated Plasterboard (min 12.3/ kgm2) Change 50mm Glasswool Batts (min 11kg/m2) to 75mm Glasswool Batts (min 14kg/m2	212	58	59	50

Walls	Components A to B	Thick mm	STC	R_w	$R_w + C_{tr}$
	10mm Standard Plasterboard (min 6.2/ kgm2) 28mm furring Channels 0.50BMT (cc 600mm) Resilient Mounts (cc 1200 x 600mm) 50mm Glasswool Batts (min 11kg/m2) 16mm Fire Rated Plasterboard (min 12.4kg/ m2) 100mm XLam CLT Panel 16mm Fire Rated Plasterboard (min 12.4kg/m2) 28mm furring Channels 0.50BMT (cc 600mm) Resilient Mounts (cc 1200 x 600mm) 75mm Glasswool Batts (min 14kg/m2) 10mm Standard Plasterboard (min 6.2/ kgm2)	282	58	58	41
Variation 1	Change 10mm Standard Plasterboard (min 6.2/ kgm2) to 13mm Sound-rated Plasterboard (min 12.3/ kgm2)	288	65	67	51

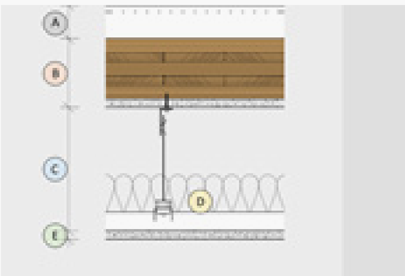
Walls	Components A to B	Thick mm	STC	R_w	$R_w + C_{tr}$
	13mm Sound-rated Plasterboard (min 12.3/ kgm2) 28mm furring Channels 0.50BMT (cc 600mm) Resilient Mounts (cc 1200 x 600mm) 50mm Glasswool Batts (min 11kg/m2) 16mm Fire Rated Plasterboard (min 12.4kg/ m2) 100mm XLam CLT Panel 16mm Fire Rated Plasterboard (min 12.4kg/ m2) 20mm Air Gap 70mm Timber Studs 50mm Glasswool Batts (min 11kg/m2) 13mm Sound-rated Plasterboard (min 12.3/ kgm2)	293	67	66	51

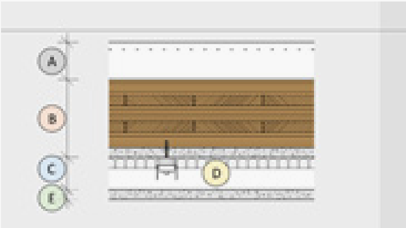
Walls	Components A to B	Thick mm	STC	R_w	$R_w + C_{tr}$
	16mm Fire Rated Plasterboard (min 12.4kg/ m2) 100mm XLam CLT Panel 50mm Glasswool Batts (min 11kg/m2) 100mm XLam CLT Panel 16mm Fire Rated Plasterboard (min 12.4kg/ m2)	282	60	60	54
Variation 1	CLT 120mm No insulation 50mm air gap	322	56	56	51

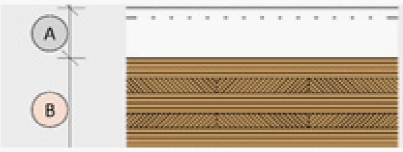
Component Descriptions

Abbreviation	Detailed Description
100mm XLam CLT wall panel	100mm XLam CLT 3-layer radiata pine wall panel (49kg/m^2)
13mm Gib standard plasterboard	13mm Gib standard plasterboard (min 8.6kg/m^2)
13mm Gib Noiseline plasterboard	13mm Gib Noiseline sound-rated plasterboard (min 12.5kg/m^2)
16mm Gib Fyreline plasterboard	16mm Gib Fyreline fire-rated plasterboard (min 13.7kg/m^2)
50mm glasswool insulation	50mm URSA glasswool insulation R1.4 (min 18kg/m^3) or 50mm Bradford Acoustiguard glasswool insulation R1.3 (min 14kg/m^3)
75mm glasswool insulation	75mm URSA glasswool insulation R1.8 (min. 17kg/m^3) or 75mm Bradford Acoustiguard glasswool insulation R1.8 (min 14kg/m^3)
70 x 45mm timber studs	70 x 45mm timber studs at 600mm centres
64mm Rondo steel studs	64mm Rondo steel studs 0.50BMT at 600mm centres
28mm Rondo 129 furring channel	28mm Rondo 129 furring channel at 600mm centres
30mm Rondo BetaGrip clip	30mm Rondo BetaGrip1 BG01 adjustable clip at 1200mm centres
Rondo STWC resilient mount	Rondo STWC resilient mount at 1200mm centres
Gib Soundseal	Gib Soundseal lining joint filler and perimeter sealant

Tested Floor Assemblies

Floors	Components	Thickness mm	STC	IIC	R_w	$R_w + C_{tr}$	$L_{n,T,w}$
	12mm Carpet on 8mm Chipfoam Underlay 170mm XLam CLT Panel 16mm Fire Rated Plasterboard (min 12.4kg/m2) 100mm Suspended ceiling Resilient Mounts (cc 1200 x 600mm) 75mm Glasswool Batts (min 14kg/m2) 13mm Standard Plasterboard (min 8.3/ kgm2)	319	57	75	58	51	26

Floors	Components	Thickness mm	STC	IIC	R_w	$R_w + C_{tr}$	$L_{n,T,w}$
	10mm Ceramic Tiles on 8mm Adhesive Bed 40mm Screed on 10mm Acoustic Rubber Underlay 170mm XLam CLT Panel 16mm Fire Rated Plasterboard (min 12.4kg/m2) Resilient Mounts (cc 1200 x 600mm) Furring Channel 75mm Glasswool Batts (min 14kg/m2) 13mm Standard Plasterboard (min 8.3/ kgm2)	334	62	56	62	55	53

Floors	Components	Thickness mm	STC	IIC	R_w	$R_w + C_{tr}$	$L_{n,T,w}$
	Floor Topping 2x9mm FC 13kg/m2 22mm Particleboard15kg/m2 90mm Timber Battens on 15mm Rubber Pads 90mm Glasswool Batts 20kg/m2 170mm XLam CLT Panel	315	59	55	58	52	55
Variation 1	Direct fix 16mm Fire Rated Plasterboard (min 12.4kg/m2)	331	60	57	60	53	53

Abbreviation	Detailed Description
170mm XLam CLT floor panel	170mm XLam CLT 5-layer radiata pine floor panel (82kg/m^2)
13mm Gib standard plasterboard	13mm Gib standard plasterboard (min 8.6kg/m^2)
16mm Gib Fyreline plasterboard	16mm Gib Fyreline fire-rated plasterboard (min 13.7kg/m^2)
20mm Strandboard floor	20mm Strandboard floor (min 14.2 kg/m^2)
40mm screed	40mm sand-cement screed (min 80kg/m^2)
50mm glasswool insulation	50mm URSA glasswool insulation R1.4 (min 18kg/m^3) or 50mm Bradford Acoustiguard glasswool insulation R1.3 (min 14kg/m^3)
75mm glasswool insulation	75mm URSA glasswool insulation R1.8 (min 17kg/m^3) or 75mm Bradford Acoustiguard glasswool insulation R1.8 (min 14kg/m^3)
100mm suspended ceiling with resilient mounts	100mm Rondo suspension ceiling with Rondo STSU resilient mounts at 1000 x 600mm centres
67mm furring channel on resilient mounts	67mm Rondo ceiling furring channel on Rondo STSL resilient mounts at 1000 x 600 centres
10mm rubber underlay	10mm Embleton Impactamat rubber acoustic underlay

Complying Floor/Ceiling Assemblies

Floor/Ceiling Test Conclusions

- Batten and rail systems should always incorporate resilient connections, to achieve STC and IIC 55dB or better.
- Acoustic performance is enhanced with an increase of cavity depth, and by including glasswool insulation within the ceiling cavity.
- Bare CLT floors require a resilient mat underlay to floor coverings in order to achieve IIC 55dB or better.
- The type of floor covering selected has little bearing on STC rating provided it is installed on a resilient underlay or bed.
- Carpet on chip foam underlay is by far the most effective floor covering to increase IIC rating.
- A 40mm sand/cement screed on a loose-laid resilient mat is effective at improving both STC and IIC ratings. (Be aware that the IIC increases in value with curing time for the screed).
- A loose-laid fibre cement sheet on a loose-laid resilient mat offers an alternative to a screed system.

Wall Test Conclusions

- Unlined single panel XLam dividing walls will not attain a compliant STC rating. However unlined XLam in discontinuous paired panels with insulation within the separation gap can achieve compliance.
- Adding 16mm Gib Fyreline plasterboard direct-fixed to both outer faces of paired panels can increase the STC by up to 5dB.
- An STC enhancement of 1dB or more can be made by adding a second lining layer of 13mm Gib Standard plasterboard, or alternatively by substituting Gib Standard plasterboard for a Gib Noiseline layer.
- A single XLam structural dividing wall panel will require linings to one or both sides packed out on resilient mounts. Alternatively, a discontinuous 75mm stud frame wall to one side, plus glasswool insulation within the cavity, will achieve compliance.

Acknowledgements

XLam would like to express special thanks to the following organisations and individuals who have contributed their professional skills and experience to the preparation of material contained in this design guide:

Forest and Wood Products Australia Ltd (FWPA) and PKA Consulting for the research, laboratory testing and reporting underlying the information contained in this Acoustic Design Guide.

User Feedback

Cross Laminated Timber (CLT) is relatively new to Australasia. Building with XLam CLT brings many benefits to the construction market. The overriding aim of this design guide is to make an easy pathway for designers. Its success is best judged by you as users. XLam welcomes all user feedback for future improvements.

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