Atlassian Central

Acoustics, Noise & Vibration

Schematic Design Report – 2.0

Prepared for: Atlassian c/- Avenor

Attention: Zig Peshos & Andreia Teixeira

Date: 16 April 2021

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Revision

Revision	Date	Comment	Prepared By	Approved By
001	16/04/2021	Draft Issue	Brandon Notaras	Brandon Notaras
002	26/04/2021	Issue	Brandon Notaras/Elle Hewett	Elle Hewett

Contents

1. Introduction

As part of the Schematic Design (2.0) for Atlassian Central, Stantec has been engaged by Atlassian c/- Avenor to provide conceptual acoustic design recommendations for the proposed commercial and hotel development located at 8-10 Lee St, Haymarket.

The conceptual design recommendations have been prepared considering the following documents:

- SSDA Architectural Drawings dated 6th April 2021
- *Western Gateway Sub-precinct Draft Design Guide June 2020*
- AS2107:2016 "Acoustics – Recommended design sound levels and reverberation times for building interiors"
- Green Star Design & As Built v1.3
- City of Sydney Development Control Plan (DCP) 2012
- NSW EPA Noise Policy for Industry (NPI) 2017
- State Environmental Planning Policy (SEPP) (Infrastructure) 2007
- NSW Development Near Rail Corridors & Busy Roads – Interim Guideline 2008
- The NSW OEH "Assessing Vibration: A Technical Guideline (2006)
- British Standard BS5228: Part 1:1997 "Noise and Vibration Control on Construction and Open Sites."
- British Standard BS7358:1993 "Evaluation and Measurement for Vibration in Buildings" – Part 2: "Guide to Damage Levels from Groundborne Vibration"
- German Standard DIN4150-Part 3 "Structural vibration in buildings – Effects on structures"
- AS1668.1:2015 "The use of ventilation and air conditioning. Part 1: Fire and smoke control in buildings"

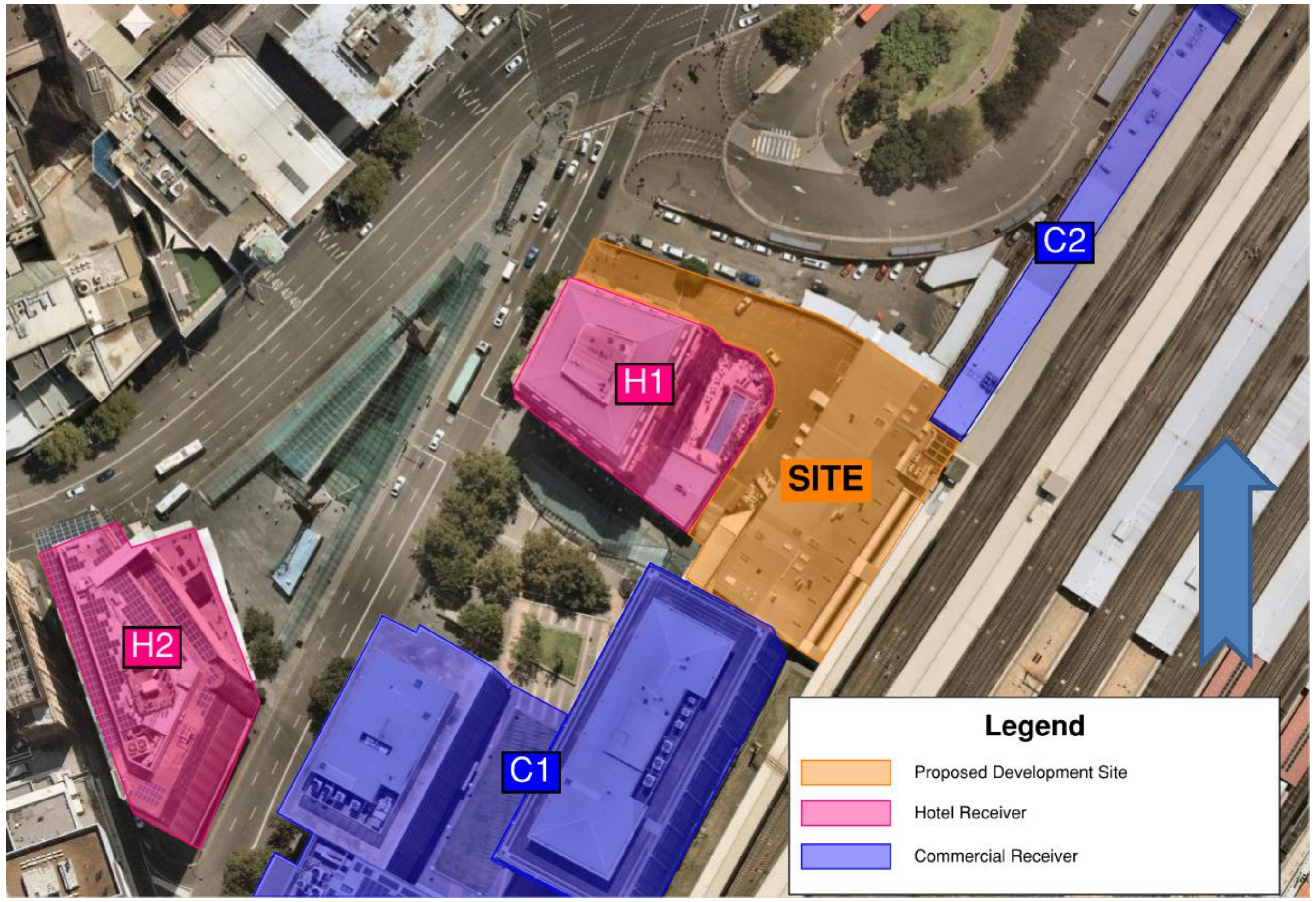
2. Site Description

2.1 Atlassian Central

The proposed development consists of a new mixed-use development – Western Gateway Sub-Precinct: Block A – at 8-10 Lee Street, Haymarket, NSW 2000, Australia. The building will accommodate Atlassian as the anchor tenant; and YHA Australia, the site's current hostel operator. The building design concept is to form a single tower on the site rising vertically. The tower will be raised and cantilever above the historic Inwards Parcels Shed.

The site is bound by a commercial development to the South-West, the Central Station rail corridor to the South-East and East, Ambulance Avenue to the North, and Adina Hotel to the West. The site location, noise-sensitive commercial receivers (C1 & C2) and noise-sensitive hotel receivers (H1 & H2) are shown in Figure 1.

Figure 1: Overview of the Atlassian Central site and surrounding noise-sensitive receivers

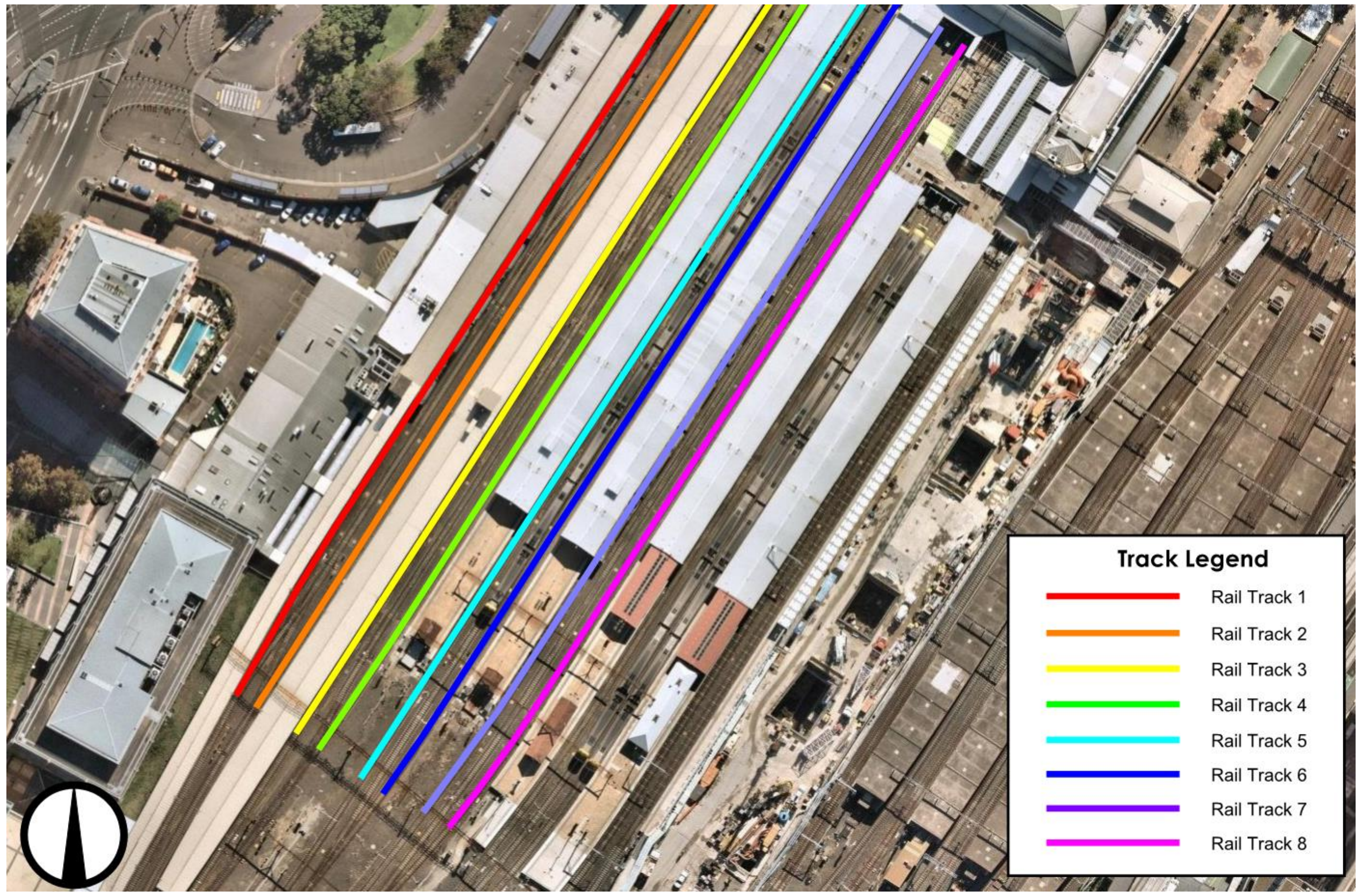


Source: nearmap.com and Stantec Australia

2.2 Adjacent Rail Corridor – Central Station

Atlassian Central is in close proximity to the adjacent above-ground rail corridor servicing Central Station. With reference to Figure 2, rail tracks 1 to 4 are used for the NSW TrainLink Regional lines and rail tracks 5 to 8 are used for the NSW TrainLink Intercity lines.

Figure 2: Rail track reference numbers (by platform)



Source: nearmap.com and Stantec Australia

Typically, platforms and tracks used for Regional and Intercity lines are not cause for concern when assessing a development's exposure to rail pass-by noise. In the instance of this development the trains servicing these lines will arrive at the platform and stop, with many trains (consisting of diesel engines) idling for periods up to 2 hours (45 minutes on average).

For rail tracks 5 to 8, this does not result in a large exposure to noise because the trains servicing these lines contain electric motors and do not idle when stopped at the platform. For rail tracks 1 to 4, the Atlassian Central site is exposed to a significant amount of noise due to trains consisting of diesel engines idling on the track for periods of up to 2 hours (45 minutes on average).

With the exception of the Indian Pacific that arrives and departs once a week, the noisiest class of train that arrives and departs from rail tracks 1 to 4 numerous times a day is the XPT. The XPT is powered by 2 diesel engines contained within a power car at either end of the train. The power car is ventilated on either side of the car as shown in Figure 3 through a large series of louvres. The significance of this, is this large series of louvres tends to be positioned directly in front of the existing YHA site and the future Atlassian Central development.

The quantity of noise emissions from these power cars is significant (shown in Section 3.3.2), particularly when considering the assessment requirements required by the City of Sydney within their Development Control Plan (assessing to the noisiest 1-hour period for both daytime and night-time).

After consulting with Sydney Trains and their asset management division, Stantec received information regarding the volume of each class of train that arrives and departs from the platforms, for each rail track accordingly. In addition to this, Stantec was provided with average exposure times for each train corridor for both the daytime (7am – 10pm) and night-time (10pm – 7am). This has been summarised in Table 4.

Figure 3: Elevation and plan showing power car for XPT class train

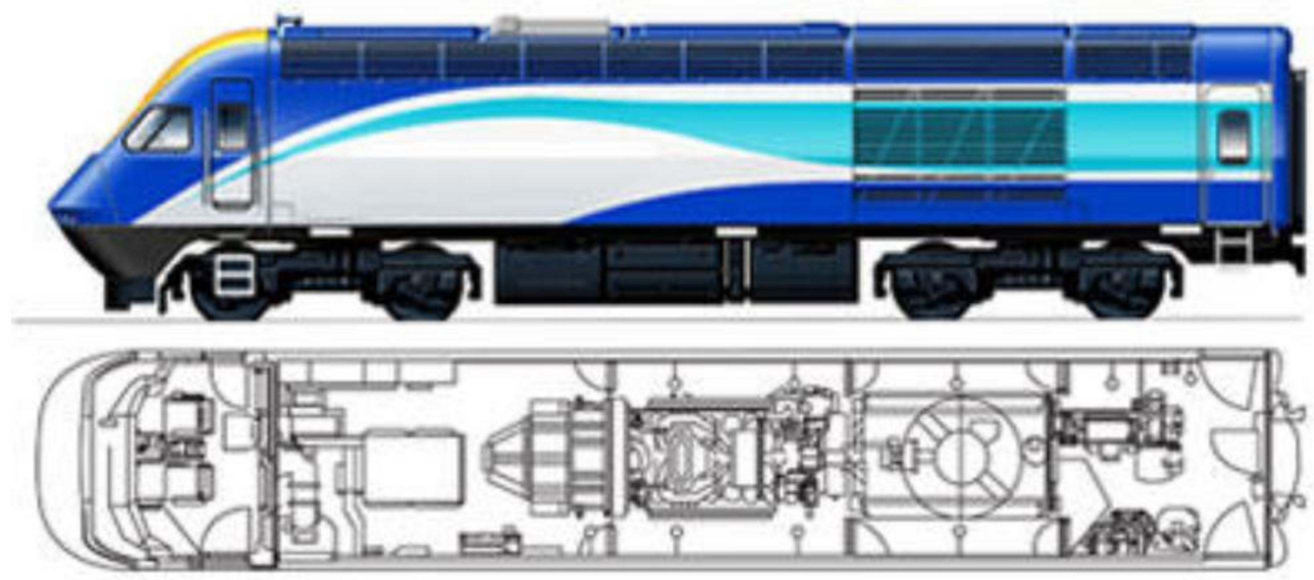


Table 1: Summary of train classes & types arriving and departing at each rail track number

Rail Track No.	Train Class	Drive Type	Average Number of Departures & Arrival per Day		Average Exposure Time for an Arrival & Departure (Minutes)
			Daytime 7am – 10pm	Night-time 10pm – 7am	
1 – 4	Indian Pacific	Diesel Locomotives	0.14 (1 per week)	0	120
	XPT	Diesel Locomotives	1	1	45
	Endeavour	Diesel-Propelled Carriages	1	1	45
	V-Set	Electric Multiple Unit	12	4	6
	Oscar	Electric Multiple Unit	12	3	6
5 – 8	V-Set	Electric Multiple Unit	20	5	6
	Waratah	Electric Multiple Unit	20	5	6
	Oscar	Electric Multiple Unit	20	5	6

Upon consulting with Transport for NSW (TfNSW), TfNSW have confirmed that the XPT Diesel train is getting retired from the Fleet, with their current program for XPT fleet retirement for late 2023 with Explorers to be retired mid 2024 to 2025. The current approach to the assessment of the noise from the adjacent rail corridor is to omit the noise generated by the XPT diesel train, and focus on the noise generated by pass-bys of existing and future trains (other than the XPT).

2.3 Acoustics, Noise & Vibration Considerations

The following components of the design have been identified as critical to ensure the Acoustics, Noise and Vibration design outcomes are achieved for Atlassian Central:

- CLT soffits in open plan offices – looking at options to control reverberation/echo within these large volumes whilst also maintaining the aesthetic intent
- CLT in the large outdoor habitats – controlling sound reflections from the beams & soffits acting as "retro-reflectors"
- Sound isolation of noise transferring between inter-tenancy walls within the YHA SOUs – interface of wall linings with lightweight structure and spatial constraints to meet NCC requirements
- Sound isolation of noise transferring between inter-tenancy floors within the YHA SOUs – isolation of ground-borne footfall noise and airborne noise sources from above to below to meet NCC requirements
- Sound isolation of noise transferring between office floors – isolation of ground-borne footfall noise on office floors together with airborne noise from any outdoor habitats above to maintain functional office environment (free from distraction & noise)
- Sound isolation of Level 07 plantroom from YHA rooms below and office tenancy above – sound isolation of mechanical and electrical plant and equipment through careful design of the plantroom floor
- The junction between the façade spandrels and CLT slab edges – to avoid flanking noise through these junctions reducing the sound isolation integrity of the floor system
- The junction between the façade and the YHA inter-tenancy walls and floors – to avoid flanking noise through transoms and mullions impacting the sound isolation integrity of the inter-tenancy wall and floor systems
- Design of the façade's glass and aluminium/steel elements – to ensure external noise from various sources (road, rail, adjacent building's plant rooms) is attenuated to a level sufficient for occupant comfort (YHA rooms, office spaces, etc.)
- Attenuation of noise through passive ventilation design to offices – examining how we attenuate noise from the external environment (road, rail, adjacent building's plant rooms) and simultaneously provide natural ventilation from openings in the façade
- Office space sound masking through design, supply and install of a sound masking system– to combat the low background noise introduced by the low-noise on-floor mechanical services
- Ground-borne noise propagation throughout the structure as a result of the adjacent rail corridor
- Preventing excessive noise emissions from the plantrooms to adjacent developments – through the use of plantroom acoustic treatment such as acoustic louvres
- Vibration propagation of the adjacent rail corridor (above-ground & underground) – investigating the requirement for vibration isolation of the structure where excessive vibration is incident on the structure
- Vibration propagation of mechanical, electrical & hydraulic plant and equipment – examining how we isolate this plant and equipment from the structure to avoid unwanted vibration and noise intruding into YHA rooms and office spaces
- Basement structure & geotechnical interface – considering the locations where the structure interfaces in-ground and how this interface occurs

3. Noise & Vibration Site Investigations

3.1 Instrumentation

The following equipment was used for the noise surveys:

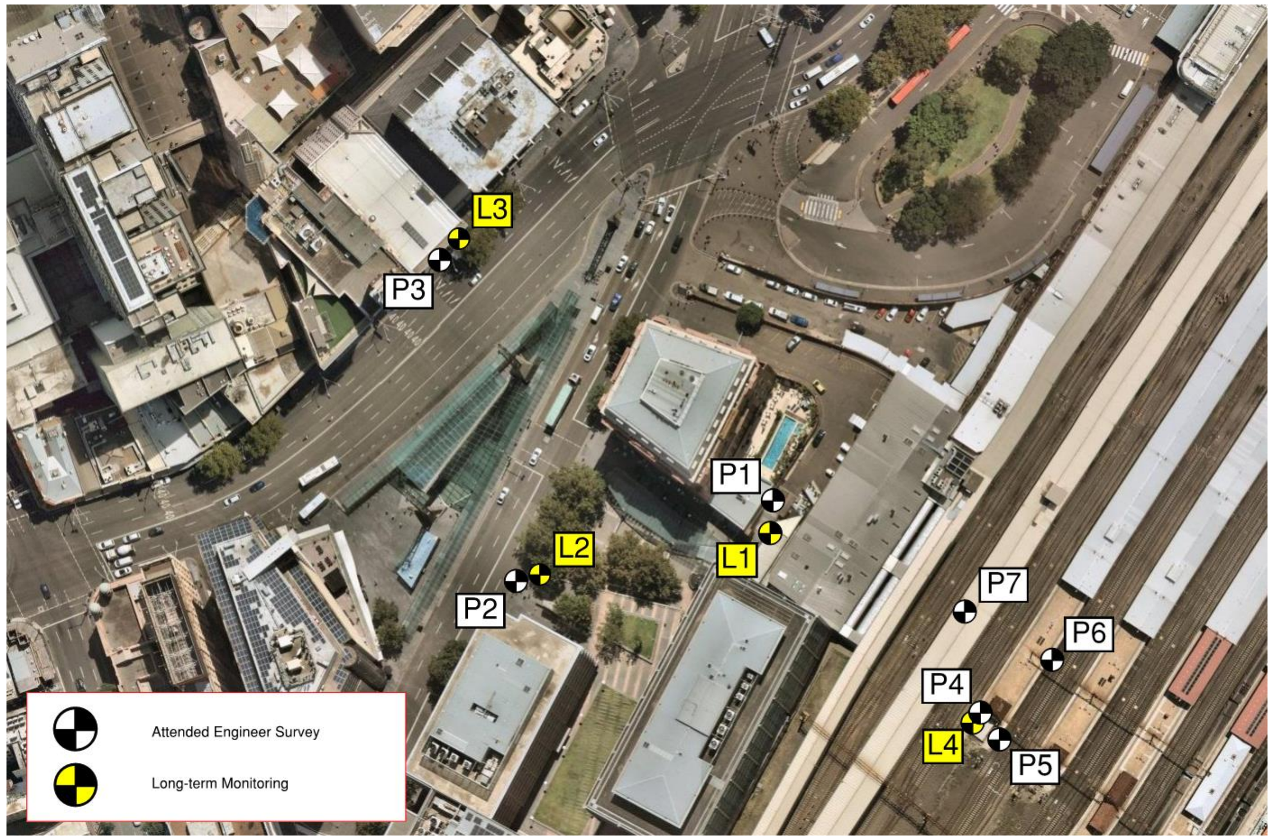
- SVAN 958 Sound and Vibration Analyser Type 1 S/N 15153
- SVANTEK SV207A Building Vibration Accelerometer S/N 22824
- AvaTrace M80 long-term vibration monitor S/N 3019
- AvaTrace Triaxial Geophone S/N 420
- Rion NL42-EX long-term noise monitor S/N 1173624
- Rion NL42-EX long-term noise monitor S/N 973279
- Rion NL42-EX long-term noise monitor S/N 345934
- Hand-held sound spectrum analyzer NTi XL2 S/N A2A-11555-E0
- Hand-held sound spectrum analyzer B&K 2250, S/N 2709742;
- Sound Calibrator B&K Type 4231, S/N 2709826;

All equipment was calibrated before and after the measurements and no significant drift was found. All equipment carries current traceable calibration certificates that can be provided upon request.

3.2 Survey Locations

The noise and vibration short-term and long-term survey locations are shown in Figure 4. These positions will be referenced within the ensuing sub-sections.

Figure 4: Noise and vibration survey locations



3.3 Noise Surveys

Short-term and long-term noise surveys were carried out on and around the proposed development site to characterise the noise generated by nearby traffic noise sources (George St, Pitt St and Lee St), noise emissions from the adjacent Central Station rail corridor, and background and ambient noise at surrounding noise-sensitive receivers.

3.3.1 COVID-19 Pandemic & Effects on Noise Surveys

These noise surveys were carried out under noise-subdued circumstances as a result of the COVID-19 pandemic. For background and ambient noise, the noise statistics obtained will be lower than that of a typical day to day operation and hence can be considered the worst-case scenario.

For the traffic noise measurements, the noise statistics obtained will not be representative of typical traffic noise on Lee Street, Pitt Street and George Street. As a result, the traffic noise measured on-site has been adjusted using comparisons between COVID-19 and standard peak hour traffic volumes on these roads.

There should be no effects as a result of the COVID-19 pandemic on the noise emissions from the adjacent Central Station rail corridor because the volume of trains passing has not been altered. Noise measurements of train pass-bys will not be affected by the COVID-19 pandemic. Therefore, the results of the noise surveys for the rail corridor noise should be considered an accurate reflection of standard operation.

3.3.2 Short-Term (Attended) Noise Surveys

Background Noise

Short-term noise measurements were conducted in the vicinity of surrounding noise-sensitive receivers to characterise the background and ambient noise associated with these receivers. The results of the background noise measurement conducted at location P2 (see Figure 4 for location) is provided in Table 2.

Table 2: Short-term noise measurement summary – Background noise

Measurement Location	Measurement Time	L_{Aeq} dB(A)	L_{A90} dB(A)	L_{A10} dB(A)	Comments
P1	12:55pm – 13:10pm	55.7	52.9	56.3	Mechanical noise sources, general noise from pedestrian traffic, residual noise from adjacent rail corridor

Traffic Noise

Short-term noise measurements of vehicle movements were carried out on Lee Street, Pitt Street & George Street. A summary of the results from the short-term noise measurements vehicle movements on these roads conducted at locations P3 – P5 (see Figure 4 for locations) is provided in Table 4.

Table 3: Short-term noise measurement summary – Traffic noise

Measurement Location	Measurement Time	L_{Aeq} dB(A)	L_{A90} dB(A)	L_{A10} dB(A)	Comments
P2	11:51am – 12:06pm	68.2	58.5	69.6	Noise from steady vehicle movements along both Lee St and George St with intermittent bus stops and pass-bys on Lee St, general noise from pedestrian traffic
P3	12:13pm – 12:28pm	72.4	64.4	73.7	Noise from steady vehicle movements along George St with consistent bus stops and pass-bys on Lee St, general noise from pedestrian traffic

Rail Corridor Noise

Short-term noise measurements of the train activity within the Central Station rail corridor were conducted on site. A summary of the results from the short-term noise measurements of the train pass-bys conducted at locations P4, P6 & P7 (see Figure 4 for survey locations) is provided in Table 4. Refer to Figure 2 for the locations of the rail track reference numbers.

Table 4: Short-term noise measurement summary – Rail corridor

Measurement Location	Measurement Time	Measurement Duration (seconds)	L_{Aeq} dB(A)	L_{A10} dB(A)	L_{Amax} dB(A)	Comments
P4	8:47am	38	75.0	78.3	84.5	Endeavour passing by and departing platform (rail track 4), 1.5 metres above from level of track and 2 metres from rail track
	8:19am	54	67.9	71.0	75.1	Endeavour passing by and arriving platform (rail track 4), 2 metres from platform 4 edge
P6	8:17am	28	66.4	69.7	72.2	V-Set passing by and leaving platform (rail track 5), 1.5 metres from platform 5 edge
	7:58am	45	69.8	72.1	80.2	V-Set passing by and leaving platform (rail track 6), 1.5 metres from platform 5 edge
	7:48am	50	66.9	70.4	75.2	V-Set passing by and arriving platform (rail track 5), 1.5 metres from platform 5 edge
P7	7:40am	15	79.1	85.9	87.7	XPT passing by and departing platform (rail track 2), 3 metres from platform 2 edge
	7:39am	17	82.9	87.9	89.4	XPT passing by and departing platform (rail track 2), 3 metres from platform 2 edge
	7:38am	18	86.0	86.5	87.1	XPT idling, in front of engine at front (rail track 2), 5 metres from louvres on face of power car

3.3.3 Long-Term (Unattended) Noise Surveys

Background Noise

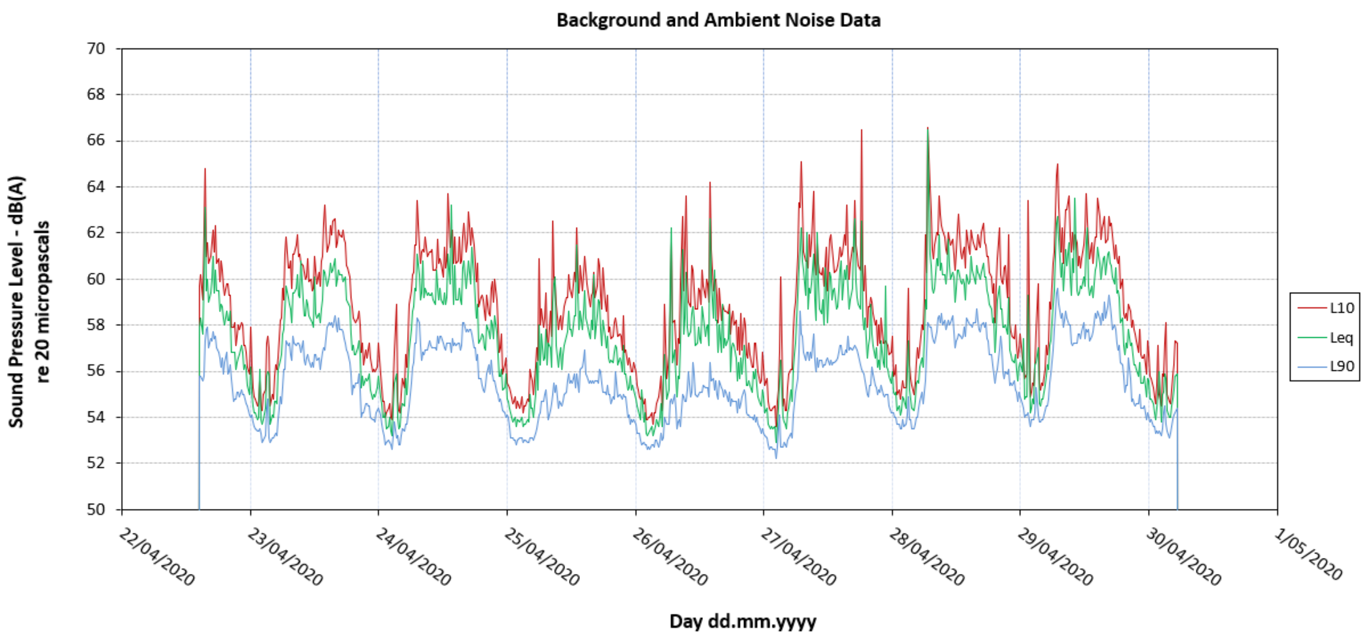
A noise monitor was placed at position L1 as shown in Figure 4 to measure the background and ambient noise that is representative of the surrounding noise-sensitive receivers. Noise monitor L1 was installed from the 22nd to the 30th of April 2020. The results of the unattended background and ambient noise survey is shown in Table 5 below (for the day, evening and night periods).

Table 5: Long-term noise survey summary – Background noise

Location	Equivalent Continuous Noise Level $L_{Aeq,period}$ - dB(A)			Background Noise Level RBL - dB(A)		
	Day	Evening	Night	Day	Evening	Night
L1	60	58	56	56	55	53

The local ambient noise environment is dominated by residual noise from existing industrial noise sources from surrounding buildings (loading docks, plant and equipment) nearby busy roads (George St and Lee St) and the adjacent rail corridor, together with pedestrian traffic throughout the majority of the day, evening and night periods. Note that any rain affected data during the period of logging has been excluded from the calculations. Refer to Figure 5 for the noise data for the total period of measurement.

Figure 5: Long-term background noise monitoring data – L1



Traffic Noise

Noise monitors were placed at positions L2 and L3 as shown in Figure 4 to measure the noise generated by vehicle movements during the noisiest 1-hour day and the noisiest 1-hour night established in the Sydney DCP 2012, and the 15-hour day and 9-hour periods established in the DPIE's Development near Rail Corridors and Busy Roads – Interim Guideline. Noise monitors L2 and L3 were installed from the 22nd to the 30th of April 2020. The results for the long-term traffic noise surveys are shown in Table 6 below (for the day and night periods).

Table 6: Long-term noise survey summary – Traffic noise

Location	Equivalent Continuous Noise Level $L_{Aeq,period}$ - dB(A)		Equivalent Continuous Noise Level $L_{Aeq,1hour}$ - dB(A)	
	Day (15hr)	Night (9hr)	Day (Noisiest 1h)	Night (Noisiest 1h)
L2	71.5	64	75	67.5
L3	73	68.5	75	71

Note that any rain affected data during the period of logging has been excluded from the calculations. Refer to Figure 6 (L2) and Figure 7 (L3) for the noise data for the total period of measurement.

It should be noted that the 90dB(A) peak on 23rd April 2020 for monitor L2 was excluded from the calculations.

Figure 6: Long-term traffic noise monitoring data – L2

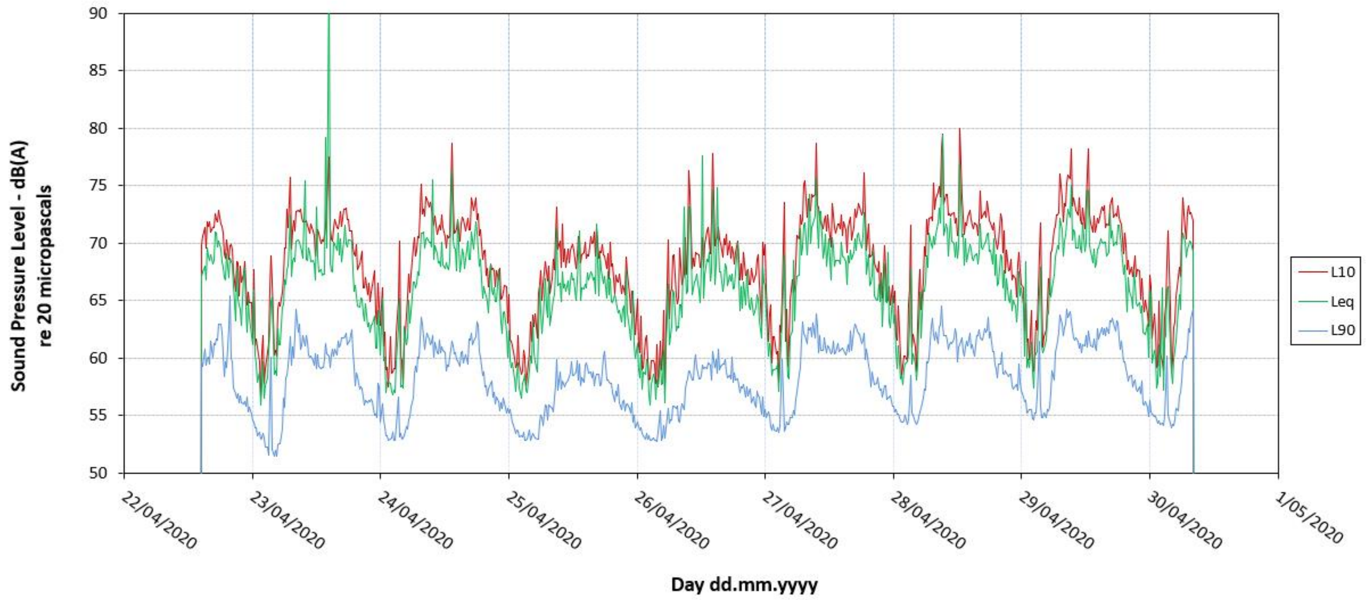
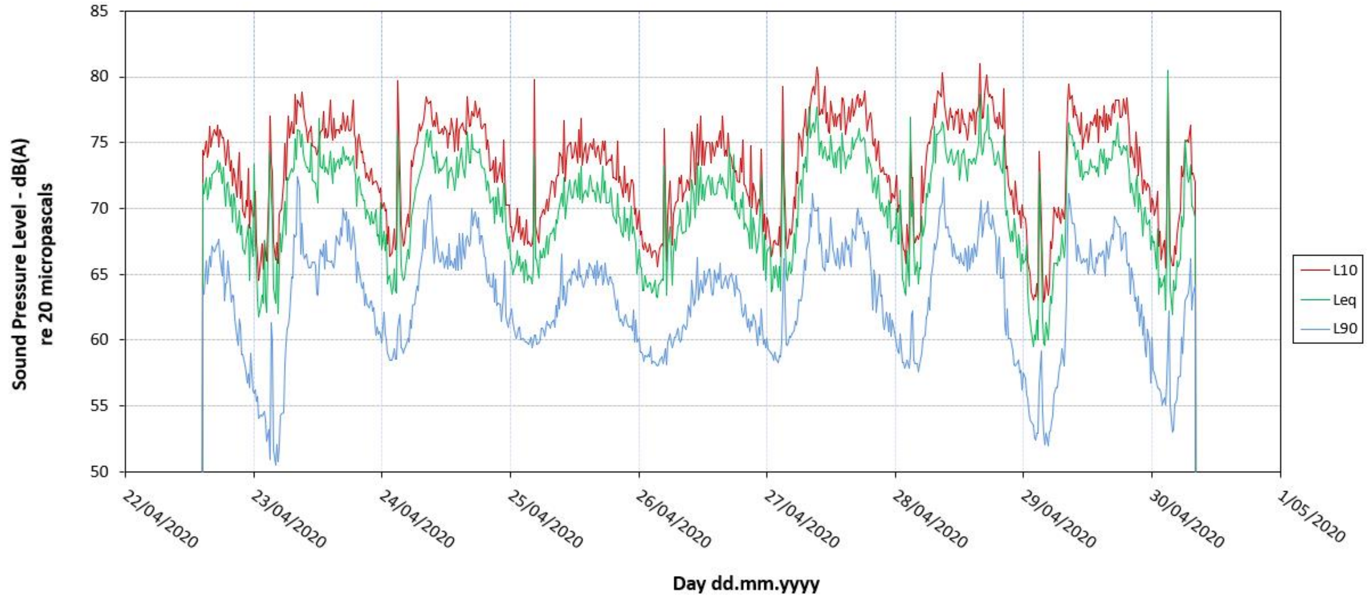


Figure 7: Long-term traffic noise monitoring data – L3



3.4 Vibration Surveys

Short-term and long-term vibration surveys were carried out within the Central Station rail corridor to obtain the vibration magnitudes and characteristics of train pass-bys within the Central Station rail corridor, and their effects on existing structures.

3.4.1 Short-Term (Attended) Vibration Surveys

Short-term vibration measurements of the train pass-bys within the Central Station rail were conducted. A triaxial accelerometer was mounted to a concrete footing approximately 2 metres from the centre of rail track 4 (P4) and rail track 5 (P5). Sydney Trains/TfNSW advised the concrete footing is approximately 1500mm deep. A summary of the results from the short-term vibration measurements of the train pass-bys conducted at locations P4 & P5 (see Figure 4 for locations) is provided in Table 7 and Table 8.

Table 7: Short-term vibration measurement summary – Rail corridor (RMS & Peak values)

Location	Train Class	Duration seconds	$a_{rms,x}$ (m/s^2)	$a_{rms,y}$ (m/s^2)	$a_{rms,z}$ (m/s^2)	Peak$_x$ (m/s^2)	Peak$_y$ (m/s^2)	Peak$_z$ (m/s^2)
P4	Endeavour	42	0.00328	0.00838	0.0122	0.0256	0.0699	0.110
P5	V-Set	74	0.00528	0.0119	0.0164	0.0528	0.139	0.191

Table 8: Short-term vibration measurement summary - Rail corridor (VDVs)

Location	Train Class	Duration seconds	VDV$_x$ (m/s$^{1.75}$)	VDV$_y$ (m/s$^{1.75}$)	VDV$_z$ (m/s$^{1.75}$)
P4	Endeavour	42	0.0340	0.0929	0.138
P5	V-Set	74	0.0772	0.298	0.330

3.4.2 Long-Term (Unattended) Vibration Surveys

Long-term vibration monitoring of train pass-bys within the rail corridor was carried out to capture the range of vibration events that occur over an average week from rail track 1 to rail track 4. Each of these rail tracks have almost identical train activity associated with them. A triaxial geophone was mounted to a concrete footing with epoxy approximately 2 metres from the centre of rail track 4 (L4). The vibration monitor was set up to trigger as soon as the vibration level exceeded a particular PPV value. As discussed in Section 3.4.1, the concrete footing is approximately 1500mm deep. A summary of the 20 vibration measurements with the largest magnitudes in the z-axis measured over the period of a week is provided in Table 9.

Table 9: Long-term trigger vibration survey summary – Rail corridor (L4)

Trigger Time	$v_{rms,x}$ (mm/s)	$v_{rms,y}$ (mm/s)	$v_{rms,z}$ (mm/s)	PPV$_x$ (mm/s)	PPV$_y$ (mm/s)	PPV$_z$ (mm/s)
22/04/2020 3:49:51 PM	0.45	0.47	0.29	2.32	6.94	4.8
22/04/2020 7:29:38 AM	0.45	0.69	0.55	1.66	6.92	5.22
22/04/2020 8:47:39 AM	0.41	0.60	0.43	2.09	10.54	7.1
22/04/2020 9:35:11 AM	0.41	0.48	0.34	2	5.88	4.55
23/04/2020 6:57:35 AM	0.41	0.34	0.56	2.66	7.28	4.92
23/04/2020 6:57:40 AM	0.40	0.57	0.46	1.5	6.59	5.14
23/04/2020 7:28:57 AM	0.42	0.90	0.63	2.43	6.86	4.05
26/04/2020 3:42:46 PM	0.45	0.84	0.61	3.34	5.94	5.44
26/04/2020 3:42:50 PM	0.45	0.72	0.61	2.3	5.99	5.36
26/04/2020 4:10:00 PM	0.43	0.87	0.59	2.77	5.9	5.32
26/04/2020 7:35:18 AM	0.40	0.25	0.63	2.14	7.41	5.57
27/04/2020 4:30:29 PM	0.41	0.72	0.58	4.16	10.93	8.26
27/04/2020 4:47:36 PM	0.45	0.77	0.59	4.56	12.27	10.29
27/04/2020 6:18:13 PM	0.41	0.46	0.37	2	6.52	5.11
27/04/2020 6:33:28 PM	0.48	0.65	0.45	2.87	6.67	3.68
28/04/2020 7:29:23 AM	0.40	0.37	0.26	1.22	6.07	3.63
28/04/2020 9:35:09 AM	0.43	0.37	0.41	2.95	6.15	5.43
29/04/2020 4:47:25 PM	0.46	0.54	0.34	2.61	6.04	4.9
30/04/2020 12:18:35 AM	0.46	0.66	0.46	2.84	9.02	9.41
30/04/2020 8:50:54 AM	0.42	0.66	0.58	3.18	7.62	5.66
30/04/2020 8:50:57 AM	0.51	0.81	0.74	2.22	6.3	5.89

4. Acoustics, Noise & Vibration Design Criteria

4.1 Internal Noise Levels

4.1.1 Commercial Zone & Base-Building

The internal noise level targets sought for the commercial zones within the development are governed by the guidelines outlined in AS 2107:2016, together with the requirement for obtaining the Green Star credit, LEED v4.1 – Commercial Interiors, and WELL v2 for Internal Noise Levels.

AS 2107:2016 "Acoustics – Recommended design sound levels and reverberation times for building interiors"

Background noise level and reverberation time design targets were obtained from standard AS/NZS 2107:2016. These criteria will affect the design of air conditioning plant and other mechanical services, the performance of the facade, and the design of sound isolation requirements between occupied areas. Table 10 presents the background noise levels that are the basis of the acoustic design for each type of space.

Table 10: Recommended design internal noise level range (AS/NZS 2107:2016)

Type of occupancy / activity	Design sound level ($L_{Aeq,T}$) range, dB(A) Noisiest 1 hour, 7am – 7pm
End of Trip Facilities	45 to 55
Atlassian Lobby	45 to 50
Café	40 to 50
Level 07 Kitchen	< 55
Office Type A (mechanically ventilated)	40 to 45
Office Type B (mixed-mode ventilation)	40 to 45 (Windows Closed)
	< 60 (Windows Open)
Office Type C (Outdoor Habitat)	< 65
Lift Lobby	45 to 50
Bathrooms	45 to 55

Sound levels within the given ranges have been found to be acceptable by most people for the space under consideration. When the sound level is greater than the upper level of the range the likelihood of people complaining due to noise will increase. When the sound level is below the lower level of the range, the inadequacy of background sound to provide masking sound can become problematic, for example, by allowing other intermittent noise sources to cause distraction, annoyance, or lack of privacy.

Green Star Design & As Built v1.3

Where a credit shall be obtained for Internal Noise Levels as part of Green Star – Design & As Built v1.3, one point is available where internal ambient noise levels in the nominated area are suitable and relevant to the activity type in the room. This includes all sound generated by the building systems and any external noise ingress.

Specifically, one point is awarded where project teams demonstrate that internal ambient noise levels in the nominated area are no more than 5 dB(A) above the lower figure in the range recommended in Table 1 of AS 2107:2016.

For the purposes of this credit, mixed mode buildings can be treated as mechanically ventilated and hence will not be required to satisfy the Green Star – Design & As Built v1.3 Provisions for Naturally Ventilated Buildings under Acoustic Comfort.

Table 11 provides a summary of the internal noise criteria for each of the spaces within the commercial zone and base-building.

Table 11: Green Star Design & As Built v1.3 requirements – Internal Noise Levels

Type of occupancy / activity	Maximum Allowable $L_{Aeq,T}$, dB(A)
End of Trip Facilities	50
Atlassian Lobby	50
Café	45
Level 07 Kitchen	55
Office Type A (mechanically ventilated)	45
Office Type B (mixed-mode ventilation)	45 (Windows Closed)
Lift Lobby	50
Bathrooms	50

Table 12: WELL v2 – Maximum Noise Levels (3 points)

Points are awarded provided the following background noise levels do not exceed thresholds below:

Sound Pressure Level (SPL)		Open Workspaces, Dining Areas	Enclosed Offices, Residential Living & Sleeping Areas (Daytime)	Conference Rooms, Classrooms, Residential Sleeping Areas (Night-time)	Points
Average SPL (Leq)	dBA	45	40	35	3
	dBC	70	65	60	
Max SPL (LMax)	dBA	55	50	45	
	dBC	80	75	70	
Average SPL (Leq)	dBA	50	45	40	2
	dBC	75	70	65	
Max SPL (LMax)	dBA	60	55	50	
	dBC	85	80	75	
Average SPL (Leq)	dBA	55	50	45	1
	dBC	80	75	70	

Note:

1. Leq measurements may exceed optimal levels by no more than a 4 dB tolerance.
2. LMax measurements are slow-weighted and may exceed optimal levels by no more than a 9 dB tolerance.

LEED v4.1 – Commercial Interiors - HVAC Background Noise

Achieve maximum background noise levels from heating, ventilating, and air conditioning (HVAC) systems per 2015 ASHRAE Handbook-- HVAC Applications, Chapter 48, Table 1; AHRI Standard 885-2008, Table 15; or a local equivalent.

If confirming compliance via measurements, use a sound level meter that conforms to ANSI S1.4 for type 1 (precision) or type 2 (general purpose) sound measurement instrumentation, the International Electrotechnical Commission (2013) IEC 61672-1:2013 Electroacoustics – Sound Level Meters – Part 1: Specifications, or a local equivalent.

Comply with design criteria for HVAC noise levels resulting from the sound transmission paths listed in 2015 ASHRAE Handbook ---HVAC Applications, Chapter 48, Table 6; or a local equivalent.

Table 13: LEED v4.1 – Commercial Interiors - HVAC Background Noise TargetsType of occupancy	Design guide – Octave band Analysis	Approximate overall sound pressure level[a]
	NC/RC[b]	dBA/dBC[c]
Executive and private offices	30	35/60
Conference rooms	30	35/60
Teleconference rooms	25	30/55
Open-plan offices	40	45/65
Corridors and lobbies	40	45/65

Notes:

a) Values and ranges are based on judgement and experience and represent general limits of acceptability for typical building occupancies.
b) NC: this metric plot octave band sound levels against a family of reference curves, with the number rating equal to the highest tangent line value.
c) dBA and dBC: these are overall sound pressure level measurements with A- and C-weighting and serve as good references for a fast, single-number measurement. They are also appropriate for specification in cases where no octave band sound data are available for design.

Ground-borne Internal Noise Targets

In the absence of any specific requirement for ground-borne noise to be limited to a value within each of the spaces part of Atlassian Central, we recommend setting an internal noise target for this type of noise source.

Our recommendation for limiting ground-borne noise within the internal spaces of the development is to ensure ground-borne noise generated is limited to the following criteria:

$L_{Amax,slow,95th\ percentile}$ ≤ Lower Range from AS 2107:2016

4.1.2 YHA Zone & Fitout

The internal noise level targets sought for the YHA Zone & Fitout are governed by the City of Sydney legislative requirements, the guidelines outlined in AS 2107:2016, and the requirement for obtaining the Green Star credit for Internal Noise Levels.

AS 2107:2016 "Acoustics – Recommended design sound levels and reverberation times for building interiors"

Similar to the Commercial Zone & Base-Building, background noise level and reverberation time design targets were obtained from standard AS/NZS 2107:2016. These criteria will affect the design of air conditioning plant and other mechanical services, the performance of the facade, and the design of sound isolation requirements between occupied areas. Table 10 presents the background noise levels and reverberation times that are the basis of the acoustic design for each type of space.

Table 14: Recommended design internal noise level range (AS/NZS 2107:2016)

Type of occupancy / activity	Design sound level ($L_{Aeq,T}$) range Noisiest 1 hour (Day or Night depending on Space)
Group Lounge	40 to 45
Catered Kitchen / Kitchen / Staff Kitchen	45 to 55
Dining / Main Lounge	40 to 45
Park Zone	< 60
Games	45 to 50
Media	40 to 45
Waiting	40 to 45
Reception	40 to 45
General Staff Area	40 to 45
Manager	35 to 40
Amenities / Staff PWD	45 to 55
H.O. 16P Meet	30 to 40
H.O. 4P Meet	40 to 45
Cafe	45 to 50
Bedrooms (night-time)	35 to 40
Offices (CEO, YHA Head Office)	35 to 40
Corridors	45 to 50
Atrium / Stairwell	45 to 50

Green Star Design & As Built v1.3

Similar to the Commercial Zone & Base-Building, one point in Internal Noise Levels is awarded where project teams demonstrate that internal ambient noise levels in the nominated area are no more than 5 dB(A) above the lower figure in the range recommended in Table 1 of AS 2107:2016.

For the purposes of this credit, mixed mode buildings can be treated as mechanically ventilated and hence will not be required to satisfy the Green Star – Design & As Built v1.3 Provisions for Naturally Ventilated Buildings under Acoustic Comfort.

Table 15 provides a summary of the internal noise criteria for each of the spaces within the commercial zone and base-building.

Table 15: Green Star Design & As Built v1.3 requirements – Internal Noise Levels

Type of occupancy / activity	Maximum Allowable $L_{Aeq,T}$, dB(A)
Group Lounge	45
Catered Kitchen / Kitchen / Staff Kitchen	50
Dining / Main Lounge	45
Games	50
Media	45
Waiting	45
Reception	45
General Staff Area	45
Manager	40
Amenities / Staff PWD	50
H.O. 16P Meet	35
H.O. 4P Meet	45
Cafe	50
Bedrooms (night-time)	40
Offices (CEO, YHA Head Office)	40
Corridors	50
Atrium / Stairwell	50

WELL v2 – Maximum Noise Levels (3 points)

Maximum noise level targets for sleeping spaces relevant to the YHA Zone can be found in Table 12.

Ground-borne Internal Noise Targets

We have not recommended a ground-borne internal noise target for the YHA Zone & Fitout because this criterion was not provided in the YHA design brief.

4.1.3 Emergency Egress – AS 1668.1:2015

During emergency egress situations, emergency mechanical system noise levels may interfere with command conversation, which may present a threat to safe occupant evacuation or may contribute to occupant distress in the event of a fire. For this reason, the maximum sound pressure level generated by smoke control systems or stair pressurization systems is required to not exceed 65 dB(A) and never exceed 80 dB(A) in the occupied space.

On reaching the safety of a fire-isolated exit, occupants can egress with considerably less verbal direction and, as such, can safely sustain higher sound levels. To this end, the maximum sound pressure level in the fire-isolate exits is required to not exceed 80 dB(A). For instance, the noise generated by the supply air fan to pressurize a stair shaft should not deter people from entering the stair shaft.

For the purpose of compliance, the noise levels shall be measured in the common paths of travel leading to the exit doorway with the door closed.

4.1.4 Project Internal Noise Level Targets (Summary)

Table 16 below outlines the project internal noise level targets for the development site-wide for the various metrics, summarizing the internal noise level recommendations and requirements from Sections 4.1.1 to 4.1.3.

Table 16: Project internal noise level targets

Type of occupancy / activity	Metric	Standard	Noise Level Range dB(A)
Commercial Zone & Base-Building			
End of Trip Facilities	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	45 to 55
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 45
Atlassian Lobby	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	45 to 50
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 50
	$L_{Amax,slow,95th\ percentile}$ (Ground-borne)	Stantec	< 45
Café	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	40 to 50
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 45
	$L_{Amax,slow,95th\ percentile}$ (Ground-borne)	Stantec	< 40
YHA Lobby	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	45 to 50
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 50
	$L_{Amax,slow,95th\ percentile}$ (Ground-borne)	Stantec	< 45
Level 07 Kitchen	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	< 55
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 55
Office Type A (mechanically ventilated)	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	40 to 45
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 45
	$L_{Amax,slow,95th\ percentile}$ (Ground-borne)	Stantec	< 40
Office Type B (mixed-mode ventilation)	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	40 to 45 (Windows Closed)
		AS 2107:2016	60 (Windows Open)
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 45 (Windows Closed)
	$L_{Amax,slow,95th\ percentile}$ (Ground-borne)	Stantec	< 40
Office Type C (Outdoor Habitat)	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	< 65
Lift Lobby	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	45 to 50
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 50
Bathrooms	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	45 to 55
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 50
YHA Zone & Fitout			
Group Lounge	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	40 to 45
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 45
Catered Kitchen / Kitchen / Staff Kitchen	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	45 to 55
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 50
Dining / Main Lounge	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	40 to 45
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 45
Park Zone	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	< 60
Games	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	45 to 50
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 50
Media	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	40 to 45
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 45
Waiting	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	40 to 45
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 45
Reception	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	40 to 45
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 45
General Staff Area	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	40 to 45
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 45
Manager	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	35 to 40
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 40
Amenities / Staff PWD	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	45 to 55
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 50
H.O. 16P Meet	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	30 to 40
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 35

Type of occupancy / activity	Metric	Standard	Noise Level Range dB(A)
H.O. 4P Meet	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	40 to 45
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 45
Cafe	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	45 to 50
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 50
Bedrooms	$L_{Aeq,1h,noisiest}$ (7am – 10pm)	Sydney DCP 2012	< 45 (Windows Closed)
			< 55 (Windows Open)
	$L_{Aeq,1h,noisiest}$ (10pm – 7am)	Sydney DCP 2012	< 35 (Windows Closed)
			< 45 (Windows Open)
	$L_{Aeq,1h,average}$ (10pm – 7pm)	Green Star	< 40 (Windows Closed)
Offices (CEO, YHA Head Office)	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	35 to 40
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 40
Corridors	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	45 to 50
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 50
Atrium / Stairwell	$L_{Aeq,1h,noisiest}$ (7am – 7pm)	AS 2107:2016	45 to 50
	$L_{Aeq,1h,average}$ (7am – 7pm)	Green Star	< 50
Emergency Egress – AS 1668.1:2015			
Non-Fire Isolated Exit / Occupied Space	L_{Amax}	Airborne	< 65
Fire-Isolated Exit	L_{Amax}	Airborne	< 80

4.2 Sound Masking

4.2.1 General

Typically, a traditional HVAC system using ducted air handling units situated in a central plant room provides a level of background noise that provides noise masking to conversation and other occupational noise within an office environment. Chilled beams, as proposed in the Atlassian office space do not produce appreciable levels of noise to be used as masking, which will result in poor speech privacy if not addressed in the design. A level quasi-stationary background noise to provide noise masking is considered essential for the Atlassian base-building office space to be considered as premium office accommodation.

Green Star Buildings v1, as part of the rating tool's Acoustic Comfort Criteria 12.1 provides a rating point for achieving an internal ambient noise level of no less than 5dB below the lower range and no greater than the upper range of AS2107.

A well design and commissioned will be required to meet these criteria.

4.2.2 WELL v2 - Implement Sound Masking (2 Points)

The WELL v2 commercial building rating tool provides up to two points for the implementation of a sound masking system as follows:

Sound masking sound levels meet the following requirements when measured from the nearest workstation:

- Open offices, libraries, cafeterias, corridors/hallways: 45 – 48 dBA.
- Enclosed offices, conference rooms, wellness rooms: 40 – 42 dBA.

4.2.3 Green Star Buildings v1 – Acoustic Comfort 12.1

Green Star Buildings v1, as part of the rating tool's Acoustic Comfort Criteria 12.1, provides a rating point when all of the following are achieved:

- Internal Noise: Internal ambient noise level of no less than 5dB below the lower range and no greater than the upper range of AS2107.
- Acoustic Separation: address either privacy OR sound insulation
- Impact Noise Transfer Through Floors: in accordance with ISO 16283-2 where the floors are located above nominated areas or adjacent spaces to different tenancies must not exceed LnT 60
- Reverberation Control: Does not exceed AS2107

4.3 Reverberation Times

The following standards and sustainability rating tools recommend performances of sensitive spaces to control reverberance, promote speech intelligibility and improve occupant comfort at Atlassian Central.

4.3.1 Commercial Zone & Base-Building

AS 2107:2016 "Acoustics – Recommended design sound levels and reverberation times for building interiors"

Reverberation design targets are recommended to achieve the guidelines outlined in AS 2107:2016. These criteria will have an impact on the internal finishes within these spaces. Table 23 presents the mid-frequency reverberation times that are the basis of the acoustic design for each type of space.

Table 17: Recommended design reverberation times (AS/NZS 2107:2016)

Type of occupancy / activity	Recommended Reverberation Time, s
End of Trip Facilities	N/A
Atlassian Lobby	< 1.0
Café	< 1.0
Level 07 Kitchen	N/A
Office Type A (mechanically ventilated)	0.4 to 0.6
Office Type B (mixed-mode ventilation)	0.4 to 0.6
Office Type C (Outdoor Habitat)	< 1.0
Lift Lobby	< 1.0
Bathrooms	N/A

Green Star Design & As Built v1.3

Where a credit shall be obtained for Reverberation as part of Green Star – Design & As Built v1.3, one point is available where the nominated area has been built to reduce the persistence of sound to a level suitable to the activities of the space.

Specifically, one point is awarded where the reverberation time in the nominated area is below the maximum stated in 'Recommended Reverberation Time' provided in Table 1 of AS 2107:2016.

Where Note 1 of Table AS 2107:2016 applies and requires that reverberation times be minimised for noise control, acoustic absorption should be installed in the noise sensitive space. There are two pathways to demonstrate compliance:

- Pathway 1 – Demonstrate the resulting performance of the installed acoustic absorption, irrespective of quantity or location installed, must result in a reverberation time equivalent to or lower than the reverberation time predicted for treating at least 50% of the combined floor and ceiling area with a material having a noise reduction coefficient (NRC) of at least 0.5.
- Pathway 2 – Treat 50% of the combined floor and ceiling area with a material having a NRC of at least 0.5

See Table 18 for a summary of the reverberation time requirements to obtain the credit.

Table 18: Green Star Design & As Built v1.3 requirements – Reverberation

Type of occupancy / activity	Maximum Reverberation Time, s
End of Trip Facilities	N/A
Atlassian Lobby	1.0
Café	1.0
Level 07 Kitchen	N/A
Office Type A (mechanically ventilated)	0.6
Office Type B (mixed-mode ventilation)	0.6
Office Type C (Outdoor Habitat)	N/A
Lift Lobby	1.0
Bathrooms	N/A

WELL v2 – Sound Absorption (3 points / 2 for commercial office space)

1 point is awarded if the following is achieved:

- Spaces meet the maximum $RT_{(60)}$ thresholds in Table 19 below:

Table 19: WELL v2 Maximum Reverberation Time (RT)

Room Type	Size	RT(60) (seconds)
Conference rooms	N/A	< 0.6
Classrooms	< 280 m³ [10,000 ft³]	< 0.6
	Between 280 m³ [10,000 ft³] and 570m³ [20,000 ft³]	0.5 to 0.8
	> 570 m³ [20,000 ft³]	0.6 to 1.0
Lecture Halls	< 280 m³ [10,000 ft³]	< 0.7
	Between 280 m³ [10,000 ft³] and 570m³ [20,000 ft³]	0.6 to 0.9
	> 570 m³ [20,000 ft³]	0.7 to 1.3
Music Rehearsal Spaces	< 280 m³ [10,000 ft³]	< 1.1
	Between 280 m³ [10,000 ft³] and 570m³ [20,000 ft³]	1.0 to 1.4
Fitness facilities	< 280 m³ [10,000 ft³]	0.7 to 0.8
	Between 280 m³ [10,000 ft³] and 570m³ [20,000 ft³]	0.8 to 1.1
	> 570 m³ [20,000 ft³]	1.0 to 1.8

1 point is awarded for spaces that have ceiling finishes that meet the following specifications:

Ceiling treatment meets the NRC/awMin values described in Table 20 below.

Table 20: WELL v2 Ceiling Treatment

Space Type	NRC/ αwMin.
Open Workspaces	0.7 for at least 75% of available ceiling area.
Enclosed Offices	
Dining Spaces	
Conference Rooms	0.7 for at least 50% of available ceiling area.

1 point is awarded to spaces have wall finishes that meet the following specifications:

Wall treatment meets the NRC/awMin values described in Table 21 below.

Table 21: WELL v2 Wall Treatment

Space Type	NRC/ αwMin.
Open Workspaces	0.7 for at least 25% of at least one wall.
Enclosed Offices	
Dining Spaces	
Conference Rooms	0.7 for at least 25% of at least two (preferably adjacent) walls.
Classrooms	

LEED v4.1 – Commercial Interiors – Reverberation time

Meet the reverberation time requirements in Table 22 (adapted from Table 9.1 in the Performance Measurement Protocols for Commercial Buildings1).

Table 22: LEED v4.1 reverberation time requirements

Room type	Application	T60 (sec), at 500Hz, 1kHz and 2kHz

Hotel/motel	Individual room or suite	< 0.6
Office Building	Meeting or banquet room	< 0.8
	Executive or private office	< 0.6
	Conference room	< 0.6
	Teleconference room	< 0.6
	Open-plan office without sound masking	< 0.8
	Open-plan office with sound masking	< 0.8
Courtroom	Unamplified speech	< 0.7
	Amplified speech	< 1.0
Performing arts space	Drama theatres, concert and recital halls	Varies by application
Laboratories	Testing or research with minimal speech communication	< 1.0
	Extensive phone use and speech communication	< 0.6
Church, mosque, synagogue	General assembly with critical music program	Varies by application
Library	-	< 1.0
Indoor stadium, gymnasium	Gymnasium and natatorium	< 2.0
	Large-capacity space with speech amplification	< 1.5

4.3.2 YHA Zone & Fitout

AS 2107:2016 "Acoustics – Recommended design sound levels and reverberation times for building interiors"

Reverberation design targets are recommended to achieve the guidelines outlined in AS 2107:2016. These criteria will have an impact on the internal finishes within these spaces. Table 23 presents the mid-frequency reverberation times that are the basis of the acoustic design for each type of space.

Table 23: Recommended design reverberation times (AS/NZS 2107:2016)

Type of occupancy / activity	Recommended Reverberation Time, s
Group Lounge	< 1.0
Catered Kitchen / Kitchen / Staff Kitchen	N/A
Dining / Main Lounge	See Note 1
Park Zone	< 1.0
Games	< 1.0
Media	< 0.6
Waiting	0.6 to 0.8
Reception	0.6 to 0.8
General Staff Area	< 0.8
Manager	0.4 to 0.6
Amenities / Staff PWD	N/A
H.O. 16P Meet	0.6 to 0.8
H.O. 4P Meet	< 0.6
Cafe	< 1.0
Bedrooms (night-time)	N/A
Offices (CEO, YHA Head Office)	0.4 to 0.6
Corridors	< 1.0
Atrium / Stairwell	< 1.1 (with volume approx. 2,100m^3)

Note 1: Reverberation time should be minimized for noise control.

Green Star Design & As Built v1.3

Similar to the Commercial Zone & Base-Building, one point is awarded where the reverberation time in the nominated area is below the maximum stated in 'Recommended Reverberation Time' provided in Table 1 of AS 2107:2016.

Where Note 1 of Table AS 2107:2016 applies and requires that reverberation times be minimised for noise control, acoustic absorption should be installed in the noise sensitive space. There are two pathways to demonstrate compliance:

- Pathway 1 – Demonstrate the resulting performance of the installed acoustic absorption, irrespective of quantity or location installed, must result in a reverberation time equivalent to or lower than the reverberation time predicted for treating at least 50% of the combined floor and ceiling area with a material having a noise reduction coefficient (NRC) of at least 0.5.
- Pathway 2 – Treat 50% of the combined floor and ceiling area with a material having a NRC of at least 0.5

See Table 24 for a summary of the reverberation time requirements to obtain the credit.

Table 24: Green Star Design & As Built v1.3 requirements – Reverberation

Type of occupancy / activity	Maximum Reverberation Time, s
Group Lounge	1.0
Catered Kitchen / Kitchen / Staff Kitchen	N/A
Dining / Main Lounge	See Alternative Pathway Note
Park Zone	N/A
Games	1.0
Media	0.6

Type of occupancy / activity	Maximum Reverberation Time, s
Waiting	0.8
Reception	0.8
General Staff Area	0.8
Manager	0.6
Amenities / Staff PWD	N/A
H.O. 16P Meet	0.8
H.O. 4P Meet	0.6
Cafe	1.0
Bedrooms (night-time)	N/A
Offices (CEO, YHA Head Office)	0.6
Corridors	1.0
Atrium / Stairwell	N/A

Alternative Pathway Note: Treat 50% of the combined floor and ceiling area with a material having a NRC of at least 0.5

4.3.3 State Works

The control of reverberation and diffusion within the space will support any amplified sound systems installed for the purposes of speech relay. The control of reverberation will be provided in accordance with the Railway & Bus Terminal – Waiting Area recommendation within AS2107:2016, as this is the most applicable criterion to the State Works built form.

The reverberation time together with the level of diffusion offered in the space should be provided to facilitate speech intelligibility across any amplified speech systems. This will be coordinated with the consultant designing the system within the State Works zone.

It is proposed that the reverberation within the link zone is designed to achieve a time less than two (2) seconds. This will allow the architectural design intent to be achieved.

4.3.4 Project Reverberation Time Targets

Table 16 below outlines the project reverberation time targets for the development site-wide, summarizing the internal noise level recommendations and requirements from Sections 4.3.1 to 4.3.3.

Table 25: Project reverberation time targets

Type of occupancy / activity	Standard	Reverberation Time Range, s
Commercial Zone & Base-Building		
End of Trip Facilities	AS 2107:2016	N/A
Atlassian Lobby	AS 2107:2016	< 1.0
	Green Star	< 1.0
Café	AS 2107:2016	< 1.0
	Green Star	< 1.0
YHA Lobby	AS 2107:2016	< 1.0
	Green Star	< 1.0

Type of occupancy / activity	Standard	Reverberation Time Range, s
Level 07 Kitchen	AS 2107:2016	N/A
Office Type A (mechanically ventilated)	AS 2107:2016	0.4 to 0.6
	Green Star	< 0.6
Office Type B (mixed-mode ventilation)	AS 2107:2016	0.4 to 0.6
	Green Star	< 0.6
Office Type C (Outdoor Habitat)	AS 2107:2016	< 1.0
Lift Lobby	AS 2107:2016	< 1.0
	Green Star	< 1.0
Bathrooms	AS 2107:2016	N/A
YHA Zone & Fitout		
Group Lounge	AS 2107:2016	< 1.0
	Green Star	< 1.0
Catered Kitchen / Kitchen / Staff Kitchen	AS 2107:2016	N/A
Dining / Main Lounge	AS 2107:2016	See Note 1
	Green Star	Alternative Pathway Note
Park Zone	AS 2107:2016	< 1.0
	Green Star	< 1.0
Games	AS 2107:2016	< 1.0
	Green Star	< 1.0
Media	AS 2107:2016	< 0.6
	Green Star	< 0.6
Waiting	AS 2107:2016	0.6 to 0.8
	Green Star	< 0.8
Reception	AS 2107:2016	0.6 to 0.8
	Green Star	< 0.8
General Staff Area	AS 2107:2016	< 0.8
	Green Star	< 0.8
Manager	AS 2107:2016	0.4 to 0.6
	Green Star	< 0.6
Amenities / Staff PWD	AS 2107:2016	N/A
H.O. 16P Meet	AS 2107:2016	0.6 to 0.8
	Green Star	< 0.8

Type of occupancy / activity	Standard	Reverberation Time Range, s
H.O. 4P Meet	AS 2107:2016	< 0.6
	Green Star	< 0.6
Cafe	AS 2107:2016	< 1.0
	Green Star	< 1.0
Bedrooms (night-time)	AS 2107:2016	N/A
Offices (CEO, YHA Head Office)	AS 2107:2016	0.4 to 0.6
	Green Star	< 0.6
Corridors	AS 2107:2016	< 1.0
Atrium / Stairwell	AS 2107:2016	< 1.1 (with volume approx. 2,100m^3)
State Works		
Link Zone	AS 2107:2016	< 2.0

4.4 Acoustic Separation

The requirements driving the design for the partition performance within the development are those outlined in Green Star Design & As Built v1.3, WELL v2, LEED v4.1 Commercial Interiors, National Construction Code 2019, and the YHA Project Brief. In addition to this, we have outlined additional acoustic requirements for the noise isolation/separation of the plant spaces within the development together with floor to floor separation in the project acoustic separation targets. Drawings showing partition performance are provided in Appendix B

4.4.1 Green Star Design & As Built v1.3

Where a credit shall be obtained for Reverberation as part of Green Star – Design & As Built v1.3, one point is available where the nominated enclosed spaces have been built to minimize crosstalk between rooms, and between rooms and open areas.

Specifically, one point is awarded where the project addresses noise transmission in enclosed spaces within the nominated area. Enclosed space is defined as meeting rooms, private offices, classrooms, residential apartments (bounding apartment construction), and any other similar space where it is expected that noise should not carry over from one space to the next.

There are two methods for the Commercial Zone & Base-Building to demonstrate compliance with this criterion:

- 10.3A (Option 1) – The partition between the spaces should be constructed to achieve a weighted sound reduction index (R_w) of:
  - At least 45; for all partitions which are:
    - i. Fixed without a door; and/or
    - ii. Glazed partitions without a door
  - At least 35; for all partition types that contain a door
- 10.3B (Option 2) – The sound insulation between enclosed spaces complies with $D_w + L_{Aeq,T} > 75$

It should be noted that for the purposes of this exercise, R_w can be interchanged with STC so long as you are attempting to achieve an R_w performance requirement using a known STC value, not vice-versa. The performance requirements have been integrated into the project acoustic separation targets.

An active sound masking system will be required to obtain the point for the Acoustic Separation credit because the stacking sliding doors separating Office Type A and Office Type B are limited to R_w 35. Option 2 then becomes the only available performance pathway and relies on a background noise level of at least 42 dB(A), which the chilled beam systems proposed in these spaces does not offer.

4.4.2 WELL v2 – Sound Barriers (3 points)

This WELL feature requires design- and performance-based compliance that projects can adhere to bolster acoustical privacy between rooms. This feature can operate in tandem with Feature S01: Sound Mapping by introducing the specific performance metrics of partition acoustical performance criteria and privacy [e.g., Noise Isolation Class (NIC), Sound Insulation (Dw), Speech Privacy Potential (SPP)].

Part 1: Ensure Adequate Wall Construction (2 points)

Points are awarded for walls that have a performance that can meet minimum SPP values listed in table below.

Source Room	Receiving Room	Minimum SPP
Enclosed Offices	Enclosed Offices	75
	Conference Rooms	80
	Open Offices	70
Conference Rooms	Enclosed Offices	85
	Conference Rooms	80
	Open Offices	70
Other Sensitive Spaces		75
Note: 1. SPP is the sum of the noise reduction across a partition and the background noise level within a receiving space.		

Part 2 – Ensure Proper Door Specifications (1 point)

Doors which connect private office, conference rooms, classrooms and dwelling units to other spaces are constructed with two of the following requirements:

- Minimum STC-30 acoustical performance.
- Gaskets at the head and jambs.
- Automatic drop seal or sweep at base.
- A non-hollow core door.

4.4.3 LEED v4.1 – Commercial Interiors – Sound Transmission

Categorise all occupied spaces by use and desired level of acoustic privacy.

Meet the composite sound transmission class (STCC) ratings or noise insulation class (NIC) listed in Table 1. For NIC measurements, use ASTM E336-17a or Annex A.3 of ANSI S12.60-2010.

Adjacency combinations		STCC**	NIC**
Retail	Retail	50	45
Collaborative / multi-use	Hallway, stairway	25	20
Private	Hallway, stairway	35	30
Confidential	Hallway, stairway	40	35
Collaborative / multi-use	Collaborative / multi-use	35	30
Collaborative / multi-use	Private	45	40
Collaborative / multi-use	Confidential	50	45
Private	Private	45	40
Private	Confidential	50	45
Confidential	Confidential	50	45
Conference room	Conference room	50	45
Mechanical equipment room*	Hallway, stairway	50	45

Mechanical equipment room	Retail	60	55

Notes:

*Minimum STCc or NIC has to be met unless proven that the equipment noise in conjunction with the sound isolation performance of the partitions and doors will not exceed the maximum background noise requirements of the adjacent space.

**If a sound masking system is implemented at a minimum level of 40 dBA, the STCc ratings or NIC values in Table 1 may be lowered by 5 points. This applies to all space types except mechanical equipment rooms. The sound masking system must be designed by an acoustical professional and meet the following criteria:

- The overall level for sound masking must be set by an acoustical professional and must not exceed 48 dBA in open offices, libraries, cafeterias, corridors/hallways, 45 dBA in enclosed offices, and 42 dBA in conference rooms, and wellness rooms. The combined level of masking and HVAC background noise must not exceed these limits.
- The system design and commissioning must provide overall level uniformity of +/-1 dBA and one-third octave band uniformity of +/-2 dB from at least 100 to 5,000 Hz when tested according to ASTM E1573-18
- The sound masking spectrum must conform to the National Research Council of Canada COPE Optimum Masking Spectrum or an alternate spectrum if specified by an acoustical engineer

4.4.4 National Construction Code 2019

Statutory requirements for Class 3 buildings which correspond to the building classification for hotel developments are provided in the NCC 2019 Part F5. Refer to Table 26 for the NCC requirements.

Table 26: NCC sound insulation requirements for Class 3 buildings

Construction	Condition	Deemed-to-Satisfy Requirements	Verification Requirements
Walls	Airborne Sound Insulation		
	Between sole-occupancy units	Minimum $R_w + C_{tr}$ 50	Minimum $D_{nT,w} + C_{tr}$ 45
	Between a sole-occupancy unit and a plant room, lift shaft, stairway corridor, public corridor or the like	Minimum R_w 50	Minimum $D_{nT,w}$ 45
	Impact Sound Insulation		
	Between a laundry, kitchen, bathroom or sanitary compartment in a sole-occupancy unit, and a habitable room other than a kitchen in an adjoining unit	Discontinuous construction	As deemed to satisfy
	Between a sole-occupancy unit and a plant room or lift shaft	Discontinuous construction	As deemed to satisfy
Floors	Airborne Sound Insulation		
	Between sole-occupancy units	Minimum $R_w + C_{tr}$ 50	Minimum $D_{nT,w} + C_{tr}$ 45
	Between a sole-occupancy unit and a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification	Minimum $R_w + C_{tr}$ 50	Minimum $D_{nT,w} + C_{tr}$ 45
	Impact Sound Insulation		
	Between sole-occupancy units	Maximum $L_{n,w}$ 62	Maximum $L_{nT,w}$ 62
	Between a sole-occupancy unit and a plant room, lift shaft, stairway, public corridor, public lobby or the like, or parts of a different classification	Maximum $L_{n,w}$ 62	Maximum $L_{nT,w}$ 62
Doors	Airborne Sound Insulation		
	Between a sole-occupancy unit and a stairway, public corridor, lobby or the like	Minimum R_w 30	Minimum $D_{nT,w}$ 25
	Providing access to services	-	Must not open into any habitable room other than a kitchen
Walls (services)	Airborne Sound Insulation		
	Between a habitable room in a sole-occupancy unit (other than a kitchen) and a duct, soil, waste or water pipe common service duct and habitable room	Minimum $R_w + C_{tr}$ 40	-

	Between a non-habitable room in a sole-occupancy unit (other than a kitchen) and a duct, soil, waste or water pipe common service duct and habitable room	Minimum $R_w + C_{tr}$ 25	-
	Pumps	Flexible couplings	-

Notes:

1) Habitable room means a room used for normal domestic activities, and—

(a) includes a bedroom, living room, lounge room, music room, television room, kitchen, dining room, sewing room, study, playroom, family room, home theatre and sunroom; but

(b) excludes a bathroom, laundry, water closet, pantry, walk-in wardrobe, corridor, hallway, lobby, photographic darkroom, clothes-drying room, and other spaces of a specialised nature occupied neither frequently nor for extended periods.

2) Wet area means an area within a building supplied with water from a water supply system, which includes bathrooms, showers, laundries and sanitary compartments and excludes kitchens, bar areas, kitchenettes or domestic food and beverage preparation areas.

3) Any door assembly located in a wall that separates a sole-occupancy unit from a stairway, public corridor, public lobby, or the like, has a weighted standardised level difference ($D_{n,T,w}$) not less than 25 when determined under AS/NZS 1276.1 or ISO717.1.

4.4.5 YHA Project Brief

In general, the acoustic separation requirements outlined in the YHA Project Brief are generally in-line with the requirements of the NCC 2019. Listed below are the over-and-above requirements required by YHA in the YHA Project Brief:

- Walls around office areas, toilet areas (not ensuites) – R_w 43
- Recommended Door Types
  - Where a door is in an R_w / STC 43 or lower wall – 35mm thick solid core door, no perimeter door seals required
  - Where a door is in an R_w / STC 50 or $R_w + C_{tr}$ 50 wall – 40mm thick solid core door, full perimeter seals and drop seals required

We also note that the development will be deviating from the YHA Project Brief with regards to the following requirement:

- Floor slabs are to be constructed using minimum 200mm thick concrete

The construction of the floors and ceiling shall be designed such that the acoustic performance achieved is $R_w + C_{tr}$ 50.

4.4.6 Isolation of Plant Spaces

Acoustic separation performance of walls and floors enclosing plant spaces have been specified to ensure the development is compliant with the project internal noise level targets outlined in Section 4.1.4. The performance requirements have been integrated into the project acoustic separation targets.

4.4.7 Office Floor to Floor Separation (Impact & Airborne)

The typical office floor-ceiling construction shall be designed to achieve the following acoustic separation performances:

- Airborne noise performance requirement – $R_w > 50$
- Impact noise performance requirements – $L_{nT,w} < 55$ & $L'_{n,AW} < 55$

Care should be given to the impact noise performance requirement in the instance an active sound masking system is not installed within the office spaces (further discussed in Section 5.7). If the background noise levels are not supported by a sound masking system, the low background noise levels as a result of the quiet chilled beam systems may introduce additional problems with audibility of footfalls. If an active sound masking system is not installed, there should be a provision for an increase in the impact noise performance requirement.

4.4.8 On-Site Acoustic Performance Specifications

The internal walls and doors within Atlassian Central shall be designed to meet the Project Acoustic Separation Performance Requirements provided in Appendix B. To meet the on-site performance requirements (D_w) for a particular partition, the weighted sound reduction index (R_w) / sound transmission class (STC) for each particular element making up the partition (wall, glazing, and door) must be specified in the first instance.

For room frontage partitions, Table 27 below provides R_w / STC values for each possible component of the room frontage partition corresponding to the overall on-site performance D_w.

It should be noted that these ratings have been provided under the assumption where the door covers no more than 20% of the total wall area. If this is not the case, further advice should be sought for the particular component R_w.

Table 27: Comparison table for on-site acoustic performance and partition component specifications

Project Acoustic Separation Performance – On-Site (D_w)	Component	Minimum Component R_w / STC
30	Glazed Partition	35
	Drywall/Solid Partition	35
	Door	30
35	Glazed Partition	38
	Drywall/Solid Partition	40
	Door	34
40	Glazed Partition	45
	Drywall/Solid Partition	45
	Door	38
45	Glazed Partition	50
	Drywall/Solid Partition	50
	Door	43
50	Glazed Partition	55
	Drywall/Solid Partition	55
	Door	47

For partitions that are not frontages/entries to spaces or for floors of spaces, Table 28 provides the R_w / STC values for the wall/floor corresponding to the overall on-site performance D_w.

Table 28: Comparison table for on-site acoustic performance and wall/floor specifications

Project Acoustic Separation Performance – On-Site (D_w)	Minimum Wall/Floor R_w / STC
30	35
35	40
40	45
45	50
50	55
55	60

4.4.9 Project Acoustic Separation Performance Targets

The acoustic separation performance targets for internal wall partitions within the Atlassian Central development are provided in the sketches in Appendix B, and the acoustic separation performance targets for internal floors provided in **Error! Reference source not found.**.

4.5 External Noise Emissions

4.5.1 Mechanical Plant & Industrial Noise Emissions

The NPI sets out noise criteria to control the noise emission from industrial noise sources from activities listed in Schedule 1 of the POEO Act and regulated by the EPA. The external noise due to mechanical services from the proposed development is also addressed following the guideline in the NSW EPA's NPI.

The calculation is based on the results of the unattended ambient and background noise monitoring, addressing two components:

- Controlling intrusive noise into nearby residences (Intrusiveness Criteria)
- Maintaining noise level amenity for particular land uses (Amenity Criteria)

Once both criteria are established, the most stringent for each considered assessment period (day, evening, night) is adopted as the project-noise trigger level (PNTL).

Intrusiveness Criteria

The noise-sensitive receivers surrounding this development are a combination of both commercial and hotel developments. As a consequence, the intrusiveness criterion is not applicable in this instance due to the absence of a surrounding noise-sensitive residential receiver.

Amenity Criteria

The NSW NPI states the following:

> *"To limit continuing increases in noise levels from application of the intrusiveness level alone, the ambient noise level within an area from all industrial noise sources combined should remain below the recommended amenity noise levels specified in Table 2.2 where feasible and reasonable. The recommended amenity noise levels will protect against noise impacts such as speech interference, community annoyance and some sleep disturbance. The recommended amenity noise levels have been selected on the basis of studies that relate industrial noise to annoyance in communities (Miedema and Voss, 2004).*

To ensure that industrial noise levels (existing plus new) remain within the recommended amenity noise levels for an area, a project amenity noise level applies for each new source of industrial noise as follows "Project amenity noise level for industrial developments = recommended amenity noise level (Table 2.2) minus 5 dB(A)"

The applicable parts of Table 2.2: Amenity noise levels which are relevant to the project are reproduced below:

Table 29: NSW NPI Table 2.2 amenity criteria for external noise levels

Type of Receiver	Noise Amenity Area	Time of Day	L_{Aeq}, dB(A) Recommended amenity noise level	Project amenity noise level $L_{Aeq, 15min}$
Hotel	Urban *	Day	65	63
	Urban *	Evening	55	53
	Urban *	Night	50	49
Commercial Premises	All	When in use	65	63

*Urban area as defined in EPA NSW NPI Table 2

'Modifying Factor' Adjustments

The NSW NPI also states:

> *"Where a noise source contains certain characteristics, such as tonality, intermittency, irregularity or dominant low-frequency content, there is evidence to suggest that it can cause greater annoyance than other noise at the same noise level."*

In order to take into account, the potential annoying character of the noise an adjustment of 5 dB(A) for each annoying character aspect and cumulative of up to a total of 10 dB(A), is to be added to the measured value to penalise the noise for its potentially greater annoyance aspect.

Table C1 of Fact Sheet C of the NSW NPI (see Table 30 below) provides procedures for determining whether an adjustment should be applied for greater annoyance aspect.

Table 30: Table C1 from the NSW NPI – Modifying factor corrections

Factor	Assessment / Measurement	When to Apply	Correction[1]	Comments
Tonal Noise	One-third octave band analysis using the objective method for assessing the audibility of tones in noise – simplified method *(ISO1996.2-2007 – Annex D).*	Level of one-third octave band exceeds the level of the adjacent bands on both sides by: • 5 dB or more if the centre frequency of the band containing the tone is in the range 500–10,000 Hz • 8 dB or more if the centre frequency of the band containing the tone is in the range 160–400 Hz • 15 dB or more if the centre frequency of the band containing the tone is in the range 25–125 Hz.	5 dB[2,3]	Third octave measurements should be undertaken using unweighted or Z-weighted measurements. **Note**: Narrow-band analysis using the reference method in *ISO1996-2:2007, Annex C* may be required by the consent/regulatory authority where it appears that a tone is not being adequately identified, e.g. where it appears that the tonal energy is at or close to the third octave band limits of contiguous bands.

Factor	Assessment / Measurement	When to Apply	Correction[1]	Comments
Low Frequency Noise	Measurement of source contribution C-weighted and A-weighted level and one-third octave measurements in the range 10–160 Hz	Measure/assess source contribution C- and A-weighted $L_{eq,T}$ levels over same time period. Correction to be applied where the C minus A level is 15dB or more and: • where any of the one-third octave noise levels in Table C2 are exceeded by up to and including 5 dB and cannot be mitigated, a 2dB(A) positive adjustment to measured/predicted A-weighted levels applies for the evening/night period • where any of the one-third octave noise levels in Table C2 are exceeded by more than 5 dB and cannot be mitigated, a 5-dB(A) positive adjustment to measured/predicted A-weighted levels applies for the evening/night period and a 2dB(A) positive adjustment applies for the daytime period.	2 or 5 dB[2]	A difference of 15 dB or more between C- and A-weighted measurements identifies the potential for an unbalance spectrum and potential increased annoyance. The values in Table C2 are derived from Moorhouse (2011) for DEFRA fluctuating low-frequency noise criteria with corrections to reflect external assessment locations.
Intermittent Noise	Subjectively assessed but should be assisted with measurement to gauge the extent of change in noise level.	The source noise heard at the receiver varies by more than 5 dB(A) and the intermittent nature of the noise is clearly audible.	5 dB	Adjustment to be applied for **night-time only.**
Duration	Single-event noise duration may range from 1.5 min to 2.5h	One event in any assessment period.	0 to 20 dB(A)	The project noise trigger level may be increased by an adjustment depending on duration of noise (see Table C3).
Maximum Adjustment	Refer to individual modifying factors	Where two or more modifying factors are indicated	Maximum correction of 10dB(A)[2] (excluding duration correction)	

1. Corrections to be added to the measured or predicted levels, except in the case of duration where the adjustment is to be made to the criterion.

2. Where a source emits tonal and low-frequency noise, only one 5-dB correction should be applied if the tone is in the low-frequency range, that is, at or below 160 Hz.

3. Where narrow-band analysis using the reference method is required, as outlined in column 5, the correction will be determined by the ISO1996-2:2007 standard.

Sleep Disturbance

Similar to the requirement for an Intrusiveness criterion, the development is not surrounded by residential receivers. As a consequence, the sleep disturbance criterion is not applicable in this instance.

Project Noise Trigger Levels

The project noise trigger levels for industrial noise sources such as mechanical plant etc. are provided in Table 31. These noise levels have been derived from the Noise Policy for Industry 2017 and will satisfy the requirements of the Sydney DCP 2012.

Table 31: Project noise trigger levels for industrial noise emissions

Period	Descriptor	Project Noise Trigger Levels dB(A)
Hotel Receivers		
Day (7:00am to 6:00pm)	$L_{Aeq,15min}$	**63**
Evening (6:00pm to 10:00pm)	$L_{Aeq,15min}$	**53**
Night (10:00pm to 7:00am)	$L_{Aeq,15min}$	**49**
Commercial Receivers		
When in use	$L_{Aeq,15min}$	**63**

4.5.2 Stand-by Generator Noise Emissions

Noise emissions during both testing and maintenance of the generators serving the development shall be controlled in accordance with the requirements of the Noise Policy for Industry 2017. The noise criteria established for this requirement is taken from Table 29 and Table 30 and adjusted in accordance with Table 32 below.

Table 32: Stand-by generator adjustment for duration of testing (Table C3 NSW NPI)

Allowable duration of noise (one event in any 24-hour period)	Allowable exceedance of $L_{AEQ,15min}$ equivalent project noise trigger at receptor for the period of noise event, dB(A)	
	Daytime and evening (7am – 10pm)	Night-time (10pm – 7am)
Hotel Receivers		
1 to 2.5 hours	*2*	Nil
15 minutes to 1 hour	*5*	Nil
6 minutes to 15 minutes	*7*	2
1.5 to 6 minutes	*15*	5
Less than 1.5 minutes	*20*	10

It should be noted that the operation and associated of the generator in the event of an emergency or power outage is reflected in the noise and vibration recommendations for the operation during testing and maintenance, as this is predictable and part of the normal operation of the building.

4.6 Vibration

4.6.1 Human Comfort

The office of Environment and Heritage (OEH) developed a document, "Assessing vibration: A technical guideline" in February 2006 to assist in preventing people from exposure to excessive vibration levels from construction and operation of a development within buildings. The guideline does not however address vibration induced damage to structures or structure-borne noise effects. Vibration and its associated effects are usually classified as continuous, impulsive or intermittent.

Continuous & Impulsive Vibration

Structural vibration in buildings can be detected by occupants and can affect them in many ways including reducing their quality of life and also their working efficiency. Complaint levels from occupants of buildings subject to vibration depend upon their use of the building and the time of the day.

Maximum allowable magnitudes of building vibration with respect to human response are shown in Table 33. It should be noted that the human comfort criteria for vibration are more stringent than the building damage criteria.

Table 33: Preferred and maximum weighted RMS values for continuous and impulsive vibration (m/s^2)

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration					
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and place of worship	Day or night-time	0.020	0.014	0.040	0.028
Impulsive vibration					
Residences	Daytime	0.30	0.21	0.60	0.42
	Night time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and place of worship	Day or night time	0.64	0.46	1.28	0.92

Intermittent Vibration

Disturbance caused by vibration will depend on its duration and its magnitude. This methodology of assessing intermittent vibration levels involves the calculation of a parameter called the Vibration Dose Value (VDV) which is used to evaluate the cumulative effects of intermittent vibration. Various studies support the fact that VDV assessment methods are far more accurate in assessing the level of disturbance than methods which is only based on the vibration magnitude.

Table 34: Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime (7:00am to 10:00pm)		Night-time (10:00pm to 7:00am)	
	Preferred value	Maximum value	Preferred value	Maximum value
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and place of worship	0.40	0.80	0.40	0.80

4.6.2 Structural Damage

Ground vibration criteria are defined in terms of levels of vibration emission from the construction activities which will avoid the risk of damaging surrounding buildings or structures. It should be noted that human comfort criteria are normally expressed in terms of acceleration whereas structural damage criteria are normally expressed in terms of velocity.

Most commonly specified structural vibration levels are defined to minimize the risk of cosmetic surface cracks and are set below the levels that have the potential to cause damage to the main structure. Structural damage criteria are presented in German Standard DIN4150-Part 3 "Structural vibration in buildings – Effects on structures" and British Standard BS7385-Part 2: 1993 "Evaluation and Measurement for Vibration in Buildings". Table 35 indicates the vibration limits presented in DIN4150-Part 3 to ensure structural damage doesn't occur.

Table 35: Guideline value of vibration velocity, vi, for evaluating the effects of short-term vibration

Line	Type of Structure	Vibration velocity, vi, in mm/s			
		Foundation At a frequency of			Plane of floor of uppermost full storey
		Less than 10Hz	10 to 50Hz	50 to 100*Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that, because of their particular sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8
*For frequencies above 100Hz, at least the values specified in this column shall be applied					

4.6.3 Cosmetic Damage

Table 36 presents guide values for building vibration, based on the lowest vibration levels above which cosmetic damage has been demonstrated as per BS7385-Part 2:1993.

Table 36: Transient vibration guide values for cosmetic damage

Type of Building	Peak Particle Velocity in frequency range of predominant pulse (PPV)	
	4 Hz to 15 Hz	15 Hz and above
Residential or light commercial type buildings	15mm/s at 4Hz increasing to 20mm/s at 15Hz	20mm/s at 15Hz increasing to 50mm/s at 40Hz and above

5. Acoustics, Noise & Vibration Performance Recommendations

5.1 Architectural Conceptual Recommendations

5.1.1 Internal Partitions

Wall Height Configurations

Acoustic partitions are often required to be extended to the underside of the slab above. In addition to this and depending on the acoustic performance required, the partition may also need to extend to the slab below (below the semi-raised floor).

Table 37 provides typical wall height configurations for each on-site acoustic performance requirement (D_w). It should be noted that these typical configurations are based on a ceiling grid containing mineral fibre tiles with a minimum CAC of 38, and with a semi-raised floor structure as per FL-001 (Wood Technical Floor).

Table 37: Wall height configurations based on on-site acoustic separation performance (D_w)

Project Acoustic Separation Performance – On-Site (D_w)	Wall Height Configuration
30	Floor to ceiling, with ceiling above enclosed spaces
35	Floor to slab
40	Floor to slab
45	Slab to slab
50	Slab to slab
55	Slab to slab

Example Partition Types – Lightweight, Glass & Masonry

To assist with the commencement of partition type designations, examples of lightweight partitions, glass partitions, and masonry style partitions have been provided in Table 38, Table 39 and Table 40, respectively.

For lightweight wall constructions, 13mm standard plasterboard is typically interchangeable with 6mm fibre cement.

Table 38: Examples of lightweight wall constructions achieving acoustic separation performance requirements

Acoustic Separation Performance R_w	Partition Make-Up
35	• 1 x 13mm plasterboard (8.4kg/m^2) • 64mm steel stud • 1 x 13mm plasterboard (8.4kg/m^2)
40	• 1 x 13mm plasterboard (8.4kg/m^2) • 64mm steel stud with 60mm polyester insulation (14kg/m^3) • 1 x 13mm plasterboard (8.4kg/m^2)
45	• 1 x 13mm plasterboard (8.4kg/m^2)

Acoustic Separation Performance R_w	Partition Make-Up
	• 76mm steel stud with 75mm polyester insulation (14kg/m^3) • 2 x 13mm plasterboard (8.4kg/m^2)
50	• 2 x 13mm plasterboard (8.4kg/m^2) • 92mm steel stud with 75mm polyester insulation (14kg/m^3) • 2 x 13mm plasterboard (8.4kg/m^2)
55	• 3 x 13mm fire-rated plasterboard (10.5kg/m^2) • 92mm steel stud with 75mm polyester insulation (14kg/m^3) • 2 x 13mm fire-rated plasterboard (10.5kg/m^2)
60	• 3 x 13mm sound-rated plasterboard (13kg/m^2) • 92mm steel stud with 75mm polyester insulation (10.5kg/m^3) • 2 x 13mm sound-rated plasterboard (13kg/m^2)

Table 39: Examples of glazing arrangements achieving acoustic separation performance requirements

Acoustic Separation Performance R_w	Glass Arrangement	Frame Details
35	• 10.38mm laminated glass	• Standard
38	• 12.38mm laminated glass	• Frame packed with 25mm thick polyester insulation (14kg/m^3)
45	• 6.38mm laminated glass • 50mm cavity • 10.38mm laminated glass	• Frame packed with 25mm thick polyester insulation (14kg/m^3) • Typically, thicker frame
50	• 10.38mm laminated glass • 100mm cavity • 12.38mm laminated glass	• Frame packed with 25mm thick polyester insulation (14kg/m^3) • Typically, thicker frame
55	• Acoustic proprietary glass from manufacturers such as IAC Acoustics	• Acoustic proprietary glass from manufacturers such as IAC Acoustics

Table 40: Examples of masonry constructions achieving acoustic separation performance requirements

Acoustic Separation Performance R_w	Partition Make-Up
Concrete	
35 to 45	• 100mm concrete wall
50	• 150mm concrete wall
55	• 200mm concrete wall
60	• 150mm concrete wall • 28mm furring channel with 50mm polyester insulation (11kg/m^3) • 1 x 13mm plasterboard (8.4kg/m^2)
Blockwork	
35	• 140mm blockwork (not filled)
40	• 190mm blockwork (not filled)
45	• 140mm core-filled blockwork
50	• 190mm core-filled blockwork
55	• 140mm core-filled blockwork • 28mm furring channel with 50mm polyester insulation (11kg/m^3) • 1 x 13mm plasterboard (8.4kg/m^2)
60	• 190mm core-filled blockwork • 28mm furring channel with 50mm polyester insulation (11kg/m^3) • 1 x 13mm plasterboard (8.4kg/m^2)

YHA Inter-tenancy Walls

The proposed inter-tenancy wall options separating the YHA accommodation rooms from other accommodation rooms to meet the performance requirements established in Section 4.4.5. The options are:

Option 1

- 2 x 13mm Boral FireStop plasterboard
- 92mm Boral Quiet Stud with 100mm glasswool insulation (14kg/m^3)
- 2 x 13mm Boral FireStop plasterboard

Option 2

- 1 x 16mm Boral FireStop plasterboard
- 64mm steel stud w/ 75mm glasswool insulation (14kg/m^3)
- 20mm air gap
- 64mm steel stud w/ 75mm glasswool insulation (14kg/m^3)

- 1 x 16mm Boral FireStop plasterboard

Option 3

- 2 x 13mm Boral Multistop plasterboard
- 70mm timber stud + 28mm furring channel w/ 50mm glasswool insulation (11kg/m^3)
- 2 x 13mm Boral Multistop plasterboard

Option 4

- 2 x 13mm Boral Multistop plasterboard
- 70mm timber stud w/ 50mm glasswool insulation (11kg/m^3)
- 20mm air gap
- 70mm timber stud w/ 50mm glasswool insulation (11kg/m^3)
- 2 x 13mm Boral Multistop plasterboard

YHA Inter-tenancy Floors

The YHA inter-tenancy floors have a performance requirement of Rw + Ctr 50 (see section 4.4.5). This requires a minimum concrete thickness of 200mm. The slab design currently shows slab thicknesses ranging between 200-300mm.

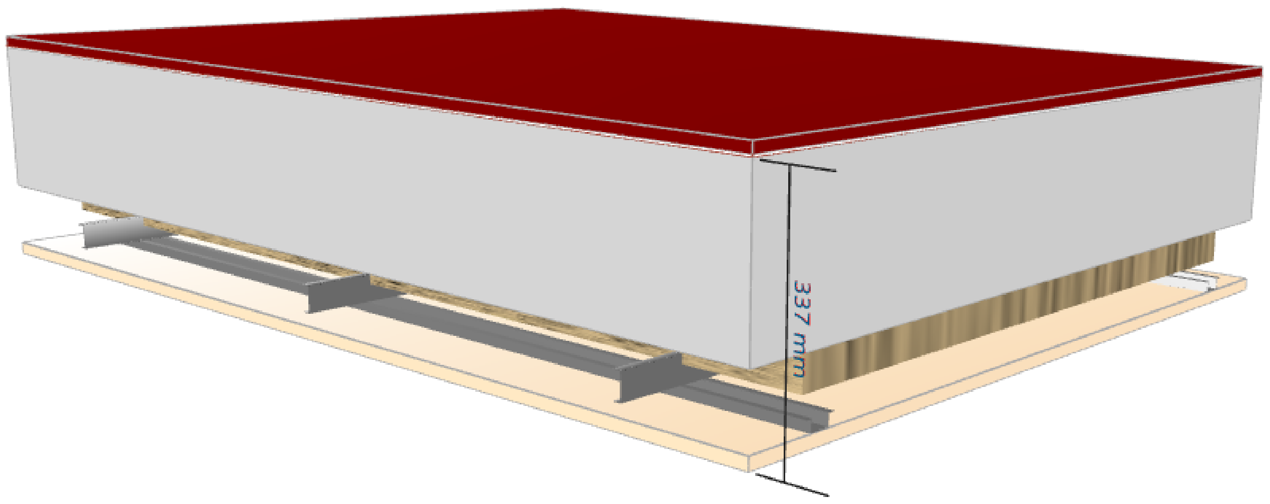
Level 06 Plantroom to YHA Below – Floor-Ceiling Construction

In accordance with the project acoustic separation performance requirements, the floor-ceiling construction separating the Level 07 Plantroom (Project East Room) from YHA rooms below is required to meet a minimum on-site acoustic separation performance of D_w 65 (airborne) & $L_{nT,w}$ 55 (impact). The airborne requirement is driven by the noise emissions from the plantroom intruding into the space below, where as the impact requirement is driven by the Sydney DCP 2012.

The following construction from the floor of the plantroom to the ceiling of the YHA room is proposed to meet both the airborne and impact requirements (illustrated in Figure 8):

- 9mm compressed fibre cement
- 5mm Embelton ImpactaMat
- 200mm thick concrete slab
- 94mm air cavity including ceiling grid with 75mm Earthwool insulation (14kg/m^3)
- 1 x 16mm fire-rated plasterboard (min. 13kg/m^2)

Figure 8: Proposed floor-ceiling construction between L07 plantroom (Project East Room) and YHA rooms below



Generator Room (Provisional) to YHA Below – Floor-Ceiling Construction

In accordance with the project acoustic separation performance requirements, the floor-ceiling construction separating the provisional generator room from YHA rooms below is required to meet a minimum on-site acoustic separation performance of D_w 85 (airborne) & $L_{nT,w}$ 55 (impact). The airborne requirement is driven by the noise emissions from the plantroom intruding into the space below, where as the impact requirement is driven by the Sydney DCP 2012.

The following construction from the floor of the provisional generator room to the ceiling of the YHA room is proposed to meet both the airborne and impact requirements (illustrated in Figure 9):

- 100mm concrete floating slab
- Jack-up Floating Floor Mount – Embelton Type CEFM
- 225mm thick composite slab – Corus Comflor 80 (as per Structural Engineer's drawings)
- 94mm air cavity including ceiling grid with 75mm Earthwool insulation (14kg/m^3)
- 1 x 16mm fire-rated plasterboard (min. 13kg/m^2)

See Figure 10, Figure 11 and Figure 12 for further details regarding floating concrete slab design and installation.

In addition to this treatment, the riser for the diesel engine exhaust will need to be vibration and noise isolated from the exhaust duct/shaft that it carries.

Figure 9: Proposed floor-ceiling construction between L07 plantroom (Generator Room) and YHA rooms below

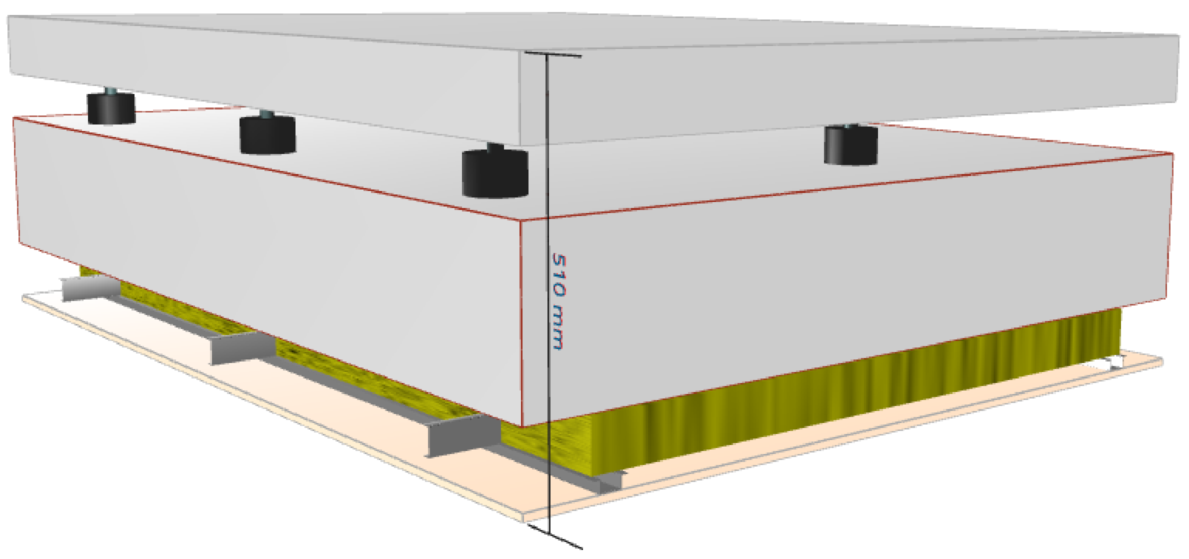


Figure 10: Beam and deck installation

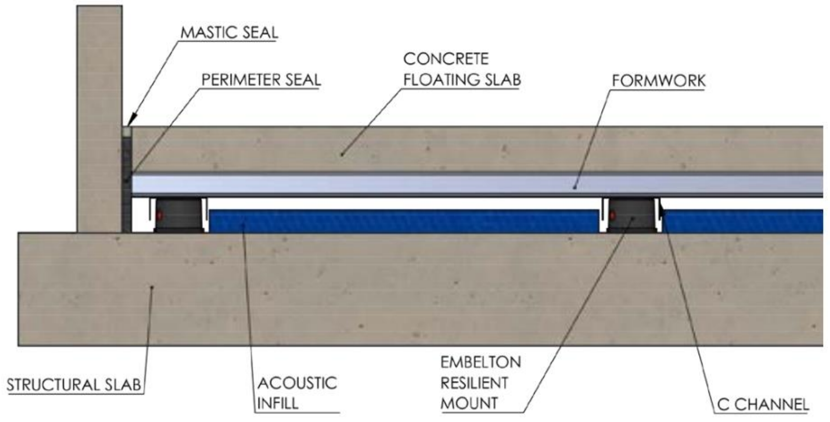


Figure 11: CEFM jack-up floating floor lowered

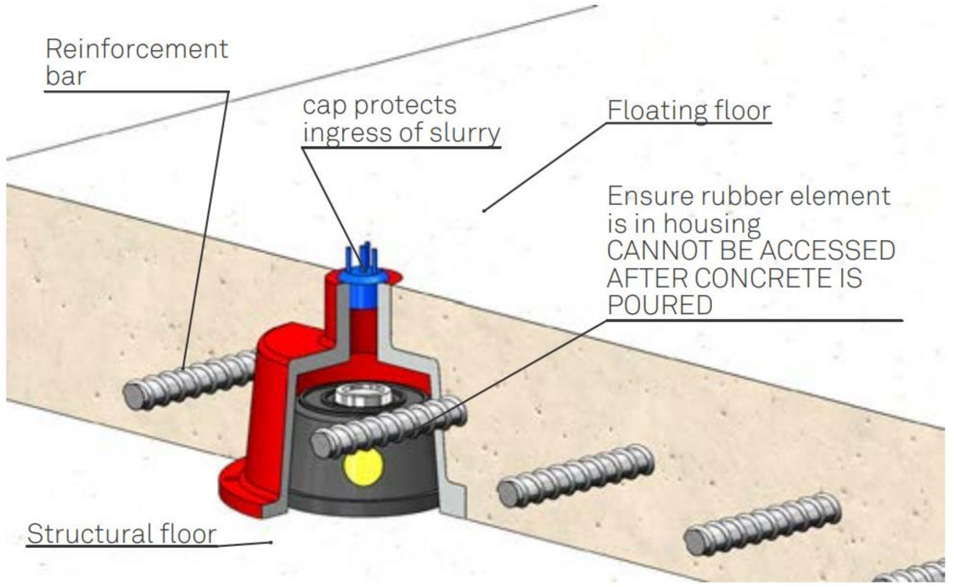
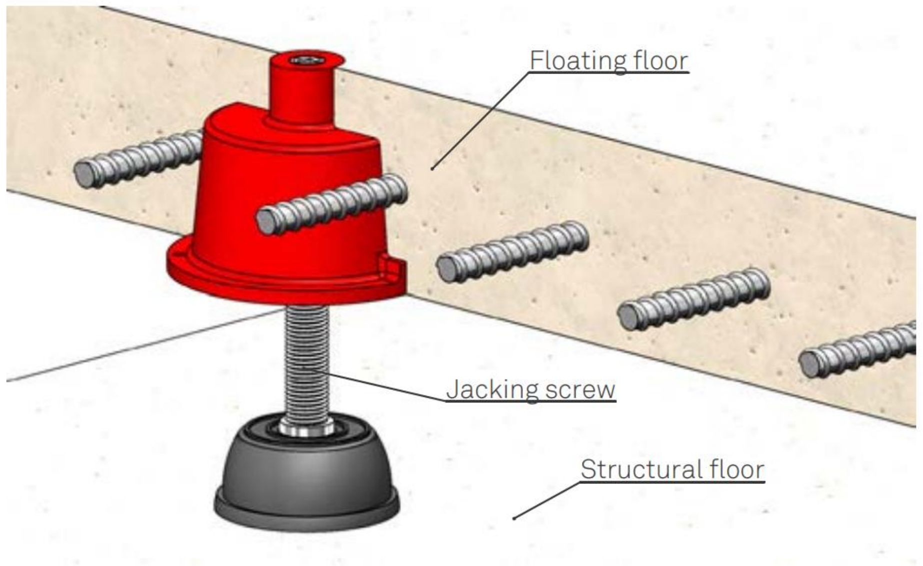


Figure 12: CEFM jack-up floating floor raised



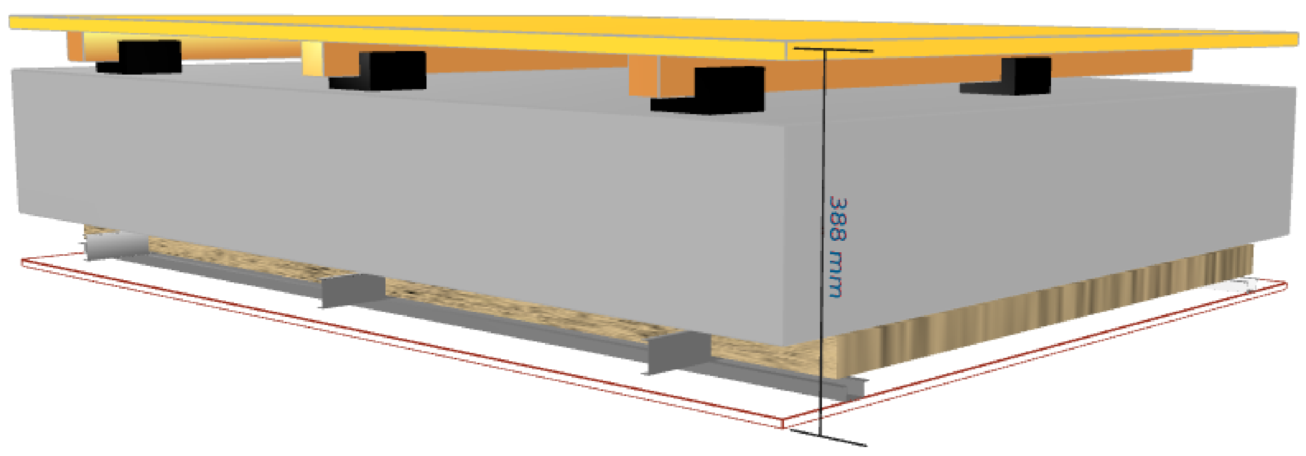
Generator Room (Provisional) to Office Above – Floor-Ceiling Construction

In accordance with the project acoustic separation performance requirements, the floor-ceiling construction separating the provisional generator room from office spaces above is required to meet a minimum on-site acoustic separation performance of D_w 75 (airborne). The airborne requirement is driven by the noise emissions from the plantroom intruding into the office spaces above.

The following construction from the floor of the plantroom to the ceiling of the YHA room is proposed to meet both the airborne and impact requirements (illustrated in Figure 13):

- 30mm hardwood timber floor
- 50mm deep timber battens or preferred mounting system
- 30mm Embelton Supershearflex pads (not required for this floor covering, but maintained for consistency in drawings)
- 225mm thick composite slab – Corus Comflor 80 (as per Structural Engineer's drawings)
- 75mm air cavity including ceiling grid with 75mm Earthwool insulation (14kg/m^3)
- 9mm James Hardie HardiePanel compressed fibre cement (or equivalent)

Figure 13: Proposed floor-ceiling construction between L07 plantroom (Generator Room) and YHA rooms below



Typical Office Floor-Ceiling Construction

The proposed floor construction options for the office spaces are provided below:

Preferred Build-up

- Floor finish
- 4-8mm Acoustica Gold4/8 polyester underlay
- Cementitious access floor tiles
- Approx 80mm floor cavity access floor and 60mm glasswool insulation (14kg/m^3) within the cavity
- 12mm thick compressed fibre cement (min. 22kg/m^2)
- Structural floor (in most cases, a 200mm thick CLT slab)

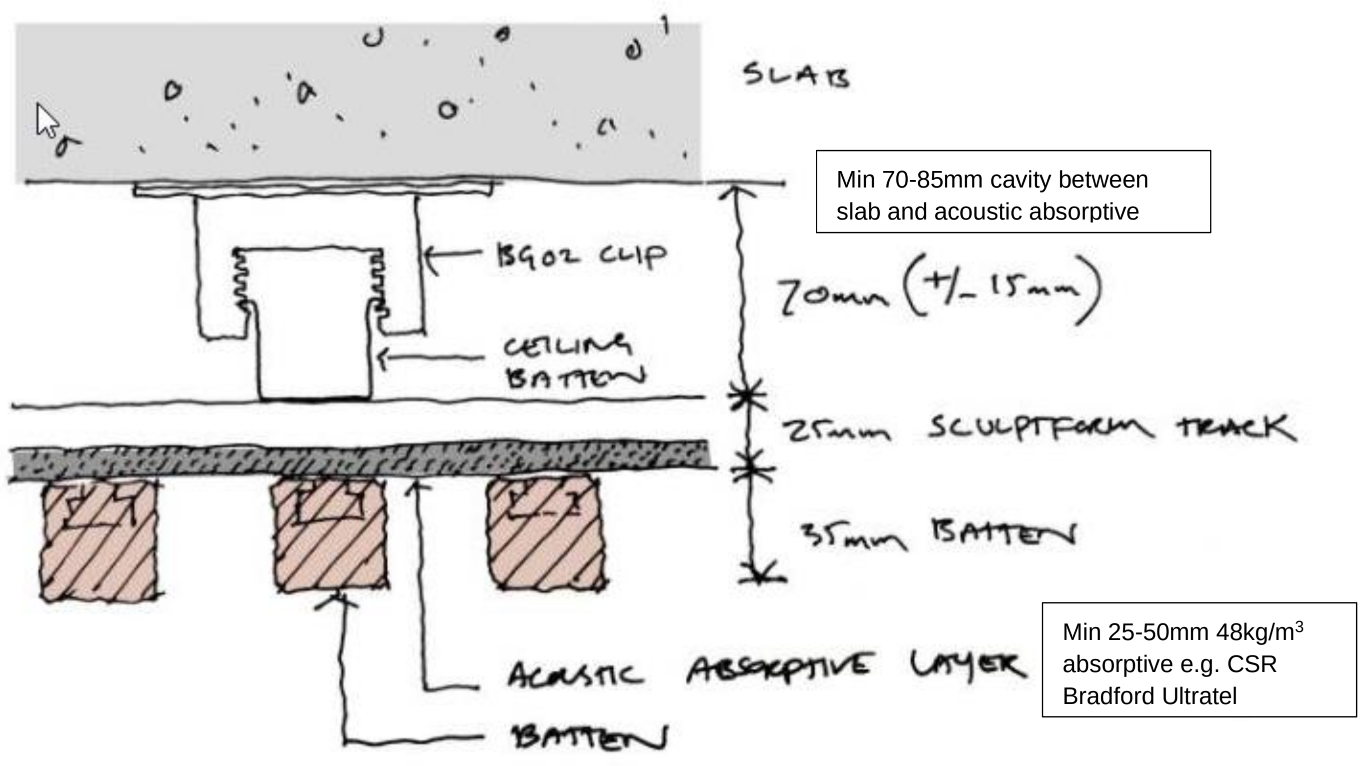
It should be noted that due to the relatively low natural frequency of the CLT structural floor substrate, it is necessary to have a 12mm thick compressed fibre cement sheet to be fixed to the access floor tiles to prevent excessive deflection causing possible discomfort to office occupants and possible "squeaking".

5.1.2 Internal Finishes

Lower Ground to OSD Level, & YHA Level 1

Acoustically absorptive ceiling finishes have been proposed to meet the project reverberation time targets outlined in Section 4.3.2. It is recommended that a minimum of 75% of the ceiling area for the YHA spaces located on Level 1 is treated by an absorptive panel system such as shown in Figure 14.

Figure 14: Acoustically absorptive ceiling system for YHA Level 1



Base-Building Office Spaces

Whilst it may be possible to meet the base building AS2107 reverberation time targets with the entire (100%) of the floor area being covered with an acoustically absorbent layer such as a thick pile carpet, it practical terms this approach is unlikely to work for the following reasons:

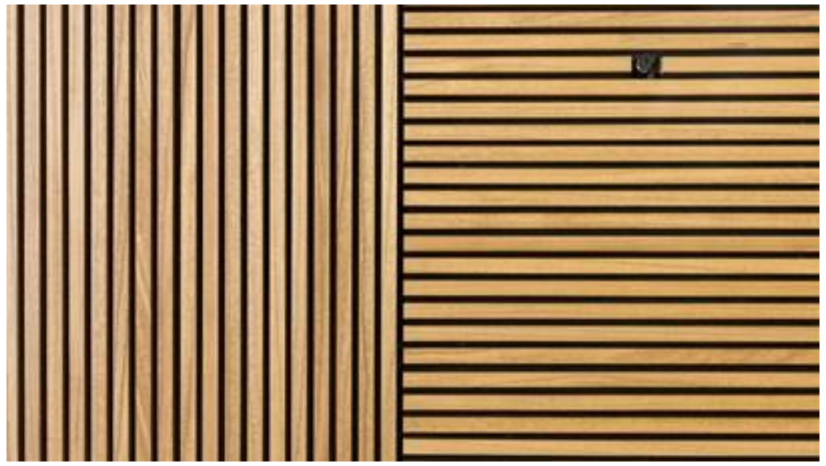
- The absorptive floor layer would require an approximate Noise Reduction Coefficient (NRC) of 0.7. This NRC performance is typically not achievable with a practical floor covering. NRC 0.4 is a typically high performing carpet with underlay, with most carpets for commercial use being significantly less. Using an NRC 0.4 carpet approximately 50-75 % of the ceiling area would also need to be treated with an NRC of >0.6.
- If a high performing floor covering with an NRC 0.7 was installed. It may meet the required RT during base building compliance. However, as soon as any furniture was moved in, areas of the absorptive surface would be covered up reducing significantly the effective area of absorption. This would then not meet the target base building RT targets.

It is therefore, strongly recommended that absorptive panels be incorporated into the ceiling plane covering a minimum of 75% of the ceiling area and have a minimum NRC 0.7.

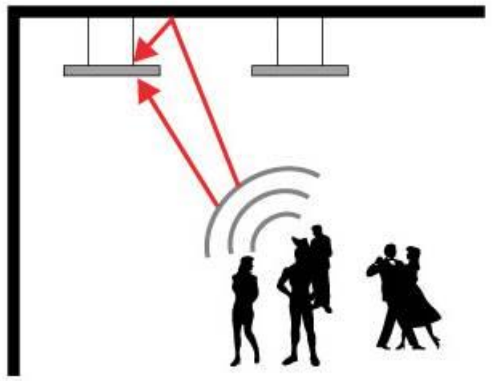
Given the ceiling is an open soffit with CLT beams, exposed chilled beams and other services it becomes difficult to readily apply absorption to the ceiling area and the aesthetic of the exposed timber is desired to be retained.

Options for acoustic absorption are as follows:

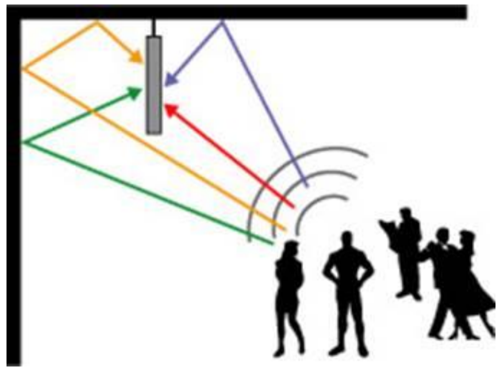
- 50-75mm acoustic insulation such as CSR Martini Absorb/Soffit. This can be fixed to available exposed soffit areas.
- Install acoustic panels to sit flush with the bottom of the CLT beams/chilled beams. This will ensure a reasonable cavity behind the panels to maximise their performance. A similar system to the YHA Level 1ceiling as shown in Figure 14 may be used.



- Install horizontally suspended panels with gaps between large enough to let sound through to reflect off of the soffit and back down onto the rear of the acoustic panel. This would allow both sides of the acoustic panel to be active and therefore act as surface area, essentially getting double the area of absorption for the price of one. If arranged properly this could reduce the required coverage of the acoustic panels to be approximately halved to cover 50% of the celling area. Or with the carpet as well this area could be reduced further.



The third option is similar to the horizontally suspended panels except the panels are suspended vertically instead.



Below is an example, or a printed absorptive panel to look like timber that achieves a minimum NRC 0.45 if direct fixed to the CLT or soffit and can improve to NRC 0.64 if installed with a 20mm airgap on a batten https://acoufelt.com/au/product/quietprint-designs-acoustic-panel/

The placement of absorptive acoustic treatment in the office space is an imperative to meet the project reverberation time targets established in Section 4.3.4. It is recommended that a combination of floor and ceiling plane treatment is applied for the base building and then tenants create their own fitout environments based on their culture and budgets.

The acoustic paneling should have minimum NRC of 0.7. The actual areas can be refined based on the materials and locations as the design develops.

Outdoor Habitats

Whilst the middoor habitat is not as sensitive to the office spaces to increased reverberance AS2107 still sets a recommended design target (<1.0s). To not have any acoustic absorption in the space would result in the external noise ingress through the ventilated faced (traffic, train and building services plant) building up to higher levels, as the noise cannot decay sufficiently before additional noise enters through the façade. This is further increased by any occupational noise in the habitat area. This would result in an uncomfortable space for the occupants. In addition, additional noise would break into the office space B, as this is partially naturally ventilated. This may result in the Office space B occupants from opening their windows to the middoor space.

Internal finishes to the outdoor habitats will be critical in absorbing noise in the habitats when the louvres are in the closed position. This will also support further reduced acoustic demand on the inner skin façade (WT-02).

Similar to the acoustic paneling proposed for the YHA Level 1 or office, the acoustic paneling proposed to the outdoor habitats could be in the form a perforated/slotted/battened timber cladding with acoustic insulation behind. See Figure 15 for the proposed locations for acoustic paneling.

Figure 15: Proposed acoustically absorptive panelling to the outdoor habitats – shaded in green

State Works

To control the reverberation within the link zone, a combination of acoustic finishes and specially formed geometry will both optimally absorb patron noise and diffuse patron noise. This combination of absorption and diffusion will allow for a holistic acoustic outcome for the link zone and wider State Works.

To manage acoustic reflections, the geometry of the jack arches have been designed to ensure the focal point of reflections arrives 3 metres above FFL of the link zone. In addition to this, further opportunities for acoustic absorptive ceilings have been identified for further design once responses from TfNSW are returned.

5.2 Façade Conceptual Recommendations

5.2.1 External Façade Noise Modelling

Noise emissions and impacts from vehicle movements on the surrounding busy roads (George St, Pitt St and Lee St) were modelled in accordance with the CoRTN prediction techniques and calibrated to measurements and logger data from around the site, with consideration given to the COVID-19 pandemic (discussed in Section 3.3.1). In addition to this, noise emissions from the adjacent rail corridor were modelled within the 3D acoustic modelling. This model is recognised by regulatory authorities around Australia and is endorsed by the NSW DPIE for use in projects of this scale. The acoustic modelling was undertaken considering specific meteorological characteristics such as wind speeds, prevailing wind directions and temperature in accordance with the hourly weather for a full calendar year described in the Test Reference Year for Mascot 1987 (94767 Mascot (Syd AMO) 1978-87 1987 available from www.ozemail.com.au/~acadsbsg).

3D modelling was implemented in this specific situation because of the complexity of integrating all noise sources and types of noise sources to develop an overall incident façade noise level. Attenuation due to distances, building shielding and environmental absorption, together with additional noise incident on the façade due to façade reflections are taken into account within the 3D model.

The following considerations were given when preparing the noise propagation model:

- Daytime (7am – 10pm) Model
  - Various train pass-bys on rail tracks 1 – 8
  - Peak hour traffic volumes on each of the surrounding busy roads and respective noise monitoring results obtained on-site
  - Noise emissions from the XPT type diesel train has been excluded from the noise propagation model
- Night-time (10pm – 7am) Model
  - Various train pass-bys on rail tracks 1 – 8
  - 6am – 7am shoulder period during the night-time 10pm – 7am time interval (defined by the City of Sydney) for traffic noise
  - Noise emissions from the XPT type diesel train has been excluded from the noise propagation model

The results of the 3D modelling are provided in Appendix B within this acoustic report, showing the incident noise levels on the façade as a result of noise emissions from the external noise sources mentioned above.

5.2.2 Inner Skin Façade

The overall façade system is made up of three system types:

- WT-01A: Wind screen/exterior facade at north and west building elevations (separating outdoor from middoor habitats).
- WT-01B:Thermal envelope/exterior façade at east and south elevations.
- WT-02: Thermal envelope/protected façade at north and west building elevations

Acoustic Recommendations

In principle, the acoustic ratings that have been assigned to each façade type are as follows:

- WT-01A – no acoustic attenuation
- WT-01B (external) – R_w / STC 36
- WT-02 (internal) – R_w / STC 36
- WT-04 (YHA) – R_w / STC 38

5.2.3 Façade / Slab-Edge Junctions – Office Floor to Office Floor

At locations where WT-01B (and in rare instances WT-01A) are fixed to the slab-edge (CLT or concrete composite slab), the noise from the office floor above to the office floor below must be controlled locally in this location to prevent noise flanking above and below.

Figure 16 shows an indicative location (clouded in red) where this junction typically occurs in the building, and Figure 17 shows a typical connection between the façade and the slab edge.

Figure 16: Typical location for a facade / slab-edge junction

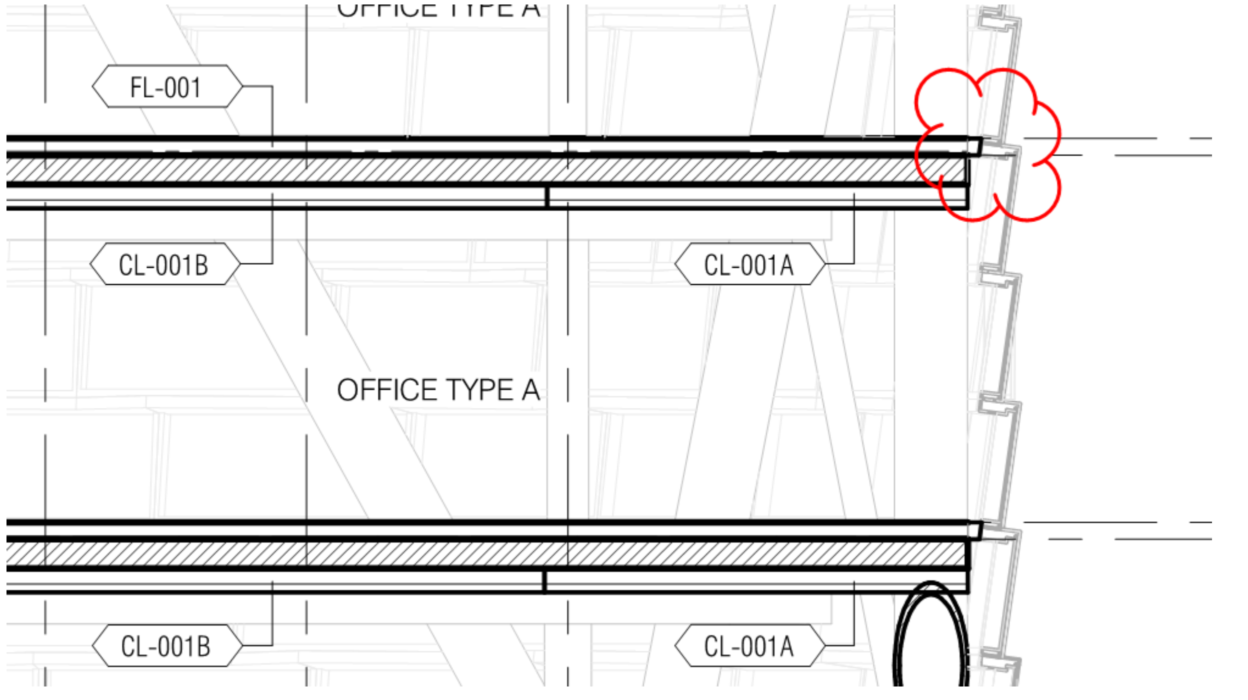
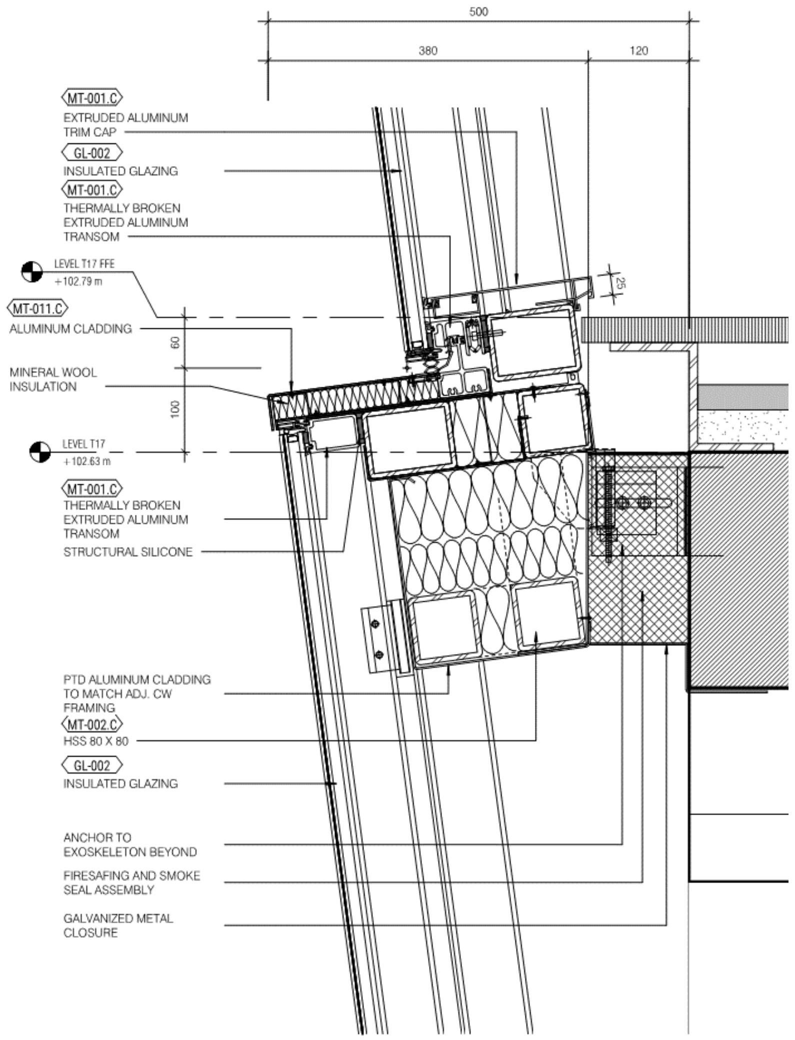
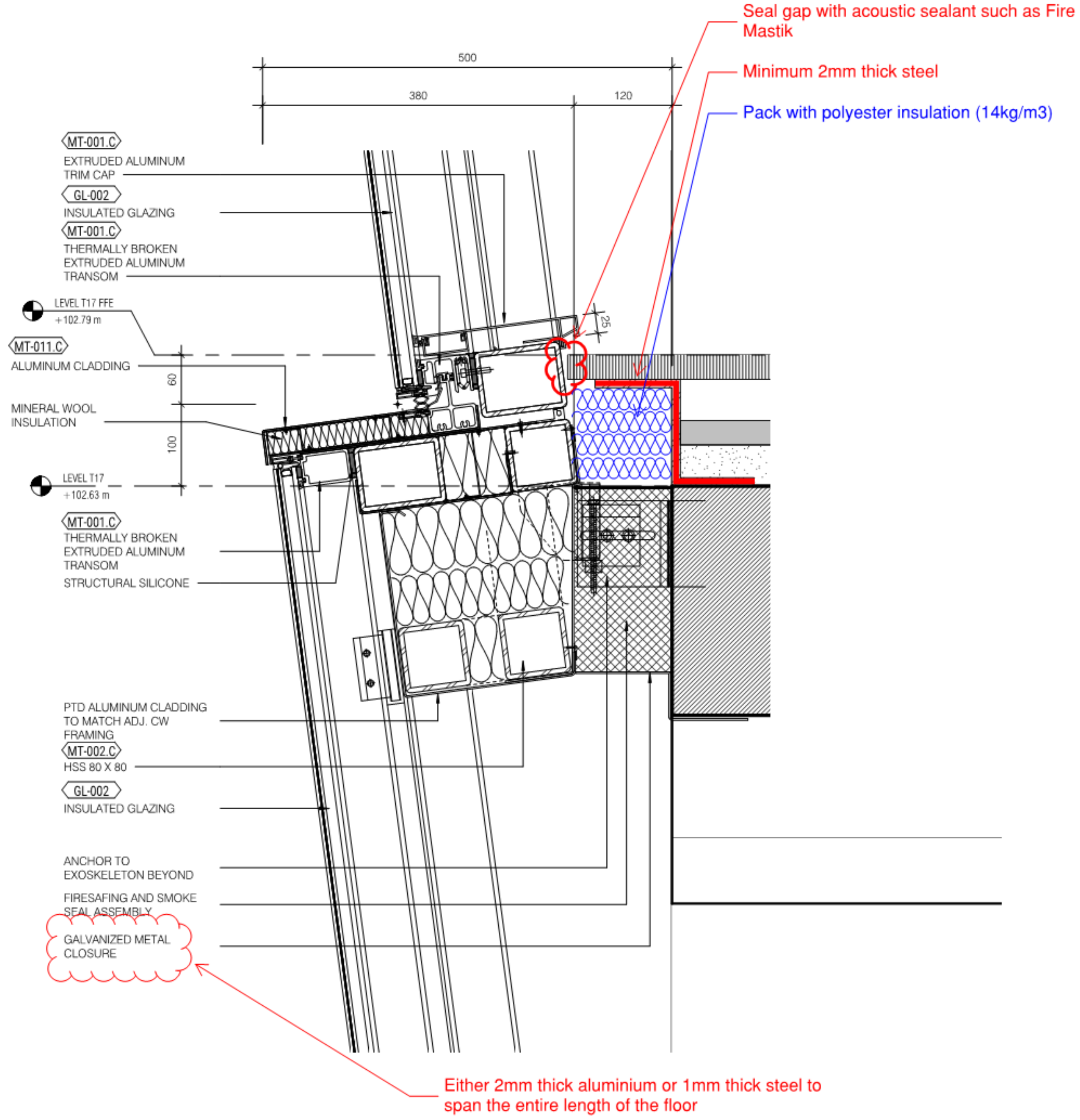


Figure 17: Typical detailed junction between facade and slab edge



With the exception of noise transferring from the plantroom to the office floors above, the proposed acoustic separation requirement from office floor to office floor (shown in Appendix D) is D_w 45. To maintain the acoustic integrity of the floor, recommendations marked up on the detailed junction drawing have been provided in Figure 18.

Figure 18: Acoustic recommendations for facade / slab-edge junction to maintain acoustic integrity of floor



5.3 Groundborne Conceptual Recommendations

5.3.1 Groundborne Vibration

Initial groundborne vibration screening (as a result of train pass-bys within the adjacent rail corridor) have been conducted to ensure compliance with the vibration criteria established in Section 4.6 for:

- Human Comfort
- Structural Damage
- Cosmetic Damage

Upon inspecting the results of the initial screening, the vibration generated at the structure in closest proximity to the development does not exceed the limits established in Section 4.6. It should be noted that this is a preliminary vibration model based on hybrid prediction techniques, and will need to be verified with finite element modelling in the Design Development phase of the project.

5.3.2 Groundborne Noise

The initial groundborne noise modelling has been conducted by modelling a train passing by on the rail track (rail track 1) closest to Atlassian Central.

Lower Ground to OSD Level

Initial groundborne noise modelling (as a result of train pass-bys within the adjacent rail corridor) have been conducted to achieve the proposed project internal noise levels established in Section 4.4.9.

Noise from the pass-by of trains within the rail corridor is estimated to generate noise levels of approximately 43 dB(A) within the lower ground lobby zone. From the results of the initial modelling, the noise generated by the pass-bys are not at a high risk of providing acoustic discomfort. Further detailed modelling (finite element modelling) will be required during the Design Development phase of the project to validate the results.

Tower YHA & Commercial

Similar to the lower ground spaces, the groundborne noise generated from the pass-by of trains was modelled to assess the risk to internal noise levels within the spaces in the tower. At this stage of the design, the vibration was assumed to propagate through the core of the structure to the YHA and commercial floors and not through the façade exoskeleton structure. This is because it is assumed there will be flexible connections between the exoskeleton and the superstructure due to movement in the structure. This will be reassessed during the Design Development phase with the aid of detailed vibration modelling techniques.

The predicted groundborne noise generated within the YHA rooms located on Level 2 is approximately 30 dB(A), and 20 dB(A) for the office floors. Further detailed modelling (finite element modelling) will be required during the Design Development phase of the project to validate the results.

5.4 Mechanical Conceptual Recommendations

5.4.1 Internal Noise Control

Office Type A & B

Office Type A & B spaces will be served by chilled beams and therefore, will not require noise control as they are inherently quiet through their passive radiant action. For this reason, they generally result in an office space that is too quiet to provide any useful noise masking. If left untreated poor speech privacy and increased noise intrusion can result in occupant dissatisfaction. Therefore, it is recommended that a sound masking system is installed for Office Types A & B.

Internal Acoustic Treatment

After an initial review of the toilet exhaust fans and air handling units (assuming the sound power levels provided in Table 42), the mechanical design should allow for 25mm internal lining to the ductwork within the plantrooms and riser spaces. At this stage and with the assumptions made, silencers/attenuators will be required.

Once further details have been provided, these recommendations will be further refined and detailed for each individual plant and equipment.

Ductwork Design Velocities

Where practical, ductwork will be dimensioned so as to conform to the maximum airflow velocities given below in Table 41. Moreover, duct distribution will be along corridors with run-out ducts serving meeting rooms, quiet rooms and break-out areas and all acoustically sensitive spaces. Note that the internal lining recommendations are for guidance only, thus decisions in that regard need to be reviewed by the acoustic engineer. Where control of crosstalk is important between rooms, lining may be required.

Table 41: Recommended duct airflow velocities

Room Type	Noise Criteria $L_{Aeq,T}$ – dB(A)	Plant Room and Riser Duct Velocity m/s	Main Duct Velocity m/s	Branch Duct Velocity m/s	Run Out Duct Velocity m/s	Internal Duct Lining Guide
Commercial Zone & Base-Building						
Toilets	45	11	8	6	4.3	Run-out
Corridors and lobbies	45	11	8	6	4.3	Run-out
Office Type A & B	40	Chilled beams	Chilled beams	Chilled beams	Chilled beams	Chilled beams
Public Spaces	40	9.5	6.8	5	3.5	Branch+Run out
Reception Areas	40	9.5	6.8	5	3.5	Branch+Run out
YHA Zone & Fitout						
Bedrooms	30	7	4.5	3.4	2	All
Board and conference rooms	30	7	4.5	3.4	2	All
Rest rooms and break-out spaces	40	9.5	6.8	5	3.5	Branch+Run out
Quiet rooms	30	9.5	6.8	5	3.5	Branch+Run out
Corridors and lobbies	45	11	8	6	4.3	Run-out
Meeting room (small)	40	9.5	6.8	5	3.5	Branch+Run out
General Office Areas	40	9.5	6.8	5	3.5	Branch+Run out
Open Plan Office	40	9.5	6.8	5	3.5	Branch+Run out
Video/audio conference rooms	30	7	4.5	3.4	2	All
Public Spaces	40	9.5	6.8	5	3.5	Branch+Run out
Reception Areas	40	9.5	6.8	5	3.5	Branch+Run out

5.4.2 Internal Vibration Control

Internal vibration control will be assessed once indicative equipment selections have occurred. Unlike noise emissions, the angular speed of plant and equipment can change quite drastically between different plant and equipment selections.

It is anticipated plant and equipment will be selected during the next stage of the project.

With regards to spatial implications of internal vibration isolation, the following allowances should be made below the structures (in height) supporting plant and equipment for each typical vibration-intensive plant and equipment type:

- Chillers – 300mm

- Cooling Towers – 250mm
- Compressors – 150mm
- Water-Cooled Heat Pumps – 100mm
- Air-Cooled Heat Pumps – 250mm
- AHUs – 150mm

Pipework, particularly large pipework such as condenser pipework reticulated from the chillers, shall be mounted to the structure with a vibration isolated mount. The type of mount will be dependent on the type and size of pipework.

5.4.3 External Noise Control

Stantec has conducted a preliminary impact assessment of the mechanical plant and equipment in the current proposed locations to the surrounding noise-sensitive developments (outlined in Section 2.1). While exact equipment has not been selected for the project, the below sound power levels (SWL) have been assumed for the preliminary assessment, based on typical SWL's of equipment of the size shown.

Table 42: Sound Power Levels of Mechanical Equipment and Plant

Plant and Equipment	Sound Power Level re 10^{-12} W, dB – Octave Band Centre Frequency								
	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	Overall dB(A)
YVWH Chiller	81	79	99	89	83	80	76	67	93
YK MAXE Chiller	86	87	91	88	86	88	81	81	93
Cooling Tower	105	106	101	94	90	86	79	74	97
YHA Air-Cooled Chiller	65	79	79	83	85	84	83	76	90
Heat Pump	92	94	96	93	92	87	77	68	96
AHU-07-4	37	64	62	60	56	45	37	22	61
AHU-07-5	43	63	70	66	62	50	44	30	67
AHU-07-6	31	44	57	53	51	41	33	23	55

Acoustic Recommendations

This insertion loss can be achieved through:

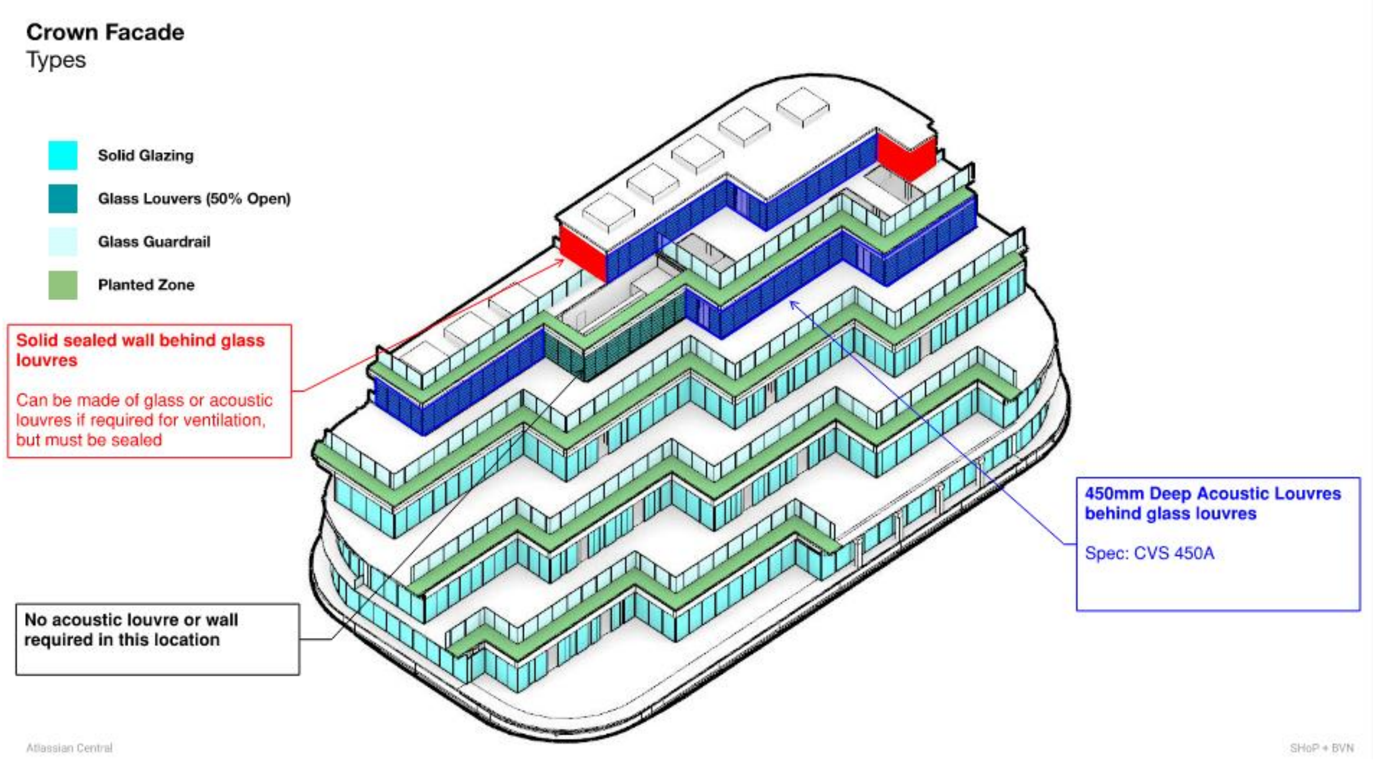
- Acoustic treatment to the plant and equipment served by these intake and discharge louvres (to reduce acoustic demand on the louvre itself)
- Acoustic treatment to the spaces housing the plant and equipment
- Solid barriers where the louvres are not required for ventilation

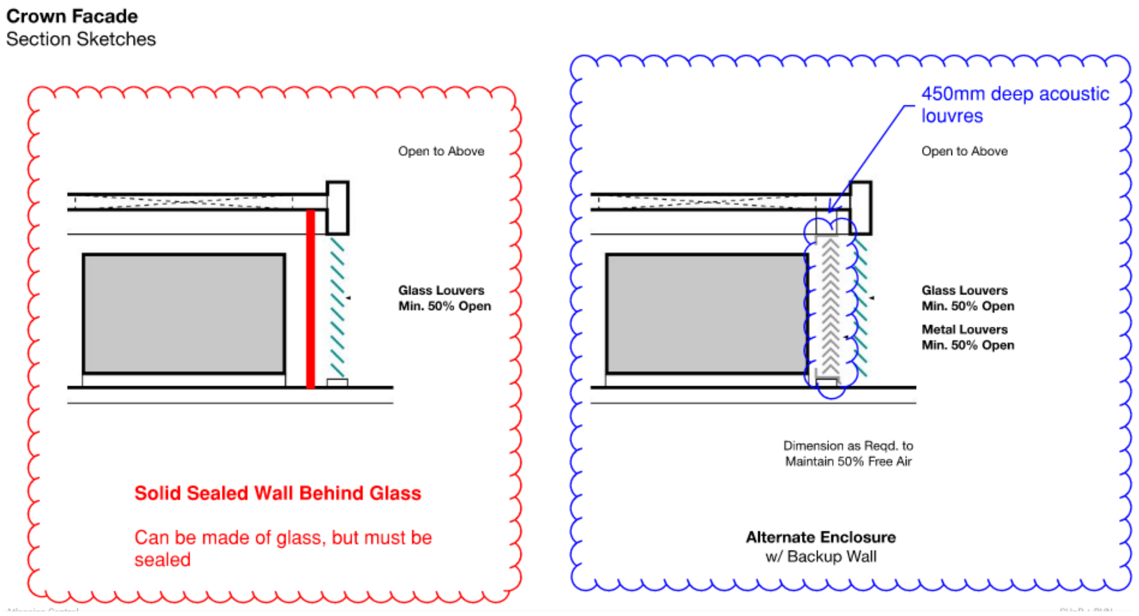
Based on the sound power levels used above in Table 42, we have recommended acoustic louvers that meet the external noise emissions requirements established in Section 4.5. The required insertion loss for the locations of the mechanical plant and equipment is outlined below in Table 43. The recommended transmission losses are based on a conservative scenario where all mechanical plant and equipment is operating at capacity and has been assessed to the future building envelopes for the surrounding noise-sensitive developments.

Table 43: Recommended louvres for mechanical plant and equipment

Location	Recommended Louvre	Transmission Loss (dB) – Octave Band Centre Frequency							
		63	125	250	500	1K	2K	4K	8K
T06 Plant Chiller Louvres T06M Heat Pump Louvres Cooling Tower External Louvres (North and West)	CVS 100A	4	2	4	6	11	10	7	7
Cooling Tower Internal Louvres (South and East) T38 Heat Pump Louvres	CVS 450A	16	11	11	21	33	32	26	24

Figure 19: Internal Louvre Locations





It should be noted that the insertion loss requirements will likely be refined and reduced once decisions are made regarding the hours of operation of the mechanical plant and equipment, together with the standard operating capacity of the plant and equipment.

5.5 Electrical Conceptual Recommendations

5.5.1 Generator Noise Control

A preliminary noise impact assessment of the current proposed location of the two generators to the nearest sensitive receivers has been conducted. The assessment has assumed the sound power levels (SWL) outlined in Table 44 during the operation of the generators while they are being tested during a maintenance regime.

Table 44: Typical Sound Power Levels of Generators

Item	Sound Power Level re 10^{-12} W, dB – Octave Band Centre Frequency								
	63	125	250	500	1K	2K	4K	8K	Overall (dBA)
Generators	89	114	118	120	120	119	116	118	126

Acoustic Recommendations

Due to the high noise levels produced within the generator room, and the close proximity of the nearby commercial and hotel receivers, the insertion losses required are significant and are provided in Table 45.

Table 45: Typical Attenuators/silencers for generator plant and equipment

Item	Typical Intake and discharge attenuator	Installed Insertion Loss (dB) – Octave Band Centre Frequency							
		63	125	250	500	1K	2K	4K	8K
Generator Room Louvres (Intake & Discharge)	2400mm-3000mm 33% open area	18	29	52	59	60	56	44	31
Generator Mufflers	To be determined with the manufacturer based on the specification								

To achieve these insertion losses at the intake and discharge louvres, consultation with manufacturers will be required during the next stage of the design once the generators have been selected.

5.6 Hydraulic Conceptual Recommendations

5.6.1 Internal Noise Control

Tower – YHA

To achieve the appropriate level of sound insulation for internal services, the acoustic treatment to the hydraulic services, ceiling and riser constructions must be implemented such that the requirements of the NCC contained in F5.6 (a) to (b) are met. Refer to Figure 20 and Figure 21 for typical treatment.

Figure 20: Acoustic treatment to services in ceiling cavities

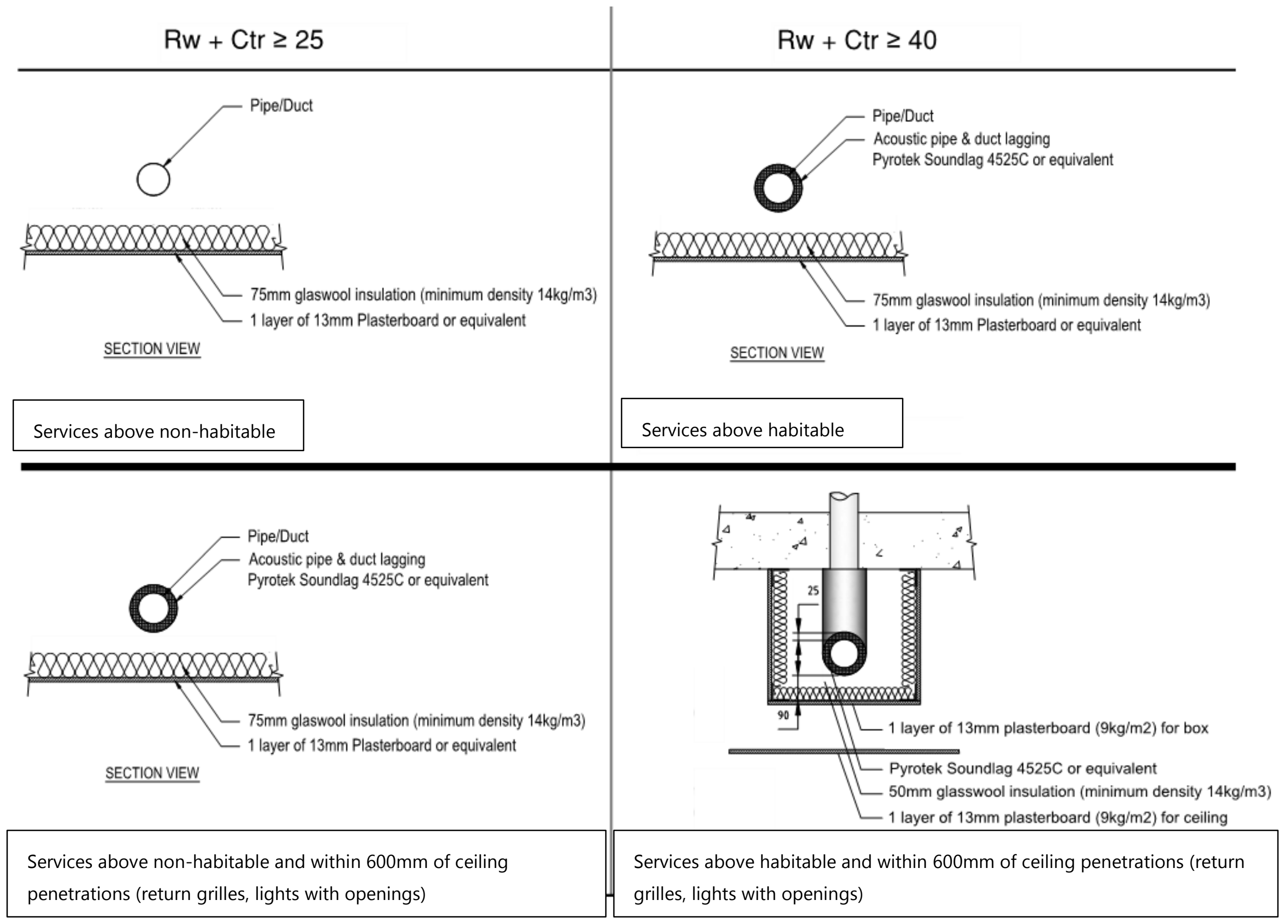
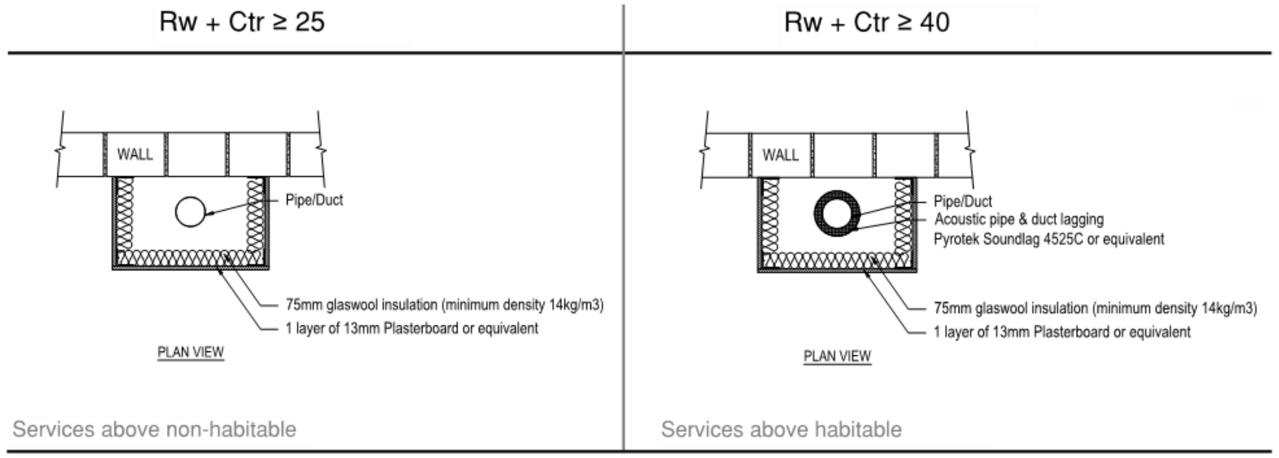


Figure 21: Acoustic treatment to services in risers



Tower – Commercial

The overall building is proposed to have a conventional gravity stormwater system to reticulate to the OSD. As such, there are not significant noise risks associated with the reticulation method (unlike methods such as symphonic drainage).

The walls enclosing sewer and stormwater services shall be constructed to achieve a minimum acoustic separation performance of D_w 40. Generally, the sewer and stormwater pipework within the commercial floors should be wrapped with acoustic lagging. Where the sensitivity of the space is low (i.e. bathrooms, kitchens), the walls enclosing these services shall generally be designed to achieve D_w 30, and will not required to be lagged.

5.7 Active Sound Masking Design

The need for an active sound masking system in a commercial development arises in the instance the base-building or fitout mechanical services do not generate enough noise to create an acoustically comfortable environment. With regards to Atlassian Central, the building is served by a chilled radiant panel system, which generates a very low background noise level.

The risks and implications of this include:

- Significantly reduced capability to provide speech privacy or protection from noise intrusion to any enclosed spaces (meetings rooms, private offices, boardrooms, etc.) within each commercial tenancy
- Cost uplift of partitions required to attempt to combat the lack of speech privacy or protection from noise intrusion
- Large distraction distances in open plan environments, reducing general workplace comfort and efficiency
- Cost uplift of obtaining a point in Acoustic Separation from Green Star Design & As-Built v1.3
- Significant attention of occupants drawn to external noise sources such as rail and road sources

It is important to ensure the background noise levels within open plan offices and other spaces within an office environment remain in the range specified in Section 4.1.4. Stantec recommend the design and installation of an active sound masking system be discussed for implementation into the design and budget. The approximate budget for sound masking supply and install is approximately $25-30/m^2.

6. Conclusion

As part of the Concept Design for Atlassian Central, Stantec has been engaged by Atlassian c/- Avenor to provide conceptual acoustic design recommendations for the proposed commercial and hotel development located at 8-10 Lee St, Haymarket.

This report presents the following information to each relevant consultant and the client:

- A description of the site and the operation of the adjacent rail corridor – Section 2
- Noise and vibration investigations conducted on-site through a series of short-term and long-term noise and vibration surveys, together with consultation with Sydney Trains – Section 3
- Acoustics, noise and vibration design criteria for Atlassian Central – Section 4
- Acoustics, noise and vibration performance recommendations for each of the major design disciplines within the project team – Section 5

Acoustics, noise and vibration recommendations have been provided based on the documentation available at the Concept Design stage. The recommendations include:

- Architectural design recommendations regarding internal partitions, doors, floors, ceilings and finishes
- Façade design recommendations for the outer and inner façade skin, together with recommendations to treat the façade / slab-edge junctions to maintain the acoustic integrity of the floors
- Groundborne design recommendations to control noise and vibration generated by train pass-bys within the adjacent rail corridor
- Mechanical design recommendations to control external and internal noise, together with internal vibration transmission
- Electrical design recommendations to control external and internal noise emissions from the generator room
- Hydraulic design recommendations to control internal noise transmission to the office spaces or YHA rooms

The recommendations within this report are based on the documents listed in Section 1. Further design advice and refinement of recommendations will be required once further information is available for Stantec's review.

Appendix A – Acoustics Glossary

NOISE	
Acceptable Noise Level:	The acceptable LAeq noise level from industrial sources, recommended by the EPA (Table 2.1, INP). Note that this noise level refers to all industrial sources at the receiver location, and not only noise due to a specific project under consideration.
Adverse Weather:	Weather conditions that affect noise (wind and temperature inversions) that occur at a particular site for a significant period of time. The previous conditions are for wind occurring more than 30% of the time in any assessment period in any season and/or for temperature inversions occurring more than 30% of the nights in winter).
Acoustic Barrier:	Solid walls or partitions, solid fences, earth mounds, earth berms, buildings, etc. used to reduce noise.
Ambient Noise:	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment Period:	The period in a day over which assessments are made.
Assessment Location	The position at which noise measurements are undertaken or estimated.
Background Noise:	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level.
Decibel [dB]:	The units of sound pressure level.
dB(A):	A-weighted decibels. Noise measured using the A filter.
Extraneous Noise:	Noise resulting from activities that are not typical of the area. Atypical activities include construction, and traffic generated by holidays period and by special events such as concert or sporting events. Normal daily traffic is not considered to be extraneous.
Free Field:	An environment in which there are no acoustic reflective surfaces. Free field noise measurements are carried out outdoors at least 3.5m from any acoustic reflecting structures other than the ground
Frequency:	Frequency is synonymous to pitch. Frequency or pitch can be measured on a scale in units of Hertz (Hz).
Impulsive Noise:	Noise having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent Noise:	Level that drops to the background noise level several times during the period of observation.
LAmax	The maximum A-weighted sound pressure level measured over a period.
LAmin	The minimum A-weighted sound pressure level measured over a period.
LA1	The A-weighted sound pressure level that is exceeded for 1% of the time for which the sound is measured.
LA10	The A-weighted sound pressure level that is exceeded for 10% of the time for which the sound is measured.
LA90	The A-weighted level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
LAeq	The A-weighted “equivalent noise level” is the summation of noise events and integrated over a selected period of time.
LAeqT	The constant A-weighted sound which has the same energy as the fluctuating sound of the traffic, averaged over time T.
Reflection:	Sound wave changed in direction of propagation due to a solid object met on its path.
R-w:	The Sound Insulation Rating R-w is a measure of the noise reduction performance of the partition.
SEL:	Sound Exposure Level is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound Absorption:	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound Level Meter:	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound Pressure Level:	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound Power Level:	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise:	Containing a prominent frequency and characterised by a definite pitch.

Appendix B – Project Acoustic Separation Performance Targets (Internal Walls)