

REPORT N° 70020194-07

NOMA ANGEL MEADOWS

STAGE 3 REPORT
ACOUSTICS

CONFIDENTIAL

SEPTEMBER 2017

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ACOUSTICS

Far East Consortium Ltd

Confidential

Project no: 70020194
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1 INTRODUCTION

1.1 OVERVIEW

1.1.1 WSP has been commissioned by Far East Consortium Ltd (FEC) to provide a Stage 3 acoustic design review of the proposed mixed use (but predominantly residential) NOMA Angel Meadows development in Manchester.

1.1.2 The scheme, which comprises four separate Plots (Plot 2, Plot 3, Plot 4 and Plot 5) comprises areas with the following uses:

- Private residential apartments;
- Indoor public space;
- Commercial units;
- Car parking.

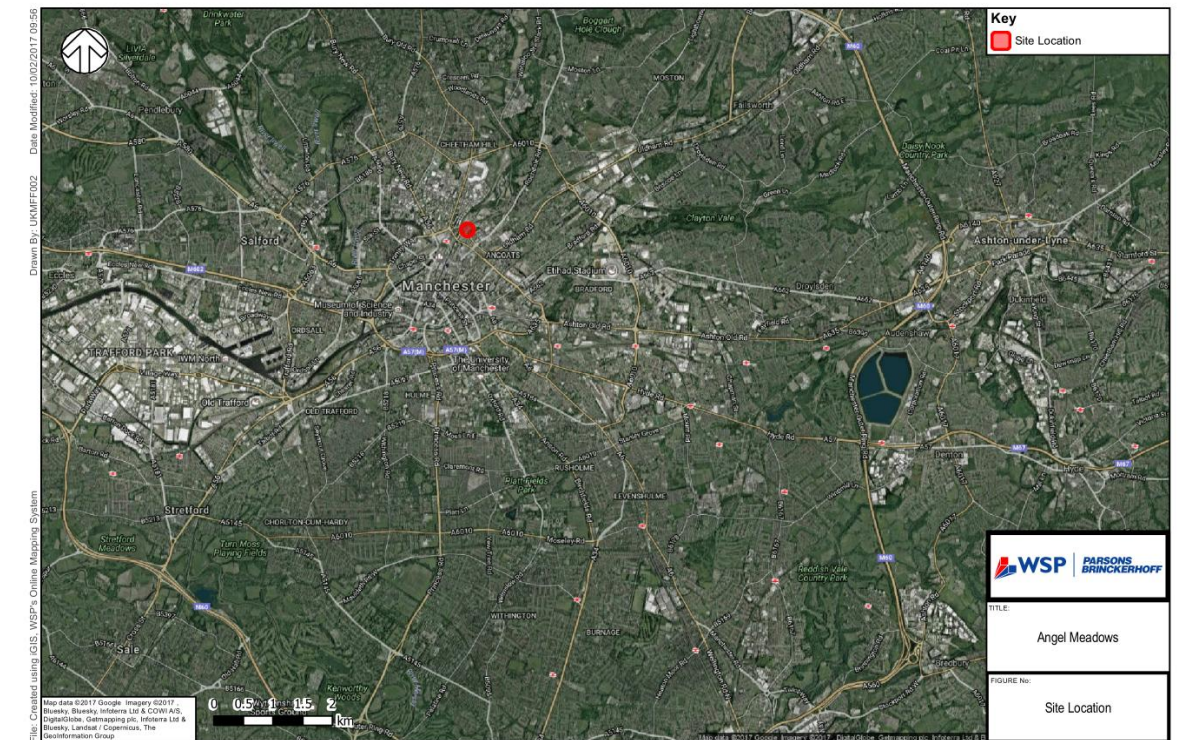
1.1.3 This report presents the Stage 3 acoustic strategy for Plots 2, 3 and 5 of the development.

2 SITE DESCRIPTION AND PROPOSALS

2.1 SITE LOCATION

2.1.1 The site is located in the city centre of Manchester and falls within the jurisdiction of Manchester City Council (MCC). See figure below for the approximate site location.

Figure 1 - Site Location



2.2 SITE DESCRIPTION

2.2.1 The site is located towards the north of Manchester city centre. It comprises land around Saint Michael's Flags and Angel Meadow and is bounded by Gould Street to the east, Dantzic Street to the north west and Angel Lane to the west. Railway (train & tram) lines run to the north of the site.

2.2.2 The Co-op office, 1 Angel Square, is located to the south west of the site, and the nearest residential properties are located to the south and the west.

Figure 2 - Site Description

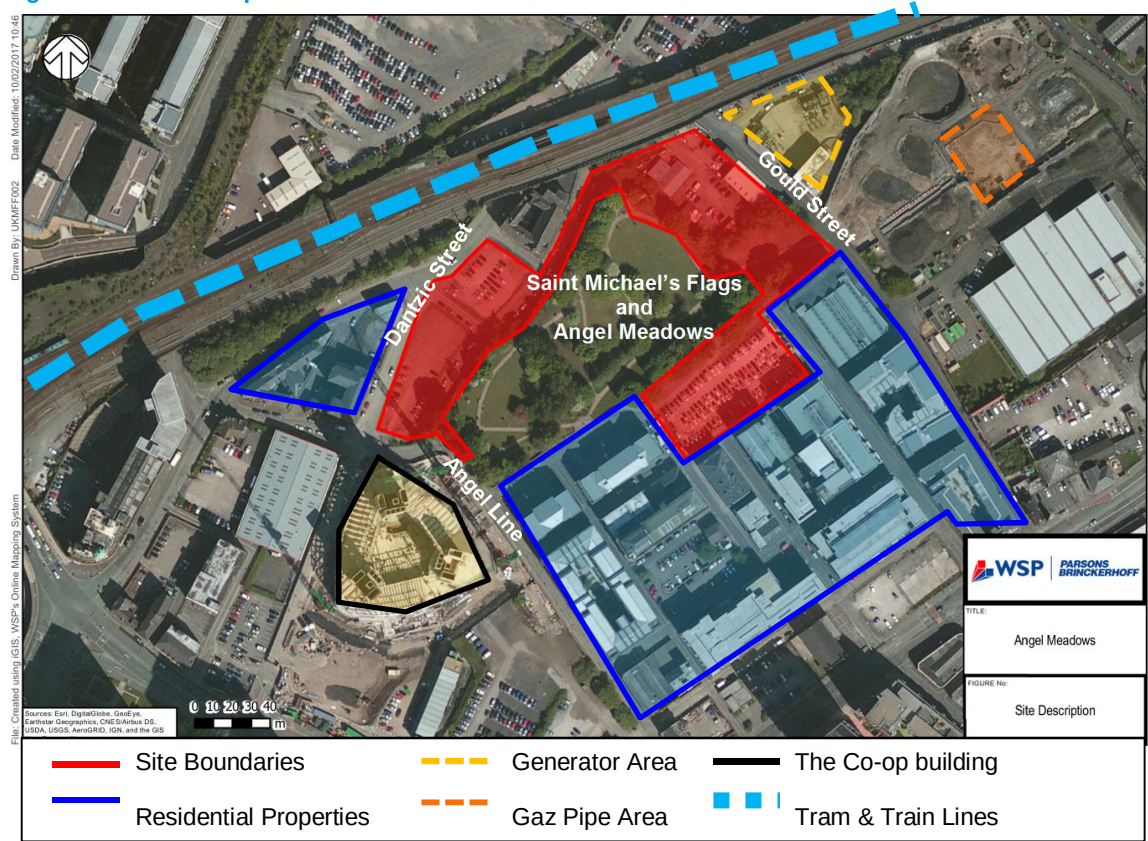


Figure 3 - Proposed Site Layout

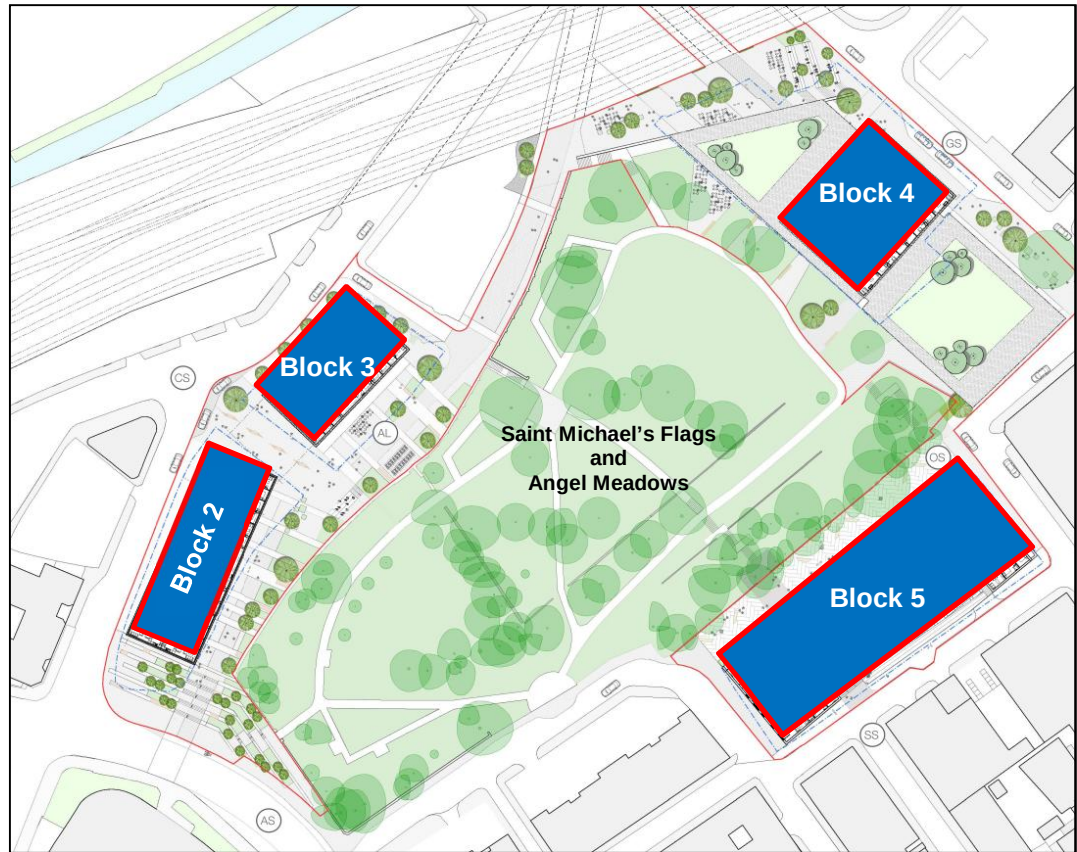


Table 2-1 - Details of Proposed Building Blocks

BLOCK NUMBER	NUMBER OF FLOORS	BUILDING USES PROPOSED
Block 2	21	Street Level: Reception, Commercial Unit, Plantrooms, Cycle Store Ground Floor: Plantrooms, Cycle Stores First Floor: Plantroom Upper Floors: Residential Dwellings
Block 3	15	Street Level: Reception, Commercial Unit, Plantrooms, Cycle Store Ground Floor: Residential Dwellings, Plantrooms First Floor: Residential Dwellings Second Floor: Gym, Apartments, Private Dining Room Upper Floors: Residential Dwellings

2.3 PROPOSALS

2.3.1 It is proposed to erect four building blocks comprising predominantly residential dwellings (some of them having terraces), gyms, commercial units, underground car parking, indoor public spaces, indoor public spaces, plant rooms and cycle stores. Figure 3 illustrates the indicative location of each Block and Table 2-1 provides details of the uses proposed within each block.

2.3.2 All areas within the development will be ventilated via mechanical ventilation means.

BLOCK NUMBER	NUMBER OF FLOORS	BUILDING USES PROPOSED
Block 4	37	Lower Ground & Ground Floors: Car Park, Offices, Plantrooms, Commercial Units and Cycle Stores First Floor: Plantrooms, Party Rooms, Gym, Private Dining Room, Lounge, Kitchenette, Cinema Upper Floors: Residential Dwellings
Block 5	12	Ground Floor & First Floor: Townhouses, Car Parks, Cycle Stores, Plantrooms Upper Floors: Residential Dwellings

2.3.3 The proposed development features numerous terrace areas associated with certain apartments. Whilst most are enclosed by the building façade/glazing, several are proposed to be external. These external balconies are to be located on the upper most floor levels of Plots 2, 3 and 5, and further more Plot 5 features balconies on its North West facing façade across various levels.

3 ASSESSMENT AND DESIGN CRITERIA

3.1 MANDATORY ACOUSTIC REQUIREMENTS

3.1.1 There are a number of mandatory acoustic requirements that the design of the residential blocks must comply with. These include:

→ **Noise ingress into apartments and external amenities within the development.**

This requirements relates to noise generated from nearby off-site environmental noise sources (such as road traffic, rail and tram movements, and noise from existing plant in the vicinity of the residential blocks) as well as any significant noise sources generated by the development itself, such as that generated from the proposed commercial spaces. The requirements must comply with criteria specified by MCC in *Planning & Noise Technical Guidance* document dated December 2015.

→ **Sound transmission to rooms for residential purpose from other internal spaces.**

This includes sound transmission from other apartments themselves, residential amenity spaces and commercial units. Rooms are required to comply with Part E of the Building Regulations: Approved Document E: Resistance to the Passage of Sound.

→ **Noise egress from the development to off-site noise sensitive premises.**

This requirement mostly relates to noise generated from any items of fixed plant. The requirements must comply with criteria specified by MCC in *Planning & Noise Technical Guidance* document dated December 2015.

3.1.2 An overview of the acoustic criteria relating to the above mandatory requirement is provided below.

3.2 NOISE INGRESS INTO APARTMENTS WITHIN THE DEVELOPMENT

3.2.1 MCC have issued the *Planning & Noise Technical Guidance* document dated December 2015 which, in regards to new residential development, stipulates the following “*outlines in relation to current guidance and policy with aspiration that new developments achieve the highest possible standards without compromising the health and well-being of people*”. The document sets the following internal and external noise limits for residential properties:

NOISE SOURCE	LOCATION	DAYTIME (07:00 – 23:00)	NIGHT TIME (23:00 – 07:00)
Road, rail or air traffic	Within bedrooms	-	30 dB L _{Aeq,8hour} 45 dB L _{Amax,F} *
	Living Rooms	35 dB L _{Aeq,16hour}	-
	External Gardens and Terraces	55 dB L _{Aeq,16hour}	-
Commercial	Closest noise sensitive receptors	5dB below** the existing background noise level in <u>each octave band</u> during the proposed period of operation***	

*to not be exceeded by Individual Noise Events by more than 15 times;

**based on BS 4142:2014 Assessment Methodology;

3.3 SOUND TRANSMISSION TO ROOMS FOR RESIDENTIAL PURPOSE FROM OTHER INTERNAL SPACES

3.3.1 Approved Document E “*Resistance to the passage of sound*” of the Building Regulations 2010 primarily sets out the Office of the Deputy Prime Minister’s (ODPM) requirements for achieving requisite levels of sound insulation between and within residential development.

3.3.2 Minimum requirements are stipulated for new build/converted residential dwellings and rooms for residential purposes. The document also sets out requirements for reverberation control within common internal areas of residential developments and for acoustic conditions within schools.

3.3.3 For residential developments, Requirements E1-E3 apply and must be achieved. These requirements are summarised below.

REQUIREMENT E1

3.3.4 Requirement E1 relates to the sound insulation performance provided by “Separating” walls and floors and stairs between adjoining residential apartments. Approved Document E states the following:

“In the Secretary of State’s view the normal way of satisfying Requirement E1 will be to build separating walls, separating floors, and stairs that have a separating function, together with the associated flanking construction, in such a way that they achieve the sound insulation values for dwelling-houses and flats set out in Table 1a, and the values for rooms for residential purposes (see definition in Regulation 2) set out in Table 1b. For walls that separate rooms for residential purposes from adjoining dwelling-houses and flats, the performance standards given in Table 1a should be achieved.”

3.3.5 The proposed residential apartments within the development would fall within the definition of “Purpose built dwelling-houses or flats” and will therefore be required to comply with the performance standards set out in Table 1a of Approved Document E. Table 3-1 below summarises the sound insulation performance requirements to be achieved by separating walls, floor and stairs to the residential apartments.

Table 3-1 - Sound Insulation Performance Requirements to be achieved by Separating Wall and Floor to Purpose Built Dwelling-House and Flats (residential Apartments)

SEPARATING ELEMENT	PERFORMANCE STANDARDS FOR SEPARATING WALLS, SEPARATING FLOORS & STAIRS THAT HAVE A SEPARATING FUNCTION	
	Airborne Sound Insulation D _{nTw} + C _{tr}	Impact Sound Insulation L’ _{nTw}
Walls	45 dB (minimum)	-
Floors	45dB (minimum)	62 dB (maximum)

3.3.6 For this particular project it has been requested by the client that a 5dB enhancement over and above the minimum ADE requirements, should apply to all separating walls and floors throughout the development. Therefore, the Table 3-2 below presents the revised sound insulation performance requirements considering ‘ADE +5 dB’.

Table 3-2 - Sound Insulation Performance Requirements to be achieved by Separating Wall and Floor to Purpose Built Dwelling-House and Flats (residential Apartments) upgraded by 5 dB (ADE +5dB)

SEPARATING ELEMENT	IMPROVED PERFORMANCE STANDARDS (TO ACHIEVE 'ADE +5') FOR SEPARATING WALLS, SEPARATING FLOORS & STAIRS THAT HAVE A SEPARATING FUNCTION	
	Airborne Sound Insulation $D_{nTw} + C_{tr}$	Impact Sound Insulation L'_{nTw}
Walls	50 dB (minimum)	-
Floors	50dB (minimum)	57 dB (maximum)

3.3.7 In addition to the sound insulation performance requirements set out in Table 3-1, Approved Document E states the following:

“The performance standards set out in Table 3-1 are appropriate for walls, floors and stairs that separate spaces used for normal domestic purposes. A higher standard of sound insulation may be required between spaces used for normal domestic purposes and communal or non-domestic purposes. In these situations, the appropriate level of sound insulation will depend on the noise generated in the communal or non-domestic space. Specialist advice may be needed to establish if a higher standard of sound insulation is required, and so, to determine the appropriate level.”

3.3.8 On this basis, an improved set of sound insulation performance criteria may be required for the separating floor constructions between the apartments and the adjoining commercial, gym and plant areas. The required set of sound insulation performance requirements to be achieved between the residential apartments and adjoining commercial, gym or plant area are discussed further in Section 0 of this report.

3.3.9 Due to the design criteria being 5dB above ADE, Robust Standard Details will not be adopted. Therefore, compliance with the Requirement E1 of Approved Document E will need to be demonstrated to the Building Control Officer (BCO) through a series of onsite pre completion impact and airborne sound insulation commissioning testing. The schedule of testing will need to be pre-agreed with the BCO. Where non-compliances are identified, remedial works and retesting will be required until compliance is demonstrated.

REQUIREMENT E2

3.3.10 Requirement E2 of Approved Document E states that internal walls and floors within individual dwellings should be designed and constructed in such a way that they provide a reasonable resistance to sound. In order to satisfy this requirement, walls within the individual room for residential purpose should provide an airborne laboratory sound insulation performance standard of not less than 40 dB R_w . This requirement includes all internal walls, such as those between bedrooms and bathrooms within apartments.

3.3.11 Note that compliance with this requirement is confirmed by design review by the Building Control Officer rather than by the results of commissioning testing.

REQUIREMENT E3

3.3.12 This requirement relates to the control of reverberant noise within common areas of the development, Approved Document E states the following:

“The common internal parts of buildings which contain flats or rooms for residential purposes shall be designed in such a way as to prevent more reverberation around the common internal areas than is reasonable.”

3.3.13 It is intended that this requirement be applied to corridors, hallways, stairwells and entrance halls that give access to flats and rooms for residential purposes. Approved Document E provides two separate methods for complying with this requirement:

Method A

“For entrance halls, corridors or hallways, cover an area equal to or greater than the floor area, with a Class C absorber or better. It will normally be convenient to cover the ceiling area with the additional absorption.

For stairwells or a stair enclosure, calculate the combined area of the stair treads, the upper surface of the intermediary landings, the upper surface of the landings (excluding ground floor) and the ceiling area on the top floor. Either cover at least an area equal to this calculated area with a Class D absorber, or cover an area equal to 50% of this calculated area with a Class C absorber or better. The absorptive material should be equally distributed between all floor levels. It will normally be convenient to cover the underside of intermediate landings, the underside of the other landings, and the ceiling area on the top floor.

Method A can generally be satisfied by the use of a proprietary acoustic ceiling. However, the absorptive material can be applied to any surface that faces into the space.”

Method B

“The total absorption area, A_T , in square metres is defined as the hypothetical area of a totally absorbing surface, which if it were the only absorbing element in the space would give the same reverberation time as the space under consideration.
“For n surfaces in a space, the total absorption area, A_T , can be found using the following equation:

$$A_T = \alpha_1 S_1 + \dots + \alpha_n S_n$$

“For entrance halls, provide a minimum of 0.20 m2 total absorption area per cubic metre of the volume. The additional absorptive material should be distributed over the available surfaces.

“For corridors or hallways, provide a minimum of 0.25 m² total absorption area per cubic metre of the volume. The additional absorptive material should be distributed over one or more of the surfaces.

Absorption areas should be calculated for each octave band. Requirement E3 will be satisfied when the appropriate amount of absorption area is provided for each octave band between 250 Hz and 4000 Hz inclusively.”

3.3.14 Method A is the simpler of the two methods to comply with but based upon the wording of the requirement, it does not allow soft furnishings such as carpet to be considered, nor does it allow for a reduced treatment area with the use of more efficient sound absorbers (Class A or B rated sound absorption). Method B does factor in the benefit of higher efficiency sound absorbers and the absorption provided by carpets etc can be taken into consideration.

3.3.15 Note that compliance with this requirement is confirmed by design review by the Building Control Officer rather than by the results of commissioning testing.

3.4 NOISE EGRESS FROM THE DEVELOPMENT TO OFF-SITE NOISE SENSITIVE PREMISES

3.4.1 The potential noise levels generated from the development will need to be assessed to ensure that they do not create an adverse noise level impact at any existing noise sensitive premises. Noise egress from the development will need to be controlled to meet the criteria specified by the MCC.

3.4.2 Following consultation with the environmental health department of MCC, it was confirmed that fixed plant associated with the proposed development should be designed to meet the following:

- With the exception of emergency plant, noise emission from all fixed plant should achieve a level no greater than 5dB below the existing background noise level (L_{90}) in each octave band at the nearest noise sensitive location;
- Noise emission from emergency plant (e.g. backup generators) should achieve a level not greater than 10dB(A) above the existing background noise level at existing noise sensitive receptors.

4 ENVIRONMENTAL NOISE SURVEY

4.1 PREVAILING LOCAL NOISE ENVIRONMENT

- 4.1.1 Each of the site's individual plots (2, 3, 4 and 5) are located in close proximity to the A664 Angel Street, and the railway and Metrolink lines running into and out of Manchester Victoria Station. Consequently the prevailing noise environment across the site is dominated by road traffic, trains and trams, although between approx. 00:00 and 06:00 road traffic is generally dominant over rail.
- 4.1.2 Plot 4, and to lesser extent Plot 5, are also close to Gould Street which is subject to relatively high traffic flows during the daytime period and therefore is a dominant noise source at these Plots.
- 4.1.3 Other notable noise sources which are audible at Plot and Plot 5 are the substation on the north eastern side of Gould Street opposite Plot 4, and the gas pipes located further to the north east within what is currently is a car park.
- 4.1.4 To the north east of Plot 4 there is a car repair garage, which generates a small degree of noise, however this is generally not audible at the site of Plot 4, where here other significant noise

4.2 OVERVIEW

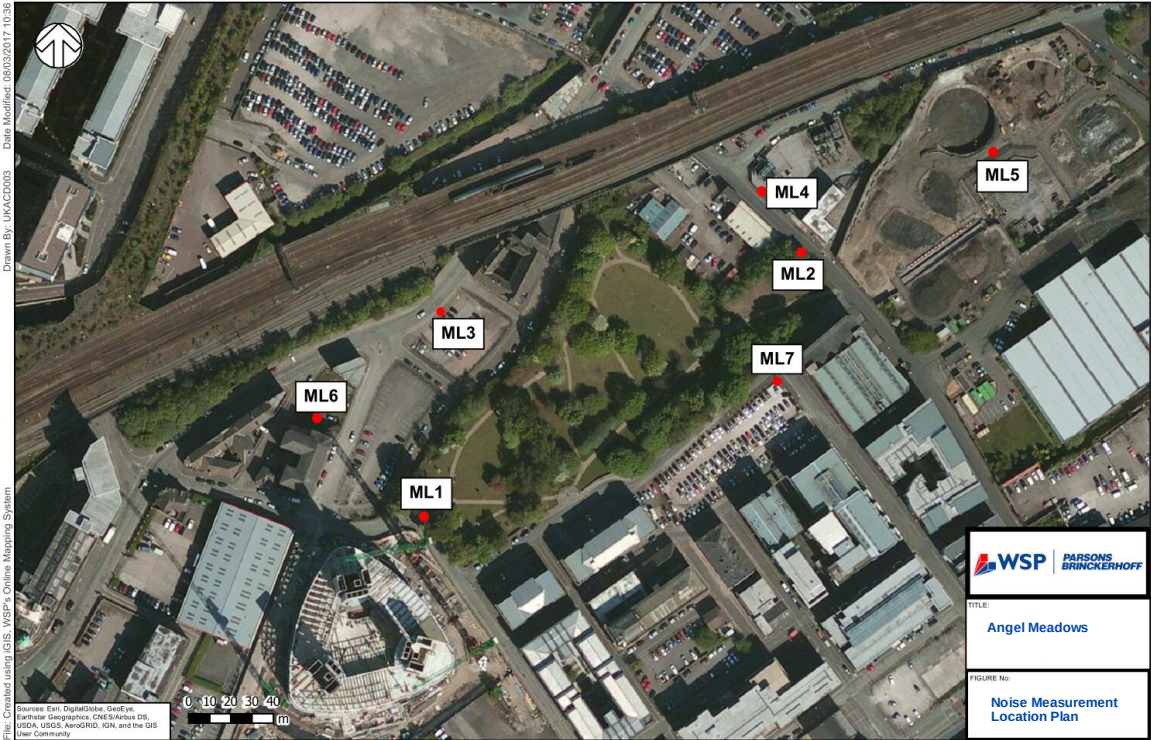
- 4.2.1 The prevailing noise environment across the site has been determined by means of a detailed baseline noise survey. The approach to the baseline noise survey was agreed during consultation with the Environmental Health Department of MCC and included both daytime (07:00 – 23:00) and night-time (23:00 – 07:00) measurements. The survey was used to determine the following:
- The levels of noise generated by road traffic movements on the Angel Street and Gould Street;
 - The noise level generated by the rail and tram movements on the lines to the north of the site;
 - The prevailing background noise levels at locations considered representative of existing noise sensitive receptors closest to the site.

4.3 NOISE MEASUREMENT LOCATIONS

- 4.3.1 Noise monitoring locations were selected such that the dominant noise sources and a sample of existing sensitive receptors were represented. The location of the measurements is shown in Figure 4 and are described as follows:
- **Measurement Location 1 (ML1)** – subject to free field conditions, approximately 1.5m above ground and 6m from the northern edge of Angel Street. Measurements were taken at this location between 10:15 and 13:15 on 19th January 2017, such that daytime road traffic noise levels generated from traffic on Angel Street could be determined in accordance with the shortened measurement procedure detailed within the Calculation of Road Traffic Noise memorandum (1988). A further measurement was undertaken between the hours of 06:00 and 07:00 on 21st February so as to determine the noise levels during what is considered to be the loudest hour of the night time. The background sound level measured at ML1 is also considered to be representative of noise sensitive receptors located to the west of the site;

- **Measurement Location 2 (ML2)** – subject to free field conditions, approximately 1.5m above ground and 4m from the southern edge of Gould Street. Measurements were taken at this location between 11:00 and 13:00 on 24th January 2017, such that daytime road traffic noise levels generated from traffic on Gould Street could be determined in accordance with the shortened measurement procedure detailed within the Calculation of road Traffic Noise memorandum (1988). A further measurement was undertaken between the hours of 06:00 and 07:00 on 21st February so as to determine the noise levels during what is considered to be one of the loudest hours of the night time;
- **Measurement Location 3 (ML3)** – subject to free field condition, approximately 12m above ground level at the boundary of the car park currently on the site of Plot 3. The height of this monitoring location was approximately level with the railway, and representative of the location where the façade of the residential block proposed for Plot 3 will be located. A measurement was undertaken for a 1 hour period between 07:00 and 08:00 on 3rd February 2017. This is considered to represent the loudest daytime hour (rush hour) due to the frequency of train and tram movements. This location is also considered representative of background sound levels at the Ragged School. It has not been possible to measure at other times of the day due to ongoing, and noisy, road works (gas main) taking place on Dantzic Street;
- **Measurement Location 4 (ML4)** – subject to free field conditions, 1.5m above the ground, on the pavement on the northern edge of Gould Street immediately adjacent to the fence surrounding the electricity substation. A measurement of 2 minutes duration was taken, during which time no car, train or tram pass-bys occurred and therefore noise from the substation was the only significant noise source. The noise from the substation was sufficiently consistent to assume the results of the measurement are representative of all times. The measurement was undertaken at 15:20 on 19th December 2016;
- **Measurement Location 5 (ML5)** – Subject to free field conditions approximately 1.5m above the ground and 10m away from the gas pipe compound within the car park to the north west of Plot 4. A 10minute measurement was taken at 12:00 on 20th December 2016. The proximity to the gas pipes (noise source) combined with the noise level of the gas pipe's noise emissions meant no other noise source was audible at this location, and it has been assumed that the noise from the gas pipes remains consistent throughout the day and night. The measurement was undertaken at 11:00 on 20th December 2016.
- **Measurement Location 6 (ML6)** – subject to free field conditions, approximately 1.5m above the ground level and representative of the background level experienced at noise sensitive receptors to the north of the site. A series of short term attended measurements were undertaken in order to determine the background sound levels at the quietest periods of the day and night. Daytime measurements were taken between 07:10 to 08:10, and 22:00 to 23:00 on 26th January 2017. Night-time measurements were taken between 23:00 to 00:00 on 26th January 2017 and between 01:50 to 02:05, and 02:30 to 02:45 on 21st February 2017.
- **Measurement Location 7 (ML7)** – subject to free field conditions, approximately 1.5m above ground level at the north east corner of the existing car park to the south of the site. A series of short term attended measurements were undertaken at what are considered to be the quietest period of the daytime and night-time. Daytime measurements were taken between 12:30 and 13:30 on 19th December 2016, 08:20 to 08:50 and 09:40 to 10:10 on 20th December 2016. Night-time measurements were taken between 01:30 to 04:46 and 02:11 to 02:26 on 21st February 2017. The background sound at this location is considered to be representative of noise sensitive receptors to the south of the site.

Figure 4 - Noise Measurement Location Plan



EQUIPMENT	MAKE AND MODEL	SERIAL NUMBER
Calibrator	01 dB-Stell CAL 21	50441999

4.4.2 All sound level meters had been calibrated to traceable standards within the preceding 2 years, with the handheld calibrators being calibrated within the previous 12 months. Each measurement system was calibrated with a hand held calibrator at the beginning and end of the survey. No significant measurement drift occurred at any time.

4.5 ENVIRONMENTAL NOISE SURVEY RESULTS

4.5.1 The measurement results from ML1, ML2 and ML3, ML4 and ML5 were all used to determine the noise levels from the dominant noise sources at the site, and in turn inform the calibration of the noise model. Summaries of the results from these locations are provided in Table 4-2 and Table 4-3.

Table 4-2 - Summary of Measured Daytime Noise Levels at ML1 and ML2

LOCATION	START TIME	PERIOD	DURATION	L _{A10,3hr}	L _{Aeq,16hour}
ML1	11:16 19/01/2017	Daytime (07:00 – 23:00)	3 hours	72.1	69.1
ML2	10:55 24/01/2017	Daytime (07:00 – 23:00)	3 hours	68.8	65.8

Calculated based on measured L_{A10,3hr} value. CRTN states that L_{A10,18hr} road traffic noise level is approximately equal to the L_{A10,3hr} level minus 1 dB, whilst PPG24 stated that the L_{Aeq,16hr} road traffic noise level is approximately equal to the L_{A10,18hr} level minus 2 dB. Both corrections applied

4.4 MEASUREMENT EQUIPMENT

4.4.1 The survey was undertaken using the Type 1 specification sound level monitoring equipment detailed within Table 4-1.

Table 4-1 - Noise and Vibration Measurement Equipment

EQUIPMENT	MAKE AND MODEL	SERIAL NUMBER
Sound Level Meter	01dB-METRAVIB Solo Master	65704
Pre-amplifier	01dB-Stell PRE 21 S	16925
Microphone	Microtech Gefell GmbH MCE212	153382
Calibrator	01dB-Metravib Cal 21	34134167
Sound Level Meter	01 dB CUBE	10621
Pre-amplifier	Acoem PRE 22	10635
Microphone	GRAS 40CD	207269
Calibrator	01 dB-Metravib CAL 21	34344463
Sound Level Meter	01 dB CUBE	10629
Pre-amplifier	Acoem PRE 22	10563
Microphone	GRAS 40CD	161937
Calibrator	01 dB-Metravib CAL 21	34344462
Sound Level Meter	01 dB-Metravib DUO	10330
Pre-amplifier	01 dB Metravib PRE 22	10219
Microphone	GRAS 40CD	141157

Table 4-3 - Summary of Measured Noise Levels at ML1 - ML5

LOCATION	L _{Aeq}	L _{eq} OCTAVE BAND CENTRE FREQUENCY (Hz), LINEAR LEVELS										L _{AMAX,F}
ML1*	69.1	69.1	74.7	69.1	66.3	63.9	65.9	61.3	55.1	48.4		74.7**
ML2*	65.8	67.2	72.0	65.1	60.9	60.5	62.2	58.6	52.7	53.9		73.9**
ML3	66.3	72.0	72.3	68.7	65.9	62.7	62.9	56.6	47.8	40.5		76.0 Train*** 72.1 Tram***
ML4	65.0	65.6	69.9	71.8	60.1	58.3	62.1	57.3	49.3	43.5		N/A
ML5	70.7	62.0	61.2	56.0	53.6	53.5	61.9	65.5	65.8	58.5		N/A

* L_{Aeq} derived as shown in Table 4-2, with measured octave band spectrum adjusted accordingly.
** L_{AMax,F} taken to be 97th percentile value from the 06:00 to 07:00 measurement period.
*** Derived by considering average L_{max} noise levels during distinct train and tram pass by events where minimal contribution from other noise sources was present.

4.5.2 The measurement results from ML1, ML3, ML6 and ML7 have been used to establish background noise levels representative of existing noise sensitive receptors near the site. A summary of the results from these locations is presented in Table 4-4, including octave band level information to allow the determination of the fixed plan noise level limits in accordance with MCC requirements.

4.5.3 Given the relatively short term, but targeted, nature of the background survey, the levels presented in Table 4-4 are the average noise levels of all the measurements taken at each respective location for the relevant period i.e. daytime and night time.

Table 4-4 - Summary of Measured Background Noise Levels, LA90 (dB)

LOCATION	PERIOD	LA90,T	L90 OCTAVE BAND CENTRE FREQUENCY (Hz), LINEAR LEVELS								
			31.5	63	125	250	500	1k	2k	4k	8k
ML1	Daytime	59	65	67	60	55	53	55	50	41	28
ML3	Daytime	58	64	64	59	56	54	54	49	39	26
ML6	Daytime	53	61	62	56	50	48	49	43	34	19
	Night-time	43	50	50	51	41	39	37	34	26	15
ML7	Daytime	52	60	61	55	50	47	48	43	39	27
	Night-time	44	49	52	59	42	39	37	32	26	14
Calculated based on measured LA10,3hr value. CRTN states that LA10,18hr road traffic noise level is approximately equal to the LA10,3hr level minus 1dB, whilst PPG24 stated that the LAeq,16hr road traffic noise level is approximately equal to the LA10,18hr level minus 2dB. Both corrections applied.											

5 NOISE MODELLING AND INCIDENT NOISE LEVELS

5.1 3D COMPUTER BASED NOISE MODELLING

5.1.1 The results of the environmental noise surveys have been used to generate a 3D computer based noise model of the development proposals in order to determine the noise levels expected across the façades of the development.

5.1.2 The following assumptions have been made in the generation of the noise model:

- The noise model was set up to apply the noise prediction methodology set out in ISO 9613-2: *Acoustics – Attenuation of Sound propagation outdoors – Part 2: General Method of Calculation*;
- In general, the ground absorption for the model has been set to $G=1$. Tarmacked and concrete areas have been modelled as $G=0$;
- The existing topography of the site and the surrounding land has been taken into account;
- The model was set to include up to second order reflected noise from solid structures;
- The model has taken into consideration the layout of existing building surrounding the site as well as the proposed development building layout.

5.1.3 The noise model has been used to predict the daytime (07:00-23:00) and night-time (23:00 – 07:00) $L_{Aeq,T}$ noise levels as well as the typical night-time L_{AFmax} noise levels across the full building envelope at every level and on each façade in each octave band from 63 Hz to 8 kHz.

5.2 NOISE MODELLING RESULTS

5.2.1 The Figures below show the results provided by the 3D computer based acoustic model. Predicted incident daytime (07:00 – 23:00) and night time noise levels (23:00 – 07:00) are presented for each façade of each building block.

Figure 5 - Northern View – Daytime (07:00 – 23:00) L_{Aeq} (dB)

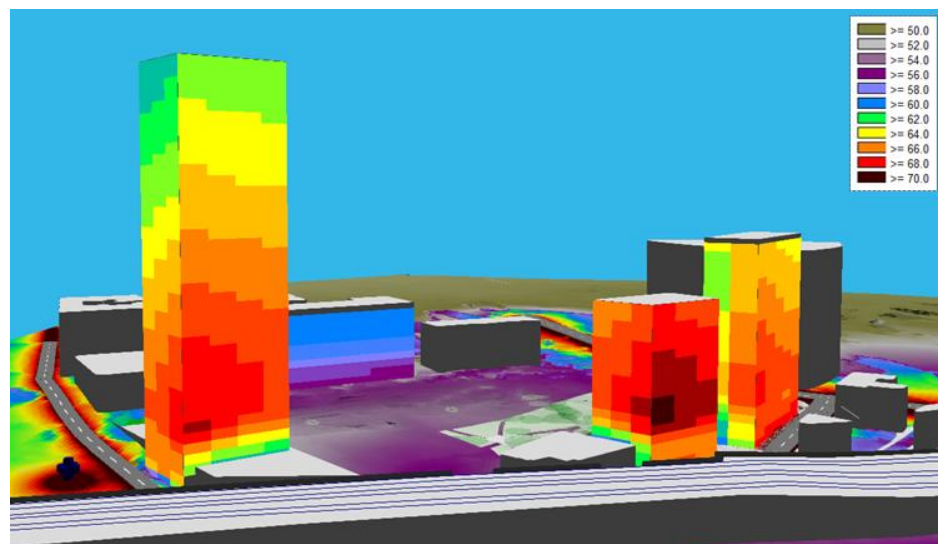


Figure 6 - Southern View – Daytime (07:00 – 23:00) L_{Aeq} (dB)

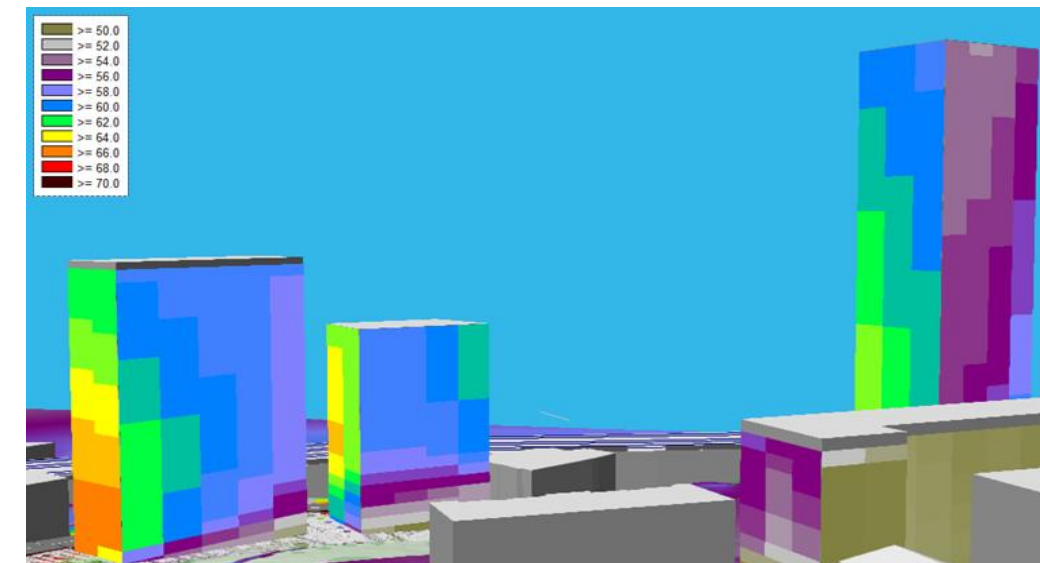


Figure 7 – Northern View - Night time (23:00 – 07:00) L_{Aeq} (dB)

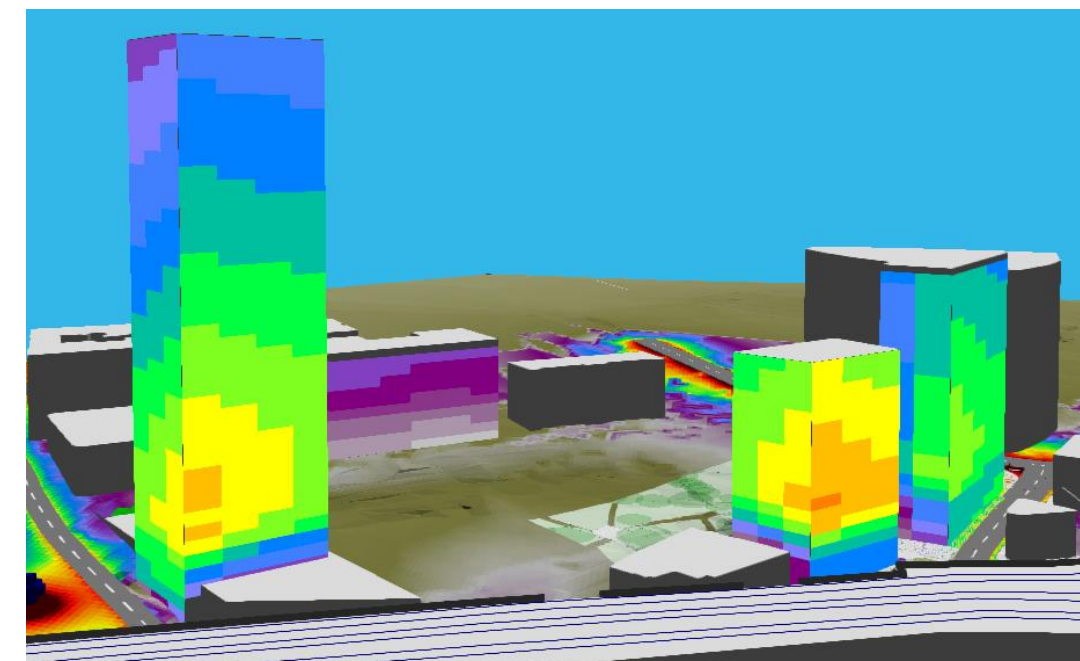


Figure 8 - Southern View – Night time (23:00 – 07:00) LAeq (dB)

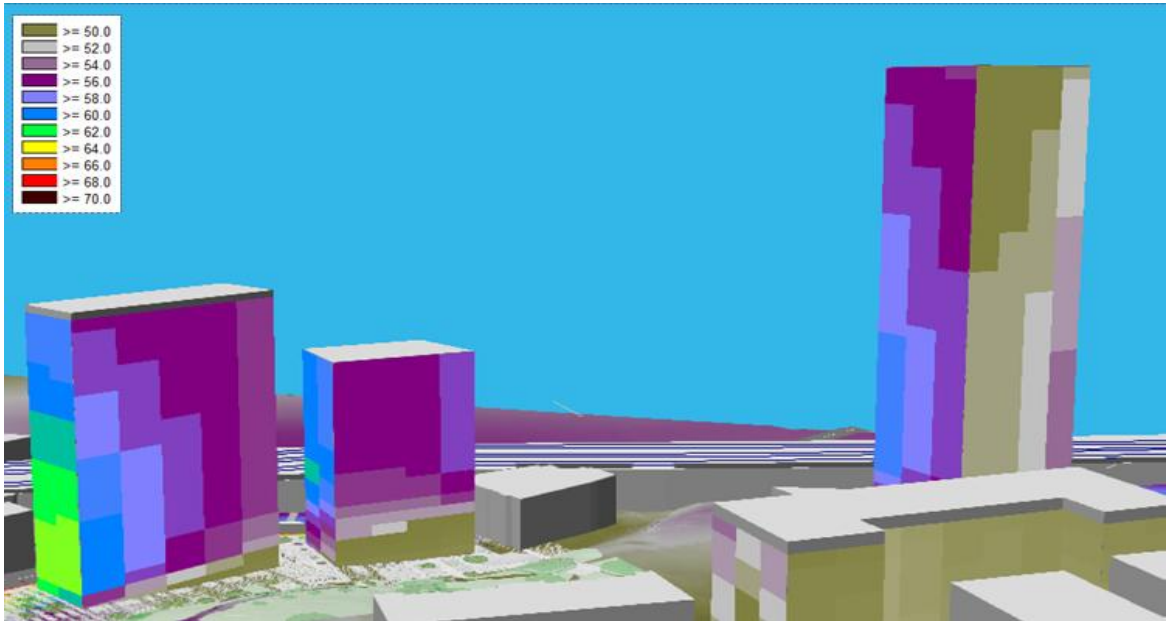
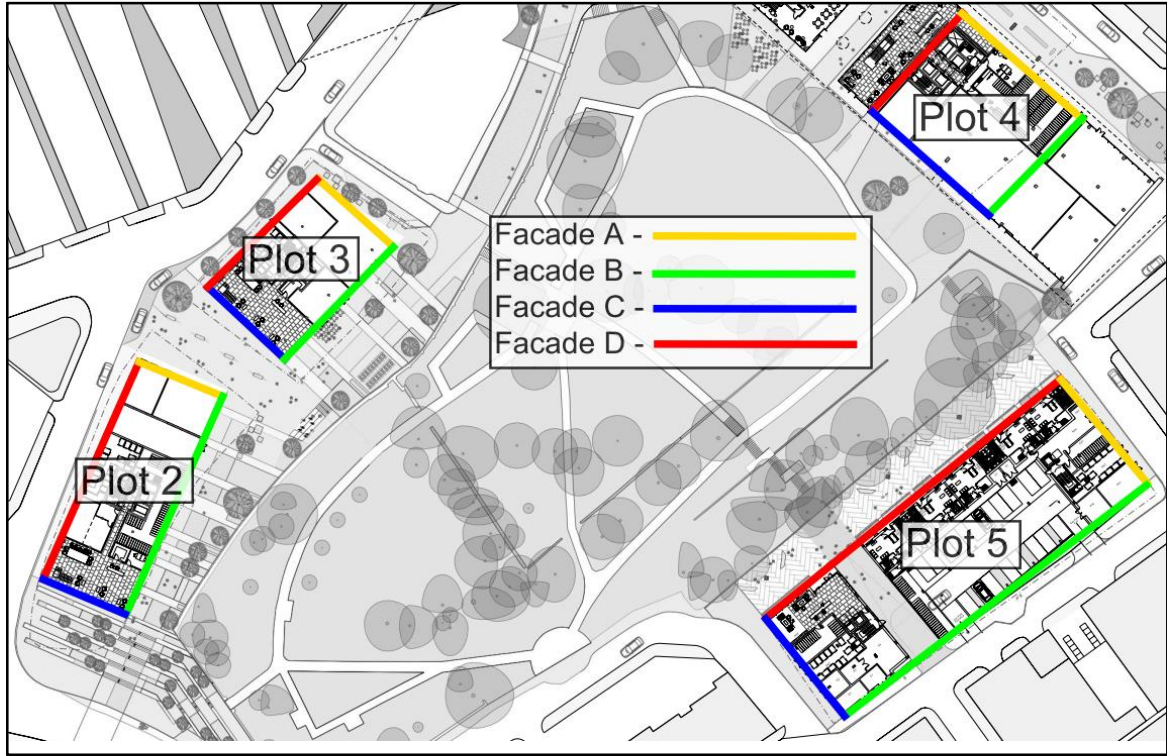


Table 5-1 - Predicted Free-Field Façade Noise Levels Predicted to be incident on the Façades of each Residential Building, dB

PLOT	FAÇADE	DAYTIME (07:00 – 23:00)	NIGHT-TIME (23:00-07:00)	TYPICAL NIGHT-TIME MAXIMUM NOISE LEVELS, L _{AMAX}
		L _{AEQ,T}	L _{AEQ,T}	
Plot 2	A	64-67	58-62	65-73
	B	59-62	56-59	59-66
	C	62-66	58-63	59-68
	D	65-68	60-63	65-73
Plot 3	A	61-68	55-64	65-76
	B	52-60	48-56	45-64
	C	60-64	54-60	64-72
	D	66-70	61-65	71-77
Plot 4	A	61-67	57-64	67-74
	B	55-58	51-53	55-63
	C	56-63	53-59	66-72
	D	63-68	59-64	67-76
Plot 5	A	52-58	49-54	61-65
	B	43-44	40-41	41-45
	C	51-56	48-53	59-64
	D	56-60	53-56	61-65

5.2.2 The calculated noise levels are presented in the Table 5-1 for each façade referenced in Figure 9 below. Note that noise levels are provided as free-field noise levels and only the resultant broadband, LAeq,T and LAFmax, A-weighted noise levels are shown.

Figure 9 – Façade References



5.2.3 The external noise levels predicted on the façades of the development have been used to determine the requirements for the external building fabric presented in Section 6 below.

6 EXTERNAL BUILDING FABRIC

6.1 FACADE REQUIREMENTS

6.1.1 The level of sound insulation afforded by the façade system as a whole is one of the key performance requirements, particularly for the glazed and spandrel panel elements which will comprise the majority of surface area.

6.1.2 Based on the results of the noise modelling exercise presented in Section 5 and the internal noise criteria for residential dwellings presented in Section 3.2, Table 6-1 provides the minimum required sound insulation performance to be achieved by the external facades (as referenced in Figure 9), including an indicative glazing configuration capable of meeting the specification, further details of which are included in Table 6-1.

Table 6-1 - Minimum Required Sound Reduction Indices

PLOT	FACADE	SOUND REDUCTION INDEX REQUIRED AT OCTAVE BAND CENTRE FREQUENCIES (HZ)						INDICATIVE GLAZING CONFIGURATION
		125	250	500	1000	2000	4000	
Plot 2	A	16	28	36	43	39	30	Type 2
	B	11	22	31	38	36	28	Type 1
	C	14	25	35	43	40	34	Type 2
	D	16	28	36	43	39	29	Type 2
Plot 3	A	19	31	39	45	41	31	Type 3
	B	11	22	29	36	31	20	Type 1
	C	15	27	35	41	37	28	Type 3
	D	18	30	38	44	40	31	Type 3
Plot 4	A	16	27	36	42	39	30	Type 2
	B	8	17	26	32	29	21	Type 1
	C	12	24	32	38	33	21	Type 1
	D	16	28	36	43	38	28	Type 2
Plot 5	A*	10	21	30	36	32	20	Type 1
	B-D	16	28	36	43	39	30	Type 2

Notes:

* Noise levels sufficiently low for glazing type not to be a significant i.e. IANL is predicted to be achieved with windows open.

Performance at 63Hz typically falls outside the testing range for accredited sound testing laboratories. However it is recommended that the 63Hz performance is no greater than 3dB below the 125Hz performance.

Table 6-2 - Indicative Glazing Configuration Sound Insulation Performances

INDICATIVE GLAZING TYPE	OCTAVE BAND CENTRE FREQUENCY (HZ)							R _w	R _w +C _{TR}	CONFIGURATION (GLASS/AIRGAP/GLASS)
	125	250	500	1k	2k	4k	8k			
Type 1	24	22	29	39	33	38	32	32	29	6mm/12mm/6mm
Type 2	24	27	36	47	49	53	47	40	34	4mm/16mm/8.8Amm
Type 3	24	31	41	46	46	59	53	42	36	8mm/16mm/10.8Amm

NB 'A' denotes Acoustic Laminate glass

6.1.3 It should be stressed that the glazing configurations in

6.1.4 Table 6-2 are provided for initial guidance/costing purposes only. Other glazing configurations could be used if preferred, providing that they meet the required numerical (dB) sound insulation performance specification in Table 6-1.

6.1.5 The minimum sound reduction indices presented in Table 6-1, are based on the proposed room dimensions and glazed areas for worst case bedrooms on each façade. They apply to glazed elements of the façade and are based on the assumption that the solid sections of the façade will be internally lined with 2 layers of 15mm plasterboard, and as such will have an acoustic performance at least 10dB above that of the glazing alone

6.1.6 The performance specifications in Table 6-1 are based on the most onerous requirement for each façade, both in terms of floor level and time of day. In all cases where there are bedrooms on a façade, the requirement is driven by the night-time L_{Aeq}, however the daytime L_{Aeq} is only marginally lower and therefore consideration of bedroom and living room façade separately has not been considered.

6.1.7 Due to the height of the railway lines above ground, the most onerous assessment location is generally at Levels 4-6. For Plots 2, 3 and 5 the vertical distribution of noise levels is between 1-3dB lower than the most onerous requirement (with noise levels reducing with height). This is not considered to be a significant enough difference to warrant consideration of different glazing for different floor levels.

6.1.8 With regards to Plot 4, noise levels above Level 30 are generally around 5dB lower than those at Level 5 (the loudest floor level). This magnitude of reduction would be the point at which different glazing may become a viable cost saving measure, but this would have to be considered together with the potential changes in frame sizing, the logistics surrounding installation of several different glazing configurations within the same façade and the potential for the glazing to look different from other parts of the façade (i.e. due to different refractive indices etc) from the ground. Further details regarding performance relaxations for higher levels can be provided at a later stage however if required.

6.1.9 The performance requirements shown in Table 6-1 are based on a reverberation time of 0.8 seconds for each apartment and guestroom, which is considered typical for a finished and furnished apartment. Unfurnished apartments could be expected to have to have longer reverberation times which would result in a marginally increased internal ambient noise level observed in the apartments. This should be taken into consideration if internal ambient commissioning noise level measurements are conducted within the development prior to handover and occupation when room furnishings are unlikely to be present.

6.1.10 Details of the external cladding are still being developed and therefore calculations have been based upon an overall sound insulation performance which all components of the external façade will be required to achieve (glazing, spandrel panels, patio doors etc). As the design progresses, and further details regarding the spandrel panels, doors etc are developed, the performance requirements of the glazed elements specifically will be continually reviewed to ensure that the glazing requirements are not un-necessarily high. It should be noted however that due to the large proportion of glazing present a significant reduction in performance specification is not considered likely.

6.1.11 On this basis, all elements of the external cladding system will need to be designed to provide at least the same sound insulation performance specified for the glazing in each octave band.

6.2 FLANKING SOUND INSULATION

- 6.2.1 The façade should provide a sound flanking performance of at least 49 dB $D_{nfw} + C_{tr}$. This performance need to be achieved where the façade construction is continuous past any separating wall or floor construction.

6.3 DEMONSTRATION OF COMPLIANCE (AIRBORNE SOUND INSULATION)

- 6.3.1 The cladding supplier will be required to demonstrate compliance with the specifications herein, by providing technical submittals based on test results for similar constructions and calculations. The evidence submitted to the design team must be sufficient to demonstrate to all parties that the relevant specifications will be achieved on-site. If significant doubt exists over any aspect of the evidence submitted, allowance should be made for factory testing in order to demonstrate compliance.
- 6.3.2 It is important that test results have been obtained in accordance with BS EN ISO 10140-2:2010 *Acoustics – Laboratory measurement of sound insulation of building elements -- Part 2: Measurement of airborne sound insulation* and that the quoted minimum sound reduction specifications are achieved by the panels, windows and doors within windows, including frames, seals, etc. Glass performance alone is not an acceptable means of demonstrating compliance with the specification for window performance.
- 6.3.3 The minimum sound reduction indices specified are required to ensure that levels of road traffic and rail noise intrusion are controlled to meet the design criteria. It is the responsibility of the glazing system supplier/manufacturer to ensure that these performances are achieved as installed on site, and that the systems proposed for this project are therefore selected in order to achieve this.
- 6.3.4 Test results should be in 1/3 octaves from at least 100 Hz to 3150 Hz inclusive, in order to allow detailed further calculations to be undertaken. Data must be representative of the design proposals for the relevant façades as set out in the specifications below. This shall include glass, framing, seals, opening lights, etc. The results from the tests should be converted into octave band values by the method approved in the above test document.

6.4 NOISE INTRUSION TO EXTERNAL AMENITIES

- 6.4.1 Terrace areas enclosed by the building façade/glazing will benefit from the sound insulation afforded by the glazing system, and given this will be uniformed and designed so as the more onerous internal noise levels can be achieved, the noise levels at the internal terraces are predicted to be under the daytime criteria of $L_{Aeq,16hour}$ 55 dB presented in Section 3.2.
- 6.4.2 Noise levels at the location of the external terraces are the generally the lower value shown in the range for each respective façade in Table 5-1.
- 6.4.3 BS 8233 provides guidance on external amenity spaces such as balconies, roof gardens and terraces or areas where external space is limited. In these locations, where the space maybe used for drying washing, storing bicycles or growing plants, then noise limits should not normally apply. Larger balconies however, where the intended use is for relaxation, can be designed to achieve the 55 dB $L_{Aeq,16hour}$ criterion through careful building design and the use of screens and this can be considered at the later design stages.
- 6.4.4 The sound level reductions that these mitigation measures could offer cannot be quantified precisely. However, based on the principle that partial screening of a noise source from the receiver location can offer up to 5 dB in attenuation, levels of between 51-56 dB $L_{Aeq,T}$ could be achieved at Plot 5 balconies, and levels of between 54-62 dB $L_{Aeq,T}$ could be achieved at the terraces within Plot 2 and Plot 3.

7 INTERNAL BUILDING FABRIC

7.1 BUILDING STRUCTURE

7.1.1 A concrete structural frame construction is proposed for each Plot, with the concrete understood to be solid (notwithstanding reinforcement) and with a minimum density of 2400 kg/m³. The floor constructions for each Plot are as follows:

Plot 2

- Ground Floor (Level 00): 250mm thick reinforced concrete slab
- Level 01 to Level 20: 200mm thick reinforced concrete slab

Plot 3

- Ground Floor (Level 00): 250mm thick reinforced concrete slab
- Level 01: 200mm thick reinforced concrete slab
- Level 02: 250mm thick reinforced concrete slab
- Level 03 to Level 15: 200mm thick reinforced concrete slab

Plot 5

- Ground Floor (Level 00): 250mm thick reinforced concrete slab
- Level 01 (townhouses only): 225mm thick reinforced concrete slab
- Level 02 to Level 11: 200mm thick reinforced concrete slab

7.2 PARTY FLOORS BETWEEN RESIDENTIAL APARTMENTS

7.2.1 The floor construction separating any residential apartments is required to provide an airborne sound insulation performance between vertically adjacent apartments of at least 50 dB $D_{nT,w} + C_{tr}$ and a standardised impact sound level of less than 57 dB $L_{nT,w}$.

7.2.2 In addition to the above requirements, it should be noted that the proposed floor construction will be continuous between horizontal adjacent apartments above and below the partition construction. This will create a potential sound flanking path between apartments which will need to be controlled. Therefore in addition to considering the sound insulation performance achieved between vertically adjacent apartments provided by the separating floor construction it is also necessary to consider flanking sound insulation performance provided by the concrete floor construction between apartments. Where the concrete floor construction is continuous above and below party wall constructions, it is recommended (in accordance with Approved Document E) that the concrete floor provided a mass per unit area of 365 kg/m² in order to control sound flanking.

7.2.3 The proposed floor constructions result in there being a minimum of 200mm thick reinforced concrete slab between all apartments. In residential apartments this will be underdrawn with a plasterboard ceiling, and will have an acoustic resilient layer above.

7.2.4 Based upon the minimum thickness of 200mm and a density of 2400 kg/m³, the floor slab should be capable of meeting the recommended minimum mass per unit area to control flanking sound transmission.

7.2.5 In order that floor construction is capable of meeting the impact sound insulation performance of less than 57dB $L_{nT,w}$, a resilient floor covering is required to be installed which must meet the following specification:

- Any resilient material, or material with a resilient base, with an overall uncompressed thickness of at least 4.5mm; or
- Any floor covering with a weighted reduction in impact sound pressure level (ΔL_w) of not less than 17dB when measured in accordance with BS ISO 140-8:1998 and calculated in accordance with BS EN ISO 717-2:1997.

7.2.6 A product such as Regupol 4515 4.5mm (which has been indicatively proposed and discussed during Stage 3) would be a suitable product capable of meeting the acoustic performance requirements.

7.2.7 For privately owned properties, there is a risk that future occupants could remove and replace any installed resilient layer which could result in the concrete floor not complying with the impact insulation requirement. To avoid this, the following measures shall be implemented:

- The resilient layer should be separate to the proposed finished floor
- The resilient layer must be bonded to floor slab to reduce the risk of being removed by future residents
- The words "Do Not Remove" (or similar) shall be printed onto the upper surface of the resilient layer
- The lease document shall state a clause that the resilient layer is not to be removed or if it is removed a new resilient layer meeting the above specification must be installed.

7.2.8 It should be noted that the requirement for resilient layers only apply to occupied floor spaces located directly above apartments. This requirement will therefore apply to the entire floor area of each residential apartment in the following locations:

- **Plot 2** – Entire floor area of apartments on Levels 02 and above
- **Plot 3** – Entire floor area of apartments on Levels 04 and above, and within the Private Dining room on Level 02. The Gym area on Level 02, will need additional and enhanced floor treatment, and is discussed in Section 7.3.1.
- **Plot 5** – Entire floor area of all apartments on Level 02 and above.

7.2.9 Given that the corridors are generally immediately adjacent to apartments along their entire length, despite not being directly above apartments it is recommended that the same resilient layer be applied to corridor areas.

7.2.10 Although the apartments on Level 01 of Plots 2 and 3, and Level 03 of Plot 3, are not located above other apartments either, a resilient layer is still recommended to be installed in these areas in order to both limit the impact noise experienced by users of the spaces beneath and also to enhance (albeit marginally) the airborne sound insulation performance of the floor construction.

7.2.11 The suspended ceiling should comprise a minimum of one layer of 15mm dense plasterboard on an MF grid with a minimum depth of 150mm including 50mm mineral fibre insulation (20–40 kg/m³ density).

7.2.12 Downlighters or recessed lighting may be installed in the ceilings of apartments:

- In accordance with the manufacturer's instructions
- At no more than one light per 2 m² of ceiling area in each room
- At centres of not less than 0.75 metres
- Into openings not exceeding 100 mm diameter or 100 x 100 mm.

7.2.13 If any of the above conditions are not met, some of the services will need to be fitted with acoustic hoods, and will be assessed on an individual basis.

7.2.14 Additional information regarding recessed lighting can be found in Building Regulations Approved Document B – Fire Safety.

7.3 SEPARATING ELEMENTS BETWEEN RESIDENTIAL APARTMENTS AND NON-RESIDENTIAL AREAS

7.3.1 The noise level in the majority of non-residential spaces is not expected to be sufficiently high to warrant significant floor build up enhancements, as the intervening slab, combined with the floor coverings is expected to be sufficient to control noise transfer to the residential areas. The following areas however will need varying degrees of additional treatment

Generator Rooms (Plot 3 and Plot 5)

- Although the generators will only be used in emergency situations, they will each be periodically tested for durations expected to be between 1-2 hours during the middle of the daytime period. On this basis the generator rooms Plots 3 and 5, will require a resiliently suspended (on spring hangers) mass barrier ceiling comprising three layers of minimum 12.5mm dense plasterboard with a minimum 200mm cavity, minimum 100mm of insulation in the cavity
- The room should also have independently lined walls which could be built off the slab.
- The ceiling requirements above should also apply to any rooms through which ducting to/from the generator is routed (i.e. the adjacent switch rooms), where the ceiling should be installed above the ducting.

Generator Rooms (Plot 2)

- As for Plots 3 and 5, a resiliently suspended mass barrier ceiling comprising three layers of minimum 12.5mm dense plasterboard with a 200mm cavity will be required.
- On account of the generator room in Plot 2 being adjacent to a structural sheer wall, separating it from the commercial unit, the generator should be mounted on a floating slab which should be minimum 100mm thick itself and have a minimum 75mm air cavity beneath.
- The room should also have independently lined walls which should be built off the floating slab, which with the ceiling, will form a box-in-box arrangement.
- The wall linings shall have a total mass per unit area of 30kg/m². For example this may comprise one layer of 25mm shaft liner (20.5kg/m²) and one layer of 13mm fire rated plasterboard (10kg.m²).
- A minimum of two linings shall be used to achieve the total mass per unit area requirement, and shall be installed with staggered joints. Seal all joints of each board layer and between the base of the linings and the structural slab using a continuous bead of non-hardening mastic or other detail acceptable to the client's representative.
- The above measures are also expected to control noise transfer to the horizontally adjacent Commercial space to an acceptable level during the running of the generator.

Gym on Level 02 (Plot 3)

7.3.2 The use of gym equipment, including weights and running machines, is well known to produce structure-borne vibration, which can manifest itself as either tactile vibration or re-radiated sound in adjacent noise sensitive areas. The following measures are therefore recommend for the Gym area:

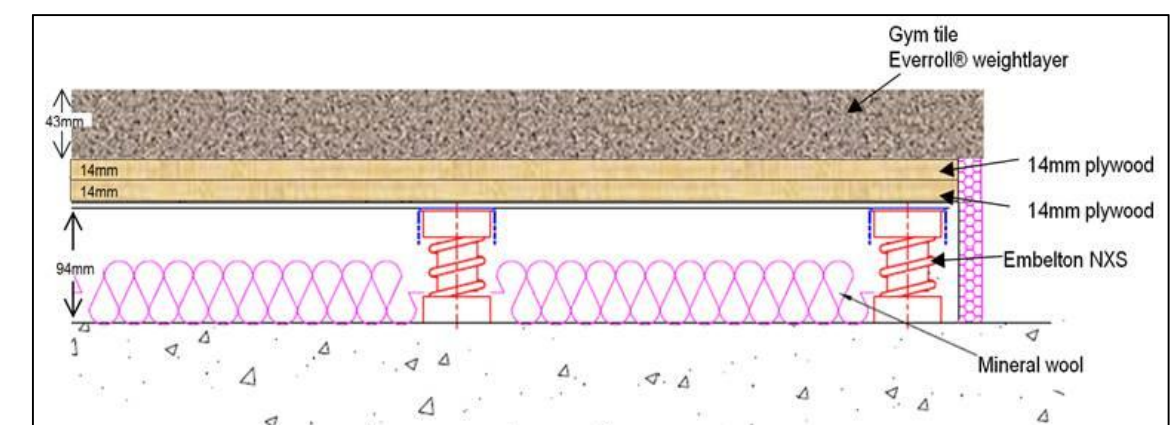
- Floating Slab for Aerobic Gym Areas: Out of all aerobic exercise activities, running machines generally produce the most vibration. The use of running machines typically produces vibration between 2.5 Hz and 3.2 Hz, for normal and fast running speeds, respectively. It is recommended that a floating floor is installed throughout the gymnasium area. The floating element should achieve a minimum mass of 300kg/m². The void should be a minimum of 100mm and should be fitted with 50 mm mineral fibre insulation. In order to provide adequate isolation, and to damp vibration with the isolation system, it is recommended that the floating slab be supported on damped helical springs (e.g. the damped spring NXS-14 supplied by Embelton).

7.3.3 In areas where drop weights are proposed, the upper floor finish must consist of a thick rubber mat, providing the following minimum specifications:

- 'Force reduction' rating of at least 40%;
- Impact resistance of at least 15 Nm;
- Impact sound improvement rating of at least 20 dB L_w.
- Suitable products include Everroll Weightlayer, available from BSW GmbH, which has a thickness of 43 mm. These recommendations are in addition to the floating slab described above.

7.3.4 Although a concrete floating slab is recommended underneath any area where free weights are used, within other areas of the gym the floating element (above the springs) could be formed from a lighter weight construction to reduce the static load placed on the slab. Such a floor could comprise 2No layers of 14mm ply with a rubberized gym floor finish on top of the same damped springs as above, as shown in Figure 10.

Figure 10 Indicative light weight floor build up for Gym (excluding free weights areas)



7.3.5 It is necessary for all final proposals for the raised floor to be verified by the acoustic consultant, to ensure that the natural frequency of the access floor does not serve to amplify vibration energy produced by the gym equipment.

Commercial Space to Residential Apartments

- 7.3.6 The level of sound insulation required from the floor constructions separating the various ground level commercial spaces and the proposed apartments above will be dependent on the noise levels generated within each of the commercial spaces.
- 7.3.7 The tenants, or indeed the final usage classes, of the commercial spaces are not yet defined and it is therefore appropriate to consider several scenarios, when determining the measures required to limit the noise transfer to dwellings. Noise transfer to the dwellings above should be controlled to approximately 10dB below the internal ambient noise level criteria for the dwellings i.e. 20dB L_{Aeq} at night and 25dB L_{Aeq} during the day, and on this basis the following floor constructions should be considered:
- **No additional treatment:** The sound insulation of the floor construction alone (200mm reinforced concrete slab, and resilient floor covering within the apartments above) is expected to be around 55dB R_w . This will be sufficient, providing that noise levels within the commercial spaces do not exceed around 72dB(A). It would be reasonable to assume that should the use classes of the space(s) be either A1, A2, A5, D1 or B1, the noise level would not exceed 72dB(A) and no additional sound insulation performance would be required.
 - **A suspended mass layer ceiling:** Where the use of the commercial space(s) is to be A3 or A4 (Food & Drink and Drinking Establishments) the internal noise would typically be expected to be higher than 72dB(A), and as a minimum enhancement, a suspected mass barrier ceiling would be required to the entire ceiling area of the commercial space(s), mounted to the soffit.
- Assuming the ceiling comprised 2 layers of 12.5mm dense plasterboard, suspended on a proprietary metal ceiling system giving at least a 240mm cavity containing 80-100mm of mineral wool, the sound insulation would be expected to be improved enough to permit noise levels of around 90dB(A) in the commercial space below.
- To improve the sound insulation further (approx. 5dB(A)) high deflection spring hangers could be used to suspend the ceiling from the slab. It would not be permissible to run M&E services in the ceiling cavity and as such a secondary ceiling may be required beneath the 'acoustic ceiling' to accommodate services and allow for treatments to control reverberant noise build up within the commercial space.
- **Bespoke mitigation measures based on known usage of space.** If enhancement of the floor construction is not undertaken prior to the fit out and occupation of the commercial space (or where a speculative design approach will not provide sufficient assurance of noise control), it will be necessary for the lease documentation to contain a suitable clause to ensure that the fit-out of the spaces includes provision of sufficient sound mitigation measures. After being furnished with details of the 'base construction', it would then be the commercial tenants' responsibility to ensure that the sound insulation afforded by the fitted out space was sufficient for the intended use. Where the base construction was not sufficient it would be the responsibility of the tenant to ensure appropriate enhancements were made and/or noise levels were controlled to a suitable level. The tenant's fit-out design must be reviewed and approved by the landlord's acoustic consultant prior to its implementation.

Function Room (Plot 3 Level 02)

The function room is understood to be intended for use by residents for relatively small functions e.g. dinner parties, drinks receptions etc. Such gatherings/functions would be expected to create elevated noise levels and in order to control sound transfer from the Function Room to the residential apartments above and below, the following measures are recommended:

- Resilient floor covering as per residential apartment specification (para 7.2.5)
- Mass barrier ceiling comprising 2 layers of 12.5mm dense plasterboard, suspended with resilient hangers on a proprietary metal ceiling system giving at least a 200mm cavity containing 80-100mm of mineral wool.
- The ceiling and linings must be solid and continuous and must not contain any unprotected building services penetrations.

It should be noted that the above measures are based on reasonable assumptions regarding the levels of noise likely to be generated within the Function Space. Should an exceptional number of people (talking) be present within the space or should music be played at high volumes, the above measures may not be sufficient.

In order to minimise the potential for music being played too loud it would be beneficial for any music to be played through a build in system linked to a noise limiter. This would however necessitate some form of management plan to ensure that the system was not bypassed or tampered with, or that other music systems were not introduced. It is also essential to ensure that the sound system does not require any penetrations in the ceiling, and avoids excessive noise being transmitted towards noise sensitive adjacent spaces.

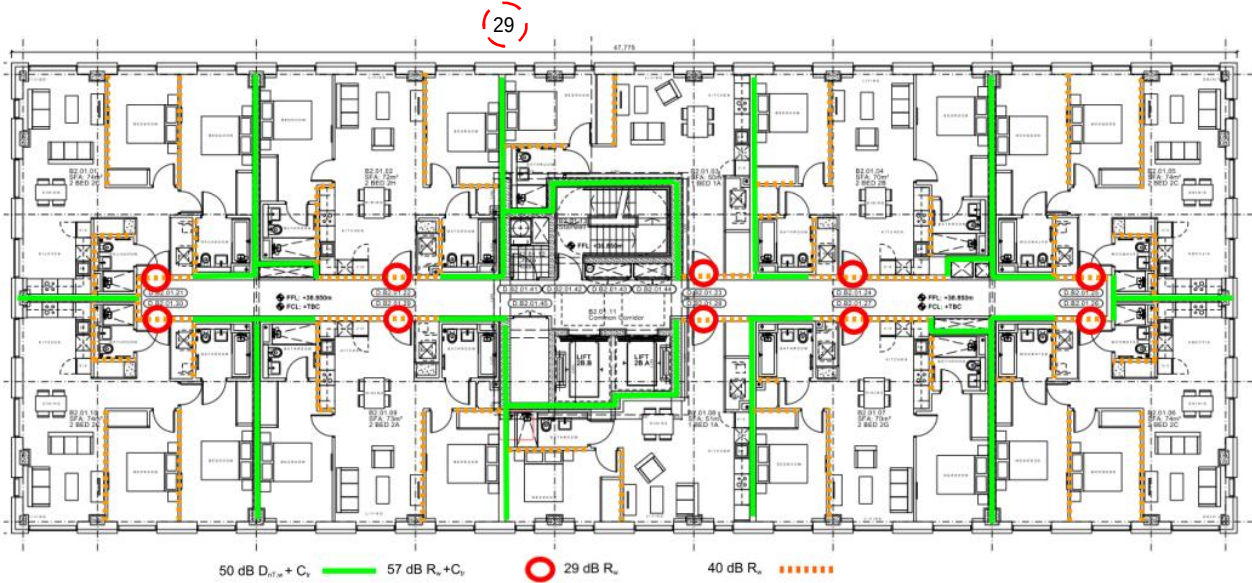
BASEMENT LEVELS - CAR PARK

- In order that the potential for vehicle-induced vibration into the structure may be minimised, it is recommended that movement joints do not occur in ramps, or between ramps and car park levels. Where this is unavoidable, any joints shall be fitted with a cover (e.g. steel plate) with resilient base that is as flush with the car park surface as possible and secured tightly. There should be no speed humps or other uneven surfaces on the suspended concrete slabs. Any covers for drainage gulleys should be firmly screwed down or sat on a neoprene base to prevent noise as vehicles pass over them.
- The car park surface should be of a brushed or tampered finish, and it is recommended that any surface finishes applied to the slabs are specified such that there is no potential for tyre squeal.

7.4 WALL CONSTRUCTIONS

7.4.1 The sound insulation requirements described in Section 3, are illustrated for a typical floor plan in Figure 11.

Figure 11 – Indicative Acoustic Mark-ups for a typical residential Floor



7.4.2 The architect, 5Plus, has developed the wall type proposals for the development based, in part, upon the minimum acoustic requirements. The main wall types proposed, together with the minimum acoustic performance rating required and example construction is provided in Table 7-1.

7.4.3 The sound insulation figures quoted for the constructions in Table 7-1 references the laboratory tested performances of the constructions, and the on-site $D_{nT,w} + C_{tr}$ performances. The difference between laboratory and in-situ performance is due to several factors including penetrations, junction detailing, pattressing, on-site workmanship and the physical and acoustical properties of the rooms either side of a partition. It is considered necessary in the case of the Angel Meadows development to allow for at least a 7dB difference between the lab tested and on-site performance, and therefore any proposed party wall construction should be rated as a minimum of 57dB $R_w + C_{tr}$ in order to achieve an on-site performance of 50dB $D_{nT,w} + C_{tr}$.

Table 7-1 – Proposed wall types and example constructions

REF	MINIMUM LABORATORY (ON-SITE IN BRACKETS) SOUND INSULATION PERFORMANCE OF PARTITION CONSTRUCTION	DETAIL	SPECIFICATION
WT-001	57 dB $R_w + C_{tr}$ (50 dB $D_{nT,w} + C_{tr}$)		2x layers of dense gypsum board (e.g. Gyproc Soundbloc) on both sides of partition - Two rows of 50mm independent C studs at max 600mm centres, and braced at max 1200mm centres 75mm mineral fibre insulation (20 – 40 kg/m³ density) within the cavity Nominal Overall Construction Width = 250mm
WT-002	52 dB $R_w + C_{tr}$ (45 dB $D_{nT,w} + C_{tr}$)		2x layers of dense gypsum board (e.g. Gyproc Soundbloc) on both sides of partition - Two rows of 50mm independent C studs at max 600mm centres, and braced at max 1200mm centres 50mm mineral fibre insulation (20 – 40 kg/m³ density) within the cavity Nominal Overall Construction Width = 200mm
WT-003	40dB R_w		1x layer 12.5mm dense plasterboard (e.g. SoundBloc), each side of 70mm metal stud frame at 600mm centres - No insulation required within the cavity.

7.4.4 To avoid confusion, only the R_w and $R_w + C_{tr}$ parameters should be included on and tender submissions. The parameters' reference suffix R_w or $R_w + C_{tr}$, as appropriate, must also be included along with the numerical performance requirement. Simple dB ratings are not appropriate.

7.4.5 In all cases, plasterboard should be installed with staggered joints. Any openings must be tailored closely to the penetrating services.

7.5 RESIDENTIAL PARTY WALLS BETWEEN DWELLINGS

7.5.1 Residential party walls will be predominantly formed by drywall constructions (WT-001) or 200mm thick reinforced concrete (lined with WT-008) which forms part of the building structure. Plot 5 and Level 01 of Plot 2 will also have some party walls comprising a combination of WT-001 and structural concrete walls. The provisions for these party wall constructions will all be capable of providing an on-site sound insulation performance of at least $50\text{dB } D_{ntw} + C_{tr}$ and therefore compliant with ADE and the enhanced performance criteria adopted for the development.

7.5.2 In the instances where WT-001 and WT-008 linings are used in conjunction with the concrete walls, it is recommended that the cavities created by the WT-008 linings are not equal either side of the concrete element. This could be achieved by the centre of the WT-001 element being offset from the centre of the concrete wall, such that the linings of the WT-001 are continued and fixed to the concrete wall leaving no cavity, and on the other side a cavity of approx. 40mm is left, which should be filled with mineral wool.

7.5.3 Irrespective of whether or not the recommended offset can be implemented, the WT-008 linings should comprise a minimum of two layers of 12.5mm dense board (e.g. Gyproc SoundBloc) two, fixed to a system such as GypLiner Universal (virtually independent), with a minimum of 25mm of mineral wool insulation in the cavity.

7.6 PARTY WALLS BETWEEN DWELLINGS AND CORRIDORS

7.6.1 The sound insulation of party walls between dwellings and circulation spaces (stairwells and corridors) are not required to perform 5dB above the minimum standard prescribed in ADE, as the proposed enhancement is a client requirement and not part of a BREEAM or Code for Sustainable Homes credit. As such these are proposed to be constructed using WT-002 wall type. This partition type is capable of providing an onsite sound insulation performance of $45\text{dB } D_{ntw} + C_{tr}$ in the absence of a door set and therefore is compliant with the requirements of ADE.

7.7 INTERNAL WALLS WITHIN DWELLINGS

7.7.1 Partitions within apartments which separate bedrooms and bathrooms from other rooms, and do not contain a door, need to be selected or designed to achieve 40 dB R_w . The latest architectural wall type drawings show internal walls typically constructed from WT-003, which will provide a minimum laboratory sound insulation performance of 40dB R_w and will therefore be compliant with the requirement of ADE.

7.8 BATHROOM PODS

7.8.1 In instances where bathroom pods are separated from other rooms, the sound insulation of the total separating wall (i.e. the pod plus additional architectural linings) should achieve the 40 dB R_w requirement, in order to meet the Building Regulations requirement. The exception to this is for walls that include the door that provides access to the bathroom.

7.8.2 On the basis that some areas of the bathroom pods will simply be lined with tiling, it is recommended that the pod construction should achieve a minimum weighted sound reduction index of 40 dB R_w without any reliance being placed on additional architectural linings. A construction such as WT-003 would therefore be appropriate and is understood to have been allowed for with respect to the partition width this would require.

7.8.3 As the pods will be separate to the party walls, they will not contribute to the sound insulation of the separating wall. In order to ensure adequate acoustic sealing of the party wall, the party wall must be fully installed before the pod.

7.8.4 In order to maintain the impact sound insulation of the entire apartment, including the bathroom area, the bathroom pod should either have a resilient layer as part of its floor build up, or the pod should be installed on top of the resilient layer installed across the wider apartment floor plate. It is noted that the bathroom pods represent significant loads compared to those normally imposed on resilient layers, so details of this are expected to require checking once a pod manufacturer is chosen.

7.9 LININGS TO LIFT AND MAIN MECHANICAL RISER CORES

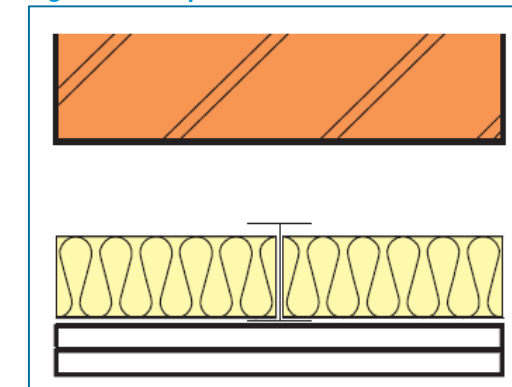
7.9.1 The walls to service risers are required to control noise from services within the riser to control sound flanking transmission between apartments via the service riser void. It is recommended that a wall construction with a capability of providing a sound insulation performance of at least 47 dB R_w is incorporated.

7.9.2 Where lift and main mechanical riser cores are adjacent to a residential unit, it is recommended that they are lined with an independent plasterboard wall lining.

7.9.3 Stair cores and lift shaft walls should comprise an inner wall lining within the residential demise comprising two layers of 12.5 mm SoundBloc on independent metal studs.

7.9.4 The cavity should be a minimum of 75 mm and be fitted with 25 mm mineral fibre. This detail is described in the British Gypsum White Book and is illustrated in Figure 12.

Figure 12: Proposed Lift Shaft and Mechanical Riser Acoustic lining



7.9.5 Where the residential lift shaft is adjacent to non-habitable areas the lift shaft wall does not need to be lined.

7.9.6 If the stair cores are used for emergency escape only, then the lining can be omitted.

7.10 WASTE CHUTES

7.10.1 Approved Document E provides the following advice regarding minimum superficial mass for walls around waste chutes:

- Walls between waste chutes and habitable rooms to provide a minimum surface mass of 1320 kg/m²; and
- Walls between waste chutes and non-habitable areas to provide a minimum surface mass of 220 kg/m².

7.10.2 The requirement for non-habitable areas is comfortably met by the current proposals for minimum 250 mm thick concrete in the cores. However, the requirement for habitable rooms would require 550 mm thick walls to be used, which would not be practical. It is therefore recommended that walls separating the waste chutes from residential units comprise a min. 200 mm thick concrete wall with two layers 12.5 mm thick plasterboard on a 25 mm deep timber batten with a mineral wool lining. It is envisaged that the lining would be on the residential side, but could be on either.

7.10.3 The waste chute should also incorporate the following specific noise control measures:

- Chutes are to be fixed from slab to slab and supported via neoprene clips which will act as anti-vibration mounts. Chutes are not to be fixed to any surrounding walls; and
- Noise radiated from the chutes will be minimised through the use of acoustic dampening material on the chute walls.

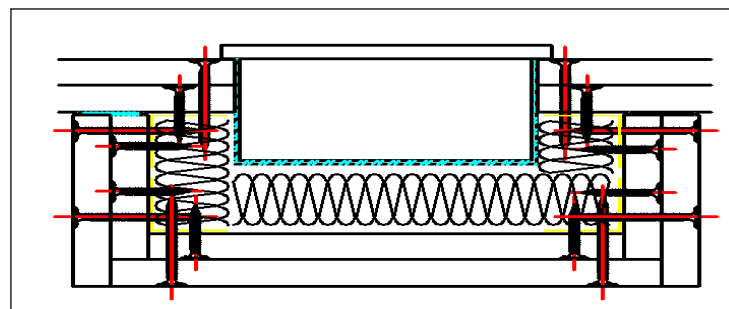
7.11 BUILDING SERVICES PENETRATIONS

7.11.1 There must be no building services pipe or duct penetrations through the *separating* walls between apartments and other spaces. Pipe and ductwork penetrations are permitted through *internal* walls and riser walls. Recommendations for pipe and ductwork penetrations through *internal* and riser walls will be provided at a later stage.

7.11.2 Vertical pipes or duct should be located within the allocated service risers and must not otherwise penetrate the floor construction. Where this is not practical and a pipe or duct is required to penetrate the floor slab, the pipe or duct must lagged with 25 mm thick mineral fibre for the full length and then installed within an enclosure with a mass per unit area of minimum 15 kg/m². This mass per unit area could be provided using 2 x 12.5 mm thick wallboard. Where fire stopping is required, this should be flexible and should prevent rigid contact between the pipe and the floor.

7.11.3 Electrical sockets and switches should be avoided in separating partitions, as far as practical. Where recessed sockets are proposed they should not be mounted in a 'back to back' formation, without acoustic protection, and care should be taken to ensure a minimum of 600mm spacing between sockets located either side of a partition. A typical baffle detail is shown in Figure 13.

Figure 13 Typical baffle box detail for plasterboard partitions



7.11.4 With regards to baffle boxes on the back of sockets and switches the following advice would apply:

- Sockets to be boxed in with two layers of plasterboard, equivalent in density to the main partition lining.
- Socket baffle boxes should not be located within the same stud bay. Staggering between adjacent stud bays is acceptable.
- The baffle box should be fully sealed on all sides, including top and bottom

- Holes in the box for cables should not be over-sized, and should be fully sealed. A further detail showing this should be subject to WSP's review.
- The baffle box should extend 150 mm above and below the socket.

7.12 DOORSETS

7.12.1 Doorsets to the dwellings will be required to meet the requirements of Approved Document E. Approved Document E does recognise that the sound insulation performance will be reduced by the presence of the doorset. With regards to the doorset, the following would be required to be achieved by the proposed doorset:

7.12.2 "Ensure that any door has good perimeter sealing (including the threshold where practical) and a minimum mass per unit area of 25 kg/m² or a minimum sound reduction index of 29 dB R_w (measured according to BS EN ISO 140-3: 1995 and rated according to BS EN ISO 717-1:1997). The door should also satisfy the Requirements of Building Regulations Part B – Fire safety."

7.12.3 This requirement applies to all front doors of apartments and town houses across all plots and also to the rear doors within Plot 5 leading to the Refuse Stores. It should also apply to the Gym and Function Room on Level 02 of Plot 3.

7.12.4 Doors to external areas from the generator rooms of all Plots and rooms adjacent to Generator rooms should be rated with a minimum sound reduction index of 35dB R_w .

7.12.5 It is also recommended that apartment front doors, refuse chute room doors, refuse store room doors and cycle store doors, all have soft closing mechanisms fitted to avoid potentially loud impulse noises in common corridors.

7.12.6 Ventilation undercuts to doorsets or the use of ventilation grilles between the corridor and apartment will affect the sound insulation performance achieved and must be avoided to any doorset rated with an acoustic performance.

7.12.7 As a guide, a laboratory rating of 29-30 dB R_w would typically be achieved by a 45 mm solid-core timber door closing onto a rebated frame with full perimeter seals along the head, jambs and threshold. The door would need to be side hinged rather than pivoted. This is provided as guidance only and the proposed door supplier must confirm compliance with the above requirement. A laboratory rating of 35 dB R_w would typically be achieved by a 54 mm solid-core timber door closing onto a rebated frame with full perimeter seals along the head, jambs and threshold. A drop threshold would be required for 38 dB R_w . The door would need to be side hinged rather than pivoted. For double doors, meeting jambs need to be rebated and fitted with seals to meet the requirements. Door leaf weights are typically around 50 to 65 kg/m². Lighter doors with composite constructions are available from some suppliers. Vision panels of thick acoustic laminate glass can be used (eg. 12.8 mm).

7.12.8 For all acoustic rated doorsets:

- Permanently flexible mastic sealant should be used to seal any gaps between the door frame and the surrounding building elements, to ensure that the overall sound insulation performance is not degraded. Ensure that continuous acoustic seals (where provided) are not interrupted by elements such as door locks, catches, hinges, closers etc, which may undermine the onsite sound insulation performance of the doorset.
- Eurolocks shall be used as opposed to 'through' keyholes. Glazed vision panels in doorsets shall be constructed to match the sound insulation requirements of the doors.
- Closing mechanisms shall be designed and adjusted to ensure that even force is applied around the perimeter of the door and that the doorsets close as quietly as possible.

- 7.12.9 All of the above is intended as guidance only, and manufacturers acoustic test data is required to demonstrate compliance with our recommended design targets.

7.1 INTERFACES WITH ADJACENT ELEMENTS

- 7.1.1 Interfaces with adjacent elements will continue to be carefully detailed as the design develops to ensure that the overall sound insulation performance is not significantly degraded by flanking sound transmission. Interfaces will include the detailing of internal walls, external façade, door frames, glazed screens, floor, soffit and ceilings.
- 7.1.2 In general, any exposed cladding elements are required to be designed to ensure they provide a minimum sound flanking performance of at least $47 \text{ dB } D_{nfw} + C_{tr}$ between all adjacent apartments. This requirement applies to the cladding panels as well as any exposed transoms or mullions.
- 7.1.3 In order to control external noise break-in via the cladding elements, the non-glazed elements of the cladding system will also need to be internally lined with 2 x 15 mm SoundBloc.

7.2 SOUND ABSORPTION

- 7.2.1 Requirement E3 of the Building Regulations, refer to Section 3.3 of this report, relates to the provision of sound absorption within common internal parts within the building. This includes all common corridors, hallways, stairwells and entrance lobbies which provide direct access to any Apartment. However, it does not apply to any corridor or hallway within Apartments.
- 7.2.2 Based upon the proposed building layouts, Requirement E3 would apply to the communal corridors and lift lobbies to all residential floors. and identify the required extent of Class C sound absorbent treatment to typical residential floors.

Figure 14 - Required Location of Sound Absorption to Typical Residential Floor

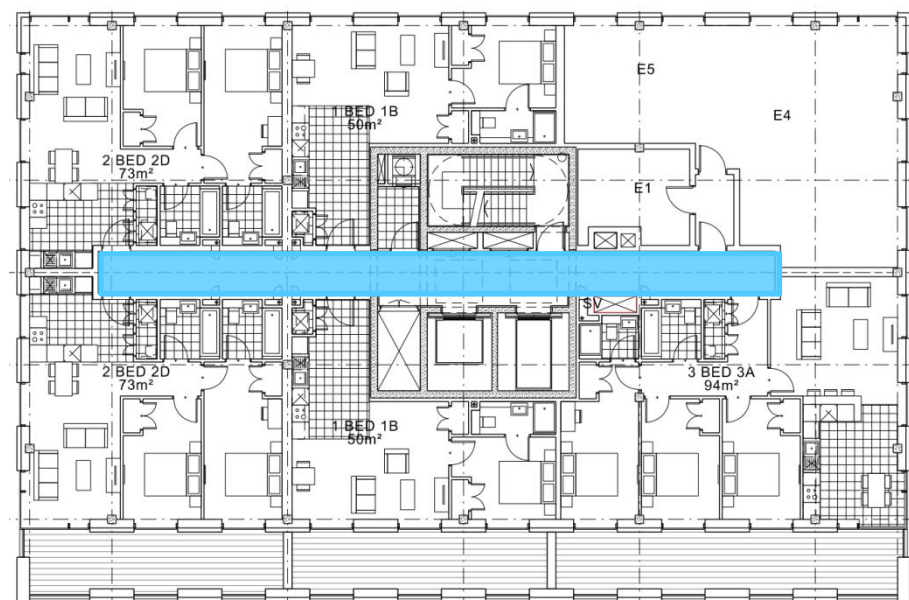
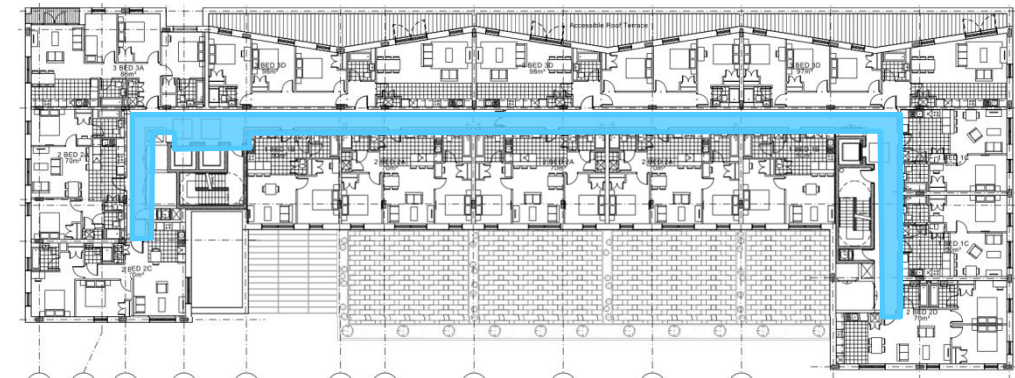


Figure 15 - Required Location of Sound Absorption to Typical Residential Floor (Block 5)



- 7.2.3 Requirement E3 of Approved Document E states that “the common internal parts of buildings which contain flat or rooms for residential purposes shall be designed and constructed in such a way as to prevent more reverberation around the common parts than is reasonable.”

Approved Document E describes two methods of complying with this requirement, as follows:

- Method A – This simplified method states that, for corridors or hallways, an area equal to or greater than that of the floor should be covered with an absorber achieving a Class C rating. This method can generally be satisfied by the use of proprietary acoustic ceilings.
- Method B – This more detailed method considers the contribution to absorption in the space from all proposed surface elements. In most cases this method allows greater flexibility in meeting requirement E3 and less additional absorption than for Method A.

- 7.2.4 For corridors giving access to dwellings, the most convenient and cost-effective means of meeting requirement E3 is usually to install a ceiling system providing a minimum Class C absorptive performance. This performance is typically achievable by lay in grid mineral fibre or perforated metal tile ceiling, or using perforated plasterboard with a suitable void and acoustic lining behind.

7.3 STAIRWELLS & ENTRANCE HALL

- 7.3.1 Given that, in practice, stairwells will only normally be used for means of escape, and do not provide direct access to apartments, it can be argued that that requirement E3 be exempt for these areas. This will require approval from Building Control.
- 7.3.2 With regards to the entrance halls, which are proposed to have exposed concrete soffits, the acoustic absorption provision on the ceiling will be will not be significant and as such the it will need to be provided by additional means e.g wall panels, hanging rafts or a combination of both. Although the entrance halls are only used to access the lifts and stair cores, they do have residential dwellings above and as such control of reverberation is considered necessary.

8 BUILDING SERVICES

8.1 VENTILATION STRATEGY

- 8.1.1 It is proposed that the residential dwellings will be mechanically ventilated.
- 8.1.2 If required, open windows could be used to the residential apartments to provide purge ventilation (the removal of pollutants or vapours such as smoke from burnt food or spillage of water) as the indoor ambient noise level requirements do not apply to purge ventilation.

8.2 MECHANICAL VENTILATION NOISE CRITERIA

- 8.2.1 Where a mechanical ventilation system is required, noise from the building services equipment will need to be controlled. Table 8-1 provides the recommended NR levels to be achieved by the building services equipment to each space.

Table 8-1 – Noise Rating Levels

LOCATION	NOISE RATING LEVEL
Apartments	NR25 $L_{eq,T}$ (design target)
Apartment bathrooms and Kitchens	NR40 $L_{eq,T}$ (maximum)
Leisure Unit	NR40 $L_{eq,T}$ (maximum)
Bar / Restaurant Unit back of house / Kitchens	NR45 $L_{eq,T}$ (maximum)
Entrance Lobbies	NR45 $L_{eq,T}$ (maximum)
Public WCs	NR50 $L_{eq,T}$ (maximum)

- 8.2.2 NR levels should be measured in accordance with ANC guidelines – Noise measurement in Buildings Part 1: Noise from Building Services, at a distance of 1.5 m from any service grille or opening, at least 1 m from any reflecting surface, under typical plant operational duties in unoccupied rooms.
- 8.2.3 It should be noted that the noise rating level requirement for the dwellings are provided as a *design target* rather than as a *maximum* noise level to be achieved.

8.3 RESIDENTIAL MECHANICAL VENTILATION

- 8.3.1 Ventilation will be provided within the apartments to:
 - assist in the dilution and removal of pollutants
 - provide outdoor air for the occupants
 - to control the humidity levels, to minimise the risk of condensation and damage to the finishes

- 8.3.2 Each residential unit will be ventilated using a mechanical ventilation heat recovery (MVHR) unit which is designed to provide outdoor air supply, extract ventilation and a high degree of heat recovery to minimise energy costs for heating the incoming air. Outdoor air inlets and exhaust air outlets will be provided in the façade of each residential unit to connect to the MVHR unit.

- 8.3.3 Purge ventilation will also be provided in line with the requirements of the Building Regulations Part F (Ventilation). This shall be achieved via the use of MVHR system in conjunction with, where required, openable windows to make up the required air volume.

- 8.3.4 The MVHR system currently proposed is a Vent-Axia Lo-Carbon Kinetic Plus E, which is vertically mounted all-in-one unit including all direct ductwork connections for supply and extract air.

- 8.3.5 MVHR units should be installed on manufacturer’s standard anti-vibration mounts to prevent structure-borne noise being transmitted into adjacent habitable rooms. If it is necessary to fix these units to a wall, 25mm plywood should be included in the wall to provide a sufficiently stiff mount to avoid excessive vibration being transmitted from the unit to the wall.

- 8.3.6 The system is likely to require acoustic mitigation measures incorporating into the design. Such measures may include:
 - Ductwork sized to avoid high resistance, minimal bends and low velocities;
 - Installed horizontally with anti-vibration mounts to the slabs;
 - Attenuation in the form of rigid attenuators close to the unit;
 - Acoustically enclosed casework.

- 8.3.7 Based on noise data provided by Vent-Axia, it has been determined that the noise emissions from the MVHR unit are sufficiently low, both breakout noise and duct noise, so as not to warrant any further mitigation/attenuation. This is however based on the assumption that they will be located in hallways in all instances. Where the units will be wall mounted (rather than floor mounted) it is recommend that a plywood element is included within the mounting wall.

8.4 BREAK-IN OF EXTERNAL NOISE VIA INTAKE AND EXHAUST PLENA

- 8.4.1 As some of the façades are specified to provide reasonably high resistances to ingress of environmental noise sources, there is the potential that façade connections for the MVHR systems could be significant acoustic weaknesses in the external building fabric. After calculating the significance of this weakness however, it has been determined that as the vent opening and ductwork will be above each apartment’s ceiling, the noise ingress via tis pathway will be negligible and no further mitigation will be required.

8.5 CROSS-TALK

- 8.5.1 Approved Document E stipulates that partitions within dwellings meet a minimum laboratory sound insulation performance of 40 dB R_w . However, there is no on-site requirement, and there is no specific advice regarding cross-talk sound transmission.
- 8.5.2 Without any additional attenuation inserted within the ductwork between rooms within the same dwelling, the corresponding sound insulation provided by the cross-talk route is predicted to be around 35 dB R_w . In order to increase this to match the Approved Document E requirement, it is recommended that a short section of lined ductwork be inserted, that is capable of achieving the following insertion losses. Suitable lined ductwork is available from Nuaire or specialist suppliers.

Table 8-2: Insertion losses for MVHR crosstalk attenuators/lined ductwork

INSERTION LOSSES AT OCTAVE BAND CENTRE FREQUENCIES	63	125	250	500	1000	2000	4000	8000
Crosstalk attenuator Typ. 600mm length	1	2	4	6	8	10	8	6

8.6 NOISE EGRESS FROM EXTERNAL BUILDING SERVICES

Based upon the background noise levels measured on the site toward the nearest noise sensitive premises and the criteria for noise egress from the site from fixed building services as stipulated by MCC, Table 8-3 provides the maximum permissible cumulative noise level limits for all proposed externally mounted building services equipment at 1m from the nearest noise sensitive receiver.

Table 8-3 Cumulative Noise level limits @ 1m from the nearest noise sensitive receiver.

PARAMETER	OCTAVE BAND CENTRE FREQUENCY, Hz							
	63	125	250	500	1 k	2 k	4 k	8 k
Daytime (07:00-23:00) L _{eq} , dB	60	61	55	47	44	45	40	34
Night-time (23:00-07:00) L _{eq} , dB	49	50	51	41	38	37	31	24

- 8.6.1 Where the noise source(s) are for emergency use only the noise limits are permitted by MCC to be 10dB(A) above the background level.
- 8.6.2 Note that the above noise level limits are the total noise level limits from the development as a whole.
- 8.6.3 In accordance with BS 4142, it is appropriate to consider whether the noise level impact contains an acoustic character i.e. whether the noise contains a distinguishable, discrete, continuous note (whine, hiss, screech, hum, etc.) or the noise contains distinct impulses (bangs, clicks, clatters, or thumps) or the noise is irregular enough to attract attention. Such characteristics must be taken into consideration, with appropriate corrections added before comparison with the above noise level limits. Such correction must be determined in accordance with the procedure outlined in BS4142:2014.
- 8.6.4 As details of the proposed externally mounted equipment develop and are confirmed, particularly regarding the commercial units, a review will be conducted to ensure that the above noise level limits can be achieved taking into consideration the location of all externally mounted equipment associated with the development. This assessment will be required in order to discharge a planning conditions relating to noise impact of the development. Based on current plant proposals however there are no specific mitigation measures expected to be required (other than for the generators) in order to ensure the noise limits can be achieved.
- 8.6.5 The noise from the generator within the Generator Room of each Plot is expected to be the most significant aspect of noise egress from the development. However, as these generators will be for emergency use only, their use will be limited to (excluding real emergency scenarios) periodic testing e.g. once a month for 1-2hrs. The generators, and associated attenuators/louvres are to be specified such that noise emissions do not exceed 75dB(A) at 1m from the external face of the louvre.

8.7 CROSSTALK ATTENUATORS

- 8.7.1 'Crosstalk' describes the level of sound transmission between separate rooms via common ductwork connections. The use of crosstalk attenuators are required in order to control sound transmission between spaces via interconnecting ductwork in order to be capable of meeting the sound insulation performance requirements.
- 8.7.2 The requirement for crosstalk attenuators will be determined as the design develops but an allowance should be made for a crosstalk attenuator for each wall penetration.

8.8 BUILDING MAINTENANCE UNIT

- 8.8.1 A building maintenance unit (BMU) is required to facilitate the safe and efficient cleaning of the building's glazing. These units are powered by low power electric motors and generally emit insignificant levels of airborne noise.
- 8.8.2 It is not possible to accurately predict any structure-borne noise arising from the use of a BMU, as there has been so little technical research in this area. The dominant sources of structure-borne noise would be the motor switching on or off quickly or the movement of the cradle over track joints.
- 8.8.3 Isolating the BMU tracks from the roof is generally considered to make future maintenance impractical and may allow the track to move, causing uneven joints.
- 8.8.4 On this basis, it is considered that the most efficient way to reduce the likelihood of complaints of structure-borne noise or vibration is to design and specify the BMU to ensure a smooth mechanical operation, thereby reducing the chance for vibration to arise in the first place. Following liaison with the façade access engineers, the following measures are recommended:
 - 'Soft start' motors which increase the force applied to the rails through the wheels gradually, to reduce vibration due to sudden movement
 - Track joints to be minimised as far as possible – it is generally possible for lengths of up to 6 metres to be possible, whilst still allowing the track sections to be manoeuvred on the rooftop
 - Tight track tolerances of 1 mm, to reduce gaps between track sections.
 - Track joints should ideally be orthogonal with respect to the direction of the track, rather than perpendicular, in order to reduce impulsive vibration as the wheels run over the gaps.
 - Track tolerances to be maintained regularly after installation, to ensure that gaps between track segments do not significantly increase due to expansion/contraction with age and use.

We are not aware of any instances in which a well installed and well maintained BMU has resulted in excessive structure-borne vibration or re-radiated noise affecting building occupants, so the risk of any issues with respect to the BMU's operation is considered to be minimal.

8.9 LIFT NOISE AND VIBRATION SPECIFICATION

Lifts can be a source of intermittent and annoying noise in apartments. The intermittency of motor and door operations can draw attention to the noise in otherwise quiet environments. Whilst regular maintenance is key to keeping lifts running smoothly and quietly, a number of design measures can be adopted to ameliorate their overall noise and vibration impact.

The following guidance and specification recommendations are proposed for the development.

SOUND CONTROL FOR LIFTS

Provide effective sound isolation between machines, secondary deflector sheaves, motor generators and solid state drive units and filters from building structures to reduce noise transmission to occupied spaces and lift cabs. When operating per plans and specifications, the elevator equipment should be designed so as not to generate noise levels in excess of those levels set out in the following section.

LIFT VIBRATION ISOLATION

The following shall be provided as a minimum:

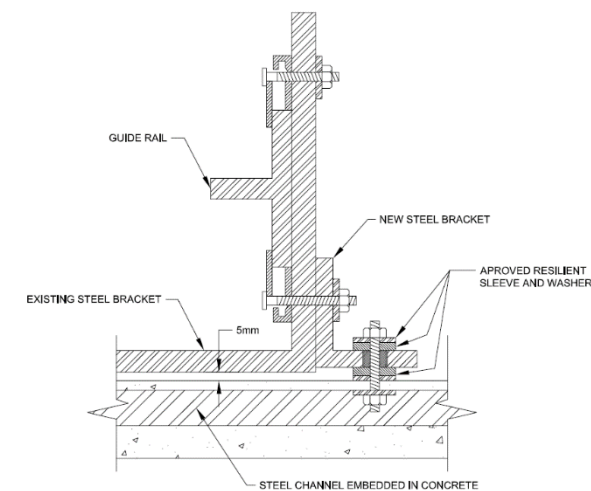
- Resiliently isolate the entire lift/secondary deflector integral unitized base from the lift machine room floor slab by means of effective neoprene-in-shear isolators having a minimum static deflection of 12mm.
- Support secondary deflector sheaves integrally from the unitized elevator base.
- Isolate the motor generators, transformers and reactance units from the building structure by means of approved neoprene-in-shear isolators having a minimum static deflection of 12mm.
- Isolate the hitch plates to the lift cab by means of an elastomeric pad in compression designed to provide 4mm minimum deflection under dynamic loading.
- Solid state rectification units and switchgear shall be mounted on 15mm thick minimum, neoprene-in-shear pad isolators.
- Conduits and electrical connections shall not be fastened to or supported by lift machinery or solid state rectification units, except by approved flexible connections or looped cables.

AIRBORNE NOISE CONTROL

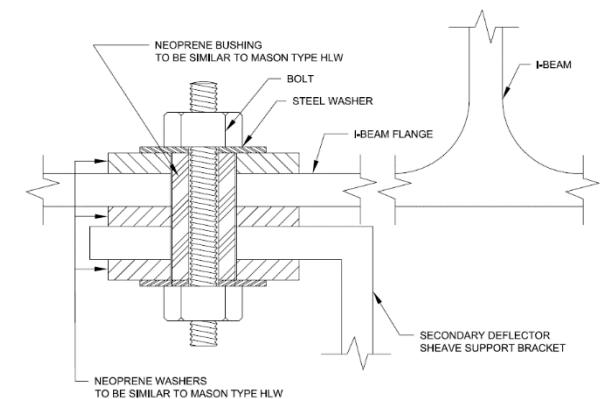
Doors opening directly to tenant areas: R_w 45dB rated doorsets with removable centre posts (centre posts are required to ensure an adequate acoustic seal – double doorsets without a centre post will not achieve the desired rating). It is recommended that the door suppliers maintain the responsibility for installing such specialist doorsets into the relevant builderswork openings, and applying the appropriate acoustic seals to maintain the requisite performance.

- Cabin door mechanisms must be selected to comply with the appended Lift Noise and Vibration Specification
- Lifts should not generate wind whistle and air pressure rattles at door panels.

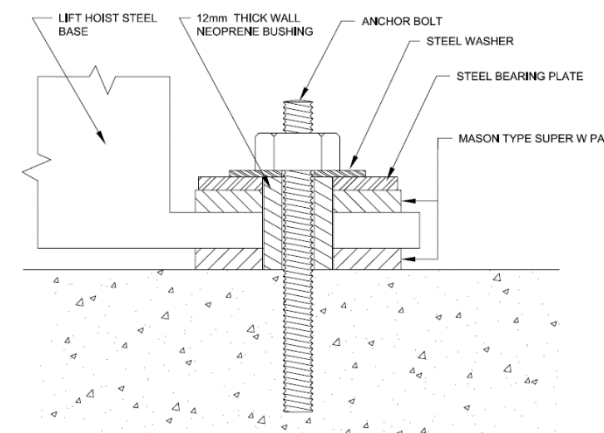
Lift Guide Rail Isolation



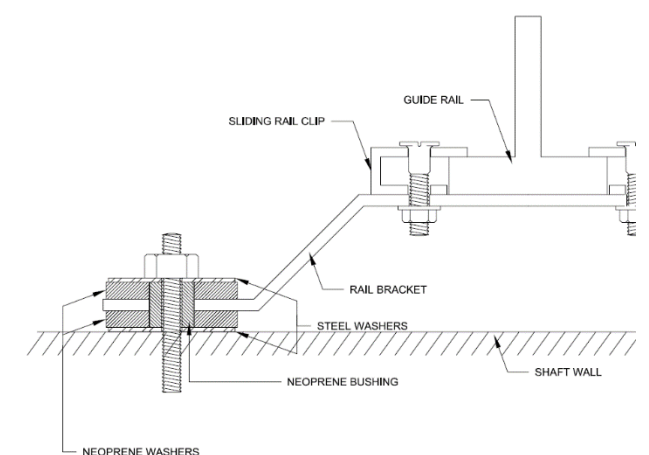
Secondary Deflector Sheave Mounting



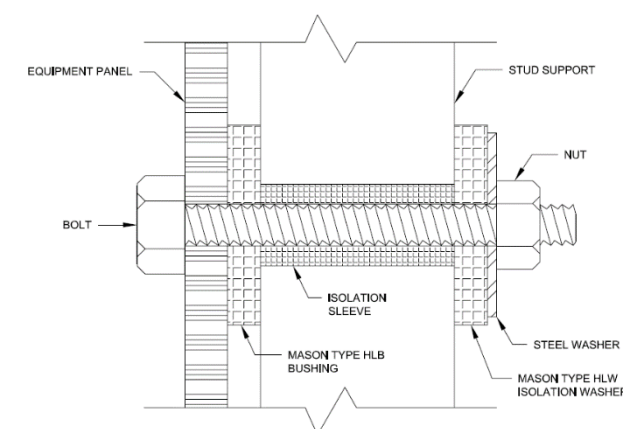
Lift Hoist Base Isolation



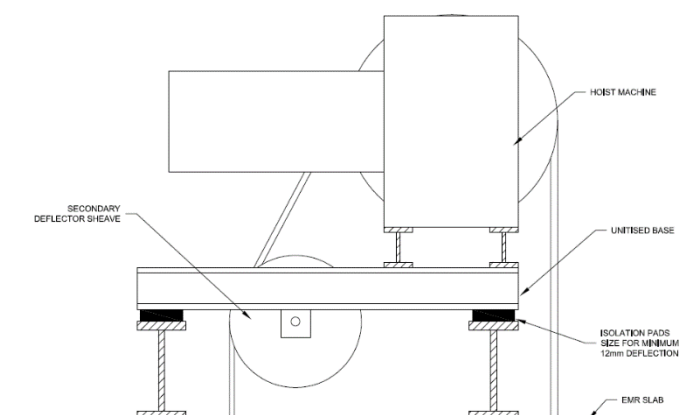
Lift Rail Bracket Mounting



Control Panel Isolation Detail



Isolated Unitised Base for Hoist and Secondary Sheave



The following acoustic specification is recommended for the lifts:

LIFT NOISE AND VIBRATION SPECIFICATION

It will be necessary to ensure that noise and vibration associated with the operation of the lifts is suitably controlled in order to mitigate any impact upon the sensitive adjacencies. Lift noise and vibration may be controlled partly by treatment to the building structure, although it is important that control is also applied at source to the lift system itself. As such, the lift systems shall conform to the following specifications:

LIFT VIBRATION

Vibration measurements must be made in the centre of the car floor, in three mutually perpendicular axes corresponding to vertical, front-to-back and side-to-side. Measurements must be made of acceleration levels in each direction over two complete cycles, one from the bottom of the building to the top, and one from the top of the building to the bottom.

The measurement method is critical to the repeatability of the results. It is therefore preferable to use an automatic recorder covering all frequency bands, as opposed to taking individual frequency band measurements over repeated lift runs.

A cycle is defined as the period from just before the doors start to close at one level, to just after the doors open at the final level.

Acceleration levels should be measured as peak values over the frequency range 2 Hz to 80 Hz inclusive over each complete lift cycle.

The following limits will apply on the floor of the car:

HORIZONTAL VIBRATION

2 Hz to 20 Hz inclusive: The maximum acceleration level should not exceed 0.15 m/s²
 >20 Hz to 80 Hz inclusive: The maximum acceleration level should not exceed 0.70 m/s²
 The above limits apply at any time during a complete cycle.

VERTICAL VIBRATION

At maximum speed: The maximum acceleration level should not exceed 0.10 m/s² in the frequency range 2 - 80 Hz.

During acceleration/deceleration and start/stop periods: The maximum acceleration level should not exceed 0.20 m/s² in the frequency range 2 - 80 Hz.

The above limits apply to lifts with speeds up to 4 m/s. Lifts having speeds above this will be subject to increased vibration limits. For lift speeds in the range 4 - 7 m/s, a multiplier of 1.5 may be used for all acceleration level limits.

ACCELERATION/DECELERATION OF LIFT CAR

Acceleration/deceleration rates of the whole cabin should not exceed 1.5 m/s² at any time during a complete cycle, and should preferably be below 1.2 m/s².

IN CAR NOISE LEVELS

Door noise, when measured at 1.5 m from the floor and 1 m from the door face, should not exceed 65 dB LA_{max} when measured with a precision grade sound level meter set to "Fast" meter response.

Noise levels in the car at the maximum car velocity in the cycle should not exceed the following when measured as above:

LOBBIES

- 8.9.1 Lift noise, when measured at 1.5 m from the floor and 1 m from the door face with a precision grade sound level meter set to "Fast" response should generally not exceed 55 dB LA_{max} at any time during the lift cycle.

LIFT MOTOR ROOMS

- 8.9.2 Noise level information shall be made available as follows:

- L_{Amax} and average L_{Aeq} level over a complete cycle of lift operation.
- L_{Amax} levels in each of the eight 63 Hz to 8 kHz centre frequency octave bands.

- 8.9.3 The measurements shall be made with a precision grade sound level meter set to "Fast" response. The positions at which measurements are made should be noted on a drawing showing the principal noise producing elements of the lift machinery. No measurements should be closer than 1 m from any wall or floor surface.

Appendix A

APPENDIX A-1

GLOSSARY OF ACOUSTIC TERMINOLOGY

NOISE

Noise is defined as unwanted sound. Human ears are able to respond to sound in the frequency range 20 Hz (deep bass) to 20,000 Hz (high treble) and over the audible range of 0 dB (the threshold of perception) to 140 dB (the threshold of pain). The ear does not respond equally to different frequencies of the same magnitude, but is more responsive to mid-frequencies than to lower or higher frequencies. To quantify noise in a manner that approximates the response of the human ear, a weighting mechanism is used. This reduces the importance of lower and higher frequencies, in a similar manner to the human ear.

Furthermore, the perception of noise may be determined by a number of other factors, which may not necessarily be acoustic. In general, the impact of noise depends upon its level, the margin by which it exceeds the background level, its character and its variation over a given period of time. In some cases, the time of day and other acoustic features such as tonality or impulsiveness may be important, as may the disposition of the affected individual. Any assessment of noise should give due consideration to all of these factors when assessing the significance of a noise source.

The most widely used weighting mechanism that best corresponds to the response of the human ear is the 'A'-weighting scale. This is widely used for environmental noise measurement, and the levels are denoted as dB(A) or L_{Aeq} , L_{A90} etc, according to the parameter being measured.

The decibel scale is logarithmic rather than linear, and hence a 3 dB increase in sound level represents a doubling of the sound energy present. Judgement of sound is subjective, but as a general guide a 10 dB(A) increase can be taken to represent a doubling of loudness, whilst an increase in the order of 3 dB(A) is generally regarded as the minimum difference needed to perceive a change under normal listening conditions.

An indication of the range of sound levels commonly found in the environment is given in the following table.

SOUND LEVELS	LOCATION
0 dB(A)	Threshold of hearing
20 to 30 dB(A)	Quiet bedroom at night
30 to 40 dB(A)	Living room during the day
40 to 50 dB(A)	Typical office
50 to 60 dB(A)	Inside a car
60 to 70 dB(A)	Typical high street
70 to 90 dB(A)	Inside factory
100 to 110 dB(A)	Burglar alarm at 1m away
110 to 130 dB(A)	Jet aircraft on take off
140 dB(A)	Threshold of pain

ACOUSTIC TERMINOLOGY

TERMINOLOGY	MEANING
dB (decibel)	The scale on which sound pressure level is expressed. It is defined as 20 times the logarithm of the ratio between the root-mean-square pressure of the sound field and a reference pressure ($2 \times 10^{-5} \text{Pa}$).
dB(A)	A-weighted decibel. This is a measure of the overall level of sound across the audible spectrum with a frequency weighting (i.e. 'A' - weighting) to compensate for the varying sensitivity of the human ear to sound at different frequencies.
$L_{Aeq,T}$	L_{Aeq} is defined as the notional steady sound level which, over a stated period of time (T), would contain the same amount of acoustical energy as the A - weighted fluctuating sound measured over that period.
L_{Amax}	L_{Amax} is the maximum A - weighted sound pressure level recorded over the period stated. L_{Amax} is sometimes used in assessing environmental noise where occasional loud noises occur, which may have little effect on the overall L_{eq} noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.
L_1 and L_{90}	If a non-steady noise is to be described it is necessary to know both its level and the degree of fluctuation. The L_n indices are used for this purpose, and the term refers to the level exceeded for n% of the time. Hence L_{10} is the level exceeded for 10% of the time, and the L_{90} is the level exceeded for 90% of the time.
Free-field Level	A sound field determined at a point away from reflective surfaces other than the ground with no significant contributions due to sound from other reflective surfaces. Generally as measured outside and away from buildings.
Façade Level	A sound field determined at a distance of 1m in front of a large sound reflecting object such as a building façade.