Acoustic Associates Sussex Ltd

Environmental Noise Assessment For Planning Condition

Site: **40 Old Shoreham Road**
Client: **Sussex Garden Rooms**

Report by: Martyn Chambers BA(Hons) TechIOA

Date: 14/11/18
Project: J2577

Acoustic Associates

Sound Insulation Testing - Acoustic Design of Buildings - BS4142 - PPG24 - Schools Acoustics BB93 - Vibration - Expert Witness Testimony - Noise at Work - Air Tightness Testing - Auditorium Acoustics

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1 Introduction

Acoustic Associates have been appointed to undertake an acoustic assessment ahead of construction of a detached self-contained annex in the side garden (east) for a dependent relative, at 40 Old Shoreham Road, Lancing. The development has gained planning approval, albeit with certain conditions.

Planning Application Number AWDM/0737/18 condition 08 relates to noise and has been copied below:

08. Construction work shall not commence until a scheme for protecting the proposed noise sensitive development from noise from the road has been submitted to and approved by the local planning authority. All works, which form part of the scheme, shall be completed before any part of the noise sensitive development is occupied. The scheme shall achieve the indoor ambient noise levels for dwellings specified in BS8233:2014 and shall have regard to the principles contained within the World Health Organisation community noise guidelines. Following approval and completion of the scheme, a competent person employed by the developer shall undertake a test to demonstrate that the attenuation measures proposed in the scheme meet the specified levels.

The purpose of this assessment is to assess the following:

- Noise levels affecting the planned development.
- Provide mitigation measures (if necessary) to show how condition 08 of the planning approval can be met.

Transportation (road) noise has been measured on the existing site.

Noise propagation around the planned development has been predicted using the computer program IMMI (Wolfel).

The noise levels for the day and the night time period have been assessed in terms of and following the guidelines of the documents listed below:

- World Health Organisation (WHO) - Guidelines for Community Noise 1999
- ISO9613 (Attenuation of sound during propagation outdoors) 1996
- BS8233 (Sound insulation and noise reduction for buildings) 2014
- Pro-PG (Planning and Noise draft guidance) 2017

Within this report, noise mitigation measures have been recommended and if they are implemented by the developer it is considered that the planning condition laid out in section 08 would be met.

2 Context, Noise Criteria & Noise Assessment Methodology

2.1 Site Description

The site is on the south side of the A27 in lancing. The building is set back from A27 with a single lane residential access road between site and the A27.

The annexe will be built in the garden to the east of the existing building. The new building will consist of a single storey and have one bedroom. The building has been designed so that there are no windows from living spaces facing towards the A27, in order to reduce the effect traffic noise has on the resident.

Noise at the site comes nearly exclusively from the A27.

2.2 BS8233 Noise Criteria

Table 5 of BS8233 provides the following guideline values:

Activity	Location	Time period of day	
		07:00-23:00	23:00-07:00
Resting	Living Rooms	35dB $L_{Aeq,16hour}$	-
Dining	Dining Room/Area	40dB $L_{Aeq,16hour}$	-
Sleeping (daytime resting)	Bedroom	35dB $L_{Aeq,16hour}$	30dB $L_{Aeq,8hour}$

Table 1: BS8233 Criteria

2.3 WHO Internal Noise Criteria

The target internal levels are based on guidelines laid out by the World Health Organisation (WHO) and are as follows:

Room Type	**Target Maximum Internal Level - L_{Aeq} dB (A)**
Living rooms	35 (Daytime only)
Bedrooms	30 (Night)
Room Type	**Maximum Internal Level – L_{Amax} dB(A)**
Bedrooms	45 (not more than 10-15 times per Night)

The target maximum internal noise level for a bedroom during the night time corresponds to the threshold of sleep disturbance. WHO state that the noise level outside a bedroom window would be less than 45dB(A) this assumes that an open window provides 15dB attenuation.

2.4 WHO External Noise Criteria

With regard to outdoor amenity areas WHO states the following:

To protect the majority of people from being seriously annoyed during the daytime, the outdoor sound level from steady, continuous noise should not exceed 55dB(A) on balconies, terraces and in outdoor living areas.

To protect the majority of people from being moderately annoyed during the daytime, the outdoor sound level from steady, continuous noise should not exceed 50dB(A) on balconies, terraces and in outdoor living areas.

2.5 Noise Policy Statement for England (NPSE)

The document "Noise Policy Statement for England" sets out the following vision for on-going noise policy:

"Promote good health and quality of life through the effective management of noise within the context of Government policy on sustainable development."

This vision should be achieved through the following Noise Policy Aims:

"Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development: avoid significant adverse impacts on health and quality of life; mitigate and minimize adverse impacts on health and quality of life; and where possible, contribute to the improvement of health and quality of life".

2.6 NPSE Noise "Effect Levels"

To achieve these objectives the Noise Policy Statement sets out three noise levels to be defined by the assessor:

- NOEL - No Observed Effect Level

This is the level below which no effect can be detected. In simple terms, below this level there is no detectable effect on health and quality of life due to the noise.

- LOAEL - Lowest Observed Adverse Effect Level

This is the level above which adverse effects on health and quality of life can be detected.

- SOAEL - Significant Observed Adverse Effect Level

This is the level above which significant adverse effects on health and quality of life occur.

The Noise Policy Statement considers that noise levels above the SOAEL would be seen to have, by definition, significant adverse effects and would be considered unacceptable.

Where the assessed noise levels fall between the LOAEL and the SOAEL noise levels, the Policy Statement requires that:

"All reasonable steps should be taken to mitigate and minimize adverse effects on health and quality of life while also taking into account the guiding principles of sustainable development... .. This does not mean that such adverse effects cannot occur."

Where noise levels are below the LOAEL it is considered there will be no adverse effect. Once noise levels are below the NOEL there will be no observable change.

2.7 ProPG –Planning and Noise: new residential development

The following has been copied from the Association of Noise Consultants' (ANC) website:

Over recent years, we have seen the introduction of the Noise Policy Statement for England, as well as substantial changes in national planning policy. But these developments have not been accompanied by detailed technical acoustic advice.

The lack of detailed guidance can lead to inconsistent application of policy, that may in turn result in unsatisfactory development and affect quality of life.

To fill that gap and facilitate efficient and consistent decision-making in the development control process, the Institute of Acoustics, the Association of Noise Consultants and the CIEH have joined to produce a Professional Practice Guidance (ProPG) focussing on noise sensitive development.

The following extract has been taken (Figure 2, Page 13) from the May 2017 ProPG document:

ACTIVITY	LOCATION	07:00 – 23:00 HRS	23:00 – 07:00 HRS
Resting	Living room	35 dB $L_{Aeq,16\ hr}$	-
Dining	Dining room/area	40 dB $L_{Aeq,16\ hr}$	-
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq,16\ hr}$	30 dB $L_{Aeq,8\ hr}$ 45 dB $L_{Amax,F}$ (Note 4)

NOTE 1 The Table provides recommended internal L_{Aeq} target levels for overall noise in the design of a building. These are the sum total of structure-borne and airborne noise sources. Ground-borne noise is assessed separately and is not included as part of these targets, as human response to ground-borne noise varies with many factors such as level, character, timing, occupant expectation and sensitivity.

NOTE 2 The internal L_{Aeq} target levels shown in the Table are based on the existing guidelines issued by the WHO and assume normal diurnal fluctuations in external noise. In cases where local conditions do not follow a typical diurnal pattern, for example on a road serving a port with high levels of traffic at certain times of the night, an appropriate alternative period, e.g. 1 hour, may be used, but the level should be selected to ensure consistency with the internal L_{Aeq} target levels recommended in the Table.

NOTE 3 These internal L_{Aeq} target levels are based on annual average data and do not have to be achieved in all circumstances. For example, it is normal to exclude occasional events, such as fireworks night or New Year's Eve.

NOTE 4 Regular individual noise events (for example, scheduled aircraft or passing trains) can cause sleep disturbance. A guideline value may be set in terms of SEL or $L_{Amax,F}$, depending on the character and number of events per night. Sporadic noise events could require separate values. In most circumstances in noise-sensitive rooms at night (e.g. bedrooms) good acoustic design can be used so that individual noise events do not normally exceed 45dB $L_{Amax,F}$ more than 10 times a night. However, where it is not reasonably practicable to achieve this guideline then the judgement of acceptability will depend not only on the maximum noise levels but also on factors such as the source, number, distribution, predictability and regularity of noise events (see Appendix A).

NOTE 5 Designing the site layout and the dwellings so that the internal target levels can be achieved with open windows in as many properties as possible demonstrates good acoustic design. Where it is not possible to meet internal target levels with windows open, internal noise levels can be assessed with windows closed, however any façade openings used to provide whole dwelling ventilation (e.g. trickle ventilators) should be assessed in the "open" position and, in this scenario, the internal L_{Aeq} target levels should not normally be exceeded, subject to the further advice in Note 7.

NOTE 6 Attention is drawn to the requirements of the Building Regulations.

NOTE 7 Where development is considered necessary or desirable, despite external noise levels above WHO guidelines, the internal L_{Aeq} target levels may be relaxed by up to 5 dB and reasonable internal conditions still achieved. The more often internal L_{Aeq} levels start to exceed the internal L_{Aeq} target levels by more than 5 dB, the more that most people are likely to regard them as "unreasonable". Where such exceedances are predicted, applicants should be required to show how the relevant number of rooms affected has been kept to a minimum. Once internal L_{Aeq} levels exceed the target levels by more than 10 dB, they are highly likely to be regarded as "unacceptable" by most people, particularly if such levels occur more than occasionally. Every effort should be made to avoid relevant rooms experiencing "unacceptable" noise levels at all and where such levels are likely to occur frequently, the development should be prevented in its proposed form **(see Section 3.D)**.

Figure 1: ProPG Criteria

3 Road Noise Survey Baseline Conditions and Results

A noise survey was carried out from the 1stth November to the 7th of November 2018 in order to measure noise levels associated with the nearby A27 Road. Noise measurements were conducted in the garden of number 40, at the location of where the lounge window will be. The Microphone was placed a on tripod about 1.6 meters high. The noise monitoring location can be seen in the existing site plan that is in the appendix.

3.1 Baseline Conditions

- Survey carried out by:
  Scott Castle BSc (Hons) CEnv, MCIEH PGDip: Acoustics MIOA
  Martyn Chambers BA (Hons) TechIOA

- Equipment used: Castle Mirus GA117
- Weather conditions: Variable: (Wet and dry) Wind: variable direction
  Sometimes greater than 3ms^{-2}

The Meter was calibrated before and after commencing the noise measurements (@94dB no drift).

The microphone was approximately 1.6m from the ground and 3m from any facade, subsequently all readings in this report are free field.

3.2 Road Noise Survey Results

The survey data has been used to calculate the 16hr day time and the 8hr night time period noise levels. The Table below shows the day and night time period noise levels that were measured at the survey position.

Date (2018)	Day	Time Period	Freefield Level $L_{Aeq,16hr/8hr}$ – dB(A)
2nd November	Friday	07:00-23:00hrs	59
3rd November	Saturday	07:00-23:00hrs	57
4th November	Sunday	07:00-23:00hrs	58
5th November	Monday	07:00-23:00hrs	60
6th November	Tuesday	07:00-23:00hrs	56
Average	**All days**	**07:00-23:00hrs**	**58**
1st/2nd November	Thur/Fri	23:00-07:00hrs	54
2nd/3rd November	Fri/Sat	23:00-07:00hrs	53
3rd/4th November	Sat/Sun	23:00-07:00hrs	49
4th/5th November	Sun/Mon	23:00-07:00hrs	52
5th/6th November	Mon/Tues	23:00-07:00hrs	54
6th/7th November	Tues/Weds	23:00-07:00hrs	53
Average	**All Nights**	**23:00-07:00hrs**	**52**

Table 2: Survey 1 Noise Levels

4 Road Computer Noise Model

In order to see how noise varies at different positions around the proposed development it is possible to produce a noise contour map. A computer noise model has been completed using the computer package IMMI. The survey data and drawings of the proposed development have been used to complete the noise models. IMMI faithfully implements the propagation method of ISO-9613:1996; Acoustics – Attenuation of sound during propagation outdoors. An “existing site” noise model was completed first to allow the calibration of the noise source (road). The existing site model contained nearby buildings and the existing buildings.

The A27 was added to the “Survey” noise model as a line source. The line source day/night time sound power was adjusted until the level at survey reception point (RP) matched the survey data in section 3. The existing model can be found in the appendices of this report.

4.1 Proposed Development Noise Model Methodology

An updated building model of the site was then added to the model. New reception points were added at different heights locations around the proposed development. RPs were predicted for the day and night time (Model says dB but levels are actually dBA values). The daytime noise contour model can be seen below:

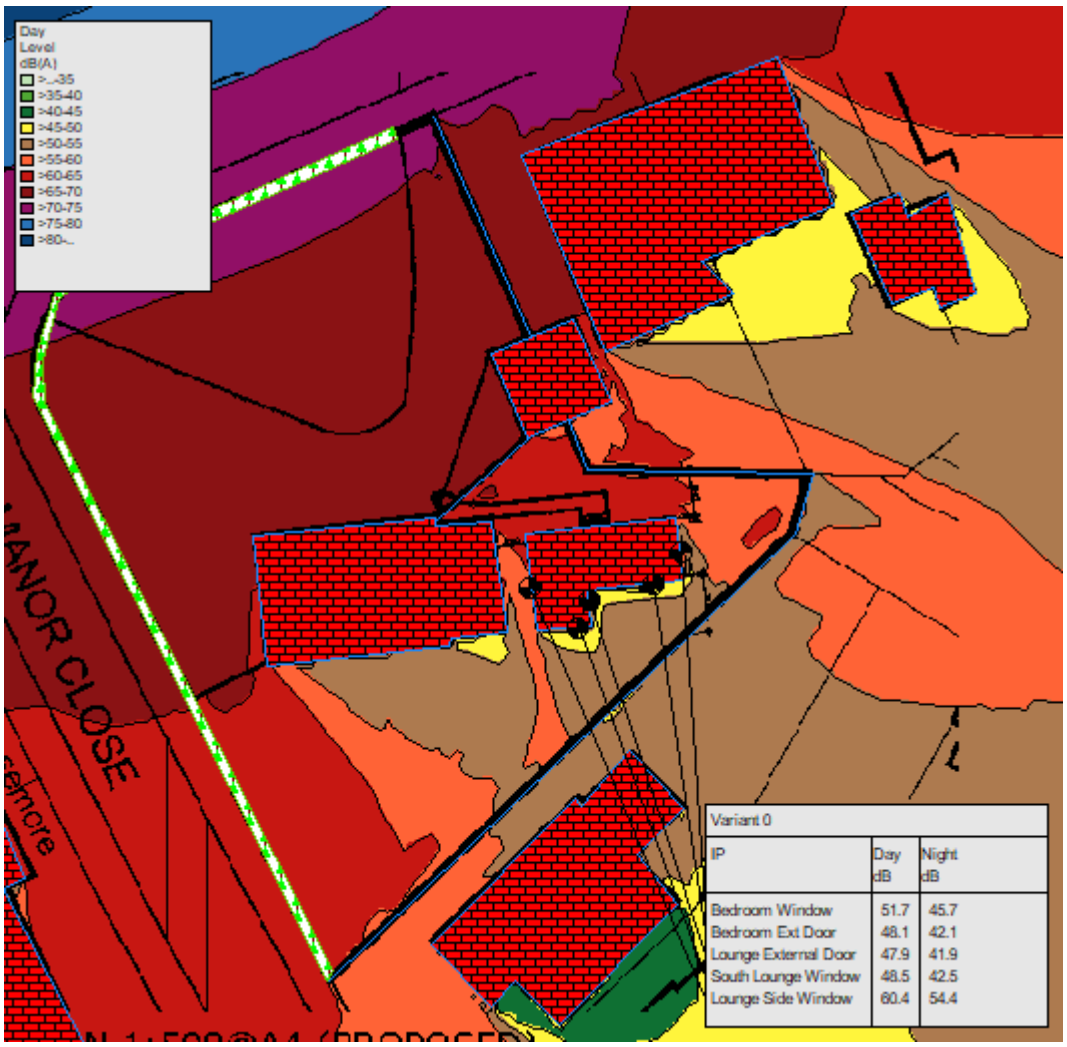

Figure 2: Noise Model

5 Noise Mitigation Measures

5.1 Noise Criteria

5.1.1 Continuous Noise Levels

The BS8233 2014 and WHO noise criteria will be used to specify the noise mitigation measures for all habitable rooms. The maximum internal noise level for each area is as follows:

- Bedrooms 35/30dBA Day/Night
- Lounges 35dBA Day

5.1.2 Road Noise Maximum Noise Levels

For LAmax events the ProPG noise LAmax criterion will be used to specify the noise mitigation measures for bedrooms only:

For a reasonable standard in noise sensitive rooms at night (e.g. bedrooms) individual noise events should not normally exceed 45dB LAFmax more than 10 times a night.

The above is similar to guidance in the WHO Guidelines for Community Noise 1999 document. However the ProPG criteria suggests limiting the number of LAmax events (over 45dBA) to less than 10 times a night as opposed to less than 10-15 times a night as stipulated by the WHO

5.2 Required Sound Reduction of Building Envelope – Continuous Noise levels

The SRI has initially been calculated so that the continuous noise level criteria can be achieved (L_{Amax} discussed in next sub section).

The Table below shows the required Sound Reduction (SRI) which will have to be achieved by the building envelope (for simplicity only worst case RP results have been detailed).

For the bedroom the night time criteria have been used and for the lounge area the day time criterion has been referenced.

Location	Ext. Noise Level	Criterion	ReqSRI
Side Lounge Window	60	35	25
South Lounge Window	48	35	13
Lounge External Door	48	35	13
Bedroom Window	52	30	22
Bedroom External Door	48	30	18

Table 3: Required SRI

5.3 Required Sound Reduction of Building Envelope – LAmax

As discussed in the section above, for the bedroom to achieve the continuous noise level criterion, an SRI of 22dB is needed at the loudest reception point (the bedroom window).

However, using this level of SRI to calculate the number of $L_{Amax,5min}$ events in the bedroom, on night 6, there would have been 11 $L_{Amax,\ 5min.}$ As detailed in section 5.1 ProPG 2017 suggests limiting the number of L_{Amax} events (over 45dBA) to no more than 10. Raising the SRI to 23dB the number of $L_{Amax,\ 5min}$ on night 6 would drop to 8, which would bring it in line with ProPG 2017 criteria. This can be seen in table 4 below.

The calculation for this was achieved by taking into account the difference between sound level at the survey point and the RP in question. Then subtracting the suggested SRI, 23, at these points and seeing how many $L_{Amax,\ 5min}$ there would be in the bedroom over a night time period (between 23:00 and 07:00).

Using this method, the below table shows the number of $L_{Amax,\ 5min}$ over 45dBA for each night which the survey took place.

Reception Point	Night 1	Night 2	Night 3	Night 4	Night 5	Night 6	Average
Bedroom	4	3	0	0	1	8	3

Table 4: $L_{Amax,\ 5min}$ with Suggested SRI

The above table shows that even on the worse night the L_{Amax} criterion will be achieved if the bedroom envelope SRI at least 23dB.

5.4 Glazing and Trickle Vents

The BS8233 "Rigorous Calculation" has been used to predict the sound insulation provided by the building envelope (Calculation detailed in BS8233 (Annex G.2) and full details of the calculations can be found in the appendix of the report.

Calculations have been completed to demonstrate how the required SRI can be achieved using basic 4-12-4 thermal double glazing and basic acoustic trickle vents. As an example, Pilkington Glazing and Velfac Trickle Vent test data was used.

The frequency profile of passing traffic has been approximated using the "Normalized road traffic noise spectrum" derived from BS EN 1793-3:1998. This traffic noise frequency profile is also discussed in BS8233. The calculation predicts the total building envelope sound reduction index SRI.

A summary of the BS8233 "Rigorous Calculation' results can be seen in the table below:

Facarde	Window size:	Req SRI	Frame+Glazing Performance	Ventilator Performance	Prediced Building Envelope SRI
Bedroom Window	1.5m^2	23	$R_{traffic}$* ≥ 25	Dn,e,w ≥ 31	30
Bedroom External Door:	2.6m^2	18	$R_{traffic}$* ≥ 25	Dn,e,w ≥ 31	23
Lounge Side Window	1.25m^2	25	$R_{traffic}$* ≥ 25	Dn,e,w ≥ 31	30
Lounge South Window	1.5m^2	13	$R_{traffic}$* ≥ 25	Dn,e,w ≥ 31	30
Lounge External Door	2.6m^2	13	$R_{traffic}$* ≥ 25	Dn,e,w ≥ 31	29

Table 5: Glazing/Ventilation Specification

** This is the required $R_{traffic}$ of the frame and glazing together. If the glazing supplier has test results for the glazing on its own an $R_{traffic}$ value 2-3dB higher would be required (glazing tested on its own will outperform glazing that is tested within a window frame).*

As can be seen from the above table, all the windows can meet the criteria using basic 4-12-4 thermal double glazing (Pilkington Glazing data used in this case). While trickle vents with a Dn,e,w value of 31(Velfac Trickle Vent test data used) would provide the required SRI.

5.5 Ventilation

Due to the level of road noise from the A27, an alternative ventilation method to opening windows would be required. As section 5.4 shows, if trickle vents where installed, they would easily be able to meet the required SRI. If two trickle vents are needed in any one room to meet the required air changes needed,then this may increase the required Dn,e,w value, however this would still easily be achiveable with basic accoustic trickle vents.

Ventilation and glazing are inextricably linked, as whilst glazing may provide protection against sound levels incident on the façade, any ventilation strategy must not inadvertently compromise the protection and performance provided by the glazing.

Ventilation requirements are dictated by the Building Regulations and currently Approved Document F. It is therefore appropriate that your ventilation engineer or M+E consultant check the requirements and proposals of this particular report to ensure that the requirements of Approved Document F are met in respect of the rooms and in particular to ensure adequate background ventilation.

5.6 Garden

The criterion laid out in section 2.4 of this report for out door spaces states that outdoor living spaces should not exceed 55 dBA. In the model below it shows that the garden of the new annexe would not exceed this criterion.

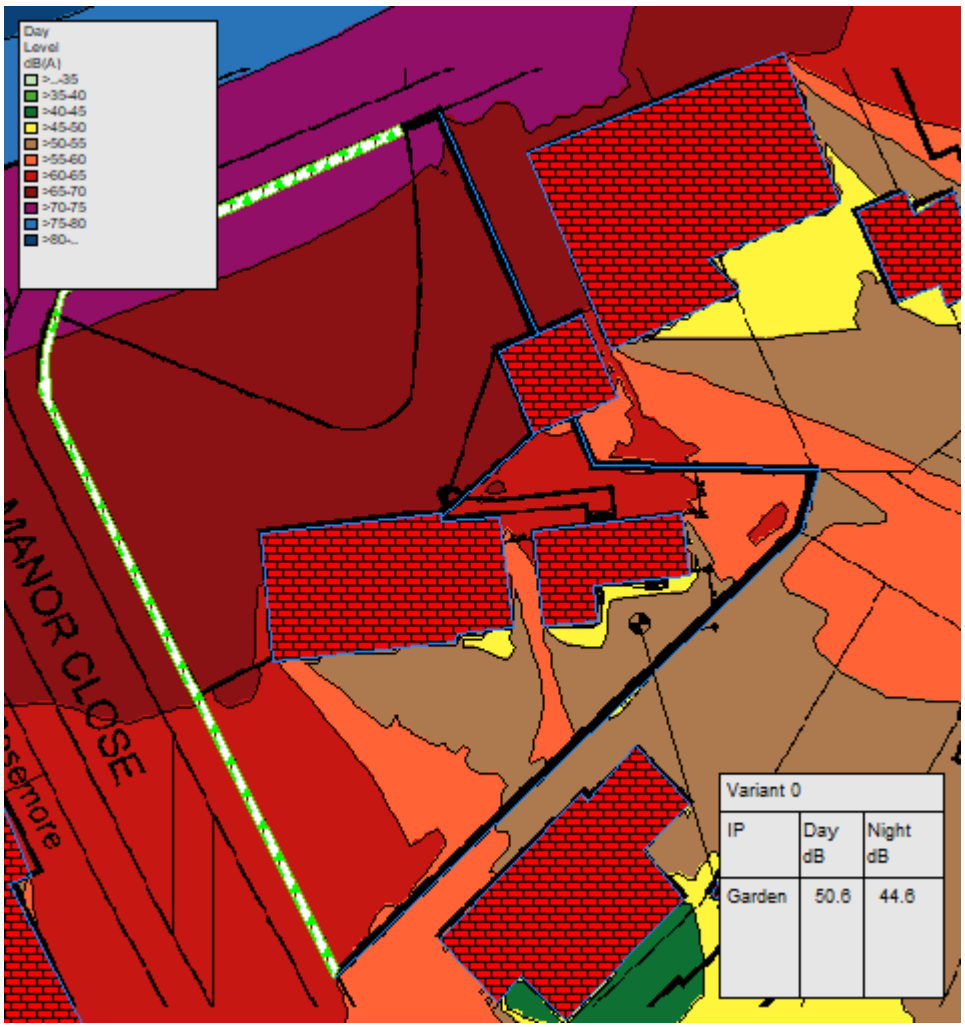

Figure 3: Garden Reception Point

6 Conclusion

Noise levels affecting the planned development have been measured and assessed.

The dominant source of noise affecting the proposed development relates to vehicles traveling on the A27.

Transportation (road) noise has been measured on the existing site (pre-build).

Noise propagation around the planned development has been predicted using the computer program IMMI (Wolfel).

The noise levels for the day and the night time period have been assessed in terms of and following the guidelines of the documents listed below:

- World Health Organisation (WHO) - Guidelines for Community Noise 1999
- ISO9613 (Attenuation of sound during propagation outdoors) 1996
- BS8233 (Sound insulation and noise reduction for buildings) 2014
- Pro-PG (Planning and Noise draft guidance) 2017

In order to demonstrate that the noise criteria can be achieved BS8233 Rigorous calculations have been completed to show what mitigation measures will be required:

- Frame/Glazing to achieve $R_{traffic} \geq 25dBA$
- Dn,e,w ≥ 31dB trickle vents

Noise mitigation measures have been recommended and if they are implemented by the developer it is considered that planning condition 08 would be met.

7 Appendix

7.1 Site and Survey Plan



Figure 4: Existing Site Location Plan



Figure 5: Survey Picture

7.2 Existing site model

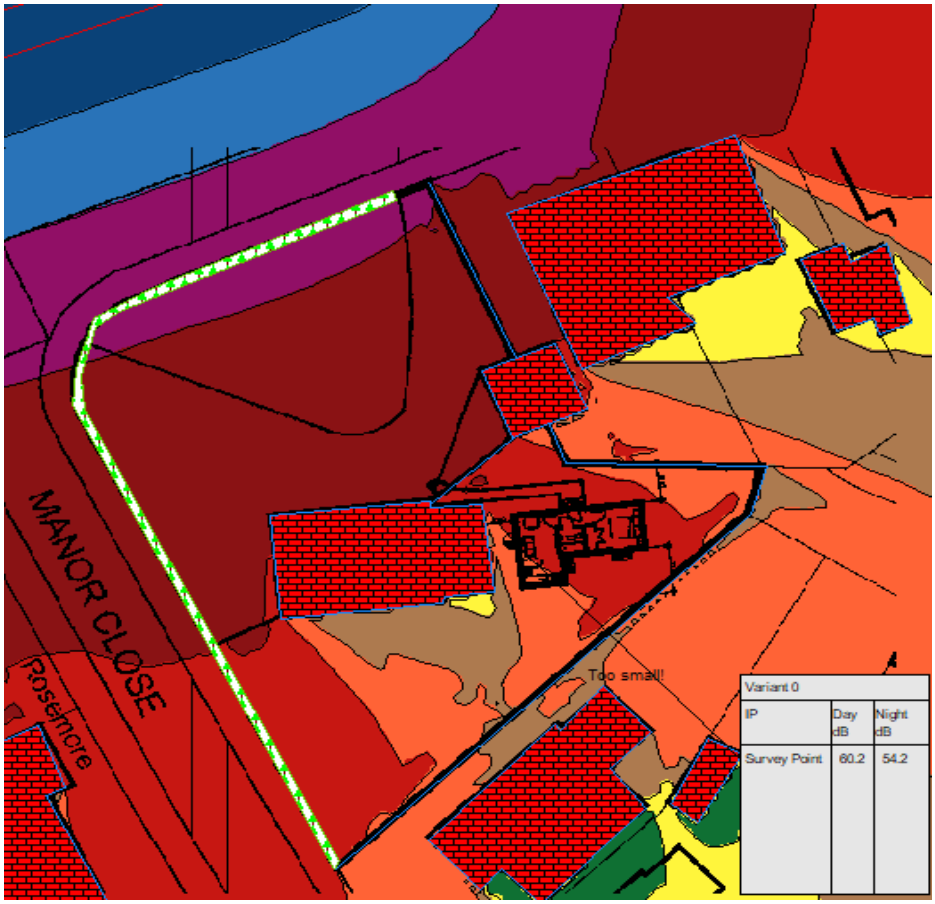

Figure 6: Existing site model

7.3 BS8233 Calculations

Non Frequency Dependent Variables		
Term	**Derivation**	**Value**
A_o	Given in BS EN 20140-10 = 10 (m^2)	10
Sf	Total Facade Area (m^2)	15.81
S_{wi}	Window Area (m^2)	1.5
S_{ew}	External Wall Area (m^2)	14.31
S_{rr}	Ceiling Area (m^2)	10.5
S	Total Area sound enters the room (m^2)	26.31

Key for Table Below	
R_{wi}	Sound Reduction of Window (Octave)
R_{ew}	Sound Reduction Index of External Wall (Octave)
R_{rr}	Sound Reduction Index of Roof/Ceiling (Octave)
A	Equivalent Absorbtion Area of Rx Room
$D_{n,e}$	Insulation of Trickle Vent (BS EN 20140-10)

Frequency Dependent Variables							
		Octave Band Centre Frequency					
Term	**Description**	**125**	**250**	**500**	**1000**	**2000**	**4000**
$L_{eq,ff}$	Free-Field External Noise Level	36.4	34.9	36.0	40.5	42.6	20.0
$D_{n,e}$	Simon Acoustic Frame Vent - Open	39.5	35.9	35.1	30.7	32.1	36.9
R_{wi}	4_12_4	24	20	25	35	38	35
R_{ew}	Cavity Masonry (Brick Cavity with Insulation lightweight block)	41	39	44	52	60	65
R_{rr}	Flat timber joist roof, asphalt on boarding, 12mm plasterboard ceiling, thermal insuation	45	45	45	45	45	45
A	Equivalent Absorbtion Area of Room (Copied from BS8233)	11.00	14.00	16.00	16.00	15.00	15.00

BS8233 Calculation Details						
	Octave Band Centre Frequency					
Term From Equation Below	**125**	**250**	**500**	**1000**	**2000**	**4000**
$L_{eq,ff}$	36.355762	34.85817	35.96092	40.48295067	42.57	19.99996308
Ao/S . 10^(-Dn,e/10)	4.265E-05	9.77E-05	0.000117	0.000323504	0.000234358	7.76031E-05
Swi/S . 10^(-Rwi/10)	0.000227	0.00057	0.00018	1.80289E-05	9.03588E-06	1.80289E-05
Sew/S . 10^(-Rew/10)	4.32E-05	6.85E-05	2.17E-05	3.43177E-06	5.439E-07	1.71996E-07
Srr/S . 10^(-Rrr/10)	1.262E-05	1.26E-05	1.26E-05	1.26203E-05	1.26203E-05	1.26203E-05
10log10(S/A)+3	6.7872816	5.739928	5.160009	5.160008654	5.44029589	5.44029589
Leq,2	8.2677643	9.34242	6.332567	11.17674756	12.10214647	-14.2084738
A-Weighting	-16.1	-8.6	-3.2	0	1.2	1
A-Weighted Leq	**-7.8322357**	**0.74242**	**3.132567**	**11.17674756**	**13.30214647**	**-13.2084738**

A-Weigted Level Outside	**46**
BS8233 Predicted Internal A-Weigted Level	**16**
Prediced Building Envelope SRI	**30**

Bedroom Window (night)

BS8233 Calculation can be seen below:

$$L_{eq,2} \approx L_{eq,ff} + 10\log_{10}\left(\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}} + \frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}} + \frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}\right) + 10\log_{10}\left(\frac{S}{A}\right) + 3$$

Figure 4: BS8233 Calculation Bedroom Window (Night)

Non Frequency Dependent Variables		
Term	Derivation	Value
A_o	Given in BS EN 20140-10 = 10 (m^2)	10
S_f	Total Facade Area (m^2)	15.81
S_{wi}	Window Area (m^2)	1.5
S_{ew}	External Wall Area (m^2)	14.31
S_{rr}	Ceiling Area (m^2)	10.5
S	Total Area sound enters the room (m^2)	26.31

Key for Table Below	
R_{wi}	Sound Reduction of Window (Octave)
R_{ew}	Sound Reduction Index of External Wall (Octave)
R_{rr}	Sound Reduction Index of Roof/Ceiling (Octave)
A	Equivalent Absorbtion Area of Rx Room
$D_{n,e}$	Insulation of Trickle Vent (BS EN 20140-10)

Frequency Dependent Variables							
		Octave Band Centre Frequency					
Term	Description	125	250	500	1000	2000	4000
$L_{eq,ff}$	Free-Field External Noise Level	44.6	43.4	43.5	50.4	43.3	29.3
$D_{n,e}$	Velfac Standard trickle vents 31dB	35	33	27	32	32	38
R_{wi}	4_12_4	24	20	25	35	38	35
R_{ew}	Cavity Masonry (Brick Cavity with Insulation lightweight block)	41	39	44	52	60	65
R_{rr}	Flat timber joist roof, asphalt on boarding, 12mm plasterboard ceiling, thermal insuation	45	45	45	45	45	45
A	Equivalent Absorbtion Area of Room (Copied from BS8233)	11.00	14.00	16.00	16.00	15.00	15.00

BS8233 Calculation Details						
	Octave Band Centre Frequency					
Term From Equation Below	125	250	500	1000	2000	4000
$L_{eq,ff}$	44.615494	43.41666	43.47198	50.35089049	43.34813533	29.3001578
Ao/S . 10^(-Dn,e/10)	0.0001202	0.00019	0.000758	0.000239817	0.000239817	6.02392E-05
Swi/S . 10^(-Rwi/10)	0.000227	0.00057	0.00018	1.80289E-05	9.03588E-06	1.80289E-05
Sew/S . 10^(-Rew/10)	4.32E-05	6.85E-05	2.17E-05	3.43177E-06	5.439E-07	1.71996E-07
Srr/S . 10^(-Rrr/10)	1.262E-05	1.26E-05	1.26E-05	1.26203E-05	1.26203E-05	1.26203E-05
10log10(S/A)+3	6.7872816	5.739928	5.160009	5.160008654	5.44029589	5.44029589
Leq,2	17.455694	18.40822	18.5128	19.88678044	12.97171918	-5.66625061
A-Weighting	-16.1	-8.6	-3.2	0	1.2	1
A-Weighted Leq	**1.3556943**	**9.808217**	**15.3128**	**19.88678044**	**14.17171918**	**-4.66625061**

A-Weigted Level Outside	**52**
BS8233 Predicted Internal A-Weigted Level	**22**
Prediced Building Envelope SRI	**30**

Bedroom Window(Day)

BS8233 Calculation can be seen below:

$$L_{eq,2} \approx L_{eq,ff} + 10\log_{10}\left(\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}} + \frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}} + \frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}\right) + 10\log_{10}\left(\frac{S}{A}\right) + 3$$

Figure 7: BS8233 Calculation Bedroom Window (Day)

Non Frequency Dependent Variables		
Term	Derivation	Value
A_o	Given in BS EN 20140-10 = 10 (m^2)	10
S_f	Total Facade Area (m^2)	15.81
S_{wi}	Window Area (m^2)	2.63
S_{ew}	External Wall Area (m^2)	13.18
S_{rr}	Ceiling Area (m^2)	10.5
S	Total Area sound enters the room (m^2)	26.31

Key for Table Below	
R_{wi}	Sound Reduction of Window (Octave)
R_{ew}	Sound Reduction Index of External Wall (Octave)
R_{rr}	Sound Reduction Index of Roof/Ceiling (Octave)
A	Equivalent Absorbtion Area of Rx Room
$D_{n,e}$	Insulation of Trickle Vent (BS EN 20140-10)

Frequency Dependent Variables							
		Octave Band Centre Frequency					
Term	Description	125	250	500	1000	2000	4000
$L_{eq,ff}$	Free-Field External Noise Level	41.1	39.9	40.0	46.9	39.8	25.8
$D_{n,e}$	Velfac Standard trickle vents 31dB	35	33	27	32	32	38
R_{wi}	4_12_4	24	20	25	35	38	35
R_{ew}	Cavity Masonry (Brick Cavity with Insulation lightweight block)	41	39	44	52	60	65
R_{rr}	Flat timber joist roof, asphalt on boarding, 12mm plasterboard ceiling, thermal insuation	45	45	45	45	45	45
A	Equivalent Absorbtion Area of Room (Copied from BS8233)	11.00	14.00	16.00	16.00	15.00	15.00

BS8233 Calculation Details						
	Octave Band Centre Frequency					
Term From Equation Below	125	250	500	1000	2000	4000
$L_{eq,ff}$	41.115494	39.91666	39.97198	46.85089049	39.84813533	25.8001578
Ao/S . 10^(-Dn,e/10)	0.0001202	0.00019	0.000758	0.000239817	0.000239817	6.02392E-05
Swi/S . 10^(-Rwi/10)	0.000398	0.001	0.000316	3.16108E-05	1.58429E-05	3.16108E-05
Sew/S . 10^(-Rew/10)	3.979E-05	6.31E-05	1.99E-05	3.16078E-06	5.0095E-07	1.58414E-07
Srr/S . 10^(-Rrr/10)	1.262E-05	1.26E-05	1.26E-05	1.26203E-05	1.26203E-05	1.26203E-05
10log10(S/A)+3	6.7872816	5.739928	5.160009	5.160008654	5.44029589	5.44029589
Leq,2	15.465797	16.68023	15.57361	16.59286983	9.58241159	-8.56304093
A-Weighting	-16.1	-8.6	-3.2	0	1.2	1
A-Weighted Leq	**-0.6342034**	**8.080231**	**12.37361**	**16.59286983**	**10.78241159**	**-7.56304093**

A-Weigted Level Outside	48
BS8233 Predicted Internal A-Weigted Level	19
Prediced Building Envelope SRI	29

Bedroom External Door (Day)

BS8233 Calculation can be seen below:

$$L_{eq,2} \approx L_{eq,ff} + 10\log_{10}\left(\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}} + \frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}} + \frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}\right) + 10\log_{10}\left(\frac{S}{A}\right) + 3$$

Figure 8: BS8233 Calculation Bedroom External Door (Day).

Non Frequency Dependent Variables		
Term	Derivation	Value
A_o	Given in BS EN 20140-10 = 10 (m^2)	10
S_f	Total Facade Area (m^2)	15.81
S_{wi}	Window Area (m^2)	2.63
S_{ew}	External Wall Area (m^2)	13.18
S_{rr}	Ceiling Area (m^2)	10.5
S	Total Area sound enters the room (m^2)	26.31

Key for Table Below	
R_{wi}	Sound Reduction of Window (Octave)
R_{ew}	Sound Reduction Index of External Wall (Octave)
R_{rr}	Sound Reduction Index of Roof/Ceiling (Octave)
A	Equivalent Absorbtion Area of Rx Room
$D_{n,e}$	Insulation of Trickle Vent (BS EN 20140-10)

Frequency Dependent Variables							
		Octave Band Centre Frequency					
Term	Description	125	250	500	1000	2000	4000
$L_{eq,ff}$	Free-Field External Noise Level	32.8	31.3	32.4	36.9	39.0	16.4
$D_{n,e}$	Velfac Standard trickle vents 31dB	35	33	27	32	32	38
R_{wi}	4_12_4	24	20	25	35	38	35
R_{ew}	Cavity Masonry (Brick Cavity with Insulation lightweight block)	41	39	44	52	60	65
R_{rr}	Flat timber joist roof, asphalt on boarding, 12mm plasterboard ceiling, thermal insuation	45	45	45	45	45	45
A	Equivalent Absorbtion Area of Room (Copied from BS8233)	11.00	14.00	16.00	16.00	15.00	15.00

BS8233 Calculation Details						
	Octave Band Centre Frequency					
Term From Equation Below	125	250	500	1000	2000	4000
$L_{eq,ff}$	41.115494	39.91666	39.97198	46.85089049	39.84813533	25.8001578
Ao/S . 10^(-Dn,e/10)	0.0001202	0.00019	0.000758	0.000239817	0.000239817	6.02392E-05
Swi/S . 10^(-Rwi/10)	0.000398	0.001	0.000316	3.16108E-05	1.58429E-05	3.16108E-05
Sew/S . 10^(-Rew/10)	3.979E-05	6.31E-05	1.99E-05	3.16078E-06	5.0095E-07	1.58414E-07
Srr/S . 10^(-Rrr/10)	1.262E-05	1.26E-05	1.26E-05	1.26203E-05	1.26203E-05	1.26203E-05
10log10(S/A)+3	6.7872816	5.739928	5.160009	5.160008654	5.44029589	5.44029589
Leq,2	15.465797	16.68023	15.57361	16.59286983	9.58241159	-8.56304093
A-Weighting	-16.1	-8.6	-3.2	0	1.2	1
A-Weighted Leq	**-0.6342034**	**8.080231**	**12.37361**	**16.59286983**	**10.78241159**	**-7.56304093**

A-Weigted Level Outside	42
BS8233 Predicted Internal A-Weigted Level	19
Prediced Building Envelope SRI	23

Bedroom External Door (night)

BS8233 Calculation can be seen below:

$$L_{eq,2} \approx L_{eq,ff} + 10\log_{10}\left(\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}} + \frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}} + \frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}\right) + 10\log_{10}\left(\frac{S}{A}\right) + 3$$

Figure 9: BS8233 Calculation Bedroom External Door (Night)

Non Frequency Dependent Variables		
Term	Derivation	Value
A_o	Given in BS EN 20140-10 = 10 (m^2)	10
S_f	Total Facade Area (m^2)	26.5
S_{wi}	Window Area (m^2)	1.25
S_{ew}	External Wall Area (m^2)	12.25
S_{rr}	Ceiling Area (m^2)	13
S	Total Area sound enters the room (m^2)	26.5

Key for Table Below	
R_{wi}	Sound Reduction of Window (Octave)
R_{ew}	Sound Reduction Index of External Wall (Octave)
R_{rr}	Sound Reduction Index of Roof/Ceiling (Octave)
A	Equivalent Absorbtion Area of Rx Room
$D_{n,e}$	Insulation of Trickle Vent (BS EN 20140-10)

Frequency Dependent Variables							
		Octave Band Centre Frequency					
Term	Description	125	250	500	1000	2000	4000
$L_{eq,ff}$	Free-Field External Noise Level	53.1	51.9	52.0	58.9	51.8	37.8
$D_{n,e}$	Velfac Standard trickle vents 31dB	35	33	27	32	32	38
R_{wi}	4_12_4	24	20	25	35	38	35
R_{ew}	Cavity Masonry (Brick Cavity with Insulation lightweight block)	41	39	44	52	60	65
R_{rr}	Flat timber joist roof, asphalt on boarding, 12mm plasterboard ceiling, thermal insuation	45	45	45	45	45	45
A	Equivalent Absorbtion Area of Room (Copied from BS8233)	11.00	14.00	16.00	16.00	15.00	15.00

BS8233 Calculation Details						
	Octave Band Centre Frequency					
Term From Equation Below	125	250	500	1000	2000	4000
$L_{eq,ff}$	53.115494	51.91666	51.97198	58.85089049	51.84813533	37.8001578
Ao/S . 10^(-Dn,e/10)	0.0001193	0.000189	0.000753	0.000238097	0.000238097	5.98073E-05
Swi/S . 10^(-Rwi/10)	0.0001878	0.000472	0.000149	1.49164E-05	7.47591E-06	1.49164E-05
Sew/S . 10^(-Rew/10)	3.672E-05	5.82E-05	1.84E-05	2.91669E-06	4.62264E-07	1.46181E-07
Srr/S . 10^(-Rrr/10)	1.551E-05	1.55E-05	1.55E-05	1.55131E-05	1.55131E-05	1.55131E-05
10log10(S/A)+3	6.8185319	5.771178	5.191259	5.191258913	5.471546149	5.471546149
Leq,2	25.489198	26.34795	26.87604	28.37894011	21.49520127	2.832568363
A-Weighting	-16.1	-8.6	-3.2	0	1.2	1
A-Weighted Leq	**9.3891981**	**17.74795**	**23.67604**	**28.37894011**	**22.69520127**	**3.832568363**

A-Weigted Level Outside	**60**
BS8233 Predicted Internal A-Weigted Level	**31**
Prediced Building Envelope SRI	**30**

Lounge Side Window (Day)

BS8233 Calculation can be seen below:

$$L_{eq,2} \approx L_{eq,ff} + 10\log_{10}\left(\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}} + \frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}} + \frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}\right) + 10\log_{10}\left(\frac{S}{A}\right) + 3$$

Figure 10:BS8233 Calculation Lounge Side Window (Day)

Non Frequency Dependent Variables		
Term	Derivation	Value
A_o	Given in BS EN 20140-10 = 10 (m^2)	10
Sf	Total Facade Area (m^2)	26.5
S_{wi}	Window Area (m^2)	1.5
S_{ew}	External Wall Area (m^2)	12
S_{rr}	Ceiling Area (m^2)	13
S	Total Area sound enters the room (m^2)	26.5

Key for Table Below	
R_{wi}	Sound Reduction of Window (Octave)
R_{ew}	Sound Reduction Index of External Wall (Octave)
R_{rr}	Sound Reduction Index of Roof/Ceiling (Octave)
A	Equivalent Absorbtion Area of Rx Room
$D_{n,e}$	Insulation of Trickle Vent (BS EN 20140-10)

Frequency Dependent Variables							
		Octave Band Centre Frequency					
Term	Description	125	250	500	1000	2000	4000
$L_{eq,ff}$	Free-Field External Noise Level	41.6	40.4	40.5	47.4	40.3	26.3
$D_{n,e}$	Velfac Standard trickle vents 31dB	35	33	27	32	32	38
R_{wi}	4_12_4	24	20	25	35	38	35
R_{ew}	Cavity Masonry (Brick Cavity with Insulation lightweight block)	41	39	44	52	60	65
R_{rr}	Flat timber joist roof, asphalt on boarding, 12mm plasterboard ceiling, thermal insuation	45	45	45	45	45	45
A	Equivalent Absorbtion Area of Room (Copied from BS8233)	11.00	14.00	16.00	16.00	15.00	15.00

BS8233 Calculation Details						
	Octave Band Centre Frequency					
Term From Equation Below	125	250	500	1000	2000	4000
$L_{eq,ff}$	41.615494	40.41666	40.47198	47.35089049	40.34813533	26.3001578
Ao/S . 10^(-Dn,e/10)	0.0001193	0.000189	0.000753	0.000238097	0.000238097	5.98073E-05
Swi/S . 10^(-Rwi/10)	0.0002253	0.000566	0.000179	1.78997E-05	8.97109E-06	1.78997E-05
Sew/S . 10^(-Rew/10)	3.597E-05	5.7E-05	1.8E-05	2.85717E-06	4.5283E-07	1.43197E-07
Srr/S . 10^(-Rrr/10)	1.551E-05	1.55E-05	1.55E-05	1.55131E-05	1.55131E-05	1.55131E-05
10log10(S/A)+3	6.8185319	5.771178	5.191259	5.191258913	5.471546149	5.471546149
Leq,2	14.412705	15.36649	15.51061	16.92546849	10.01980194	-8.52653724
A-Weighting	-16.1	-8.6	-3.2	0	1.2	1
A-Weighted Leq	**-1.6872946**	**6.76649**	**12.31061**	**16.92546849**	**11.21980194**	**-7.52653724**

A-Weigted Level Outside	**49**
BS8233 Predicted Internal A-Weigted Level	**19**
Prediced Building Envelope SRI	**30**

Lounge South Window (Day)

BS8233 Calculation can be seen below:

$$L_{eq,2} \approx L_{eq,ff} + 10\log_{10}\left(\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}} + \frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}} + \frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}\right) + 10\log_{10}\left(\frac{S}{A}\right) + 3$$

Figure 11: BS8233 Calculation Lounge South Window (Day)

Non Frequency Dependent Variables		
Term	Derivation	Value
A_o	Given in BS EN 20140-10 = 10 (m^2)	10
S_f	Total Facade Area (m^2)	26.5
S_{wi}	Window Area (m^2)	2.63
S_{ew}	External Wall Area (m^2)	10.87
S_{rr}	Ceiling Area (m^2)	13
S	Total Area sound enters the room (m^2)	26.5

Key for Table Below	
R_{wi}	Sound Reduction of Window (Octave)
R_{ew}	Sound Reduction Index of External Wall (Octave)
R_{rr}	Sound Reduction Index of Roof/Ceiling (Octave)
A	Equivalent Absorbtion Area of Rx Room
$D_{n,e}$	Insulation of Trickle Vent (BS EN 20140-10)

Frequency Dependent Variables							
		Octave Band Centre Frequency					
Term	Description	125	250	500	1000	2000	4000
$L_{eq,ff}$	Free-Field External Noise Level	44.6	43.4	43.5	50.4	43.3	29.3
$D_{n,e}$	Velfac Standard trickle vents 31dB	35	33	27	32	32	38
R_{wi}	4_12_4	24	20	25	35	38	35
R_{ew}	Cavity Masonry (Brick Cavity with Insulation lightweight block)	41	39	44	52	60	65
R_{rr}	Flat timber joist roof, asphalt on boarding, 12mm plasterboard ceiling, thermal insuation	45	45	45	45	45	45
A	Equivalent Absorbtion Area of Room (Copied from BS8233)	11.00	14.00	16.00	16.00	15.00	15.00

BS8233 Calculation Details						
	Octave Band Centre Frequency					
Term From Equation Below	125	250	500	1000	2000	4000
$L_{eq,ff}$	44.615494	43.41666	43.47198	50.35089049	43.34813533	29.3001578
Ao/S . 10^(-Dn,e/10)	0.0001193	0.000189	0.000753	0.000238097	0.000238097	5.98073E-05
Swi/S . 10^(-Rwi/10)	0.0003951	0.000992	0.000314	3.13841E-05	1.57293E-05	3.13841E-05
Sew/S . 10^(-Rew/10)	3.258E-05	5.16E-05	1.63E-05	2.58812E-06	4.10189E-07	1.29713E-07
Srr/S . 10^(-Rrr/10)	1.551E-05	1.55E-05	1.55E-05	1.55131E-05	1.55131E-05	1.55131E-05
10log10(S/A)+3	6.8185319	5.771178	5.191259	5.191258913	5.471546149	5.471546149
Leq,2	18.935478	20.15253	19.07169	20.12977246	13.12929082	-4.94119394
A-Weighting	-16.1	-8.6	-3.2	0	1.2	1
A-Weighted Leq	**2.8354777**	**11.55253**	**15.87169**	**20.12977246**	**14.32929082**	**-3.94119394**

A-Weigted Level Outside	**52**
BS8233 Predicted Internal A-Weigted Level	**23**
Prediced Building Envelope SRI	**29**

Lounge Entrance (Day)

BS8233 Calculation can be seen below:

$$L_{eq,2} \approx L_{eq,ff} + 10\log_{10}\left(\frac{A_0}{S}10^{\frac{-D_{n,e}}{10}} + \frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}} + \frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}\right) + 10\log_{10}\left(\frac{S}{A}\right) + 3$$

Figure 12: BS8233 Calculation Lounge External Door (Day).