

Acoustic Associates Sussex Ltd

Discharge of Planning Condition.

Site: Tile Barn Farm Barnham, West Sussex PO22 0BL.

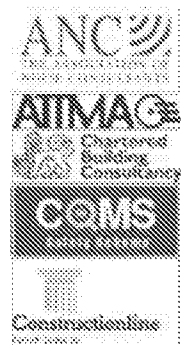
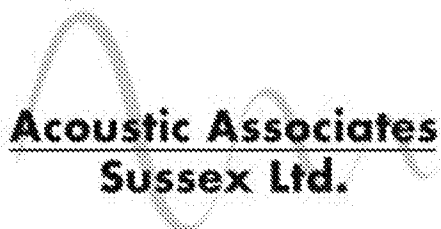
Client: Matt Lonsdale

Report by: Scott Castle BSc (Hons) CEnvH, MCIEH PGDip: Acoustics MIOA

Date: 18/06/2021

Project: J3193

Issue 1.



Sound Insulation Testing - Acoustic Design of Buildings - BS4142 - PPG24 - Schools Acoustics B893 -
Vibration - Expert Witness Testimony - Noise at Work - Air Tightness Testing - Auditorium Acoustics

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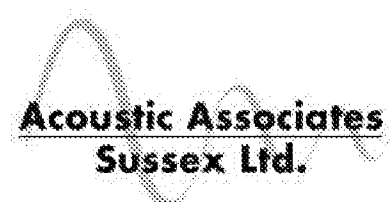
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Report by: Scott Castle BSc (Hons) CEnvH, MCIEH PGDip: Acoustics MIOA

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1 Introduction

Acoustic Associates have been appointed to undertake an acoustic assessment to support a discharge of planning condition. Specifically, the planning condition requires a scheme to ensure that the internal sound pressure levels of a consented dwelling meet BS8233:2014 criteria.

Standards and guidance referenced for this assessment include:

- World Health Organisation (WHO) - Guidelines for Community Noise 1999
- BS8233 (Sound insulation and noise reduction for buildings) 2014
- ISO9613 (Attenuation of sound during propagation outdoors) 1996
- ProPG2017: Planning & Noise – New Residential Development.
- Acoustics Ventilation and Overheating Guidance, January 2020

An unattended class 1 sound level meter was used to measure the received sound pressure levels on the client's consented site over a 11-day period, from 4th to 15th June 2021. The survey deliberately included two weekend periods. The longer survey was carried out with a view to minimising contamination from construction site noise, however, subjectively this was some distance away and only faintly audible.

The measured data showed an arithmetic average of 50dB $L_{Aeq,16\text{ hour}}$ for the daytime period and 48dB $L_{Aeq,8\text{ hour}}$ for the night time period. The sound pressure levels measured remained consistent with only a 4dB variation in the daytime and a 3dB variation in the measured night time periods. Data also showed very low sound levels during the night time period between 01:00 to 04:00 hours (20dB $L_{Aeq,5\text{ minutes}}$)

Given an obvious lack of sound sources, the measured external sound pressure levels have been applied to carry out rigorous calculations for the habitable rooms on the different facades to determine the glazing and ventilation scheme required to protect future occupants from environmental noise.

The results indicate that standard thermal double glazing (R_{traffic} 25dB) may be used with passive through the wall ventilators applied. Future occupants would have the freedom to open windows for background ventilation as they choose and this would only increase internal sound pressure levels no more than 5dB above BS8233:2014 criteria.

Sufficient data has been presented within the report to allow the local planning authority to discharge condition 5 of the planning inspectorates decision (W/4001228).

2 Context, Noise Criteria & Noise Assessment Methodology

2.1 Context

A planning inspector has determined that a new residential dwelling and vehicular access may be constructed at 32 Hill Lane, Barnham, PO22 0BL. Specifically, in making the decision, a condition (5) has been placed which requires as follows:

“Prior to the commencement of the development hereby approved, a scheme shall be submitted to demonstrate that the internal noise levels within the residential unit will conform to the “Indoor ambient noise levels for dwellings” guideline values specified within Table 4 under section 7.7.2 of BS 8233:2014. Details shall be compiled by a competent acoustician on sound insulation and noise reduction for buildings and shall be submitted to and approved in writing by the Local Planning Authority. The scheme should take into account the correct number of air changes required for noise affected rooms. The works specified in the approved scheme shall then be carried out in accordance with the approved details prior to occupation of the premises and be retained thereafter. “

This report therefore provides evidence of a scheme capable of being submitted to the local planning authority. In reviewing the technical consultee comments for the application and more specifically, those received from the Environmental Health department, it is apparent that the condition wording likely originated from the concerns raised by the Environmental Health Officer as follows:

I refer to the above application and make the following comments:

1. The site is adjacent to a number of nurseries and close to agricultural buildings which could be a source of noise disturbance to occupiers of the new property. I would therefore recommend the following condition:

Prior to the commencement of the development hereby approved, a scheme shall be submitted to demonstrate that the internal noise levels within the residential units will conform to the “Indoor ambient noise levels for dwellings” guideline values specified within Table 4 under section 7.7.2 of BS 8233:2014.

Details shall be compiled by a competent acoustician on sound insulation and noise reduction for buildings and shall be submitted to and approved in writing by the Local Planning Authority. The scheme should take into account the correct number of air changes required for noise affected rooms. The works specified in the approved scheme shall then be carried out in accordance with the approved details prior to occupation of the premises and be retained thereafter.

Site drawings and elevations may be viewed on Arun Council’s planning website at BN/24/20/PL.

The NPPF(2019) and ProPG(2017) are of limited application as the building location, design and internal layout has already been approved by the local planning authority, albeit subject to condition.

2.2 Consented Location

The location of the new dwelling is detailed in Figure 1 below, which is on the grounds of Tile Barn Farm and to the East of Hill Lane, Barnham.

The new dwelling is located approximately 73m due East of the nearest agricultural building/glass house which are reported to be owned by Arun District Council.

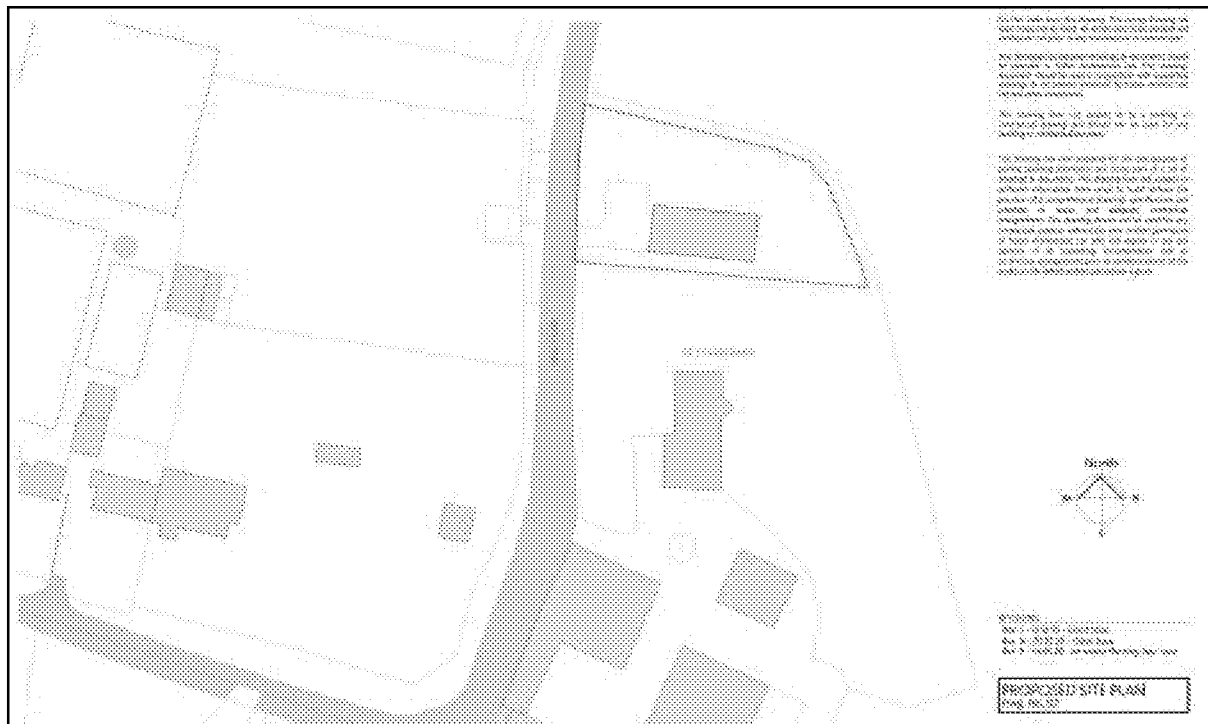


Figure 1. Site Location

2.3 Consented Internal Layout

The ground floor and first floor layout are presented in Figure 2 below with limited windows on the Southern façade.



Figure 2. Consented Internal Layout

2.4 Soundscape

The soundscape at the time of the survey set up and collection was dominated by birdsong and the occasional passing vehicle without any noise heard from the nursery or agricultural buildings. Train noise was also faintly audible and occasional dog barking was also detected in the distance. Faint road traffic noise could also be heard in the distance. Whilst construction noise was occurring, it was only faintly audible.

2.5 Condition 5 Specifics

In reviewing the wording of condition 5, specific reference is made to Table 4 of BS8233:2014 which provides sound pressure levels for inside new dwellings. The internal sound pressure levels and criteria are referenced below in an extract from BS8233:2014.

Table 4 of BS8233:2014 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. BS8233:2014 Criteria

BS8233:2014, Note 7 which accompanies Table 4 also has the following narrative:

"NOTE 7 Where development is considered necessary or desirable, despite external noise levels above WHO guidelines, the internal target levels may be relaxed by up to 5 dB and reasonable internal conditions still achieved."

Whilst not specifically included within the condition it is also good practice to include ProPG2017.

Recent planning guidance (ProPG2017) relates to new residential development and airborne transportation noise, which includes exposure to road traffic, railway and aviation noise. Whilst ProPG, 2017 generally mirrors the requirements of BS8233:2014 and the World Health Organisation Guidelines, 1999, it goes further in setting a limit for inside bedrooms for L_{Amax} events and specifically, no more than 10 L_{Amax} events per night time period above 45dB(A).

3 Sound Survey Baseline Conditions & Results

A sound survey was carried out between Friday 4th June 2021 and Monday 15th June 2021. The duration of the survey deliberately covered two weekends as it was reported by the client that a nearby construction site (both Matthew Homes and Redrow) was operational, just off of Yapton Road.

Whilst construction site noise will clearly not impact the night time measured events, it was proposed to leave the survey in position to gather at least two Sundays without any contamination of construction site noise. The soundscape on setting up and decommissioning the survey position was particularly quiet (circa 16:00 hours on a Friday) with birdsong, very distant road traffic noise and railway noise noted.

3.1 Sound Survey Details

Survey(s) carried out by	Scott Castle BSc(Hons) Env Health, MCIEH CEnvH PGDip Acoustics MIOA
Equipment Used	Castle/Svantek Mirus – Class 1 Sound Level Meter. Serial No. 96147
Location	Grid Reference : SU 96427/03799, 1.95m above ground level.
Duration	4 th June 2021 to 15 th June 2021

Table 2. Survey Equipment

The sound level meter was calibrated before and after commencing the noise measurements (@94dB with no drift). All measurements were taken with the time base set to record 5-minute intervals. All measurements were taken with the microphone located in freefield conditions.

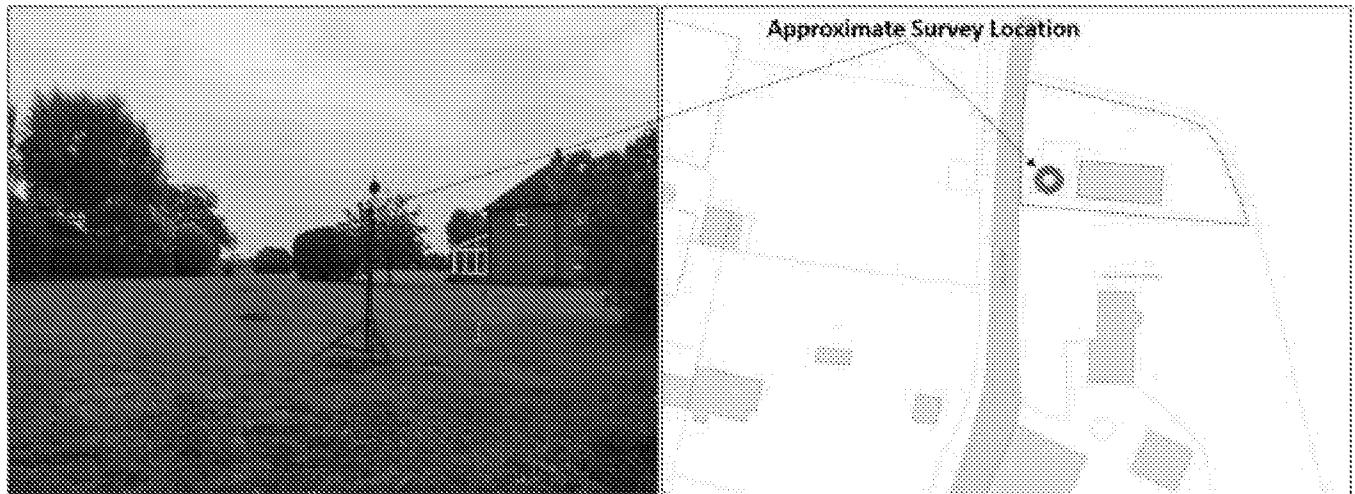


Figure 3. Survey Location

3.2 Measured External Sound Pressure Levels

3.2.1 Measured $L_{Aeq,T}$ Sound Pressure Levels

Figure 4 below details the freefield measured sound pressure level data for the survey duration.

Logarithmically Averaged Day and Night time Periods (External - Freefield)-dB(A)			
$L_{Aeq, 16 \text{ hour } 07:00-23:00}$		$L_{Aeq, 8 \text{ hour } 23:00-07:00}$	
Day 1	48.5	Night 1	48.7
Day 2	49.7	Night 2	49.3
Day 3	54.0	Night 3	48.3
Day 4	48.7	Night 4	48.2
Day 5	50.5	Night 5	47.7
Day 6	49.5	Night 6	48.1
Day 7	51.7	Night 7	48.1
Day 8	52.1	Night 8	46.7
Day 9	47.5	Night 9	49.2
Day 10	51.6	Night 10	48.6
		Night 11	49.9
Arithmetic Average	50.4	Arithmetic Average	48.4

Figure 4. Survey Results (Freefield)

Weather conditions were good without any adverse weather periods. The time history $L_{Aeq,T}$ presentations for day and night can be seen in Appendix A

3.2.2 Measured L_{Amax} Levels (at the survey position)

As stated, it is also relevant to consider L_{Amax} levels for the night time period for how these might impact a bedroom environment and a future occupant's sleep. The L_{Amax} levels were assessed to determine the impact of a partially open window providing 13dB attenuation from the freefield external sound pressure levels.

With an open window at the survey position, the L_{Amax} events would exceed 10 events per night. An SRI of 24dB would be required to ensure that the L_{Amax} events inside a bedroom do not exceed 10 events per night.

It must be remembered that the L_{Amax} value applies only to bedrooms at night.

4 Discussion

4.1 Data Consistency and Quality

As seen in Figure 4, the measured dataset remains consistent with only a 4dB variation in the daytime measured $L_{Aeq,16hour}$ sound pressure levels and a 3dB variation for the $L_{Aeq,8hour}$ night time periods. Given the lack of immediate and obvious sound sources, and the low-level impact of the construction site noise (subjectively assessed), the whole of the data period has been applied for consideration as opposed to just the two Sundays.

If only the two Sunday periods (ie without construction noise) were considered, these would still equate to 49dB $L_{Aeq,16 hour}$, which is only 1dB less than the arithmetic average of the measured data set.

Attention is also drawn to the $L_{Aeq,T}$ time history trace in Appendix A for the night time period where the externally measured sound pressure levels were as low as 20dB between 01:00 and 04:00 hours. Post 04:00 hours, the sound pressure levels increase which is to be anticipated with the dawn chorus and sunrise, especially in such a rural location.

4.2 Measured External Noise Levels

The survey position was measured at 1.95m high at 5m from the road. It is therefore reasonable to consider that the BS8233:2014 upper limit for external spaces of 55dB $L_{Aeq,16 hour}$ has not been exceeded with measured external sound pressure levels comfortably below the BS8233:2014 criterion.

The World Health Organisation, (1999) Guidelines for Community noise are also satisfied where it is stated that the onset of moderate annoyance occurs at 50dB $L_{Aeq,16 hour}$ and the onset of serious annoyance at 55dB $L_{Aeq,16 hour}$.

This is consistent with the subjective findings observed on site and a lack of obvious and immediate sound sources.

4.3 Predicted Internal Sound Pressure Levels

A number of rigorous calculations were applied to consider the different room sizes as these differ considerably in their façade exposure and the ratio of brickwork to glazing. For example, the master bedroom which has an outlook on the Eastern façade has a large amount of glazing which accounts for the relatively low SRI achieved in Figure 5 below. Similarly, the kitchen area also has a significant amount of glazing to façade area with over 5 different windows presents.

Where a room has numerous windows, the glazed areas have been summed and considered as a ratio to the masonry façade.

The rigorous calculations can be seen in Appendix B. It should be noted that whilst the freefield external sound pressure level of 50dB $L_{Aeq, 16 \text{ hour}}$ has been entered into the calculations, account has not been taken of the solid balconies on both the Western and Eastern facades which would likely account for a small reduction in decibels on the receiving façade.

The results of the glazing and ventilation configuration can be seen below in Figure 5. The rationale behind the master bedroom having 2 sets of specification is that the required SRI was only just achieved with a 4/12/4 window specification due to the high ratio of glazed area to masonry façade. Therefore, an option has been provided to show how the predicted SRI would increase with 10/12/4 glazing.

Similarly, the kitchen also achieves a low SRI, again due to the high proportion of glazing on the East facade. It is however noted that a kitchen/dining space is only required to achieve 40dB $L_{Aeq, 16 \text{ hour}}$ and that the SRI value also takes account of the L_{Amax} values which would not apply to a kitchen/dining area space.

The achieved internal sound pressure levels are all below the requirements of BS8233:2014, Table 4 values.

Room Type	Total Window Size (m ²)	Façade Size (m ²)	Remaining Façade	Ceiling	Glazing Applied	Vent Applied	Internal SPL	SRI Achieved
Master Bedroom	10.9	22.1	11.2	18.2	4\12\4	31dB Trickle Vent	26	24
Master Bedroom	10.9	22.1	11.2	18.2	10\12\4	31dB Trickle Vent	24	26
Bedroom 2	3.4	10	6.6	14	4\12\4	31dB Trickle Vent	23	27
Bedroom 3	7.1	19.3	12.2	13.3	4\12\4	31dB Trickle Vent	25	25
Bedroom 4	4.2	17.3	13.1	10.6	4\12\4	31dB Trickle Vent	23	27
Sitting Room	9.5	27	17.5	N/A	4\12\4	31dB Trickle Vent	25	25
Study	1	5.2	4.2	N/A	4\12\4	31dB Trickle Vent	21	29
Kitchen	20.2	50.4	30.2	N/A	4\12\4	31dB Trickle Vent	28	22

Figure 5. Predicted Internal Sound Pressure Levels

It is apparent from Figure 5 that with the relatively low external sound pressure levels and a lack of obvious and immediate sound sources that standard thermal double glazing is likely to be sufficient.

Whilst the report has used Pilkington glazing with a configuration of 4\12\4, should the client wish to assess different glazing providers, then the metric to be compared is referred to as $R_{traffic}$. $R_{traffic}$ is essentially the $R_w + C_{tr}$ which includes a low frequency correction. The $R_{traffic}$ of a Pilkington 4\12\4 glazed unit is 25dB.

4.4 Predicted Internal L_{Amax} Levels

As previously stated, it is good practice to also consider ProPG2017 in addition to the wording of condition 5, to ensure that future occupants are protected against L_{Amax} levels during the night time period. The minimum requirement at the survey position was an SRI of 24dB. The results shown in figure 5 show that an SRI of 24dB would be achieved in all bedrooms with the glazing and trickle vent configurations used.

4.5 ProPG2017

Given that the location, massing, design and orientation have already been approved by the local planning authority, site risk assessments and design quantification are not necessary to support the application for a discharge of condition. However, as good practice, the L_{Amax} element of ProPG2017, although not worded into the condition has been applied to protect future occupants in bedrooms.

4.6 Openable Windows for Background Ventilation

Whether windows are openable to provide background ventilation will depend on the external soundscape, which if elevated externally, might mean the practice of opening windows will likely see an increase in the internal soundscape, above the criteria in Table 4, BS8233:2014 and ProPG2017.

It is noted that as part of condition 5, reference is made to the correct number of air changes per room. It is strongly recommended that there is liaison with the client's M+E consultant about the required number of air changes in Building Regulations Approved Document F.

The calculations performed in 4.3 above assumed a closed window with a standard 31dB trickle vent applied. For bedrooms these are typically 2500mm² in free area (trickle vent), however for larger rooms, greater ventilation rates may be needed.

In the Acoustics, Overheating and Ventilation Guidance dated Jan 2020, it is stated that the loss of sound energy through a partially open window is taken to be a reduction of 13dB from outside freefield sound pressure levels to inside sound pressure levels.

Figure 6 below shows the likely internal noise levels with open windows using the survey position data and these are within 5dB tolerance of BS8233:2014 internal criteria as per note 7 to BS8233:2014 and allowing reasonable ventilation conditions under the Acoustics, Ventilation and Overheating Guide (Jan 2020).

Assessment of whether windows may be opened for background ventilation						
Description	Average Measured Daytime External Sound Pressure Level ($L_{Aeq, 16 \text{ hour}}$)	Open Window (-13dB)	Closed Window (-30dB)	BS8233:2014 Daytime Criterion	5dB Tolerance above BS8233:2014	Openable Windows (Yes/No)
Survey Position (1.95m)	50	37	20	35 dB $L_{Aeq, 16 \text{ hour}}$	40 dB $L_{Aeq, 16 \text{ hour}}$	Yes
Description	Average Measured Night Time External Sound Pressure Level ($L_{Aeq, 8 \text{ hour}}$)	Open Window (-13dB)	Closed Window (-30dB)	BS8233:2014 Night Time Criterion	5dB Tolerance above BS8233:2014	Openable Windows (Yes/No)
Survey Position (1.95m)	48	35	18	30 dB $L_{Aeq, 8 \text{ hour}}$	35 dB $L_{Aeq, 8 \text{ hour}}$	Yes

All predicted External data presented is dB(A) and Freefield

Figure 6. Openable Windows Assessment

Figure 7 below is an extract from the Acoustics Ventilation and Overheating Guide dated Jan 2020 indicating that with the freefield externally measured sound pressure levels, opening windows as a means of mitigating overheating is not likely to result in an adverse effect. The Figure has been annotated with a solid red line to show the measured levels falling into a negligible category.

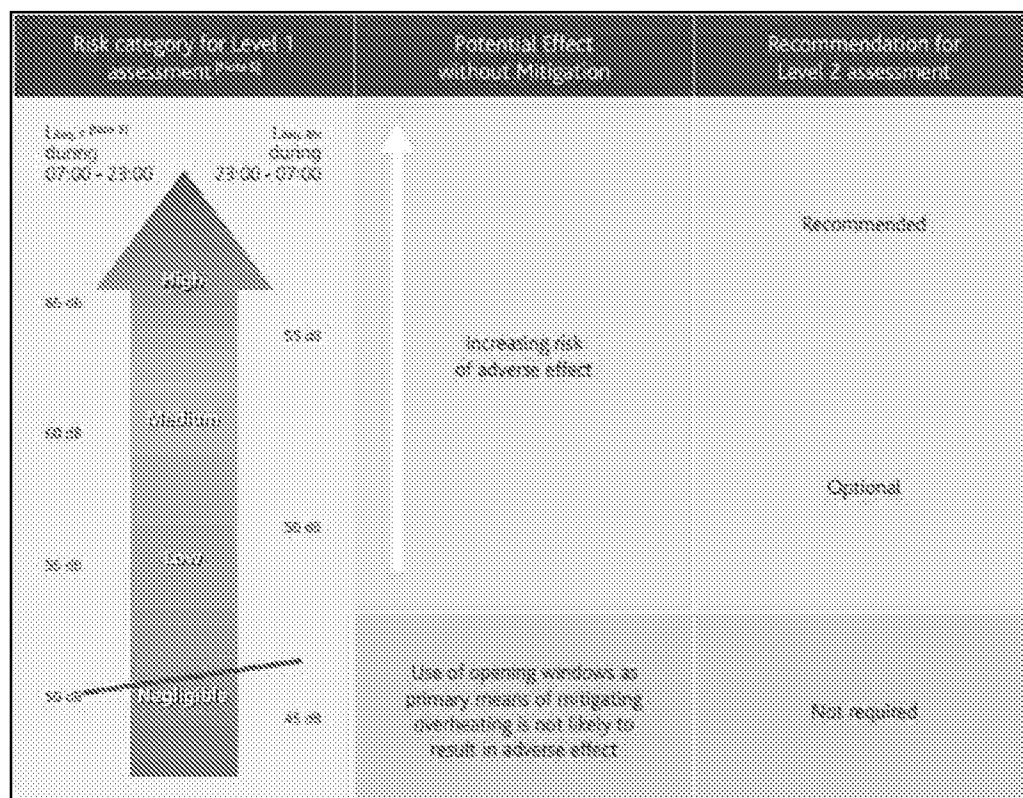


Figure 7. Overheating Level 1 Risk Assessment

If it was determined that sufficient air flow was not achievable from either opening windows or trickle ventilation, as it was detailed earlier that opening windows may cause the internal soundscape to be elevated inside the property (above the requirements of BS8233:2014), then the Part F Building Regulations hierarchy would dictate that either a larger through the wall ventilator is possible, or mechanical extract ventilation (MEV) may be considered.

As an example to consider a larger ventilation space, the sitting room has been re-assessed with a Titen through the wall passive vent ($D_{n,e,w}$ 42dB -open) achieving a much larger free space of 9800mm². The calculation identifies that for the sitting room area, this would still achieve 24dB $L_{Aeq,16\text{ hour}}$, 11dB below the level for a lounge set out in table 4 of BS8233:2014.

Through the wall passive ventilators are commercially available with high acoustic performance which the end resident may have open or closed and exercise a degree of control. The future occupants are also able to exercise control over whether they wish to open windows and it is relevant to note that there are not any criteria applied for short term boost ventilation such as removing odours of burnt toast for example.

5 Uncertainty

The sound level meter used in the site survey was calibrated before and after the survey in situ, without any significant drift having occurred, to ensure that the information and data being obtained was representative and that the sound level meters were operating correctly.

The survey data has also only used whole data periods, ie whole days or nights.

The survey ran over a much longer period than normal with a view to only using the Sundays to avoid contamination of the dataset through construction site noise. However, given the subjective assessment made on site and the faintly audible construction site impact, the whole data set was used which presents a robust and worst case of 10 full days data and 11 nights including two weekends.

Without an obvious and immediate sound source to measure and quantify in a model and make predictions on other facades of the building, the assessment has used the same measured survey external sound pressure level ($L_{Aeq,T}$).

For example, with a busy road adjacent, one would take roadside readings and calibrate the acoustic model accordingly with the new dwelling then introduced and predictions made for windows on different facades. However, Hill Lane does not have frequent traffic and the agricultural buildings related to the distant nursery are not active sound sources that are capable of being measured at source. Construction site noise is not permanent and will only last a finite amount of time before it ceases to be audible with the completion of the houses.

6 Conclusion

An unattended class 1 sound level meter was used to measure the received sound pressure levels on the client's consented site over a 11-day period, from 4th to 15th June 2021. The survey deliberately included two weekend periods. The longer survey was carried out with a view to minimising contamination from construction site noise, however, subjectively this was some distance away and only faintly audible.

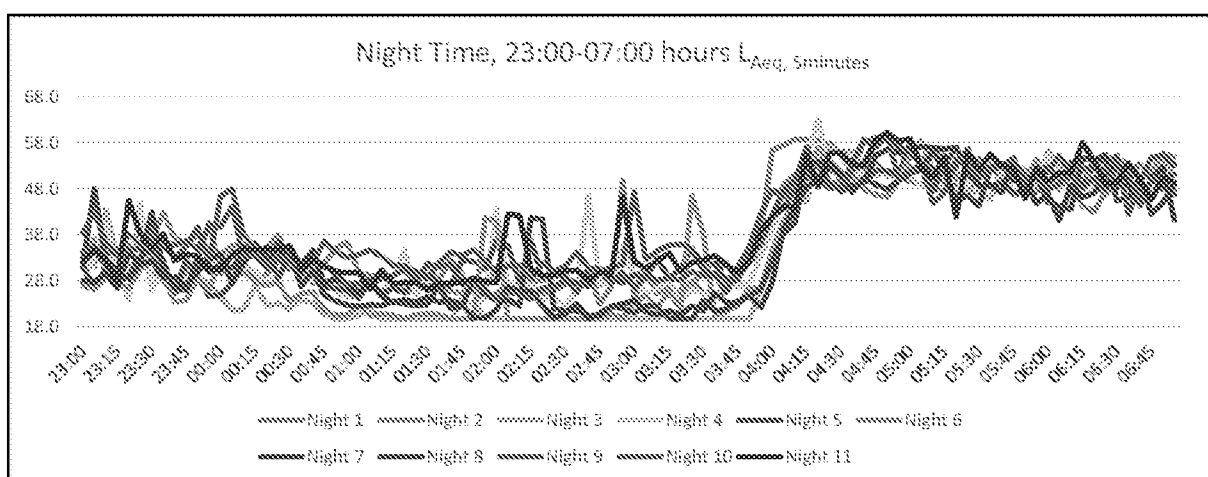
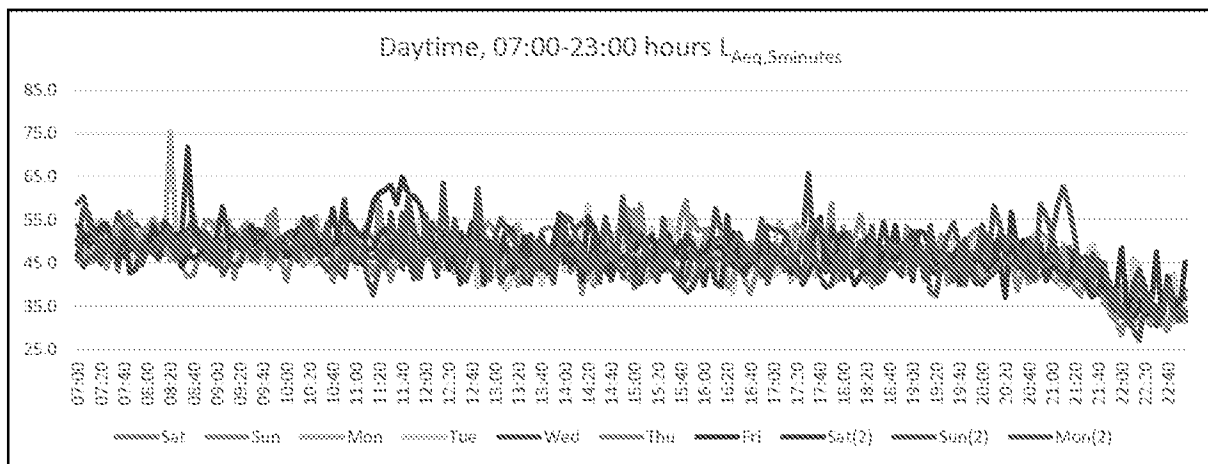
The measured data showed an arithmetic average of 50dB $L_{Aeq,16\text{ hour}}$ for the daytime period and 48dB $L_{Aeq,8\text{ hour}}$ for the night time period. The sound pressure levels measured remained consistent with only a 4dB variation in the daytime and a 3dB variation in the measured night time periods. Data also showed very low sound levels during the night time period between 01:00 to 04:00 hours (20dB $L_{Aeq,5\text{ minutes}}$)

Given an obvious lack of sound sources, the measured external sound pressure levels have been applied to carry out rigorous calculations for the habitable rooms on the different facades to determine the glazing and ventilation scheme required to protect future occupants from environmental noise.

The results indicate that standard thermal double glazing ($R_{\text{traffic}} 25\text{dB}$) may be used with passive through the wall ventilators applied. Future occupants would have the freedom to open windows for background ventilation as they choose and this would only increase internal sound pressure levels no more than 5dB above BS8233:2014 criteria.

Sufficient data has been presented within the report to allow the local planning authority to discharge condition 5 of the planning inspectorates decision (W/4001228).

7 Appendix A – Time History Presentation



8 Appendix B – Rigorous Calculations

8.1 Bedroom 3

Non-Frequency Dependent Variables			Key for Table Below	
Term	Derivation	Value	R _w	Sound Reduction of Window (Octave)
A ₀	Given in BS EN 20140-10 = 10 (m ²)	10	R _{ew}	Sound Reduction Index of External Wall (Octave)
S _t	Total Facade Area (m ²)	19.3	R _{ce}	Sound Reduction Index of Roof/Ceiling (Octave)
S _w	Window Area (m ²)	7.1	A	Equivalent Absorption Area of Rx Room
S _{ew}	External Wall Area (m ²)	12.2	D _{se}	Insulation of Trickle Vent (BS EN 20140-10)
S _c	Ceiling Area (m ²)	13.3		
S	Total Area sound enters the room (m ²)	32.6		

Frequency Dependent Variables							
Term	Description	Octave Band Centre Frequency					
		125	250	500	1000	2000	4000
L _{eq,ff}	Free-Field External Noise Level	52	48	46	46	43	36
D _{se}	31 dB Vent	31	31	31	31	31	31
R _w	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 _{ce}	Tile on Felt, Pitched Roof, 100mm mineral wool on plasterboard ceiling	43	43	43	43	43	43
A	Equivalent Absorption Area of Room (Copied from BS8233)	11.00	14.00	16.00	16.00	15.00	15.00

BS8233 Calculation Details							
Term From Equation Below	Octave Band Centre Frequency						
	125	250	500	1000	2000	4000	
L _{eq,ff}	52	48	46	46	43	36	
A ₀ /S · 10 ⁴ (-D _{se} /10)	0.00024366	0.000244	0.000244	0.000243659	0.000243659	0.000243659	
5w _l /S · 10 ⁴ (-R _w /10)	0.00086704	0.002178	0.000689	6.88717E-05	3.45176E-05	6.88717E-05	
S _{ew} /S · 10 ⁴ (-R _{ew} /10)	2.9726E-05	4.71E-05	1.49E-05	2.36125E-06	3.74233E-07	1.18343E-07	
S _{rr} /S · 10 ⁴ (-R _{rr} /10)	2.0447E-05	2.04E-05	2.04E-05	2.04472E-05	2.04472E-05	2.04472E-05	
10log10(S/A)+3	7.71824915	6.670896	6.090976	6.090976174	6.37126341	6.37126341	
L _{eq,2}	30.3661067	28.63138	21.94848	17.34581837	14.12794657	7.596960339	
A-Weighting	-16.1	-8.6	-3.2	0	1.2	1	
A-Weighted L _{eq}	14.2661067	20.03138	18.74848	17.34581837	15.32794657	8.596960339	

A-Weighted Level Outside	50
BS8233 Predicted Internal A-Weighted Level	25
Predicted Building Envelope SRI	25

BS8233 Calculation can be seen below:

$$L_{eq,2} = L_{eq,ff} + 10 \log_{10} \left(\frac{A_0}{S} 10^{\frac{-D_{se}}{10}} + \frac{S_{w1}}{S} 10^{\frac{-R_{w1}}{10}} + \frac{S_{ew}}{S} 10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S} 10^{\frac{-R_{rr}}{10}} \right) + 10 \log_{10} \left(\frac{S}{A} \right) + 3$$

8.2 Bedroom 4

Non Frequency Dependent Variables			Key for Table Below	
Term	Derivation	Value	R _w	Sound Reduction of Window (Octave)
A ₀	Given in BS EN 20140-10 = 10 (m ²)	10	R _{ew}	Sound Reduction Index of External Wall (Octave)
S _t	Total Facade Area (m ²)	17.3	R _r	Sound Reduction Index of Roof/Ceiling (Octave)
S _w	Window Area (m ²)	4.2	A	Equivalent Absorption Area of Rx Room
S _{ew}	External Wall Area (m ²)	13.1	D _{tr,v}	Insulation of Trickle Vent (BS EN 20140-10)
S _c	Ceiling Area (m ²)	10.6		
S	Total Area sound enters the room (m ²)	27.9		

Frequency Dependent Variables							
Term	Description	Octave Band Centre Frequency					
		125	250	500	1000	2000	4000
L _{eq,ff}	Free-Field External Noise Level	52	48	46	46	43	36
D _{tr,v}	31 dB Vent	31	31	31	31	31	31
R _w	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 _r	Tile on Felt, Pitched Roof, 100mm mineral wool on plasterboard ceiling	43	43	43	43	43	43
A	Equivalent Absorption Area of Room (Copied from BS8233)	11.00	14.00	16.00	16.00	15.00	15.00

BS8233 Calculation Details							
Term from Equation Below	Octave Band Centre Frequency						
	125	250	500	1000	2000	4000	
L _{eq,ff}	52	48	46	46	43	36	
A ₀ /S . 10 [^] (-D _{tr,v} /10)	0.00028471	0.000285	0.000285	0.000284705	0.000284705	0.000284705	
S _w /S . 10 [^] (-R _w /10)	0.0005993	0.001505	0.000476	4.76042E-05	2.38586E-05	4.76042E-05	
S _{ew} /S . 10 [^] (-R _{ew} /10)	3.7296E-05	5.91E-05	1.87E-05	2.96256E-06	4.69534E-07	1.4848E-07	
S _r /S . 10 [^] (-R _r /10)	1.9042E-05	1.9E-05	1.9E-05	1.90415E-05	1.90415E-05	1.90415E-05	
10log10(S/A)+3	7.04211518	5.994762	5.414842	5.414842206	5.695129442	5.695129442	
L _{eq,2}	28.7749851	26.70907	20.43749	16.90872193	13.85486246	7.154378314	
A-Weighting	-16.1	-8.6	-3.2	0	1.2	1	
A-Weighted L _{eq}	12.6749851	18.10907	17.23749	16.90872193	15.05486246	8.154378314	

A-Weighted Level Outside	50
BS8233 Predicted Internal A-Weighted Level	23
Predicted Building Envelope SRI	27

BS8233 Calculation can be seen below:							
$L_{eq,2} = L_{eq,ff} + 10 \log_{10} \left(\frac{A_0}{S} 10^{\frac{-D_{tr,v}}{10}} + \frac{S_w}{S} 10^{\frac{-R_w}{10}} + \frac{S_{ew}}{S} 10^{\frac{-R_{ew}}{10}} + \frac{S_r}{S} 10^{\frac{-R_r}{10}} \right) + 10 \log_{10} \left(\frac{S}{A} \right) + 3$							

8.3 Bedroom 2

Non Frequency Dependent Variables			Key for Table Below			
Term	Derivation	Value	R _w	Sound Reduction of Window (Octave)		
A ₀	Given in BS EN 20140-10 = 10 (m ²)	10	R _{ew}	Sound Reduction Index of External Wall (Octave)		
S _t	Total Facade Area (m ²)	10	R _r	Sound Reduction Index of Roof/Ceiling (Octave)		
S _w	Window Area (m ²)	3.4	A	Equivalent Absorption Area of Rx Room		
S _{ew}	External Wall Area (m ²)	6.6	D _{tr,v}	Insulation of Trickle Vent (BS EN 20140-10)		
S _c	Ceiling Area (m ²)	14				
S	Total Area sound enters the room (m ²)	24				

Frequency Dependent Variables							
Term	Description	Octave Band Centre Frequency					
		125	250	500	1000	2000	4000
L _{eq,ff}	Free-Field External Noise Level	52	48	46	46	43	36
D _{tr,v}	31 dB Vent	31	31	31	31	31	31
R _w	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 _r	Tile on Felt, Pitched Roof, 100mm mineral wool on plasterboard ceiling	43	43	43	43	43	43
A	Equivalent Absorption Area of Room (Copied from BS8233)	11.00	14.00	16.00	16.00	15.00	15.00

BS8233 Calculation Details							
Term from Equation Below	Octave Band Centre Frequency						
	125	250	500	1000	2000	4000	
L _{eq,ff}	52	48	46	46	43	36	
A ₀ /S . 10 [^] (-D _{tr,v} /10)	0.00033097	0.000331	0.000331	0.00033097	0.00033097	0.00033097	
S _w /S . 10 [^] (-R _w /10)	0.00056399	0.001417	0.000448	4.47989E-05	2.24527E-05	4.47989E-05	
S _{ew} /S . 10 [^] (-R _{ew} /10)	2.1844E-05	3.46E-05	1.09E-05	1.73513E-06	0.000000275	8.69626E-08	
S _r /S . 10 [^] (-R _r /10)	2.9236E-05	2.92E-05	2.92E-05	2.92359E-05	2.92359E-05	2.92359E-05	
10log10(S/A)+3	6.38818557	5.340832	4.760913	4.760912591	5.041199827	5.041199827	
L _{eq,2}	28.1472585	25.9212	19.89451	16.85408235	13.8724354	7.116735591	
A-Weighting	-16.1	-8.6	-3.2	0	1.2	1	
A-Weighted L _{eq}	12.0472585	17.3212	16.69451	16.85408235	15.0724354	8.116735591	

A-Weighted Level Outside	50
BS8233 Predicted Internal A-Weighted Level	23
Predicted Building Envelope SRI	27

BS8233 Calculation can be seen below:							
$L_{eq,2} = L_{eq,ff} + 10 \log_{10} \left(\frac{A_0}{S} 10^{\frac{-D_{tr,v}}{10}} + \frac{S_w}{S} 10^{\frac{-R_w}{10}} + \frac{S_{ew}}{S} 10^{\frac{-R_{ew}}{10}} + \frac{S_r}{S} 10^{\frac{-R_r}{10}} \right) + 10 \log_{10} \left(\frac{S}{A} \right) + 3$							

8.4 Master Bedroom (4/12/4 Glazing)

Non Frequency Dependent Variables			Key for Table Below					
Term	Derivation	Value	R _w	Sound Reduction of Window (Octave)				
A ₀	Given in BS EN 20140-10 = 10 (m ²)	10	R _{ew}	Sound Reduction Index of External Wall (Octave)				
S _t	Total Facade Area (m ²)	22.1	R _r	Sound Reduction Index of Roof/Ceiling (Octave)				
S _w	Window Area (m ²)	10.9	A	Equivalent Absorption Area of Rx Room				
S _{ew}	External Wall Area (m ²)	11.2	D _{tr,v}	Insulation of Trickle Vent (BS EN 20140-10)				
S _c	Ceiling Area (m ²)	18.2						
S	Total Area sound enters the room (m ²)	40.3						

Frequency Dependent Variables							
Term	Description	Octave Band Centre Frequency					
		125	250	500	1000	2000	4000
L _{eq,ff}	Free-Field External Noise Level	52	48	46	46	43	36
D _{tr,v}	31 dB Vent	31	31	31	31	31	31
R _w	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 _r	Tile on Felt, Pitched Roof, 100mm mineral wool on plasterboard ceiling	43	43	43	43	43	43
A	Equivalent Absorption Area of Room (Copied from BS8233)	11.00	14.00	16.00	16.00	15.00	15.00

BS8233 Calculation Details							
Term from Equation Below	Octave Band Centre Frequency						
	125	250	500	1000	2000	4000	
L _{eq,ff}	52	48	46	46	43	36	
A ₀ /S . 10 [^] (-D _{tr,v} /10)	0.0001971	0.000197	0.000197	0.000197104	0.000197104	0.000197104	
S _w /S . 10 [^] (-R _w /10)	0.00107677	0.002705	0.000855	8.55306E-05	4.28668E-05	8.55306E-05	
S _{ew} /S . 10 [^] (-R _{ew} /10)	2.2076E-05	3.5E-05	1.11E-05	1.75353E-06	2.77916E-07	8.78846E-08	
S _{rt} /S . 10 [^] (-R _{rt} /10)	2.2634E-05	2.26E-05	2.26E-05	2.26343E-05	2.26343E-05	2.26343E-05	
10log10(S/A)+3	8.63912361	7.59177	7.011851	7.011850635	7.292137871	7.292137871	
L _{eq,2}	31.8401883	30.30387	23.37058	17.88354784	14.48975953	8.14020976	
A-Weighting	-16.1	-8.6	-3.2	0	1.2	1	
A-Weighted L _{eq}	15.7401883	21.70387	20.17058	17.88354784	15.68975953	9.14020976	

A-Weighted Level Outside	50
BS8233 Predicted Internal A-Weighted Level	26
Predicted Building Envelope SRI	24

BS8233 Calculation can be seen below:							
$L_{eq,2} = L_{eq,ff} + 10 \log_{10} \left(\frac{A_0}{S} 10^{\frac{-D_{tr,v}}{10}} + \frac{S_w}{S} 10^{\frac{-R_w}{10}} + \frac{S_{ew}}{S} 10^{\frac{-R_{ew}}{10}} + \frac{S_{rt}}{S} 10^{\frac{-R_{rt}}{10}} \right) + 10 \log_{10} \left(\frac{S}{A} \right) + 3$							

8.5 Master Bedroom (10/12/4 Glazing)

Non Frequency Dependent Variables			Key for Table Below			
Term	Derivation	Value	R _w	Sound Reduction of Window (Octave)		
A ₀	Given in BS EN 20140-10 = 10 (m ²)	10	R _{ew}	Sound Reduction Index of External Wall (Octave)		
S _t	Total Facade Area (m ²)	22.1	R _{ce}	Sound Reduction Index of Roof/Ceiling (Octave)		
S _w	Window Area (m ²)	10.9	A	Equivalent Absorption Area of Rx Room		
S _{ew}	External Wall Area (m ²)	11.2	D _{tr,v}	Insulation of Trickle Vent (BS EN 20140-10)		
S _{ce}	Ceiling Area (m ²)	18.2				
S	Total Area sound enters the room (m ²)	40.3				

Frequency Dependent Variables							
Term	Description	Octave Band Centre Frequency					
		125	250	500	1000	2000	4000
L _{eq,ff}	Free-Field External Noise Level	52	48	46	46	43	36
D _{tr,v}	31 dB Vent	31	31	31	31	31	31
R _w	10_12_4	25	22	33	40	43	44
R _{ew}	Cavity Masonry (Brick Cavity with Insulation lightweight block)	41	39	44	52	60	65
R _{ce}	Tile on Felt, Pitched Roof, 100mm mineral wool on plasterboard ceiling	43	43	43	43	43	43
A	Equivalent Absorption Area of Room (Copied from BS8233)	11.00	14.00	16.00	16.00	15.00	15.00

BS8233 Calculation Details							
Term from Equation Below	Octave Band Centre Frequency						
	125	250	500	1000	2000	4000	
L _{eq,ff}	52	48	46	46	43	36	
A ₀ /S . 10 [^] (-D _{tr,v} /10)	0.0001971	0.000197	0.000197	0.000197104	0.000197104	0.000197104	
S _w /S . 10 [^] (-R _w /10)	0.00085531	0.001707	0.000136	2.70471E-05	1.35557E-05	1.07677E-05	
S _{ew} /S . 10 [^] (-R _{ew} /10)	2.2076E-05	3.5E-05	1.11E-05	1.75353E-06	2.77916E-07	8.78846E-08	
S _{ce} /S . 10 [^] (-R _{ce} /10)	2.2634E-05	2.26E-05	2.26E-05	2.26343E-05	2.26343E-05	2.26343E-05	
10log10(S/A)+3	8.63912361	7.59177	7.011851	7.011850635	7.292137871	7.292137871	
L _{eq,2}	31.0416631	28.51718	18.65092	16.96579117	13.97633902	6.920610179	
A-Weighting	-16.1	-8.6	-3.2	0	1.2	1	
A-Weighted L _{eq}	14.9416631	19.91718	15.45092	16.96579117	15.17633902	7.920610179	

A-Weighted Level Outside	50
BS8233 Predicted Internal A-Weighted Level	24
Predicted Building Envelope SRI	26

BS8233 Calculation can be seen below:							
$L_{eq,2} = L_{eq,ff} + 10 \log_{10} \left(\frac{A_0}{S} 10^{-\frac{D_{tr,v}}{10}} + \frac{S_w}{S} 10^{-\frac{R_w}{10}} + \frac{S_{ew}}{S} 10^{-\frac{R_{ew}}{10}} + \frac{S_{ce}}{S} 10^{-\frac{R_{ce}}{10}} \right) + 10 \log_{10} \left(\frac{S}{A} \right) + 3$							

8.6 Sitting Room

Non Frequency Dependent Variables			Key for Table Below			
Term	Derivation	Value	R _w	Sound Reduction of Window (Octave)		
A _G	Given in BS EN 20140-10 = 10 (m ²)	10	R _{ew}	Sound Reduction Index of External Wall (Octave)		
S _T	Total Facade Area (m ²)	27	R _r	Sound Reduction Index of Roof/Ceiling (Octave)		
S _w	Window Area (m ²)	9.5	A	Equivalent Absorption Area of Rx Room		
S _{ew}	External Wall Area (m ²)	17.5	D _{tr}	Insulation of Trickle Vent (BS EN 20140-10)		
S _{cr}	Ceiling Area (m ²)	0.0001				
S	Total Area sound enters the room (m ²)	27				

Frequency Dependent Variables							
Term	Description	Octave Band Centre Frequency					
		125	250	500	1000	2000	4000
L _{eq,ff}	Free-Field External Noise Level	52	48	46	46	43	36
D _{tr}	31 dB Vent	31	31	31	31	31	31
R _{ew}	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}	No Roof	100	100	100	100	100	100
A	Equivalent Absorption Area of Room (Copied from BS8233)	11.00	14.00	16.00	16.00	15.00	15.00

BS8233 Calculation Details							
Term From Equation Below	L _{eq,ff}	Octave Band Centre Frequency					
		125	250	500	1000	2000	4000
	L _{eq,ff}	52	48	46	46	43	36
A _G /S . 10 ⁴ (-D _{tr,e} /10)		0.0002942	0.000294	0.000294	0.000294196	0.000294196	0.000294196
S _w /S . 10 ⁴ (-R _w /10)		0.00140075	0.003519	0.001113	0.000111265	5.57648E-05	0.000111265
S _{ew} /S . 10 ⁴ (-R _{ew} /10)		5.1484E-05	8.16E-05	2.58E-05	4.08954E-06	6.48148E-07	2.04962E-07
S _{rr} /S . 10 ⁴ (-R _{rr} /10)		3.7037E-16	3.7E-16	3.7E-16	3.7037E-16	3.7037E-16	3.7037E-16
10log10(S/A)+3		6.89971079	5.852357	5.272438	5.272437815	5.552725051	5.552725051
L _{eq,2}		31.321216	29.75666	22.83385	17.39551248	14.00095009	7.6344104
A-Weighting		-16.1	-8.6	-3.2	0	1.2	1
A-Weighted L _{eq}		15.221216	21.15666	19.63385	17.39551248	15.20095009	8.6344104

A-Weighted Level Outside	50
BS8233 Predicted Internal A-Weighted Level	25
Predicted Building Envelope SRI	25

BS8233 Calculation can be seen below:							
$L_{eq,2} = L_{eq,ff} + 10 \log_{10} \left(\frac{A_G}{S} 10^{\frac{-D_{tr,e}}{10}} + \frac{S_w}{S} 10^{\frac{-R_w}{10}} + \frac{S_{ew}}{S} 10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S} 10^{\frac{-R_{rr}}{10}} \right) + 10 \log_{10} \left(\frac{S}{A} \right) + 3$							

8.7 Study

Non Frequency Dependent Variables			Key for Table Below			
Term	Derivation	Value	R _w	Sound Reduction of Window (Octave)		
A _o	Given in BS EN 20140-10 = 10 (m ²)	10	R _{ew}	Sound Reduction Index of External Wall (Octave)		
S _t	Total Facade Area (m ²)	5.2	R _r	Sound Reduction Index of Roof/Ceiling (Octave)		
S _w	Window Area (m ²)	1	A	Equivalent Absorption Area of Rx Room		
S _{ew}	External Wall Area (m ²)	4.2	D _{re}	Insulation of Trickle Vent (BS EN 20140-10)		
S _{rr}	Ceiling Area (m ²)	0.0001				
S	Total Area sound enters the room (m ²)	5.2				

Frequency Dependent Variables							
Term	Description	Octave Band Centre Frequency					
		125	250	500	1000	2000	4000
L _{eq,ff}	Free-Field External Noise Level	52	48	46	46	43	36
D _{re}	31 dB Vent	31	31	31	31	31	31
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}	No Roof	100	100	100	100	100	100
A	Equivalent Absorption Area of Room (Copied from BS8233)	11.00	14.00	16.00	16.00	15.00	15.00

BS8233 Calculation Details							
Term From Equation Below	L _{eq,ff}	Octave Band Centre Frequency					
		125	250	500	1000	2000	4000
	L _{eq,ff}	52	48	46	46	43	36
A _o /S . 10 [^] (-D _{re} /10)		0.00152755	0.001528	0.001528	0.001527554	0.001527554	0.001527554
S _w /S . 10 [^] (-R _w /10)		0.00076559	0.001923	0.000608	6.0813E-05	3.04787E-05	6.0813E-05
S _{ew} /S . 10 [^] (-R _{ew} /10)		6.4157E-05	0.000102	3.22E-05	5.09619E-06	8.07692E-07	2.55415E-07
S _{rr} /S . 10 [^] (-R _{rr} /10)		1.9231E-15	1.92E-15	1.92E-15	1.92308E-15	1.92308E-15	1.92308E-15
10log10(S/A)+3		-0.2538934	-1.301247	-1.881166	-1.88116639	-1.600879154	-1.60087915
L _{eq,2}		25.4702594	22.20387	17.4791	16.14225487	13.32713822	6.409328606
A-Weighting		-16.1	-8.6	-3.2	0	1.2	1
A-Weighted L _{eq}		9.37025937	13.60387	14.2791	16.14225487	14.52713822	7.409328606

A-Weighted Level Outside	50
BS8233 Predicted Internal A-Weighted Level	21
Predicted Building Envelope SRI	29

BS8233 Calculation can be seen below:							
$L_{eq,2} = L_{eq,ff} + 10 \log_{10} \left(\frac{A_o}{S} 10^{\frac{-D_{re}}{10}} + \frac{S_w}{S} 10^{\frac{-R_w}{10}} + \frac{S_{ew}}{S} 10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S} 10^{\frac{-R_{rr}}{10}} \right) + 10 \log_{10} \left(\frac{S}{A} \right) + 3$							

8.8 Kitchen

Non Frequency Dependent Variables			Key for Table Below			
Term	Derivation	Value	R _w	Sound Reduction of Window (Octave)		
A _G	Given in BS EN 20140-10 = 10 (m ²)	10	R _{ew}	Sound Reduction Index of External Wall (Octave)		
S _T	Total Facade Area (m ²)	50.4	R _r	Sound Reduction Index of Roof/Ceiling (Octave)		
S _w	Window Area (m ²)	20.2	A	Equivalent Absorption Area of Rx Room		
S _{ew}	External Wall Area (m ²)	30.2	D _{tr,e}	Insulation of Trickle Vent (BS EN 20140-10)		
S _{rr}	Ceiling Area (m ²)	0.0001				
S	Total Area sound enters the room (m ²)	50.4				

Frequency Dependent Variables							
Term	Description	Octave Band Centre Frequency					
		125	250	500	1000	2000	4000
L _{eq,ff}	Free-Field External Noise Level	52	48	46	46	43	36
D _{tr,e}	31 dB Vent	31	31	31	31	31	31
R _w	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}	No Roof	100	100	100	100	100	100
A	Equivalent Absorption Area of Room (Copied from BS8233)	11.00	14.00	16.00	16.00	15.00	15.00

BS8233 Calculation Details							
Term From Equation Below	L _{eq,ff}	Octave Band Centre Frequency					
		125	250	500	1000	2000	4000
	L _{eq,ff}	52	48	46	46	43	36
A _G /S . 10 [^] (-D _{tr,e} /10)		0.0001576	0.000158	0.000158	0.000157605	0.000157605	0.000157605
S _w /S . 10 [^] (-R _w /10)		0.00159559	0.004008	0.001267	0.000126742	6.35215E-05	0.000126742
S _{ew} /S . 10 [^] (-R _{ew} /10)		4.7597E-05	7.54E-05	2.39E-05	3.78074E-06	5.99206E-07	1.89486E-07
S _{rr} /S . 10 [^] (-R _{rr} /10)		1.9841E-16	1.98E-16	1.98E-16	1.98413E-16	1.98413E-16	1.98413E-16
10log10(S/A)+3		9.61037851	8.563025	7.983106	7.983105538	8.263392774	8.263392774
L _{eq,2}		34.1650085	32.83768	25.59343	18.57895454	14.72154975	8.804770717
A-Weighting		-16.1	-8.6	-3.2	0	1.2	1
A-Weighted L _{eq}		18.0650085	24.23768	22.39343	18.57895454	15.92154975	9.804770717

A-Weighted Level Outside	50
BS8233 Predicted Internal A-Weighted Level	28
Predicted Building Envelope SRI	22

BS8233 Calculation can be seen below:							
$L_{eq,2} = L_{eq,ff} + 10 \log_{10} \left(\frac{A_G}{S} 10^{\frac{-D_{tr,e}}{10}} + \frac{S_w}{S} 10^{\frac{-R_w}{10}} + \frac{S_{ew}}{S} 10^{\frac{-R_{ew}}{10}} + \frac{S_{rr}}{S} 10^{\frac{-R_{rr}}{10}} \right) + 10 \log_{10} \left(\frac{S}{A} \right) + 3$							