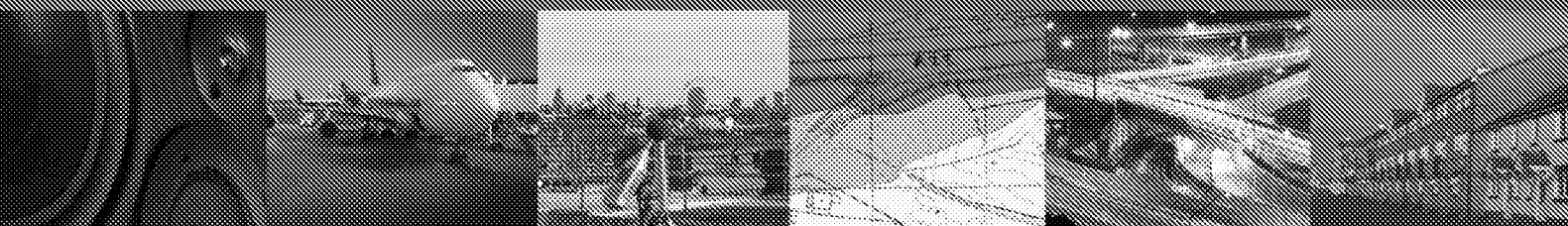


Noise and Vibration Assessment



Site: 224 London Road, Bognor Regis
Client: Counterpoint Properties Ltd
Job No.: J2473
Date: 11/06/2018
Issue: 1



Providing Better Living, Working & Learning Environments

Acoustic Associates Sussex Ltd

Measurement and Assessment of Noise and Ground-borne Vibration (Rail)

Site: 224 London Road, Bognor Regis

Client: Counterpoint Properties Ltd



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Report by: Simon Barrett BSc(Hons) MSc MIOA

Checked by: George Orton BEng(Hons) MIOA

Issue No.	Date	Comments
1	11/06/2018	Initial Issue

1 Introduction

Acoustic Associates have been appointed to undertake an assessment of noise and ground-borne vibration relating to part of the proposed re-development of 224 London Road, Bognor Regis in to residential dwellings.

The purpose of this assessment is to assess levels of noise and vibration associated with the adjacent by railway in relation to a planning application.

Measurements of Train pass-by events were carried out between 09:30hrs and 13:30hrs on 6th June 2018 to record the associated Sound Exposure Levels (SELs) and Maximum Sound Pressure Levels (L_{max}).

A vibration survey was carried out between the 6th and 11th June 2018 in order to measure ground-borne vibration levels associated with the nearby railway.

The survey and assessment have been carried out following the guidelines of the Calculation of Rail Noise (CRN), BS8233:2014 and ProPG Planning and Noise 2014 documents for the noise element of the report and BS6472 (Part 1 – 2008) for the vibration element of the report.

The noise assessment shows that the $L_{Aeq,T}$ sound levels for the daytime period (07:00hrs – 23:00hrs) and night time (23:00hrs – 07:00hrs) due to train pass-by events alone are such that utilising standard thermal double-glazing (which provides a sound reduction of $R_{RAIL} = 36\text{dB}$) will be sufficient to ensure compliance with the requirements of BS8233 for daytime and night time periods within residences so long as windows are closed. However, if Bedrooms are to be located on the façade facing the railway line, glazing capable of providing a sound reduction of $R_{RAIL} = 45\text{dB}$ would be required to satisfy the night-time L_{max} requirements of the ProPG Planning and Noise. Background Ventilation will also need to be achieved by alternative means to open windows, such as acoustic trickle vents or acoustically attenuated powered ventilation units. Please see section 4 of this report for further information regarding mitigation measures.

Measurements of vibration were taken in 3 axes and the correct frequency weighting was applied to all measurements. The measurements were used to calculate the VDV_{day} & VDV_{night} values for all three axes. The magnitude of weighted acceleration is greatest in the vertical Z-axis. However, the VDV_{day} and VDV_{night} levels are such that adverse comment is not expected. The vibration assessment concludes that if traditional strip or trench-fill type foundations, or similar, was used there would be no need for vibration mitigation measures.

2 Planning Policy, Context & Noise Assessment Criteria

2.1 Context

Currently at 224 London Road, Bognor Regis, there resides a public house. The proposal is to demolish this and re-build an apartment block containing up to 12 flats. The site sits directly adjacent to the railway line a few hundred metres from the end-of-line station. The site sits near-by to several other residential dwellings which shield it from a close-by main road. The general situation is a relatively quiet urban area.

2.2 Rail Noise Measurement and Prediction Methodology

The noise levels for the day and night time periods have been predicted, using on site measurements, rather than measuring constantly for 24 hrs or more. The predictions have been made using the following information:

- Current timetable data which details the number of passenger trains that pass by the site (between Bognor Regis and Barnham stations).
- Train Sound Exposure Levels (SELs) that were measured on site during the day time. These individual measurements were then grouped into train types based on train length and direction of travel.

The individual measurements have been averaged for each train type, per direction in order to create a “typical” sound exposure level (SEL) for each train type.

Figure 1 overleaf shows the location of the application site in relation to the existing rail network.



Figure 1. Railway line main stations and location of the new residential property

The above methodology is in accordance with Calculation of Rail Noise 1995 which states the following in section 43 paragraph 2 and 3.

"In order to determine the $L_{Aeq,16h}$ or $L_{Aeq,8h}$ noise level it may be necessary to carry out SEL noise measurements of each train pass-by over the full time period of interest. Exceptions to this may occur when the train mix and speed of individual train types remain reasonably constant over the relevant time period. For this situation, it is acceptable to measure a representative sample of individual train pass-by events of each train type running on each track and determine an arithmetic mean value for the SEL for each case."

In paragraph 3, CRN goes on to say that having established by measurement the mean values for the SELs of each train type operating on the railway, the day and the night time

noise levels ($L_{Aeq,16hr}$ and $L_{Aeq,8hr}$) should be calculated using a formula that is also stated in CRN. The SEL to $L_{Aeq,day/night}$ formula is detailed below and implemented in section 4.

For each train type: $L_{Aeq} = SEL - 10\log T + 10\log N$

- $N =$ no. of events in period (For each train type based upon timetable information)
- $T =$ no. of seconds in period (57600 seconds for the day and 28800 for the night)

In order to sample all types of train that travel on the particular line the survey was deliberately conducted over a period of a few hours (09:30 to 13:30 hours).

It should be noted that a train SEL measured in the daytime is likely to be marginally higher than if an identical train SEL was measured at night time. This is due to the fact that in the daytime the background noise levels are generally higher than at night time and during the train SEL measurement background noise will be “captured” as well as the train noise.

2.3 Non-Passenger Train Activity

The effect of noise from night time freight train activity is sometimes difficult to assess due to irregularity of freight operations and the non-existence of any useful timetable information.

Assessment of the Rail Utilisation Strategy for the area south of London indicates that commercial freight trains do not use the railway line in this location.

There may well be occasional leaf clearing or maintenance trains that operate during the day or night-time period. These trains will be seasonal/infrequent and it is very unlikely that there would be several in a week let alone more than one in any night time hour.

Because of infrequency of such events, it has not been possible to carry out measurements of the rail traffic noise associated with them.

It should be borne in mind that such trains pass the site only on an occasional basis, as the need arises. Therefore, it would not normally be the case that Planning Decisions would hinge upon such irregular events.

2.4 ProPG Planning Guidance, June 2017

Recent planning guidance released in 2017 relates to new residential development and airborne transportation noise, which includes exposure to railway 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).

ProPG, 2017 advocates that it is not necessarily about satisfying internal target criteria, but additionally that there should be a demonstration of good acoustic design. The format of ProPG, 2017 is followed and shown in the report

2.5 BS8233:2014

Table 4 of BS8233:2014 provides the following guideline values:

Activity	Location	Design Range LAeq,T dB	
		Day 07:00-23:00hrs LAeq,16hr (dB)	Night 23:00-07:00hrs LAeq,8hr (dB)
Resting	Living Rooms	35	-
Dining	Dining Rooms	40	-
Sleeping (daytime resting)	Bedrooms	35	30

Table 1: BS8233:2014 Criteria

Annex G of BS8233:2014 states that if partially open windows were relied upon for background ventilation, the insulation of the building envelope would be reduced to approximately 15 dB

For traditional external areas that are used for amenity space, such as gardens and patios, it is desirable that the external noise level does not exceed 50 dB LAeq,T, with an upper guideline value of 55 dB LAeq,T which would be acceptable in noisier environments. However, it is also recognized that these guideline values are not achievable in all circumstances where development might be desirable. In higher noise areas, such as city

centres or urban areas adjoining the strategic transport network, a compromise between elevated noise levels and other factors, such as the convenience of living in these locations or making efficient use of land resources to ensure development needs can be met, might be warranted. In such a situation, development should be designed to achieve the lowest practicable levels in these external amenity spaces but should not be prohibited.

Further to the above, Planning Practice Guidance 2014 (Noise) states the following:

Are there further considerations relating to mitigating the impact of noise on residential developments? Yes – the noise impact may be partially off-set if the residents of those dwellings have access to: A relatively quiet, protected, external publicly accessible amenity space (e.g. a public park or a local green space designated because of its tranquillity) that is nearby (e.g. within a 5 minutes walking distance).

2.6 BS6472 (New edition - 2008)

Part 1 of BS 6472 provides guidance on predicting human response to vibration in buildings over the frequency range 0.5 Hz to 80 Hz. Frequency weighting curves for human beings exposed to whole-body vibration are included, together with advice on measurement methods to be employed. Methods of assessing continuous, intermittent and impulsive vibration are presented. This part of BS 6472 describes how to determine the vibration dose value, VDV, from frequency-weighted vibration measurements. The vibration dose value is used to estimate the probability of adverse comment which might be expected from human beings experiencing vibration in buildings. Consideration is given to the time of day and use made of occupied space in buildings, whether residential, office or workshop.

2.7 BS6472 Criteria

In homes, adverse comment about building vibrations is likely when the vibration levels to which occupants are exposed are only slightly above thresholds of perception. When the appropriately-weighted vibration measurements or predictions have been used to derive the VDV for either 16h (daytime) or 8h (night-time) at the relevant places of interest, their significance in terms of human response for people in those places can be derived from the table below which has been taken from BS6472:

<i>Place & Time</i>	<i>Low probability of adverse comment¹ $ms^{-1.75}$</i>	<i>Adverse comment possible $ms^{-1.75}$</i>	<i>Adverse comment Probable² $ms^{-1.75}$</i>
Residential Building 16h Day	0.2 - 0.4	0.4 - 0.8	0.8 - 1.6
Residential Building 8h Night	0.1 - 0.2	0.2 - 0.4	0.4 - 0.8

Table 2: BS6472 Criteria

2.8 ANC Guidelines for Measurement & Assessment of Groundborne Vibration

These guidelines, published in 2012 aim to provide additional guidance in relation to all aspects of vibration monitoring and assessment in line with BS6472, BS7385 and BS5228. Its aim is to provide interpretation and useful practical methods to assist the assessor in real-terms.

Were possible, this assessment has followed these guidelines.

¹ Below these ranges adverse comment is not expected.

² Above these ranges adverse comment is very likely.

3 Rail Noise Survey

3.1 Measurements of Train Pass-by Events

Measurements of SELs due to train pass-by events were carried out on 6th June 2018 between the time frame of 09:30hrs and 13:30hrs. 24 train pass-by events were measured where only one train pass-by occurred at a time (there were others where trains passed both ways simultaneously but these were removed to improve the rigidity of the data).

Ambient noise measurements were also taken. As the train noise measurements were at least 10dB greater than the ambient noise level, no correction has been applied.

Taking the (arithmetic) averages of the SEL values for each train type (and direction) gave the following results:

Inbound Trains			
No. of Coaches	No of Trains	Percentage	SEL
3	5	45.5	93.8
4	5	45.5	84.9
8	1	9.1	87.6
All	11	100	-
Outbound Trains			
No. of Coaches	No of Trains	Percentage	SEL
3	6	46.2	92
4	6	46.2	84.5
8	1	7.7	86
All	13	100	-

Table 3: Average Sound Exposure Level of Train Type (per direction)

3.2 Train Timetable

Train timetable information for trains operating between Bognor Regis and Barnham were examined and from this data it was determined that the following numbers of trains passing the proposed site per day and per direction are as follows (as of 20th May 2018):

Day Type	No. of Trains Inbound		No. of Trains Outbound		No. of Trains Total	
	Day	Night	Day	Night	Day	Night
Weekday	67	7	60	10	127	17
Saturday	62	6	69	7	131	13
Sunday	30	3	34	0	64	3

Table 4: Time-Tabled Train Pass-by events per day type

The timetable information above and the survey information have been used to predict the number of trains of each type that will pass the site. The percentages observed during the survey period are seen below in Table 5 and have been applied to the rail traffic in Table 4, providing an indication of the train carriage/coach composition and directions to populate Table 6.

Inbound Trains		
No. of Coaches	No of Trains	Percentage
3	5	45.5
4	5	45.5
8	1	9.1
All	11	100
Outbound Trains		
No. of Coaches	No of Trains	Percentage
3	6	46.2
4	6	46.2
8	1	7.7
All	13	100

Table 5: Percentages of Trains per type (per direction)

The SEL data from Table 3 has been used along with Number of Train Movements from Table 4 and the percentages from Table 5. These data have been used to provide the information in Table 6, below:

Day Type	No. of Trains Inbound		No. of Trains Outbound	
	Day	Night	Day	Night
Weekday (Total)	67	7	60	10
3 Coach	31	3	28	5
4 Coach	30	3	27	4
8 Coach	6	1	5	1
Saturday (Total)	62	6	69	7
3 Coach	29	3	32	3
4 Coach	28	2	31	3
8 Coach	5	1	6	1
Sunday (Total)	30	3	34	0
3 Coach	14	2	16	0
4 Coach	13	1	15	0
8 Coach	3	0	3	0

Table 6: Time-Tabled Train Pass-by events per day, per train type

3.3 Converting Sound Exposure Levels (SEL) to L_{Aeq} Levels (measurement position)

In paragraph 3 CRN states that having established, by measurement, the mean values for the SELs of each train type operating on the railway, the day and the night time noise levels ($L_{Aeq,16hr}$ and $L_{Aeq,8h}$) can be calculated. The day and the night time period noise level relating to each train type can be calculated using the following formula

$$\text{Train Type } L_{Aeq, \text{ day/night}} = \text{SEL} - 10\log T + 10\log N$$

- N = no. of events in period (For each train type based upon timetable information)
- Day = 07:00-:23:00hrs & Night = 23:00-07:00hrs
- T = no. of seconds in period (57600 seconds for the day and 28800 for the night)

3.4 Train Type Day/Night Noise Levels

Table 7 below shows the calculated results of the train type noise levels with the formula from 4.3 and the SEL's from Table 3 applied in each train operator and direction.

Day Type	$L_{Aeq,T}$ of Trains Inbound		$L_{Aeq,T}$ of Trains Outbound	
	Day	Night	Day	Night
Weekday (Total)	61.79532574	54.80078207	59.71787701	55.16035934
3 Coach	61.1093921	53.97728767	58.86735548	54.39577517
4 Coach	52.06698771	45.07728767	51.20941281	45.92667504
8 Coach	47.77728767	43.00607512	45.38547521	41.40607512
Saturday (Total)	61.48577922	54.64369358	60.30862534	53.18635813
3 Coach	60.81975514	53.97728767	59.44727495	52.17728767
4 Coach	51.76735548	43.31637508	51.8093921	44.67728767
8 Coach	46.98547521	43.00607512	46.17728767	41.40607512
Sunday (Total)	58.34272363	52.48747	57.2784877	-
3 Coach	57.65705552	52.21637508	56.43697499	-
4 Coach	48.43520869	40.30607512	48.65668776	-
8 Coach	44.76698771	-	43.16698771	-

Table 7: Train Type Day/Night Noise levels

3.5 Total Noise Level at Measurement Position

The noise levels detailed above can be added together (logarithmically) to show the total day and night time noise level at the measurement position for all trains in both directions. For weekday daytime this would be $10\log(10^{6.2} + 10^{6.0}) = 64 \text{ dB(A)}$.

Weekdays

- $L_{Aeq,07:00-23:00} = 64 \text{ dB(A)}$
- $L_{Aeq,23:00-07:00} = 58 \text{ dB(A)}$

Saturday

- $L_{Aeq,07:00-23:00} = 64 \text{ dB(A)}$
- $L_{Aeq,23:00-07:00} = 57 \text{ dB(A)}$

Sunday

- $L_{Aeq,07:00-23:00} = 61 \text{ dB(A)}$
- $L_{Aeq,23:00-07:00} = 52 \text{ dB(A)}$

N.B. It should be noted that the measurement position equates to the same position as the proposed building façade and so no distance correction calculations will be required.

3.6 Predicted Internal LAeq Noise Levels

Table 7 overleaf shows the likely sound levels experienced with both windows open, closed and additionally any external amenity areas, albeit these are not explicitly shown on the plans provided.

Given that railway noise is being assessed, it is appropriate to consider whether the same protection is afforded from standard thermal double glazing against road traffic noise. PPG24, albeit withdrawn, still includes relevant detail concerning railway noise. Table 1 in Annex 6 shows that for electric locomotives, standard double glazing is likely to provide 36dB(A) difference between outside and inside levels. This is further reinforced in Pilkington Glass data sheets dated 2007 which state that $R_{RAIL} = R_{TRA} + 3$. Therefore, the protection afforded for standard thermal double glazing for this particular assessment is 36dB(A).

In summary, with the assumption of standard thermal double-glazing (4/12/4), with windows closed, interior sound criteria are likely to be met. However, with windows open during the daytime and night time periods, the internal noise criteria will likely be above the requirements of BS8233:2014.

It is important to note that the information in Table 7 overleaf is without any mitigation measures applied.

3.7 Corrections Applied

It is noted that whilst the survey position was free-field, there is a need to add 3dB(A) to represent façade conditions to allow the consideration of noise transfer from outside to inside. When using an SEL formulae, there is no requirement for on time corrections, as this is already incorporated within the calculations.

With the 3dB(A) addition for a façade correction, Table 8 below applies the correct data.

	Daytime (07:00-23:00 hours)	Night-time (23:00-07:00 hours)
Weekdays		
Sound level	67 dB(A), LAeq,16 hour	61 dB(A) LAeq,8 hour
Internal sound level with window closed (-36dB(A))	31 dB(A)	25 dB(A)
BS8233:2014 criteria	35 dB(A)	30 dB(A)
Criteria met	Yes	Yes
Internal sound level with window open (-15dB(A))	52 dB(A)	46 dB(A)
BS8233:2014 criteria	35 dB(A)	30 dB(A)
Criteria Met	No	No
Saturday		
Sound level	67 dB(A), LAeq,16 hour	60 dB(A) LAeq,8 hour
Internal sound level with window closed (-36dB(A))	31 dB(A)	24 dB(A)
BS8233:2014 criteria	35 dB(A)	30 dB(A)
Criteria met	Yes	Yes
Internal sound level with window open (-15dB(A))	52 dB(A)	45 dB(A)
BS8233:2014 criteria	35 dB(A)	30 dB(A)
Criteria Met	No	No
Sunday		
Sound level	64 dB(A), LAeq,16 hour	55 dB(A) LAeq,8 hour
Internal sound level with window closed (-36dB(A))	28 dB(A)	19 dB(A)
BS8233:2014 criteria	35 dB(A)	30 dB(A)
Criteria met	Yes	Yes

Internal sound level with window open (-15dB(A))	49 dB(A)	43 dB(A)
BS8233:2014 criteria	35 dB(A)	30 dB(A)
Criteria Met	No	No

Table 8. Criteria and Performance Table and assessment against Survey data

3.8 Lmax Sound Levels

Table 8, above deals with the daytime and night time period $L_{Aeq,T}$ sound levels for Weekdays, Saturday and Sunday. However, it is important, under the requirements of BS8233 and the Local Authority to assess for the Lmax sound levels due to train pass-by events. These were measured at the same time as the SELs and the general cause of these Lmax values was two-fold: Horns and Air Brakes. During night time periods, it is considered that horns will not be used as a matter of policy and thus air-brakes will be the driving force of the Lmax values as the trains move in to and out of the station at the end of the line, a few hundred metres away.

The Lmax values of each train size and direction of travel have been investigated and the worst-case values (rounded as appropriate) are shown in table 9 below:

No. of Coaches	Lmax Sound Level (dBA)	
	Inbound	Outbound
3	95	93
4	83	90
8	81	80

Table 9: Worst Cast Measured L_{Amax} sound levels for each train type per direction of travel

As it has been shown in section 3.7, that a correction of +3dB needs to be applied to account for façade levels and thus when considering the internal Lmax sound levels within the bedrooms during night time periods, the figures from Table 8 will actually be 3dB louder.

It has been calculated that 81dBA – 36dB (sound reduction of standard thermal double glazing) = 45dBA. Therefore, all L_{max} values measured will account for a value too loud within a bedroom at night time. During Weekdays and Saturdays, there are more than 10 train pass-by events during the night time period of 23:00 hrs – 07:00 hrs and thus the resultant number of L_{max} sound levels higher than 45dBA internally during the night time will be greater than 10. For this reason, without further acoustically enhanced glazing (and sound

attenuating trickle vents or a ducted system for background ventilation), it would not be appropriate for bedrooms to exist on this rail-facing façade.

3.9 Outdoor Amenity Areas

It is understood that the planning application for this site is to re-develop the site for up to 12 flats. Whilst this is only outline planning with no specific designs, it is understood that there will be no directly attached outdoor amenity area associated with the building. This eclipses the need to satisfy the requirement of BS8233 and WHO Guidelines for Serious Annoyance or Moderate Annoyance of $L_{eq,16hr} = 55\text{dBA}$ or 50dBA respectively.

Outdoor Amenity Areas can be facilitated by near-by parks such as Hotham Park, which is just a short walk away, half-way down London Road.

If an amenity area is to be provided, then this would need to be located in the area shielded from the railway by the building itself, however it is not considered likely that an area will be provided on site. It is worthy to note that it would not be possible to achieve significant attenuation for an amenity area between the building and the railway even if an acoustic fence was provided due to the high sound level from the train pass-by events.

4 Mitigation Measures

4.1 Glazing

As shown in Table 7 within Section 3.7 of this report, the protection of sound due to the R_{RAIL} rating of standard thermal double glazing with a specification of 4/12/4 (4mm glass, 12mm cavity, 4mm glass), which is 36dB, can provide, when windows are closed, enough attenuation to the daytime $L_{\text{Aeq},16\text{hr}}$ and night time $L_{\text{Aeq},8\text{hr}}$ sound levels such that the requirements of BSS8233:2014 are satisfied.

In terms of L_{max} requirements for the night time period of 23:00hrs – 07:00hrs, should bedrooms be placed upon the façade facing the rail the requirements for attenuation (R_{RAIL}) by the glazing will need to increase to have a sound reduction index (SRI) of at least 45dB. This will reduce the number of L_{max} sound levels to below 10 events exceeding 45dB internally (when windows are closed) such that L_{max} levels due to the 4-coach and 8-coach trains will be attenuated to within the required tolerable limits.

In all cases, however, for windows facing the railway lines, background ventilation will need to be achieved by means other than using open windows (which is not a typical method, such as acoustic trickle vents or acoustically attenuated powered ventilation units

4.2 Ventilation

As stated above, background ventilation will need to be achieved using one of the following methods:

- Sound attenuated assisted ventilation systems such as “Mechanical Extract Ventilation” (MEV) in conjunction with Acoustic Trickle Vents or “Mechanical Ventilation with Heat Recovery” (MVHR). The intake for supply air for such units should be taken from the quietest façade (that which faces away from the busy roads) but the advice of a ventilation engineer should be sought for full installation methodology.
- Passive ventilation of acoustic air bricks, which can achieve attenuation of up to 42dB.
- Acoustically Enhanced Trickle Vents

These ventilation systems will allow windows to remain closed, achieving the required attenuation of noise levels, whilst also providing adequate background ventilation.

4.3 Internal Layouts / Building Orientation / Good Acoustic Design

If it is not a viable solution to introduce significantly enhanced acoustic glazing in terms of controlling the night time Lmax sound levels within the property during the night time hours of 23:00 – 07:00, then an alternative method to mitigate this noise would be to design the internal layouts such that no bedroom windows are placed on the façade of the building that faces the railway lines.

As there is no specific internal layout design for the proposed development, it is recommended that “Good Acoustic Design”, as championed within the ProPG guidance document is adopted for this development. This would comprise using buffer-zones to protect habitable rooms from noisy facades by arranging the rooms accordingly so that bathrooms, kitchens and other non-habitable rooms such as hall-ways are the most exposed to sound levels. Additionally, the orientation of the whole building should be considered.

These methods are preferable to just installing enhanced glazing and preventing windows from being opened.

5 Vibration Survey Baseline Conditions & Results

A vibration survey was carried out between the 6th and 11th June 2018 in order to measure ground-borne vibration levels associated with the adjacent railway.

5.1 Survey Details

5.1.1 Equipment

- Vibrock V901 3-Axis Vibration Meter
- Vibrock VDV Tri-Axial Accelerometer

5.1.2 Personnel

Survey carried out by: Simon Barrett BSc(Hons) MSc MIOA

5.1.3 Site/Survey Drawings

The site location and accelerometer position used during the vibration survey are shown in the figure overleaf:



Figure 2: Survey Location Plan

5.1.4 Measurement Position/Details

The Vibrock tri-axial accelerometer was embedded in to the hard-packed soil in line with the proposed building façade that is closest to the railway line and was held in place with a sandbag to ensure a good connection to the ground. Axis X was perpendicular to the railway, Axis Y was parallel to the railway and axis Z was the vertical axis. The Vibrock V901 was set up to continuously monitor vibration levels over the whole measurement period in hourly intervals.

5.2 Frequency Weighting

The way, in which people perceive building vibration depends on various factors, including the vibration frequency and direction. Different frequency weightings are required for different axes of motion. BS6472 states which frequency weightings should be used for each axis. The weighting curve modulus for vertical acceleration is W_b and W_d for horizontal motion. The weighting curves are defined in BS 6841. The Vibrock V901 was set up so that the correct frequency weightings were applied to the measurements.

5.3 Noise Survey Results

5.3.1 All VDV Measurements

The effect of building vibration on the people within is assessed by finding the appropriate vibration dose. Present knowledge shows that this type of vibration is best evaluated with the vibration dose value (VDV). The VDV is given by the fourth root of the time integral of the fourth power of the acceleration after it has been frequency-weighted. The Vibrock V901 calculates the hourly VDV values internally and also provides a summed value for the full 16 or 8 hour periods.

Due to the survey setup time being part way through the hour and also midway through the day, this event is incomplete in itself. Likewise, the event on the survey collection date was stopped mid-hour and before the daytime period was up. However, the two events together allow for a full daytime period to be made and thus adding all the full-hour measurements for these two events, will provide a full “VDV_{day}” value. The events affected are 000 and 010.

Measurements started at approximately 10:00hrs on the 06/06/2018 and finished at approximately 10:15hrs on the 11/06/2018. The measurements were conducted for 120hrs in total. The VDV values have been summed to show the VDV_{day} and VDV_{night} values:

$$VDV_{day} = \left(\sum_{23:00hrs}^{07:00hrs} VDV_{hr}^4 \right)^{0.25}$$

$$VDV_{night} = \left(\sum_{07:00hrs}^{23:00hrs} VDV_{hr}^4 \right)^{0.25}$$

The table below shows the day and night time period VDV levels that were measured during the survey.

The frequency weighting (F_w) applied to each axis is also shown:

Day	Time Period	X-Axis		Y-Axis		Z-Axis	
		F_w	$VDV\ ms^{-1.75}$	F_w	$VDV\ ms^{-1.75}$	F_w	$VDV\ ms^{-1.75}$
Wednesday	07:00-23:00hrs	W_d	0.028	W_d	0.036	W_b	0.091
	23:00-07:00hrs	W_d	0.024	W_d	0.031	W_b	0.02
Thursday	07:00-23:00hrs	W_d	0.035	W_d	0.036	W_b	0.154
	23:00-07:00hrs	W_d	0.023	W_d	0.031	W_b	0.101
Friday	07:00-23:00hrs	W_d	0.028	W_d	0.033	W_b	0.148
	23:00-07:00hrs	W_d	0.023	W_d	0.032	W_b	0.095
Saturday	07:00-23:00hrs	W_d	0.028	W_d	0.037	W_b	0.154
	23:00-07:00hrs	W_d	0.022	W_d	0.031	W_b	0.084
Sunday	07:00-23:00hrs	W_d	0.027	W_d	0.037	W_b	0.127
	23:00-07:00hrs	W_d	0.023	W_d	0.032	W_b	0.097

Table 10: Measured Day & Night time VDV levels

N.B. The graphs in the Appendices show the raw vibration level data for each of the three axes per measurement period per day. Please note that Event 000 and Event 010 have been stitched together to provide a full daytime period, ignoring the first hour of Event 000 and the last hour of Event 010.

6 Transfer Function

BS6472 states that when vibration transfers from one medium to another, a transfer function should be applied to the measured levels to indicate the factor of change created by the change in medium. This is important as the measurements of vibration need to be assessed for the point where vibration enters the human body, in this case, the building where a person is located.

As the measurements were taken in what would effectively be free-field conditions (within the soil) a transfer function to convert the vibration to how it would be felt within a building will need to be applied.

The ANC Guidelines for the Measurement and Assessment of Groundborne Noise and Vibration provides a table (table 14.3 on page 121 of the document). This has been repeated below for completeness:

Ground Surface to building slab (in contact with the ground)	Ground surface to foundation	Floor to Floor	Floor Resonance
0 dB at low frequencies (from Reference [46])	woodframe: -5dB 1-2 storey commercial: -7dB 2-4 storey masonry: -10dB Large masonry on Spread footings: -3dB Foundation in Rock: 0dB (from Reference [46] & [17])	1 – 5 floors: -2dB/floor 5 – 10 floors: -1dB/floor (from Reference [17]) -3dB/floor (from Reference [46])	= 5 to 15dB over 16-80 Hz (from Reference [46]) = 6dB (from Reference [17])

Table 11: ANC Guidelines - Groundbourne Vibration Transfer Functions

In summary, it is typical that as the vibration enters the foundation from the ground surface, there will be a large reduction in the vibration level, followed by a smaller reduction per storey that the vibration travels through. This will be offset by the resonance of each floor (which will increase the vibration magnitude).

This ultimately means that the vibration reduction due to building structure will be cancelled out by mid-floor resonances and thus there will be no change in vibration level to be applied.

It should also be noted that the worst-case measured vibration levels, even for the most affected Z axis, are significantly below the criterion values for “Adverse Comment Possible” that even with uncertainties in the transfer function guidelines, there would need to be at least a doubling in measured vibration values to even come close to the lowest criterion values shown in Table 10.

7 Conclusion

The purpose of this assessment has been to assess levels of noise and vibration associated with the adjacent by railway in relation to a planning application.

Measurements of Train pass-by events were carried out between 09:30hrs and 13:30hrs on 6th June 2018 to record the associated Sound Exposure Levels (SELs) and Maximum Sound Pressure Levels (L_{max}).

A vibration survey was also carried out between the 6th and 11th June 2018 in order to measure ground-borne vibration levels associated with the nearby railway.

The survey and assessment have been carried out following the guidelines of the Calculation of Rail Noise (CRN), BS8233:2014 and ProPG Planning and Noise 2014 documents for the noise element of the report and BS6472 (Part 1 – 2008) for the vibration element of the report.

The noise assessment shows that the $L_{Aeq,T}$ sound levels for the daytime period (07:00hrs – 23:00hrs) and night time (23:00hrs – 07:00hrs) due to train pass-by events alone are such that utilising standard thermal double-glazing (which provides a sound reduction of $R_{RAIL} = 36\text{dB}$) will be sufficient to ensure compliance with the requirements of BS8233 for daytime and night time periods within residences so long as windows are closed. However, if Bedrooms are to be located on the façade facing the railway line, glazing capable of providing a sound reduction of $R_{RAIL} = 45\text{dB}$ would be required to satisfy the night-time L_{max} requirements of the ProPG Planning and Noise. Background Ventilation will also need to be achieved by an acoustically enhanced system such as acoustic trickle vents, acoustic air bricks or sound attenuated mechanical ventilation. Please see section 4 of this report for further information.

As there is no specific internal layout design for the proposed development, it is recommended that “Good Acoustic Design”, as championed within the ProPG guidance document is adopted for this development. This would comprise using buffer-zones to protect habitable rooms from noisy facades by arranging the rooms accordingly so that bathrooms, kitchens and other non-habitable rooms such as hall-ways are the most exposed to sound levels. Additionally, the orientation of the whole building should be considered.

These methods are preferable to just installing enhanced glazing and preventing windows from being opened.

Measurements of vibration were taken in 3 axes and the correct frequency weighting was applied to all measurements. The measurements were used to calculate the VDV_{day} & VDV_{night} values for all three axes. The magnitude of weighted acceleration is greatest in the vertical Z-axis. However, the VDV_{day} and VDV_{night} levels are such that adverse comment is not expected. The vibration assessment concludes that if traditional strip or trench-fill type foundations, or similar, was used there would be no need for vibration mitigation measures.

Appendix A – RAW SEL Data

Time	Duration	Coaches	Direction	LAFmax	LAE	Company
09:34	(0:0:22.0)	3	out	91.5	92.2	Southern
10:35	(0:0:19.0)	3	out	89.6	90.4	Southern
10:41	(0:0:39.0)	8	in	80.9	87.6	Southern
11:03	(0:0:20.0)	3	out	91.4	93.6	Southern
11:08	(0:0:32.0)	8	out	80.1	86	Southern
11:24	(0:0:20.0)	3	in	93.7	91.3	Southern
11:27	(0:0:26.0)	4	out	89.5	87.5	Southern
11:30	(0:0:27.0)	4	in	79.2	84.2	Southern
11:34	(0:0:22.0)	3	out	92.7	95	Southern
11:41	(0:0:26.0)	4	in	78.6	83.9	Southern
11:53	(0:0:15.0)	3	in	94.1	92.8	Southern
11:54	(0:0:18.0)	4	out	76.8	82.3	Southern
12:03	(0:0:17.0)	3	out	90.2	91.8	Southern
12:13	(0:0:19.0)	4	in	78.3	83.9	Southern
12:25	(0:0:20.0)	3	in	94.8	94.4	Southern
12:27	(0:0:21.0)	4	out	78	83.2	Southern
12:34	(0:0:20.0)	3	out	90.1	88.9	Southern
12:41	(0:0:22.0)	4	in	82.6	85.5	Southern
12:53	(0:0:24.0)	3	in	96.5	96.3	Southern
12:54	(0:0:17.0)	4	out	78.2	82.6	Southern
13:03	(0:0:16.0)	4	out	88.2	88.9	Southern
13:14	(0:0:21.0)	4	in	81.9	86.8	Southern
13:27	(0:0:43.0)	4	out	77.4	82.4	Southern
13:29	(0:0:28.0)	3	in	98.3	94.1	Southern

Appendix B – Calibration Certificate

CERTIFICATE OF CALIBRATION		BS EN ISO 9001:2008 APPROVED BY LRQA CERT No: 653810
ISSUED BY: CALIBRATION MAINTENANCE & REPAIR LTD		
DATE OF ISSUE: 4 May 2017	CERTIFICATE NUMBER: 167351	

	Home Farm Industrial Park Norwich Road Marsham	Page 1 of 8 Approved Signatory Electronically Authorised Document ☒ P K CLARK ☐ R J WADE ☐ M A FROST ☐ M S PARDOE
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<u>Customer</u>	ACOUSTIC ASSOCIATES SUSSEX LTD
<u>Order No</u>	AASL/CAL/118A/030517
<u>Equipment Description</u>	INTEGRATING-AVERAGING SOUND LEVEL METER
<u>Manufacturer</u>	NORSONIC
<u>Model</u>	118
<u>Serial No</u>	31460
<u>Ident No</u>	NORSONIC A
<u>Date Of Calibration</u>	4 MAY 2017

<u>INSTRUMENT CONDITION</u>	
<u>Adjustments Made</u>	NO
<u>Repairs Made</u>	NO

ENVIRONMENT

The instrument was placed in the laboratory environment for a minimum period of 4 hours and was operated prior to calibration.

Measurements were made in ambient conditions of 22°C ± 3°C and 45% ± 15% RH.

PROCEDURE

Measurements were performed in accordance with the in house laboratory procedure 1335. All equipment used has been calibrated/verified against measurement standards or reference equipment traceable to International or National Measurement Standards as specified in our control procedure W164.

The results attached to this certificate refer to measurements made at the time of test and not to the instrument's ability to maintain calibration.

The attached results are a true record of the levels required to return the instrument to the original stated manufacturer's specification and accuracy where known.