BACTON LOW RISE DEVELOPMENT

Noise and Vibration Assessment to discharge Condition 19

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1 INTRODUCTION

Noise and Vibration due to trains using the railway line to the north of the Bacton Low Rise site have been assessed within Building B1, in compliance with planning condition 19 and the results set out in this technical note .

The lightweight, cross laminate timber (CLT) construction, vibration and vibration perceived as structureborne noise was a concern in building B1, which was the closest to the railway. Building B1 was assessed as it progressed to 4th floor CLT frame, with screed laid to 2nd floor and first fix internal studwork progressing. Some Velfac windows have been installed, but the building is not weather tight at any level.

Sustainable Acoustics, working with Peter Brett Associates have carried out two on-site vibration monitoring surveys to establish whether vibration and structureborne noise on finished floors would be expected to comply with the requirements of condition 19. This document provides a report into the latest findings. Tests on unfinished floor were useful to provide an indication of how the unfinished structure was behaving, but is not be considered overly helpful to determine the final finished conditions, and so have been disregarded in determination of compliance with Condition 19.

2 REVIEW OF CRITERIA AND PLANNING CONDITIONS

For ease of reading, the relevant planning conditions and criteria are presented below:

2.1 Planning permission conditions

The planning permission for the site, issued on 25th April 2013, reference 2012/6338/P contains Condition 19, which relates to noise and vibration, with Condition 19 specifically referencing noise and vibration:

<u>*Condition 19*</u>*: Before the first occupation of any residential unit within Block B1 and Block C of the development, a refined scheme shall be submitted to and approved by the Local Planning Authority for the sound insulation (for both airborne and impact sound at separating walls and floors) in relation to windows on the north elevation of Blocks B1 and C (adjacent to the railway line on the DHO part of the site). The scheme shall provide adequate sound insulation to prevent the transmission of noise and/or vibration from the normal activities and or external noise sources (including the use/operation of equipment) performed at the lower levels to the upper floors to a level that the internal noise levels (including LAmax) are not increased and vibration levels are not perceived as measured in BS.6472:1992 "Evaluation of human exposure to vibration in buildings [1 Hz to 80 Hz]." The scheme is required to achieve 'good' internal noise levels criteria, as set out in BS 8233:1999 Sound Insulation and Noise Reduction for Buildings - Code of Practice."*

BS 8233

Noise Residential criteria

The British Standard BS 8233: 1999, *Sound insulation and noise reduction for buildings – Code of Practice* is the relevant standard referenced by condition 19, which provides additional guidance on levels of steady, anonymous noise in the built environment, based on the recommendations of the World Health Organisation. The criteria for steady state, “anonymous” noise levels in unoccupied spaces within residential properties, from sources such as road traffic, mechanical services and other continuously running plant, are tabulated below:

Criterion	Typical situation	Design range, $L_{Aeq,T}$ dB	
		Good	Reasonable
Reasonable conditions for sleeping and resting	Living rooms Bedrooms	30 30	40 35

For a reasonable standard in bedrooms at night, individual noise events (measured with the F time-weighting) should not normally exceed 45 dB L_{Amax}

NB: BS 8233 has been updated since the planning condition, and excluded specific design ranges and further does not include a L_{Amax} criterion - but it is assumed that the Condition refers back to the above. However less weight should therefore be placed on the L_{Amax} results in light of this.

BS 6472

Vibration Assessment

Guidance on the evaluation of human exposure to vibration in buildings is given in BS 6472-1:2008, *Guide to Evaluation of human exposure to vibration in buildings*. The 1992 version has been superseded and is no longer suitable to apply, given the current state of knowledge in relation to vibration.

Section 3.3 Thresholds of Perception states:

Perception thresholds for continuous whole-body vibration vary widely among individuals. Approximately half the people in a typical population, when standing or seated, can perceive a vertical peak acceleration of 0.015m/s^2.

Section 3.5 Vibration Dose summation;

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). Section 6 Table 1: gives VDV ranges which might result in various probabilities of adverse comment within residential buildings. A summary of this table is as below:

Place and Time	Low probability of adverse comment m/s$^{1.75}$
Residential buildings 16h day	0.2-0.4
Residential buildings 8 h night	0.1-0.2

Section 3.6.2 discusses Structure-borne noise as a ‘Parallel’ effect, which is noise arising from the vibration of building structures (whether caused by ground –borne vibration, acoustic excitation from external sources) heard within the building. The noise is typically low frequency in the spectral region below 100 Hz, and perceived as a low rumble.

3 MEASUREMENTS

Vibration measurements were carried out on 21 January 2015. An accelerometer to measure the vibration was mounted on the unscreeded CLT structure at a mid-room position at 1st floor level, on the 4th floor unscreeded CLT Structure and then on the ground floor slab. It should be noted that the four floor at the time of measurements was being constructed and therefore formed the roof.

Figure 1: Vibration monitoring on CLT at first floor level and fourth floor level on the floor and wall

Train movements were noted, through an observational position on the CLT scaffolding. The following graph show the vibration levels measured at first un-screeded first floor, the slab, at four and at second floor levels.

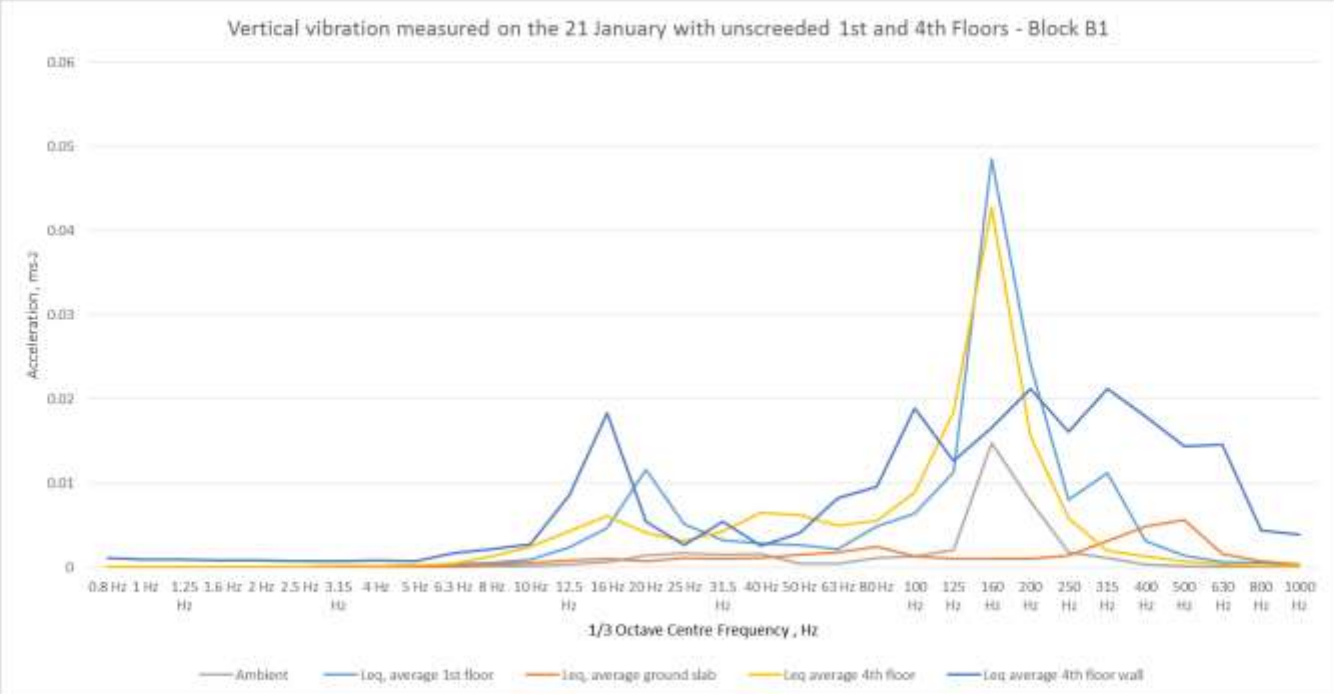

Figure 2: Measured vibration acceleration at second floor level for Max, L_{eq} average for trains & ambient levels

The graphs shows a vibration response with each train pass-by resulting in a peak in floor response at around 20 Hz; and in the wall at around 16Hz. As reported in previous documents "*For a typical wood-frame structure, like a CLT build, the assumed fundamental resonance is usually in the 15 Hz to 20Hz"*. This is the suggested range that we would expect resonances in the CLT structure to occur, and the results support that in reality this is seen. It should be noted that for building A the floor and wall responses occurred at 16 Hz. Of further interest is that there is a significant response at 160 Hz. This CLT response was not seen at all in Building A, and as it is at a higher frequency (reference to A –weighting and human ear frequency response), is more of a relevance for Structureborne Noise.

Figure 3 shows that the floor response from 1st to 4th floor is comparable, suggesting no additional amplification or loss between CLT floor levels.

Through research, and relating the response back to building A, this 160 Hz is expected to be due because the measurements were taken on the un-screeded CLT structure. Concrete screeding would increase the mass, stiffness and structural damping, as was seen in the results in. It was therefore felt important to return back to site, to carry out comparative measurements once the floor had been screeded.

A second site was made on 28th January 2015, once the screed was completed at first floor level in B1. This site visit was only partially successful, as the screed was continuing at upper levels. Some useful data was extracted from the survey and Figure 3 below.

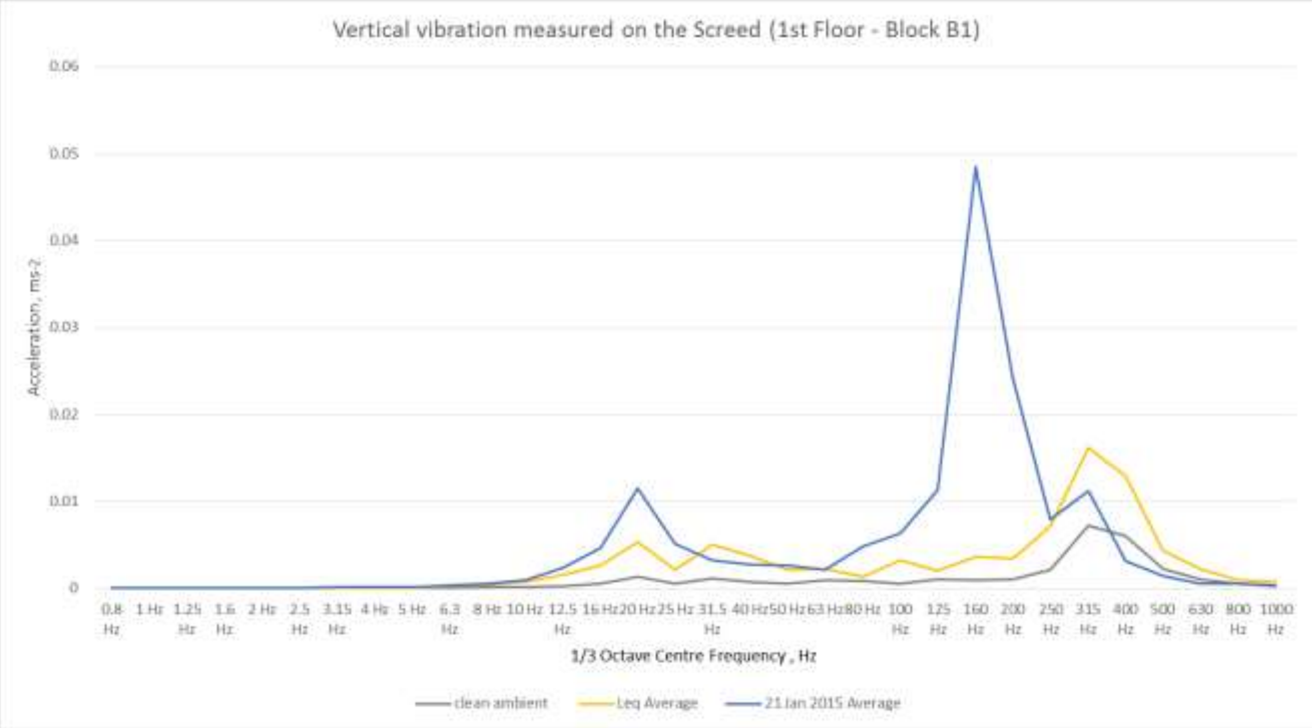

Figure 3: Results on 1st floor in B1 with Screed down, with non-screeded results included, from Figure 2

As is clear from Figure 3, the installation of screed does have an effect on the floor responses, as can be seen from the yellow line (with screed) verses the blue line (without screed). The natural floor response frequency then becomes 20Hz, with the level of the peak reduced in level. At the second natural floor response frequency, the screed has resulted in a frequency shift from 160Hz to 315 Hz, coupled with a significant reduction in vibration levels measured. The frequency shift is most likely to be as a result of stiffening the structure with the screed, and the reduction in level is probably related to the increase in mass of the floor, with the screed. As the mass of the building increases it is expected that the vibration levels will drop further, although not as significant. From a point of interest, it would be useful to carry out comparison measurements once the building is complete, but this is not necessary where the levels already comply with condition 19, as it would only be likely to improve.

3.1 Structureborne Noise

In a practically completed building, one would normally measure structureborne noise with a sound level meter, as a spacial average over the room of interest. However , because the rooms are not sealed if we attempted to measure structureborne noise in this way we would be also be measuring airborne external noise and site noise. At this interim stage of construction it is therefore necessary to measure the structureborne vibration in the floor, make a correction for the radiation effect of the floor and walls, and then convert it to a predicted radiated noise level, which tends to slightly overestimate the result in our experience. The vibration in the floor has been taken from measurements with the laid screed down, and therefore is restricted to 1st floor measurements only.

The related predicted resultant airborne noise levels in the rooms are therefore as presented in the Table 1 below:

Train type/ running rail	Measurement location	Predicted structureborne noise from slab L_{Aeq},dB during passby	Calculated from pile cap measurements, L_{Aeq}, dB
1 fast up train on near side	1st Floor	46.9	41
fast train on near rails	1st Floor	47.3	42
4 coaches slow to right on far tracks	1st Floor	47.7	42
med long freight on near tracks	1st Floor	46.9	-
10 slow on near track , 8 slow on furthest track	1st Floor	41	40
8 coach slow on far tracks	1st Floor	41.4	34
8 coach nearest	1st Floor	46.6	
8 coach on near line with screed	1st Floor	46.9	

Table 1: Predicted Structureborne noise levels (worst case)

These structureborne noise levels are some 5 dB higher than predicted from pile cap measurements, which is similar to what was found in Building A. It is likely, as concluded with building A, there is an amplification from basement to CLT structure resulting in an average 5 dB increase at first floor due to the CLT resonant effects. Although no measurements could be taken at higher levels because of screeds were not down, Figure 2 shows that the floor response from 1st to 4th floor is comparable, suggesting no additional amplification or loss can be expected to occur between CLT floor levels.

4 DATA ANALYSIS

4.1 BS 8233 Assessment: L_{Aeq}

In order to compare with criteria for typical day and night-time noise levels as required by condition 19, a 16 hour and 8 hour period and the equivalent L_{Aeq} noise levels has been derived from the typical profile of train movements through the day. The profile allows for the typical train movements on all four running tracks. The trains comprise a mixture of 5 to 10 car electric and diesel units travelling at varying speeds, as described in results table above, with one freight train assumed to occur during the day (as was observed). We derived our profile from the clean vibration measurements available from the B1 excercise. The internal structureborne noise level from typical train pass-bys through the day, is predicted to be 34-35 dB $L_{Aeq,\ 16\ hrs.}$, which meets the limits of 'reasonable' criteria set at 40 dB $L_{Aeq\ (0700\text{-}2300)}$ for lounges and 35dB $L_{Aeq\ (0700\text{-}2300)}$ for bedrooms (when they are not in use for sleeping). At night the frequency of trains falls such that it is expected that the requirement of "good" will be achieved. It is felt that given that a reasonable balance is expected to enable sustainable development to occur, and that the quality of life of residents will not be affected as a result that only achieving between the "good" and "reasonable" range during the day is supported by the balance that needs to be stuck in accordance with the National Planning and Noise Policy[1].

4.2 Maximum noise levels, L_{AMax}

Condition 19 does mention LAMax and it is interpreted that what is meant by this is that the levels set out in BS 8233:1999 should be achieved at night, as to not see a variation in noise levels when there would be a train pass –by would be not practicable, reasonable or necessary to achieve in this location, in order to make the dwelling acceptable for human occupation. The standard for this is set out in BS8233.

It is difficult to give a fair indication of likely maximum noise levels, especially in light of the fact that this parameter has been dropped in the latest revision of the standard, so not too much weight should be placed

[1] Para 123 of NPPF and NPSE (Noise Policy Statement for England)

on it in light of the current state of knowledge. However regard has been given for completeness of compliance with the wording of condition 19.

From the measurements taken on 28th February this tentatively suggest that maximum noise level could be around 46-47 dB L_{Amax} with medium to fast trains running on the inside tracks nearest to B1. From the surveys carried out, typically over a 1 hour period, 4 out of 14 trains would be pass at medium speed on the inside tracks, so may result in these maximum levels, so an estimate is that roughly 28% may exceed the interpreted Condition 19 target of 45. Some variation is to be expected and a balanced view, in light of the change of tone in the standard which the condition is based on is considered to be reasonable.

4.3 VDV vibration levels

An estimate of potential VDV vibration levels has been carried out based on the ½ hour measurements carried out at 1st floor screeded slab level. The predictions have used the Estimated Vibration Dose Value to estimate the vibration dose value using the formulae:

eVDV = k . a (rms) . $t^{0.25}$; where k is nominally 1.4 for Crest Factors below 6, a (rms) = weighted RMS Acceleration (m/s^2), t = total cumulative time (seconds) of the vibration events(s) or period(s) of vibration. Each event VDV has been calculated and then summed over the 16 hour time period.

The calculated eVDV for daytime (16 hour vibration) is 0.076 $ms^{-1.75}$ at 1st floor level. These are very similar to predicted from the initial pile cap predictions, and can be confirmed to be in good agreement and confirm that this is a robust assessment. With reference to the assessment criteria in 2.2 there is therefore **Low probability of adverse comment** during train movements. As a result Condition 19 has been achieved, without a further need for mitigation to address vibration ingress in Block B1, and the completed building is likely to be an improvement on this.

5 CONCLUSIONS

Two noise and vibration monitoring exercises have been within a constructed CLT structure has taken place on site at Bacton Low Rise, within Block B1 within the London Borough of Camden.

Sustainable Acoustics Ltd. completed the exercise on behalf of Peter Brett Associates over two sessions, on 21st January and 28th January 2015 respectively. This was in order to establish the levels of noise and vibration in the closest apartments of Block B1, against the requirements of planning condition 19 which deals with noise and vibration ingress from the railway.

The monitoring was carried out to establish how close the earlier predictions of vibration and structureborne noise were to the reality inside the building. The measurements show that when the CLT is unscreeded, the CLT floor responds at two noticeable frequencies 20Hz and 160 Hz, when the CLT is screeded, there is a shift in the second frequency from 160 Hz to 315 Hz and a reduction in vibration level such that it complies with the requirements of BS 6472 and the newest update of BS8233.

The data from Block A does not suggest that there is then further amplification as you move to higher floor levels, so the measurements at first floor with the screed laid were sufficient to complete a robust assessment of the predicted levels of noise and vibration.

We are confident that the spirit of condition 19 will be achieved. The vibration VDV levels are within the planning condition 19 requirement for Block B1. The worst case predicted daytime structureborne noise levels resulting from train vibration levels for Block B1 are likely in the worst case to be between “good” and “reasonable” limits for lounges in apartments facing the railway, with others likely to achieve “good” at all times. At night it is expected that in all bedrooms that “good” according to BS8233:1999 will be achieved.

Regard for maximums indicated that over 72% of trains are likely to satisfy the intent of planning condition 19 at all times, with some 28% being expected to exceed the maximum criteria when they run fast on the nearest tracks for the overlooking rooms. The number of incidence during the early hours are likely to be a very low number of events and so the maximum criteria will not normally be exceeded, which is acceptable having regard for the wording in BS8233:1999. In reality the maxima that are a result of the structureborne noise will be similar or less than the airborne noise experienced through the windows during a train pass by, and the close proximity to the railway. Consideration of context is important here as the inner city location means that we'd expect this to provide some acceptable level of connection with the urban soundscape which will be unlikely to cause disturbance to residents. This approach is consistent with that the interpretation placed on Local Authorities by National Planning and Noise Policy, and strikes the balance intended by Condition 19.

In conclusion a thorough assessment has been completed of the noise and vibration ingress that results from the railway into the habitable areas within Block B1, to check that design predictions were robust. It can be concluded that they were and it is our opinion that the intent of condition 19 has been discharged, with regard for other factors such as context and the inner city location close to a railway.