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Acoustic Associates Sussex Ltd

Measurement and Assessment of Ground-borne Vibration

Site: 13-23 St Dunstans Road, Worthing
Client: Chipping & Dawson Ltd

Report by: George Orton BEng(Hons) MIOA

Date : 6th April 2011

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1 Introduction

Acoustic Associates have been appointed to undertake a ground-borne vibration assessment relating to part of the proposed residential development at St. Dunstans Road, Worthing

The purpose of this assessment is to assess levels of vibration associated with the near by railway in order to satisfy a planning condition. (The planning condition states that vibration needs only to be assessed with respect to the two houses) A separate noise assessment has also been completed by Acoustic Associates Sussex Ltd.

A vibration survey was carried out between the 21st and 23rd March 2011 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 BS6472 (Part 1 – 2008)

Measurements 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 report concludes that if a raft foundation, or similar, was used there would be no need for vibration mitigation measures.

2 Planning Policy, Context & Noise Assessment Criteria

2.1 Context

The St Dunstans Road development sits between St Dunstans Road and the South Coast Railway Line. The development contains two individual accommodation blocks - One block of houses (the assessment applies to the houses only as stated by planning condition)which are near to the railway and one block of flats, further from the railway, facing on to St. Dunstans Road.

2.2 Planning Policy Guidance 24 (Planning and Noise)

Planning policy guidance notes set out the Government's policies on different aspects of planning. Local authorities must take their content into account in preparing their development plans. They may be material to decisions on individual planning applications and appeals.

With regard to ground-borne vibration PPG24 states the following (Annex 3, paragraph 4)

The likelihood of significant ground-borne vibration will depend on the nature of the ground and the types of train. The possibility of vibration and re-radiated noise caused by trains running in tunnels should not be overlooked. Advice on acceptable levels of vibration can be found in BS 6472

2.3 BS6472 (New edition - 2008)

Part 1of 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.

2.4 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:

Place & Time	*Low probability of adverse comment*[1] $ms^{-1.75}$	*Adverse comment possible* $ms^{-1.75}$	*Adverse comment Probable*[2] $ms^{-1.75}$
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 1: BS6472 Criteria

[1] Below these ranges adverse comment is not expected.

[2] Above these ranges adverse comment is very likely.

3 Vibration Survey Baseline Conditions & Results

A vibration survey was carried out between the 21st and 23rd March 2011 in order to measure ground-borne vibration levels associated with the nearby railway.

3.1 Survey Details

3.1.1 Equipment

- RION 3-Axis Vibration Meter VM-54
- Rion PV-83CW Tri-Axial Accelerometer
- DIN 45669-2 Mounting Plate

3.1.2 Personnel

Survey carried out by: George Orton BEng(Hons) MIOA

3.1.3 Site/Survey Drawings

The site location and accelerometer position used during the vibration survey are shown on the figure below:

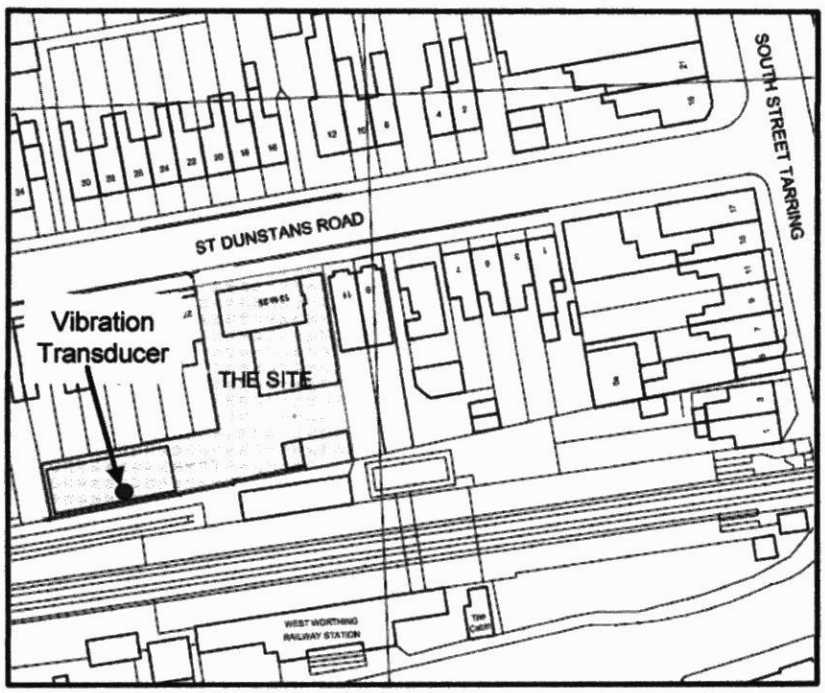

Figure 1: Survey Location Plan

3.1.4 Measurement Position/Details

The Rion tri-axial accelerometer was fixed to the mounting plate; the accelerometer and plate were then positioned on the floor of the existing warehouse. Axis X was parallel to the railway, Axis Y was perpendicular to the railway and axis Z was the vertical axis. The floor of the warehouse was concrete and it is assumed that it is a concrete raft floor. The VM-54 was set up to continuously monitor vibration levels over consecutive hourly periods.

3.2 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 Wb* and *Wd* for horizontal motion. The weighting curves are defined in BS 6841. The VM-54 was set up so that the correct frequency weightings were applied to the measurements.

3.3 Noise Survey Results

3.3.1 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 VM-54 calculates the hourly VDV values internally. The graph below[3] shows the measured rail noise VDV values for all three axes.

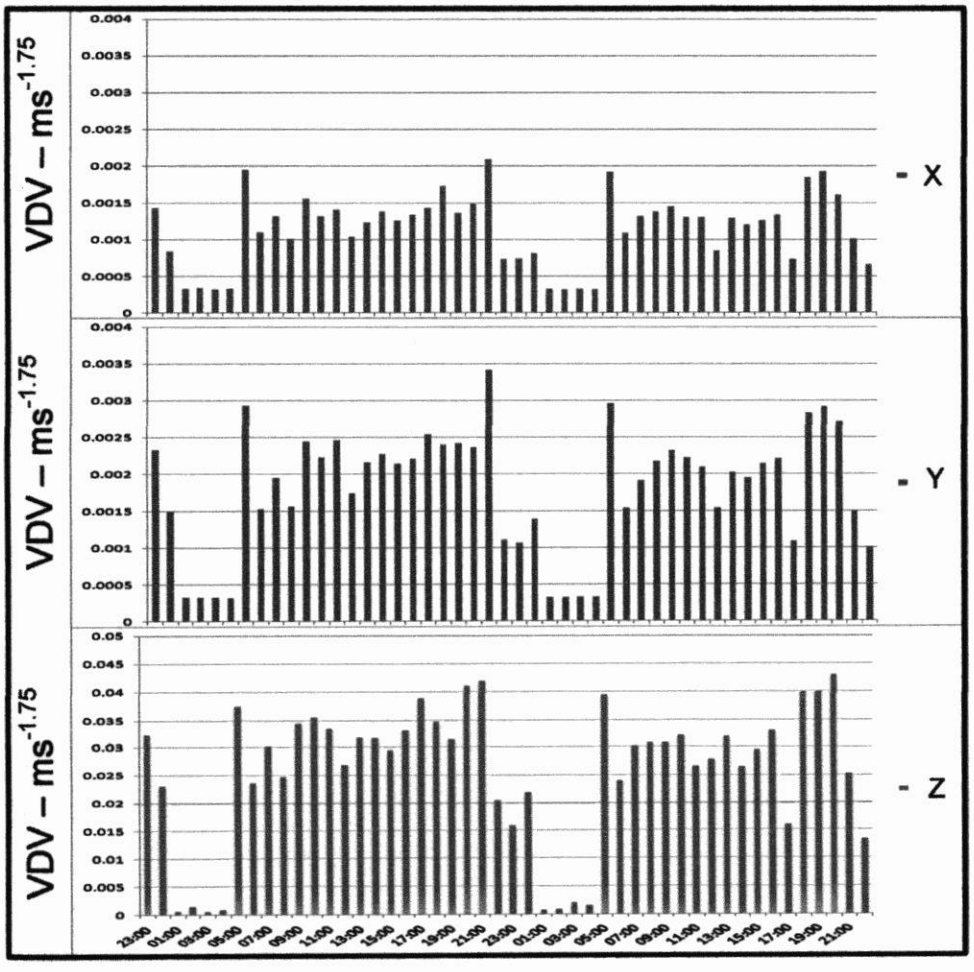

Figure 2: Measured Vibration Levels

[3] The scale on the Z-axis is different to the X & Y axes scale

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Measurements started at approximately 17:00hrs on the 21/03/2011 and finished at approximately 15:00hrs on the 23/03/2011. The measurements were conducted for 46hrs in total and order to complete the 48hr period the 2 "missing" hours have been copied from the previous day's measurements (15:00 &16:00hr measurements). The measurements have been arranged so that the graph starts at the beginning of the night-time period. The hourly VDV values have been summed to show the VDV_{day} and VDV_{night} values:

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

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

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:

Time Period	*X-Axis*		*Y-Axis*		*Z-Axis*	
	F_w	*VDV* $ms^{-1.75}$	F_w	*VDV* $ms^{-1.75}$	F_w	*VDV* $ms^{-1.75}$
23:00-07:00hrs	W_d	0.002	W_d	0.003	W_b	0.044
07:00-23:00hrs	W_d	0.003	W_d	0.005	W_b	0.068
23:00-07:00hrs	W_d	0.002	W_d	0.003	W_b	0.042
07:00-23:00hrs	W_d	0.003	W_d	0.004	W_b	0.064

Table 2: Measured Day & Night time VDV levels

4 Conclusion

BS6473 states that the vibration is to be evaluated for the single axis, determined by tri-axial measurement, in which the magnitude of weighted acceleration is greatest.

The table above demonstrates that 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.

Even if the VDV levels were subject to a 10 fold increase adverse comment would still not be expected.

Measurements of vibration should normally be taken on a building structural surface supporting a human body. Where measurements are made other than at the point of entry of vibration to the body an allowance should be made for the transfer function between the measurement point and the point of entry to the body. As the vibration measurements were taken directly on an area of concrete which would be similar to a raft type of foundation there will be no need to estimate a transfer function. If deep foundations or piled foundations were to be used the vibration levels experienced within the new dwelling may increase.

Therefore it is considered that if a raft foundation, or similar, was used there would be no need for vibration mitigation measures.