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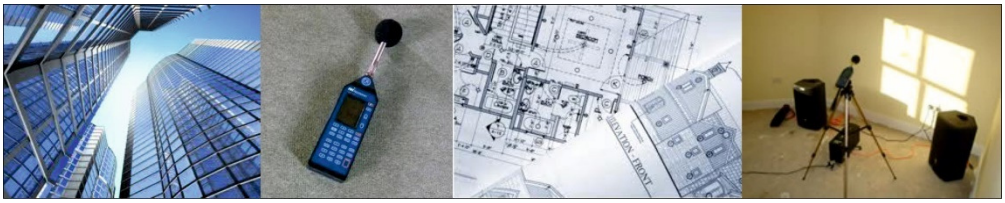

156 WEST END LANE
WEST HAMPSTEAD
LONDON
NW6 1SD

ASSESSMENT OF GROUND-BORNE VIBRATION TO DISCHARGE CONDITION 35 OF PLANNING PERMISSION 2019/4140 (14/07/21)

v.2

Client:
ASTIR LIVING LIMITED
85 Great Portland Street
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27 July 2021
Ref: M4720

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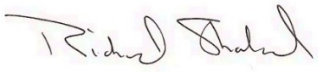
Signature	
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1. SUMMARY

1.1 This assessment of building vibration levels has been prepared on behalf of Astir Living Limited Developments Ltd ("the applicant") to discharge Condition 35 (Details of building vibration levels) of planning permission 2019/4140/P.

1.2 Planning permission was granted for the following:

> *"Variation of Conditions 2 (approved plans), 9 (wheelchair units), 33 (obscure glazing), 44 (cycling spaces) and 46 (unit numbers) of planning permission 2015/6455/P dated 23rd June 2017 for: Comprehensive redevelopment following demolition of all existing buildings to provide self-contained residential dwellings (Class C3), flexible non-residential use (Class A1-A3, D1, D2), employment floorspace (Class B1) and community meeting space (Class D1) in buildings ranging from 3 to 7 storeys. New vehicular access from West End Lane and provision of accessible car parking spaces. Provision of new public open space and widening of Potteries Path and associated cycle parking and landscaping".*

1.3 Condition 35 states:

> "Prior to commencement of works on site, other than demolition, site clearance and preparation, details shall be submitted to and approved in writing by the Local Planning Authority, of building vibration levels, together with appropriate mitigation measures within residential units where necessary. Details shall demonstrate that vibration will meet a level that has a low probability of adverse comment and the assessment method shall be as specified in BS 6472:2008. No part of the development shall be occupied until the approved details have been implemented. The approved details shall thereafter be permanently retained".

1.4 Current levels of ground-borne vibration have been established across the site (Section 3), and the survey has confirmed a typical variation in daytime and night-time levels, reflecting local transport movements.

1.5 Section 4 provides a description of the relevant national planning policies and defines the criteria which would commonly be applied to projects of this nature.

1.6 A formal assessment of vibration levels, to BS6472:2008, has been undertaken (Section 5) and this indicates that the predicted values within both buildings would below the category described as indicating '**Low Probability of Adverse Comment**'.

1.7 It is therefore concluded that the development would not require specialist acoustic measures in order to protect the amenity of future occupants from levels of ground borne vibration.

2. INTRODUCTION

2.1 In order to discharge the details of Condition 35 (building vibration levels) of planning permission 2019/4140/P, an assessment of ground-borne vibration noise has been undertaken at 156 West End Lane, West Hampstead, London, NW6 1SD, on behalf of Astir Living Limited.

2.2 The site is situated east of West End Lane and south of Lymington Road, and is north of the Thameslink, Overground and Jubilee Railways serving West Hampstead (Figure 1 – Site Location).

2.3 Planning permission has been granted for 180 residential dwellings in two buildings - ~~,~~the West Building ~~is proposed~~ will offer~~to have~~ 79~~no~~ units across 6 floors, and the East Building will have ~~to have~~ 101~~no~~ units spread over 7 floors. ~~.~~ The scheme will ~~It is also~~ also include ~~proposed to have~~ commercial units within the ground and 1st floor levels of the West Building~~,~~ (Figures 2 to 4 – Proposed Site Plan and South Elevations).

2.4 It is recognised that the proposals may be subject to ground-borne vibration, ~~noise~~ due predominantly to ~~emanating from~~ the nearby railway lines.

2.5 In order to discharge Condition 35, this assessment seeks to:

(i) measure ground-borne vibration levels across the site
(ii) assess these ~~ground vibration~~ levels on the site against relevant British Standard guidelines, and
(iii) ~~-~~provide appropriate mitigation measures if necessary.

2.6 This report details the investigations carried out in respect of each of these objectives and summarises the conclusions which have been reached.

3. SURVEY OF GROUND VIBRATION LEVELS

3.1 The first step in the assessment of potential impact is to measure and describe the existing ground-borne vibration levels affecting the site ~~from passing trains~~.

3.2 A survey was undertaken from Monday 20th to Thursday 23rd July 2020 with the equipment set to record the VDV (vibration dose values) in the X, Y & Z axis over 5 and 10mins samples.

3.3 Two Rion VM-54 3-axis vibration meters were set up with the accelerometers connected to a ~~heavy plate and placed on hard standings of ground~~. These were located along the southern boundary of the site ~~close to the nearby railway~~, as shown in the picture below.

3.4 Weather conditions throughout the survey period are summarized in Table 3.1.

Date	Average Temperature (°C)	Rainfall (mm)	Average Wind Speed m/sec	Wind Direction
Monday 20/07	19	0.0	1.8	Variable
Tuesday 21/07	19	0.0	2.0	NW
Wednesday 22/07	22	0.0	2.2	SW
Thursday 23/07	23	0.0	4.3	W

Table 3.1 – Summary of Weather Conditions

3.5 Figures 5 & 6 show the variations in the vibration levels over the survey period at each location, and Table 3.2 confirms the measured levels during each of the standard day time and night-time periods.

P1 – SOUTHEAST CORNER				
Period		**X axis VDV** $m/s^{1.75}$	**Y axis VDV** $m/s^{1.75}$	**Z axis VDV** $m/s^{1.75}$
Monday 20/07	Daytime	0.0365	0.0360	0.0233
	Night-time	0.0314	0.0335	0.0194
Tuesday 21/07	Daytime	0.0401	0.0369	0.0253
	Night-time	0.0325	0.0252	0.0148
Wednesday 22/07	Daytime	0.0374	0.034	0.0243
	Night-time	0.0238	0.0258	0.0164
Thursday 23/07	Daytime	0.0442	0.0362	0.0286
	Night-time	n/a	n/a	n/a

P2 – SOUTHWEST CORNER				
Period		**X axis VDV** $m/s^{1.75}$	**Y axis VDV** $m/s^{1.75}$	**Z axis VDV** $m/s^{1.75}$
Monday 20/07	Daytime	0.1445	0.1458	0.0493
	Night-time	0.0241	0.0295	0.0290
Tuesday 21/07	Daytime	0.0664	0.0694	0.0466
	Night-time	0.0290	0.0305	0.0275
Wednesday 22/07	Daytime	0.0763	0.0722	0.0598
	Night-time	0.0270	0.0309	0.0270
Thursday 23/07	Daytime	0.0743	0.0768	0.0485
	Night-time	n/a	n/a	n/a

Table 3.2 – Summary of Measured Vibration Levels

3.6 The higher levels at P2 on Monday 20/07 are due to vehicular movements within the site and therefore should be discounted.

3.7 The significance of the figures shown in Table 3.2 will be discussed in Section 5.

4. REVIEW OF RELEVANT PLANNING POLICY & GUIDELINES

4.1 National Planning Policy Framework (February 2019)

4.1.1 The National Planning Policy Framework (NPPF) sets out the Government's planning policies for England and how these should be applied. It provides a framework within which locally prepared plans for housing and other development can be produced.

4.1.2 Planning law requires that applications for planning permission be determined in accordance with the development plan unless material considerations indicate otherwise. The National Planning Policy Framework must be considered in preparing the development plan and is a material consideration in planning decisions. Planning policies and decisions must also reflect relevant international obligations and statutory requirements.

4.1.3 The purpose of the planning system is to contribute to the achievement of sustainable development. At an extremely high level, the objective of sustainable development can be summarised as meeting the needs of the present without compromising the ability of future generations to meet their own needs.

4.1.4 Achieving sustainable development means that the planning system has three overarching objectives, which are interdependent and need to be pursued in mutually supportive ways (so that opportunities can be taken to secure net gains across each of the different objectives):

a) an economic objective – to help build a strong, responsive and competitive economy, by ensuring that sufficient land of the right types is available in the right places and at the right time to support growth, innovation and improved productivity; and by identifying and coordinating the provision of infrastructure;

b) a social objective – to support strong, vibrant and healthy communities, by ensuring that a sufficient number and range of homes can be provided to meet the needs of present and future generations; and by fostering a well-designed and safe built environment, with accessible services and open spaces that reflect current and future needs and support communities' health, social and cultural well-being; and

c) an environmental objective – to contribute to protecting and enhancing our natural, built and historic environment; including making effective use of land, helping to improve biodiversity, using natural resources prudently, minimising waste and pollution, and mitigating and adapting to climate change, including moving to a low carbon economy.

4.1.5 These objectives should be delivered through the preparation and implementation of plans and the application of the policies in this Framework; they are not criteria against which every decision can or should be judged. Planning policies and decisions should play an active role in guiding development towards sustainable solutions, but in doing so should take local circumstances into account, to reflect the character, needs and opportunities of each area.

4.1.6 So that sustainable development is pursued in a positive way, at the heart of the Framework is a presumption in favour of sustainable development

4.1.7 Paragraph 180 of the NPPF states:

180. Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development. In doing so they should:

a) mitigate and reduce to minimum potential adverse impacts resulting from noise from new development – and avoid noise giving rise to significant adverse impacts on health and the quality of life[1] ;

b) identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason; and

c) limit the impact of light pollution from artificial light on local amenity, intrinsically dark landscapes, and nature conservation.

4.1.8 The Framework continues:

182. Planning policies and decisions should ensure that new development can be integrated effectively with existing businesses and community facilities (such as places of worship, pubs, music venues and sports clubs). Existing businesses and facilities should not have unreasonable restrictions placed on them as a result of development permitted after they were established. Where the operation of an existing business or community facility could have a significant adverse effect on new development (including changes of use) in its vicinity, the applicant (or 'agent of change') should be required to provide suitable mitigation before the development has been completed.

183. The focus of planning policies and decisions should be on whether proposed development is an acceptable use of land, rather than the control of processes or emissions (where these are subject to separate pollution control regimes). Planning decisions should assume that these

[1] Refers here to the NPSE, discussed in Section 4.2 of this report.

regimes will operate effectively. Equally, where a planning decision has been made on a development, the planning issues should not be revisited through the permitting regimes operated by pollution control authorities.

4.2 Noise Policy Statement for England (March 2010)

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

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

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

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

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

- **NOEL** - No Observed Effect Level

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

- **LOAEL** - Lowest Observed Adverse Effect Level

  This is the level above which adverse effects on health and quality of life can be detected. Where levels lie between the LOAEL and SOAEL, the Statement requires that all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life while also taking into account the guiding principles of sustainable development, as set out in the NPPF.

- **SOAEL** - Significant Observed Adverse Effect Level

  This is the level above which significant adverse effects on health and quality of life occur. It notes, however, that "it is not possible to have a single objective noise-based measure that describes SOAEL that is applicable to all sources of noise in all situations. Consequently, the SOAEL is likely to be different for different noise sources, for different receptors and at different times".

4.2.3 Paragraph 2.7 states that "… the application of the NPSE should enable noise to be considered alongside other relevant issues and not to be considered in isolation. In the past, the wider benefits of a policy, development or other activity may not have been given adequate weight when assessing the noise implications".

4.2.4 This provides clear guidance that noise must not be considered in isolation but as part of the overall scheme, taking into account the overall sustainability and associated impacts of the proposed development; there is no benefit in reducing noise to an excessively low level if this creates or increases some other adverse impact. Similarly, it may be appropriate in some cases for noise to have an adverse impact if this is outweighed by the reduction or removal of some other adverse impact that is of greater significance to the development.

4.2.5 The Noise Policy Statement considers that noise levels above the SOAEL would be seen to have, by definition, significant adverse effects and would be considered unacceptable. Where the assessed noise levels fall between the LOAEL and the SOAEL noise levels, the Policy Statement requires that:

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

4.2.6 Where noise levels are below the LOAEL it is considered there will be no adverse effect. Once noise levels are below the NOEL there will be no observable change. An indication of the numerical definition of LOAEL may be derived from the following guidance.

4.3 Planning Practice Guide 'Noise' (July 2019)

4.3.1 The Ministry of Housing Communities and Local Government provided further guidance to support the NPPF. The section, Noise, published in July 2019 advises:

When is noise relevant to planning?

> *Noise needs to be considered when development may create additional noise or would be sensitive to the prevailing acoustic environment (including any anticipated changes to that environment from activities that are permitted but not yet commenced). When preparing plans, or taking decisions about new development, there may also be opportunities to make improvements to the acoustic environment. Good acoustic design needs to be considered early in the planning process to ensure that the most appropriate and cost-effective solutions are identified from the outset.*

Can noise override other planning concerns?

It can, where justified, although it is important to look at noise in the context of the wider characteristics of a development proposal, its likely users and its surroundings, as these can have an important effect on whether noise is likely to pose a concern.

How can noise impacts be determined?

Plan-making and decision making need to take account of the acoustic environment and in doing so consider:

- *whether or not a significant adverse effect is occurring or likely to occur.*
- *whether or not an adverse effect is occurring or likely to occur; and*
- *whether or not a good standard of amenity can be achieved.*

In line with the Explanatory note of the noise policy statement for England, this would include identifying whether the overall effect of the noise exposure (including the impact during the construction phase wherever applicable) is, or would be, above or below the significant observed adverse effect level and the lowest observed adverse effect level for the given situation. As noise is a complex technical issue, it may be appropriate to seek experienced specialist assistance when applying this policy.

What are the observed effect levels?

- *Significant observed adverse effect level: This is the level of noise exposure above which significant adverse effects on health and quality of life occur.*
- *Lowest observed adverse effect level: this is the level of noise exposure above which adverse effects on health and quality of life can be detected.*
- *No observed effect level: this is the level of noise exposure below which no effect at all on health or quality of life can be detected.*

Although the word 'level' is used here, this does not mean that the effects can only be defined in terms of a single value of noise exposure. In some circumstances adverse effects are defined in terms of a combination of more than one factor such as noise exposure, the number of occurrences of the noise in a given time period, the duration of the noise and the time of day the noise occurs.

How can it be established whether noise is likely to be a concern?

At the lowest extreme, when noise is not perceived to be present, there is no effect. As the noise exposure increases, it will cross the 'no observed effect' level. However, the noise has no adverse effect so long as the exposure does not cause any change in behaviour, attitude, or other physiological responses of those affected by it. The noise may slightly affect the acoustic character of an area but not to the extent there is a change in quality of life. If the noise exposure is at this level no specific measures are required to manage the acoustic environment.

As the exposure increases further, it crosses the 'lowest observed adverse effect' level boundary above which the noise starts to cause small changes in behaviour and attitude, for example, having to turn up the volume on the television or needing to speak more loudly to be heard. The noise therefore starts to have an adverse effect and consideration needs to be given to mitigating and minimising those effects (taking account of the economic and social benefits being derived from the activity causing the noise).

Increasing noise exposure will at some point cause the 'significant observed adverse effect' level boundary to be crossed. Above this level the noise causes a material change in behaviour such as keeping windows closed for most of the time or avoiding certain activities during periods when the noise is present. If the exposure is predicted to be above this level the planning process should be used to avoid this effect occurring, for example through the choice of sites at the plan-making stage, or by use of appropriate mitigation such as by altering the design and layout. While such decisions must be made taking account of the economic and social benefit of the activity causing or affected by the noise, it is undesirable for such exposure to be caused.

At the highest extreme, noise exposure would cause extensive and sustained adverse changes in behaviour and / or health without an ability to mitigate the effect of the noise. The impacts on health and quality of life are such that regardless of the benefits of the activity causing the noise, this situation should be avoided.

4.3.2 Table 4.1 presents the PPG's noise exposure hierarchy table, which is based on likely average response of those affected:

Perception	Examples of Outcomes	Increasing Effect Level	Action
No Observed Effect Level			
Not Present	No Effect	No Observed Effect	No specific measures required
No Observed Adverse Effect Level			
Present and not intrusive	Noise can be heard but does not cause any change in behaviour or attitude. Can slightly affect the acoustic character of the area but not such that there is a change in the quality of life.	No Observed Adverse Effect	No specific measures required
Lowest Observed Adverse Effect Level			
Present and intrusive	Noise can be heard and causes small changes in behaviour attitude or other physiological response, e.g. turning up volume of television; speaking more loudly; where there is no alternative ventilation, having to close windows for some of the time because of the noise. Potential for some reported sleep disturbance. Affects the acoustic character of the area such that there is a perceived change in the quality of life.	Observed Adverse Effect	Mitigate and reduce to a minimum
Significant Observed Adverse Effect Level			
Present and disruptive	The noise causes a material change in behaviour, attitude or other physiological response, e.g. avoiding certain activities during periods of intrusion; where there is no alternative ventilation, having to keep windows closed most of the time because of the noise. Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening, and difficulty in getting back to sleep. Quality of life diminished due to change in acoustic character of the area.	Significant Observed Adverse Effect	Avoid
Present and very disruptive	Extensive and regular changes in behaviour, attitude or other physiological response and/or an inability to mitigate effect of noise leading to psychological stress or physiological effects, e.g. regular sleep deprivation/awakening; loss of appetite, significant, medically definable harm, e.g. auditory and non-auditory	Unacceptable Adverse Effect	Prevent

Table 4.1 – Noise Exposure Hierarchy[2]

[2] Taken from Planning Practice Guidance Note: Noise (July 2019)

4.3.3 The guidance further advises:

What factors influence whether noise could be a concern?

The subjective nature of noise means that there is not a simple relationship between noise levels and the impact on those affected. This will depend on how various factors combine in any situation.

These factors include:

- the source and absolute level of the noise together with the time of day it occurs. Some types and level of noise will cause a greater adverse effect at night than if they occurred during the day – this is because people tend to be more sensitive to noise at night as they are trying to sleep. The adverse effect can also be greater simply because there is less background noise at night.
- for a new noise making source, how the noise from it relates to the existing sound environment.
- for non-continuous sources of noise, the number of noise events, and the frequency and pattern of occurrence of the noise.
- the spectral content of the noise (i.e. whether or not the noise contains particular high or low frequency content) and the general character of the noise (i.e. whether or not the noise contains particular tonal characteristics or other particular features), and;
- the local arrangement of buildings, surfaces and green infrastructure, and the extent to which it reflects or absorbs noise.

More specific factors to consider when relevant include:

- the cumulative impacts of more than one source of noise.
- whether any adverse internal effects can be completely removed by closing windows and, in the case of new residential development, if the proposed mitigation relies on windows being kept closed most of the time (and the effect this may have on living conditions). In both cases a suitable alternative means of ventilation is likely to be necessary. Further information on ventilation can be found in the Building Regulations.
- In cases where existing noise sensitive locations already experience high noise levels, a development that is expected to cause even a small increase in the overall noise level may result in a significant adverse effect occurring even though little to no change in behaviour would be likely to occur.
- Noise Action Plans (where these exist), and the Important Areas identified through the process associated with the Environmental Noise Directive and corresponding regulations should be considered. Defra's website has information on Noise Action Plans and Important Areas. Local authority environmental health departments will also be able to provide information about Important Areas.

- the effect of noise on wildlife. Noise can adversely affect wildlife and ecosystems. Consideration needs to be given to the potential effects of noisy development on international, national, and locally designated sites of importance for biodiversity.
- where external amenity spaces are an intrinsic part of the overall design, the acoustic environment of those spaces should be considered so that they can be enjoyed as intended.
- some commercial developments including restaurants, hot food takeaways, night clubs and public houses can have impacts, not least because activities are often at their peak in the evening and late at night. Local planning authorities will wish to bear in mind not only the noise that is generated within the premises but also the noise that may be made by customers in the vicinity.

When proposed developments could include activities that would be covered by the licensing regime, local planning authorities will need to consider whether the potential for adverse noise impacts will be addressed through licensing controls (including licence conditions). Local planning authorities should not however presume that licence conditions will provide for noise management in all instances and should liaise with the licensing authority.

Can planning policies include noise standards?

Plans may include specific standards to apply to various forms of proposed development and locations in their area. Care should be taken, however, to avoid these being applied as rigid thresholds, as specific circumstances may justify some variation being allowed.

What factors are relevant if seeking to identify areas of tranquillity?

For an area to justify being protected for its tranquillity, it is likely to be relatively undisturbed by noise from human sources that undermine the intrinsic character of the area. It may, for example, provide a sense of peace and quiet or a positive soundscape where natural sounds such as birdsong or flowing water are more prominent than background noise, e.g. from transport.

Consideration may be given to how existing areas of tranquillity could be further enhanced through specific improvements in soundscape, landscape design (e.g. through the provision of green infrastructure) and/or access.

How can the risk of conflict between new development and existing businesses or facilities be addressed?

Development proposed in the vicinity of existing businesses, community facilities or other activities may need to put suitable mitigation measures in place to avoid those

activities having a significant adverse effect on residents or users of the proposed scheme.

In these circumstances the applicant (or 'agent of change') will need to clearly identify the effects of existing businesses that may cause a nuisance (including noise, but also dust, odours, vibration and other sources of pollution) and the likelihood that they could have a significant adverse effect on new residents/users. In doing so, the agent of change will need to take into account not only the current activities that may cause a nuisance, but also those activities that businesses or other facilities are permitted to carry out, even if they are not occurring at the time of the application being made.

The agent of change will also need to define clearly the mitigation being proposed to address any potential significant adverse effects that are identified. Adopting this approach may not prevent all complaints from the new residents/users about noise or other effects, but can help to achieve a satisfactory living or working environment, and help to mitigate the risk of a statutory nuisance being found if the new development is used as designed (for example, keeping windows closed and using alternative ventilation systems when the noise or other effects are occurring).

It can be helpful for developers to provide information to prospective purchasers or occupants about mitigation measures that have been put in place, to raise awareness and reduce the risk of post-purchase/occupancy complaints.

How can planning address the adverse effects of noise sources, including where the 'agent of change' needs to put mitigation in place?

This will depend on the type of development being considered the type of noise involved and the nature of the proposed location. In general, for developments that are likely to generate noise, there are 4 broad types of mitigation:

- engineering: reducing the noise generated at source and/or containing the noise generated.
- layout: where possible, optimising the distance between the source and noise-sensitive receptors and/or incorporating good design to minimise noise transmission using screening by natural or purpose-built barriers, or other buildings.
- using planning conditions/obligations to restrict activities allowed on the site at certain times and/or specifying permissible noise levels differentiating as appropriate between different times of day, such as evenings and late at night, and.
- mitigating the impact on areas likely to be affected by noise including through noise insulation when the impact is on a building.

For noise sensitive developments, mitigation measures can include avoiding noisy locations in the first place; designing the development to reduce the impact of noise from adjoining activities or the local environment; incorporating noise barriers; and optimising the sound insulation provided by the building envelope. It may also be possible to work with the owners/operators of existing businesses or other activities in the vicinity, to explore whether potential adverse effects could be mitigated at source. Where this is the case, it may be necessary to ensure that these source-control measures are in place prior to the occupation / operation of the new development. Where multiple development sites would benefit from such source control measures, developers are encouraged to work collaboratively to spread this cost. Examples of source control measures could include increased sound proofing on a building (e.g. a music venue) or enclosing an outdoor activity (e.g. waste sorting) within a building to contain emissions.

Care should be taken when considering mitigation to ensure the envisaged measures do not make for an unsatisfactory development.

Are there further considerations relating to mitigating the impact of noise on residential developments?

Noise impacts may be partially offset if residents have access to one or more of:

- a relatively quiet facade (containing windows to habitable rooms) as part of their dwelling.
- a relatively quiet external amenity space for their sole use, (e.g. a garden or balcony). Although the existence of a garden or balcony is generally desirable, the intended benefits will be reduced if this area is exposed to noise levels that result in significant adverse effects.
- a relatively quiet, protected, nearby external amenity space for sole use by a limited group of residents as part of the amenity of their dwellings; and/or
- 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-minute walking distance).

4.4 BS 6472:2008 Evaluation of Human Exposure to Vibration in Buildings (1 – 80 Hz)

4.4.1 Human response to vibration may be determined by a number of factors, including:

(i) The physical condition and mental disposition of the person experiencing the vibration;
(ii) The characteristics of the vibration (the frequency, direction, and whether it is continuous or intermittent;
(iii) Any noise which is re-radiated from the structural vibration;
(iv) The duration of the vibration and the time of the day;
(v) The nature of the existing environment, in the absence of the vibration;

4.4.2 Guidance on the acceptability of vibration levels can be found in a number of sources. For continuous exposure to vibration, BS 6742:2008 "Evaluation of Human Exposure to Vibration in Buildings (1 - 80 Hz)" provides limiting criteria for acceptable levels of vibration in different building types.

4.4.3 This defines the Vibration Dose Value of a vibration event, a quantity which may be used to estimate the probability of adverse comment from human beings experiencing vibration in buildings.

4.4.4 The Standard advises that:

> *"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. In workplaces, adverse comment often arises at rather higher levels, although people in sedentary occupations respond more like home residents."*

4.4.5 The evaluation includes measurements of the frequency-weighted rms acceleration in each orthogonal axis (foot to head, back to front, side to side). The assessment of perceptibility of vibration is made with respect to the highest weighted value determined in any axis at the point of contact, at any time.

4.4.6 BS6472 confirms that human perception does depend on the vibration frequency and direction. It therefore offers a series of frequency weightings which should be applied to vibration, so that the resulting overall levels can be interpreted in terms of perception, comfort or adverse comments. In this instance, the Standard advises that Wb frequency weighting should be applied to the z-axis (foot to head) component of vibration, and that the Wd frequency weighting should be applied to the x and y planes (back-to-chest and side-to-side, respectively).

4.4.7 The range of frequencies usually associated with the effects of whole-body vibration is between 0.5 Hz and 80 Hz.

4.4.8 The Vibration Dose Value may then be calculated as the product of the weighted rms acceleration and the duration of the event over a standard 16hr daytime period (07.00 – 23.00hrs) and 8hr night-time period (23.00 – 07.00hrs). Where there are a number of different events producing the vibration (as here), of varying duration and vibration level, the Standard provides a means of combining the individual Dose Values to provide an overall VDV for the period.

4.4.9 BS6472 defines values of Vibration Dose Values above which various degrees of adverse comment may be expected in residential buildings. These limits are confirmed below:

Location	Low Probability of Adverse Comment	Adverse Comment Possible	Adverse Comment Probable
Residential Buildings 16hr Daytime	0.2 – 0.4 $m/s^{1.75}$	0.4 – 0.8 $m/s^{1.75}$	0.8 – 1.6 $m/s^{1.75}$
Residential Buildings 8hr Night-time	0.1 – 0.2 $m/s^{1.75}$	0.2 – 0.4 $m/s^{1.75}$	0.4 – 0.8 $m/s^{1.75}$
Offices 16hr Day Time	0.4 – 0.8 $m/s^{1.75}$	0.8 – 1.6 $m/s^{1.75}$	1.6 – 3.2 $m/s^{1.75}$

Table 4.2 – BS6472 Guideline Thresholds

5. ASSESSMENT OF VIBRATION LEVELS

5.1 As discussed in ~~Para~~ Section 4.~~47~~, guidance on the acceptability of vibration levels can be found in BS6742 "Evaluation of Human Exposure to Vibration in Buildings (1 - 80 Hz)". This ~~which~~ provides limiting criteria for acceptable levels of vibration in different building types.

5.2 Paragraph 3.5 confirms the ground-borne vibration levels measured on a concrete slab at both locations within the site.

5.3 When considering the residual vibration within the new flats~~, however~~, there are a number of additional factors which will affect the residual values therein.

~~5.4~~ Firstly, there may be a distance correction. Vibration from a point source broadly dissipates as an inverse square law. Therefore, for a doubling of distance, there is a 6 dB reduction in amplitude. For a line source, the reduction would be half of this value. Research papers suggest that vibration transmission from a railway line acts as something between a point and line source.

5.4 In this instance, a conservative view will be adopted, by assuming the railway acts as a line source.

~~5.5~~ The ratio of source-to-receiver distance for the measurement positions and the proposed building positions is 1.3 and 1.4 at P1 & P2, respectively. A reduction of 1.1 dB (P1) and 1.5 dB (P2) might therefore be expected if measurements were repeated at the position of the nearest facades.

5.5 Thereafter, there are a series of transfer functions which would be applied to the vibration as it moves from the ground, into a building foundation and then up through a building.

5.6 Having sampled levels on a concrete foundation slab, it may be expected that vibration within the ground floor of the buildings would be ~~the~~ equivalent to those measured.

5.7 At upper floors, two corrections should be applied – one for the loss as the vibration moves up the building frame (+2 dB per floor), and one potential increase for resonance which may occur in the suspended floor structure (+6 dB)[3].

~~5.8~~ ~~I~~ If the ground floor slab is suspended also, there would be a potential increase for resonance there.

[3] ANC publication 'Measurement and assessment of Ground borne Noise and Vibration' 2012

5.89 It has been confirmed that the form of construction will be a traditional RC frame, external walls being brick cavity with SFS internal leaf on ground beams and piled foundations.

~~5.10 Therefore, measurements will be representative of the vibration on the top of the piles. However, there could have be a +6dB resonance in the middle of the lowest floor slab and then +4dB on the floor above that (and thereafter, a 2dB reduction per level as the building rises).~~

5.911 On the basis of these transfer functions, the predicted vibration dose within the 1st floor flats ~~rooms~~ of the West Building and ground floor of the East Building are shown in Table 5.1.

PREDICTED VDV ON 1st FLOOR ROOMS IN WEST BUILDING				
Period		**X axis VDV** $m/s^{1.75}$	**Y axis VDV** $m/s^{1.75}$	**Z axis VDV** $m/s^{1.75}$
Monday 20/07	Daytime	0.06	0.06	0.04
	Night-time	0.05	0.06	0.03
Tuesday 21/07	Daytime	0.07	0.06	0.04
	Night-time	0.06	0.04	0.03
Wednesday 22/07	Daytime	0.07	0.06	0.04
	Night-time	0.04	0.05	0.03
Thursday 23/07	Daytime	0.08	0.06	0.05
	Night-time	n/a	n/a	n/a

PREDICTED VDV ON GROUND FLOOR ROOMS IN EAST BUILDING				
Period		**X axis VDV** $m/s^{1.75}$	**Y axis VDV** $m/s^{1.75}$	**Z axis VDV** $m/s^{1.75}$
Monday 20/07	Daytime	~~0.19~~n/a	~~0.19~~n/a	~~0.06~~n/a
	Night-time	0.03	0.04	0.04
Tuesday 21/07	Daytime	0.09	0.09	0.06
	Night-time	0.04	0.04	0.04
Wednesday 22/07	Daytime	0.10	0.09	0.08
	Night-time	0.04	0.04	0.04
Thursday 23/07	Daytime	0.10	0.10	0.06
	Night-time	n/a	n/a	n/a

Table 5.1 – Predicted Floor Vibration within Nearest Dwellings

5.10~~2~~ A comparison of these predicted levels against the criteria of BS6472 (~~see~~ Para. 4.~~46~~.9) indicates that these levels of vibration would give rise to less than a low probability of adverse complaint during the day and night.

5.11 It is therefore concluded that the scheme will not require any specialist anti-vibration treatments within the foundation or superstructure design.

6. CONCLUSION

6.1 In order to discharge Condition 35 of planning permission 2019/4140/P dated 14th July 2021, an assessment of building vibration levels has been carried out at the development site, 156 West End Lane, West Hampstead.

6.2 The assessment has been carried out in accordance with BS 6472:2008.

6.3 The results demonstrate that vibration will meet a level that has "low probability of adverse comment".

6.4 In accordance with the reasons for the condition, the amenity of future occupiers of the development site will not be adversely affected by ground-borne vibration in accordance with the requirements of policies A1 (Managing the impact of development) and A4 (Noise and vibration) of the London Borough of Camden Local Plan 2017.

6.5 The results have confirmed that the measured vibration dose values would not require specific mitigation measures within the residential units.

FIGURE 1: SITE LOCATION

FIGURE 2: SITE LAYOUT PLAN

FIGURE 3: WEST BUILDING – SOUTH ELEVATION

FIGURE 4: EAST BUILDING – SOUTH ELEVATION

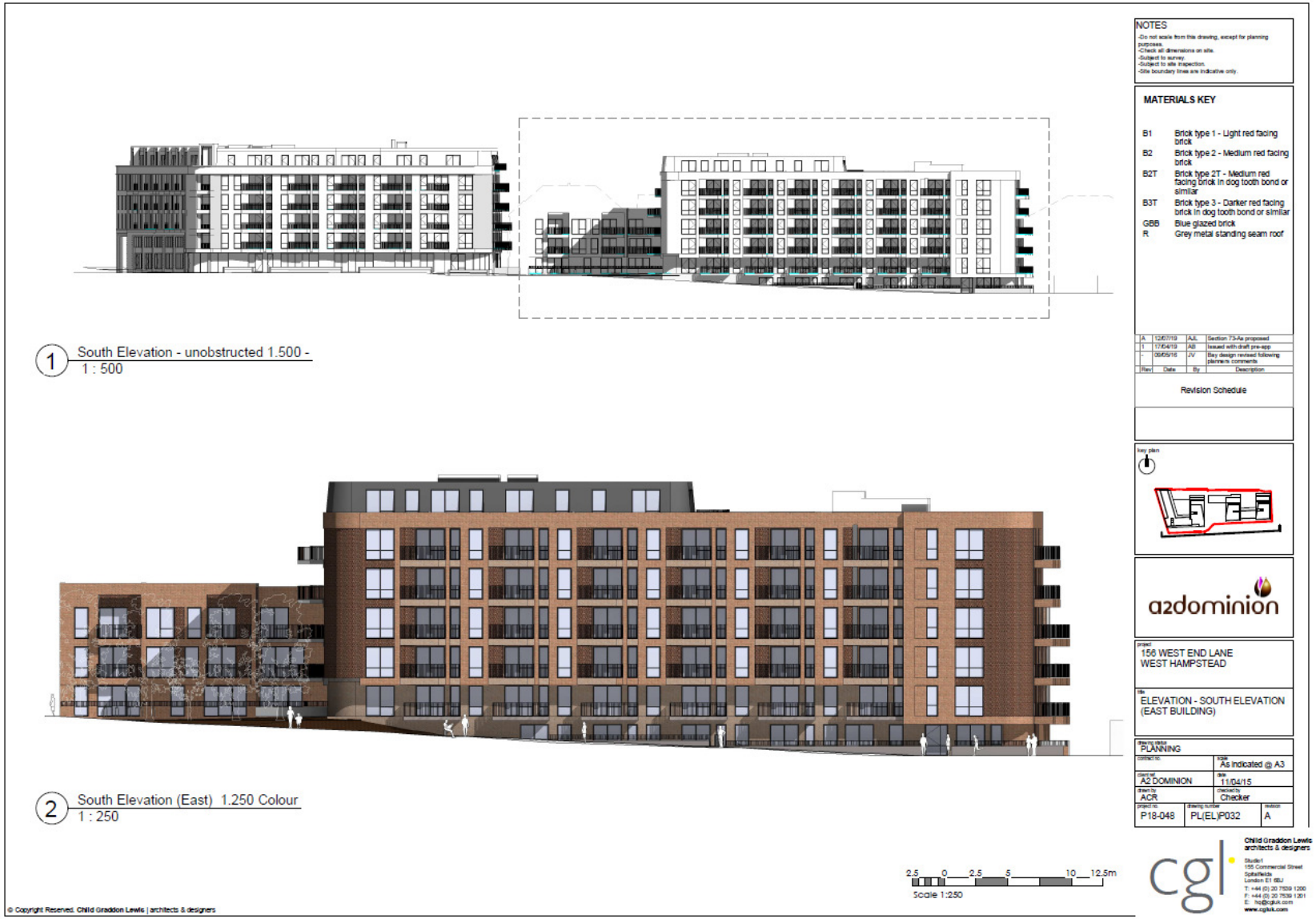


FIGURE 5: VARIATION OF VIBRATION LEVELS – P1

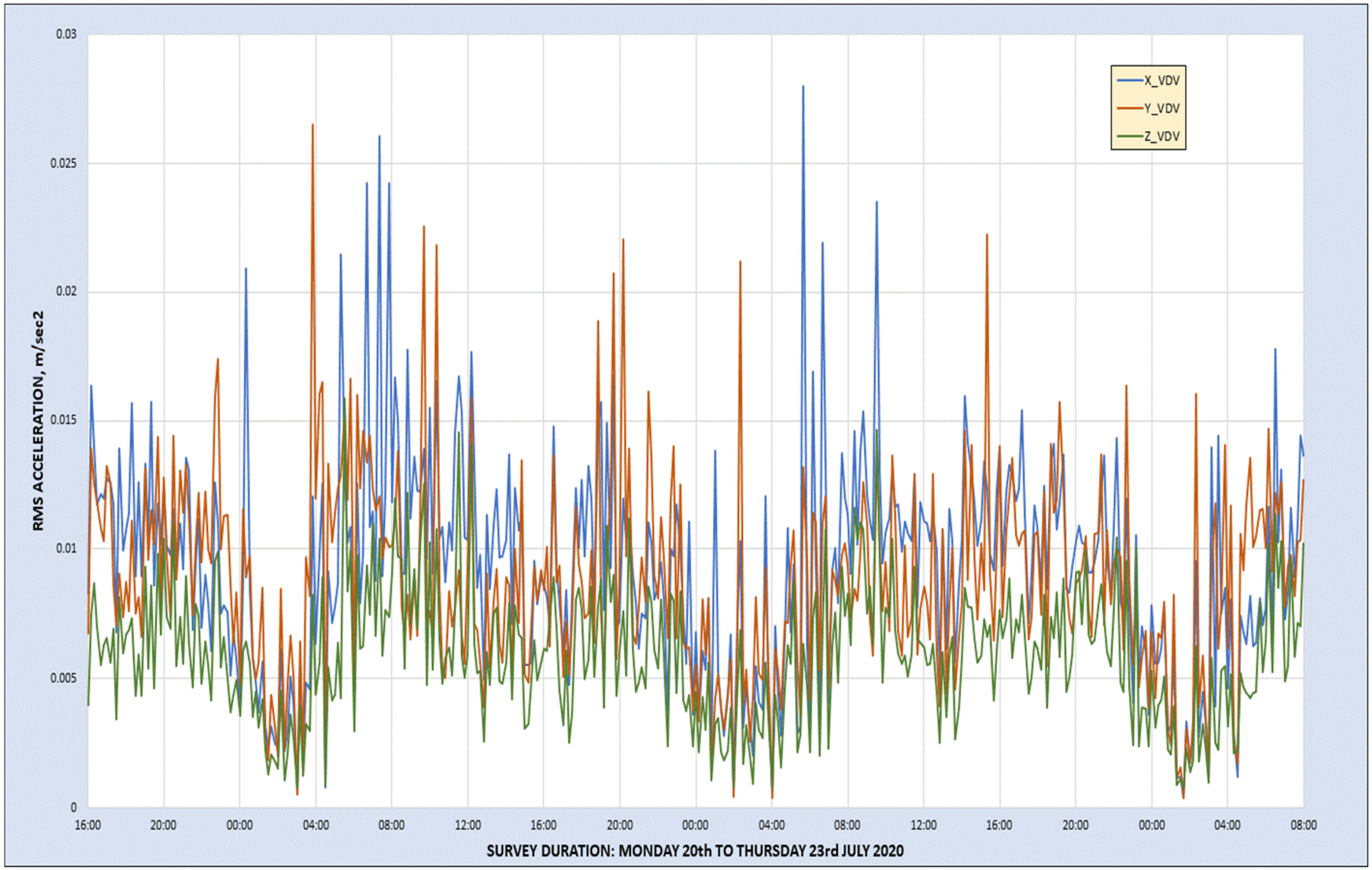
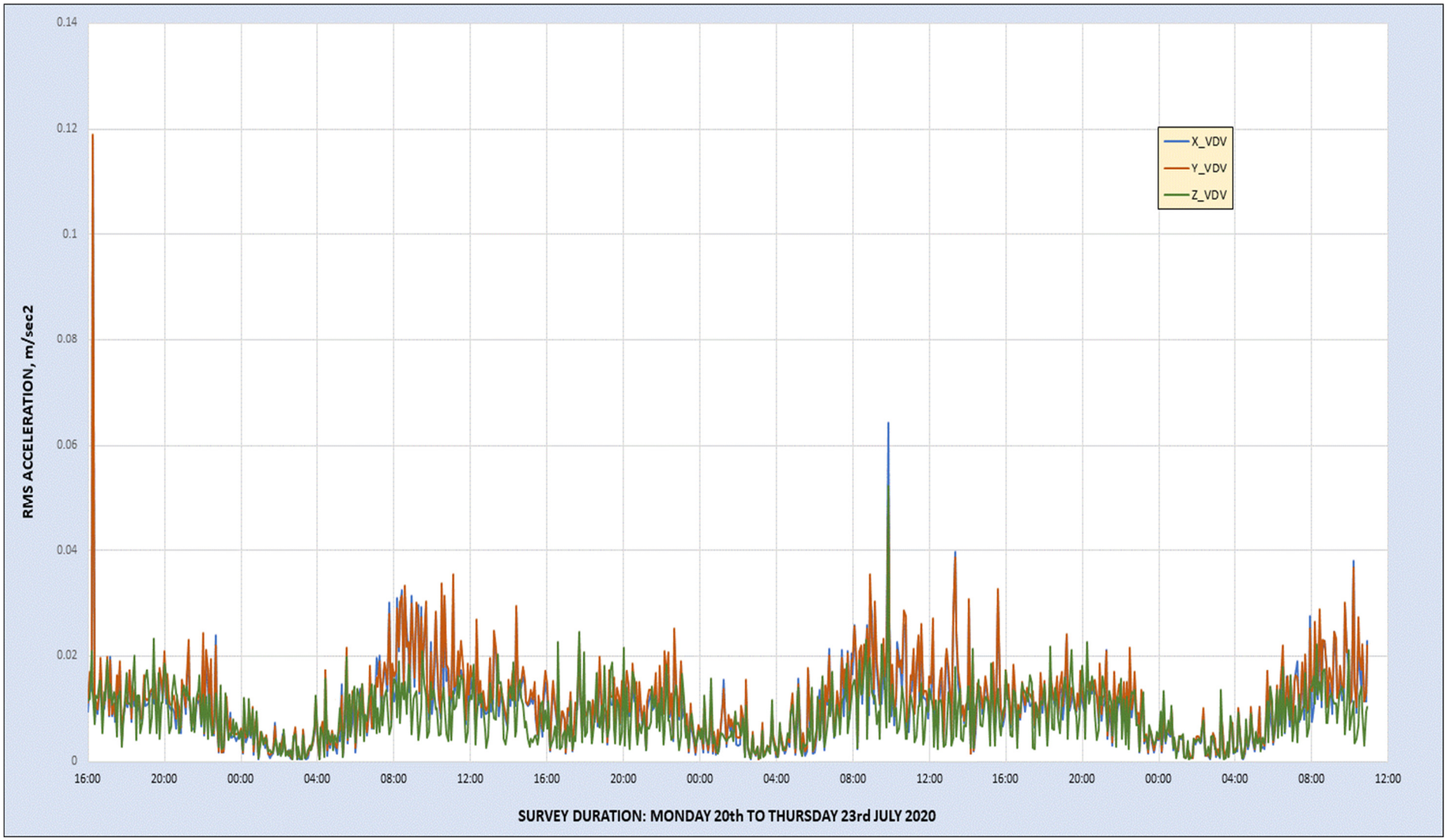


FIGURE 6: VARIATION OF VIBRATION LEVELS – P2



APPENDIX I - TERMINOLOGY RELATING TO NOISE

Sound Pressure	Sound, or sound pressure, is a fluctuation in air pressure over the static ambient pressure.
Sound Pressure Level	The sound level is the sound pressure relative to a standard reference pressure of 20µPa (20x10-6 Pascals) on a decibel scale.
Decibel (dB)	A scale for comparing the ratios of two quantities, including sound pressure and sound power. The difference in level between two sounds s1 and s2 is given by 20 log10 (s1 / s2). The decibel can also be used to measure absolute quantities by specifying a reference value that fixes one point on the scale. For sound pressure, the reference value is 20µPa.
A-weighting, dB(A)	The unit of sound level, weighted according to the A scale, which takes into account the increased sensitivity of the human ear at some frequencies.
Noise Level Indices	Noise levels usually fluctuate over time, so it is often necessary to consider an average or statistical noise level. This can be done in several ways, so a number of different noise indices have been defined, according to how the averaging or statistics are carried out.
Leq,T	A noise level index called the equivalent continuous noise level over the time period T. This is the level of a notional steady sound that would contain the same amount of sound energy as the actual, possibly fluctuating, sound that was recorded.
Lmax,T	A noise level index defined as the maximum noise level during the period T. Lmax is sometimes used for the assessment of occasional loud noises, which may have little effect on the overall Leq noise level but will still affect the noise environment. Unless described otherwise, it is measured using the 'fast' sound level meter response.
L90,T	A noise level index. The noise level exceeded for 90% of the time over the period T. L90 can be considered to be the "average minimum" noise level and is often used to describe the background noise.
Free-Field	Far from the presence of sound reflecting objects (except the ground), usually taken to mean at least 3.5m.
Façade Noise Level	At a distance of 1m in front of a large sound reflecting object such as a façade.
Fast/Slow Time Weighting	Averaging times used in sound level meters.
Octave Band	Range of frequencies whose upper limit is twice the lower limit.
DnT,w	The single number quantity that characterises airborne sound insulation between rooms over a range of frequencies.
Rw	Single number quantity that characterises the airborne sound insulating properties of a material or building element over a range of frequencies.