Vibration Monitoring Assessment Report (February 2021)

Tweed Valley Hospital Project, Cudgen NSW

Prepared for: Lendlease Building Pty Ltd

LND-01-Q1299 | VIB19.V1.7F | Date: 1/07/2021

ADE CONSULTING GROUP

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For and on behalf of
ADE Consulting Group Pty Ltd

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CONTENTS

Executive Summary

ADE Consulting Pty Ltd (ADE) has been commissioned by Lendlease Building Pty Ltd (Lendlease) to undertake construction vibration monitoring during the construction of the Tweed Valley Hospital Project (the 'Site'), located in the Northern Rivers Region of New South Wales (NSW). The site is bounded by Tweed Coast Road to the West, Cudgen Road to the South and Turnock Street to the East. Environmental monitoring and auditing during construction is a requirement of the project under the Development Consent SSD-10353.

The Vibration Assessment consisted of the real time data observation and discussion to achieve the following:

- Compliance with regulatory requirements and standards for vibration management;
- Avoid excessive vibration generation through site planning and the adoption of appropriate work methods and practices; and
- Prevent or minimize to the greatest extent, the impact of construction vibration on neighbours and to establish and maintain positive relationships with project stakeholders.

This report details the outcome of the real time vibration assessment conducted by ADE Consulting Group Pty Ltd throughout the month of **February 2021.**

Results from vibration monitoring undertaken during the monitoring period [February 2021] indicated no exceedance of DIN 4150 (Line 2) threshold used to assess the effects of short-term vibration on structures.

Works were only conducted between 7am and 6pm, Monday – Friday from **1 – 28 February 2021** and only data within this range should be considered.

Definitions

Vibration:	The mechanical oscillations occurring about an equilibrium point. The oscillations may be periodic such as the motion of a pendulum or random. Vibration is most commonly expressed in terms of displacement, velocity, acceleration and frequency, all of which are related.
Displacement:	The change in position of an object, is a vector quantity (Stress indicator).
Velocity:	The rate of change of displacement, is a vector quantity (Fatigue indicator).
Acceleration:	The rate of change of velocity, is a vector quantity. (Indicator of force).
Frequency:	The number of times a periodic function or vibration occurs or repeats itself in a specified time, often 1 second – cycles per second. Frequency is measured in Hertz.
Hertz (Hz):	The unit of frequency or pitch of a sound. One hertz equals one cycle per second.
Peak Particle Velocity (PPV):	Assessment of short-term vibration – the PPV is the square root of the sum of each vector (axis) squared, and is the metric used in evaluation of the transient of a vibration waveform which could cause damage to a structure. Measured in millimetres per second (mm/s). Velocity generally refers to the rate of change in the position of a sine wave
Root Mean Square (RMS):	The RMS value of a set of numbers is the square root of the average of their squares. Best used when assessing building damage.
Vibration Dose Value (VDV):	The vibration dose value (VDV) is used for assessing intermittent vibration. A cumulative measurement of the vibration level received over an 8-hour or 16-hour period. Best used when structure is occupied.
Peak:	The peak is the maximum amplitude during a measurement period.
Peak to Peak (P-P):	The peak to peak (P-P) is the difference between the maximum positive and maximum negative amplitudes of a waveform.
Logarithmic Scale:	Comparing frequency with large amplitude differences can be accomplished using a logarithmic scale. Critical vibration components usually occur at low amplitudes compared to the rotational frequency vibration. These components are not revealed on a linear amplitude scale because low amplitudes are compressed at the bottom of the scale. But a logarithmic scale shows prominent vibration components equally well at any amplitude.
Zero Crossing Frequency:	Determining the apparent dominant frequency of a given sample can be achieved by using the Zero Crossing Frequency.
Primary Waves (P Waves):	Alternating compressions ('pushes') and dilations ('pulls') in the same direction as the wave is propagating. P waves are the first arriving energy, smaller and higher frequency than S waves.

Secondary Waves (S Waves):	Alternating transverse motions perpendicular to the direction of propagation. Slower than P waves.
Rayleigh Waves (R Waves):	Motion is both in the direction of propagation and perpendicular (in a vertical plane). R waves are also dispersive, and amplitudes decrease with depth.
Accelerometer:	A vibration sensor whose electrical output is directly proportional to the acceleration component of the vibration. The two most common accelerometer types are the traditional charge type and the IEPE, integrated electronic piezoelectric type with a built-in line-drive amplifier to enable the output signal to be transmitted over 'longer cable runs.
Filter:	A device for separating components of a signal on the basis of their frequency. It allows components in one or more frequency bands to pass relatively unattenuated, and it attenuates components in other frequency bands. Modifies the frequency spectrum of a signal usually while it is in electrical form.
Short-term vibration	Vibration which does not occur often enough to cause structural fatigue, and which does not produce resonance in the structure being evaluated.
Long-term vibration	All types of vibration not covered by the definition of 'short-term' vibration.
VDV	Vibration Dose Value (VDV) is described in BS 6472-2008 as *the fourth root of the integral with respect to time of the fourth power of the acceleration after it has been weighted.* VDV is the total accumulated vibration energy over a specified time period (daytime and night-time).
Impulsive Vibration:	Rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration. It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short (typically <2 seconds). Impulsive vibration (no more than 3 occurrences) in an assessment period is assessed on the basis of weighted rms acceleration, and peak particle velocity.
Continuous Vibration:	Continuous vibration continues uninterrupted for a defined period (usually throughout daytime and/or night-time). This type of vibration is assessed on the basis of weighted rms acceleration.
Intermittent Vibration:	Defined as interrupted periods of continuous (e.g., a drill) or repeated periods of impulsive vibration (e.g., a pile driver), or continuous vibration that varies significantly in magnitude. It may originate from impulse sources (e.g., pile drivers and forging presses) or repetitive sources (e.g., pavement breakers), or sources which operate intermittently, but which would produce Continuous vibration if operated continuously (for example, intermittent machinery, railway trains and traffic passing by). This type of vibration is assessed on the basis of vibration dose value.

1 Introduction

1.1 Project Background

ADE Consulting Group Pty Ltd (ADE) was commissioned by Lendlease Building Pty Ltd (Lendlease) to assess the levels of vibration during the construction of the Tweed Valley Hospital Project, located at 771 Cudgen Road, Cudgen NSW (hereinafter referred to as 'the Site'). At the time of the vibration monitoring, Lendlease is continuing superstructure works on site.

The Vibration Assessment consisted of the real time data observation and discussion to achieve the following:

- Compliance with regulatory requirements and standards for vibration management;
- Avoid excessive vibration generation through site planning and the adoption of appropriate work methods and practices; and
- Prevent or minimize to the greatest extent, the impact of construction vibration on neighbours and to establish and maintain positive relationships with project stakeholders.

An overview of the project specific information is provided in **Table 1** below.

Table 1. Project Specific Information.

Site Details	
Client Name:	Lendlease
ADE Project Number:	LND-01-Q1299
Site Address:	771 Cudgen Road, Cudgen NSW
Date of Report:	01/07/2021
Development Consent	SSD-10353, Health Administration Corporation. Authorized by the Minister for Planning and Public Spaces on 9 March 2020. Consent approved on 12 June 2020.
Objectives:	▪ Comply with DIN 4150-3:2016 guidelines and conditions C18 - C20 of the SSD-10353 consent; ▪ Manage potential vibration impacts from construction activities which have the potential to affect the nearby buildings (Kingscliff TAFE and residential properties); ▪ To minimise the generation of vibration which could affect the neighbours of the Site, workers on the Site, associated buildings, and other members of the public; and ▪ Establish and maintain good relationships with the neighbours and wider community.
Key Legislation:	Protection of the Environment Operations Act 1997 (NSW) (POEO Act). The POEO Act is a key piece of environmental protection legislation and regulates activities via: ▪ Environmental protection licensing, as per schedule 1; ▪ Regulation of scheduled and non-scheduled activities; ▪ Environmental protection offences and penalties; and ▪ Establishment of a general duty of care to notify environment harm.

1.2 Scope of Work

The scope of work included the following:

- Completion of a Safety, Health & Environment Work Method Statement prior to undertaking any works;
- Real time continuous monitoring of vibrations in three (3) locations along the Southern boundary of the Site; and
- Preparation of a Vibration Monitoring Assessment Report outlining the Site data, conclusions and recommendations.

1.3 Whole Report

No one section or part of a section of this report should be taken as giving an overall idea of this report. Each section must be read in conjunction with the entire report, including its appendices and attachments.

1.4 Previous Report

Refer to the previous report (DLT-01-Q10103 / VIB18 / V1F) for details from earlier monitoring periods.

1.5 Monitoring Locations

Three (3) vibration monitors are located within the Site adjacent Cudgen Road. Monitoring locations were determined by the client (refer to *Appendix I – Aerial Photograph*).

Vibrations were recorded at the above locations during the preparation and construction works of the Tweed Valley Hospital Project.

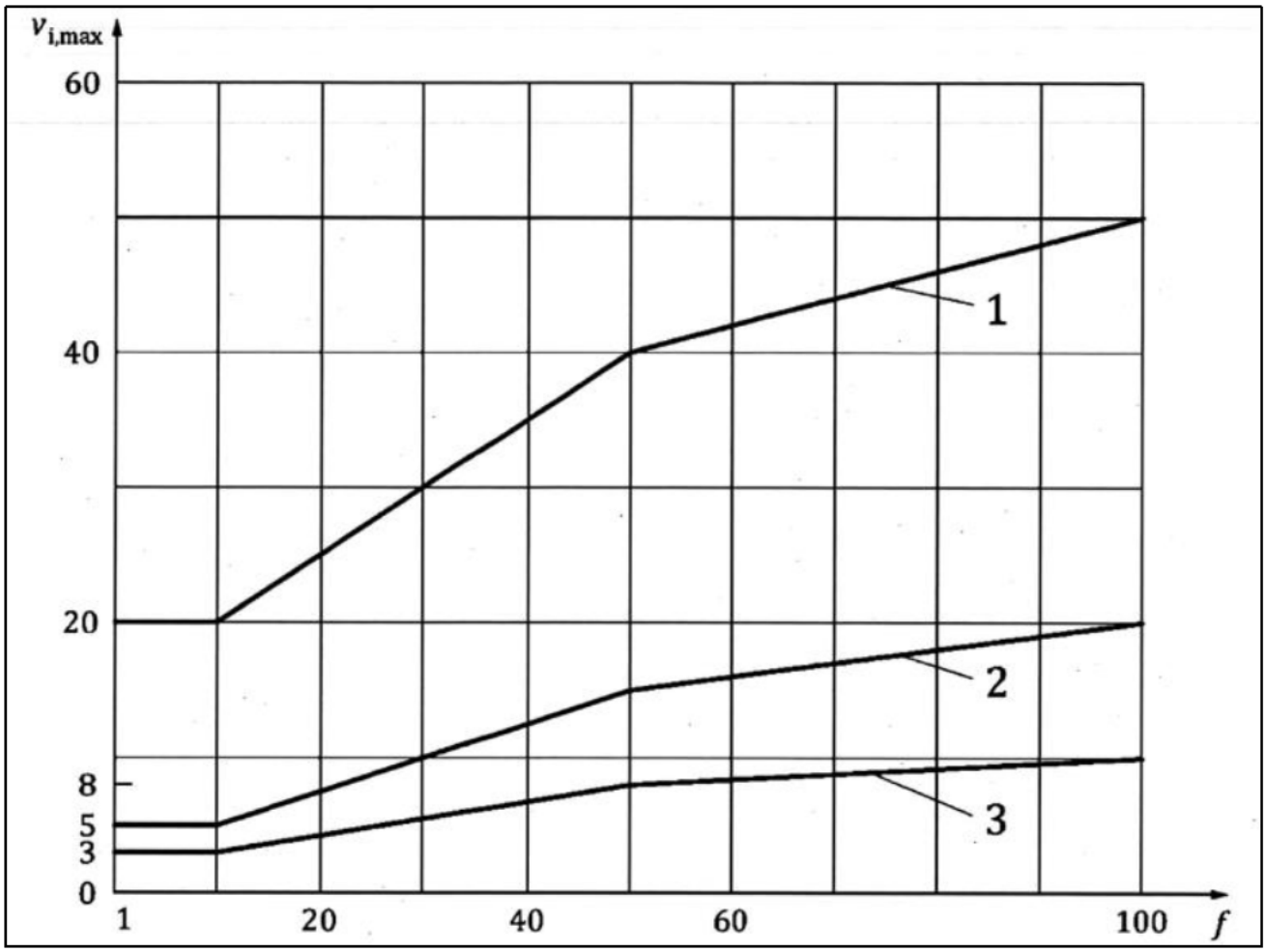
The vibration monitors were operational from 06:45 to 19:00, throughout the month of **February 2021.** However, works were only conducted between 7am and 6pm, Monday – Friday for the month of **February 2021** and only data within this range has been considered.

1.6 Limits for Vibration

The Peak Vibration Velocity (PVV) limits for the duration of work have been adopted from *Vibrations in buildings Part 3: Effects on structures DIN4150-3 February 2016.* Lines 1 and 2 in Table 2 on the following page apply to the surrounding structures of the Tweed Valley Hospital project, including the Kingscliff TAFE and nearby residences. A visual representation of Table 2 is also shown below in Graph 1 on the following page.

Table 2. Guideline Values for Vibration Velocity (Evaluating Effects of Short-Term Vibration on Structures).

Line	Type of Structure	Peak Vibration Velocity, mm/s				
		At foundation at a frequency of			Highest floor, horizontal direction	Floor Slabs, vertical direction
		1 to 10 Hz	10 to 50 Hz	50 to 100 Hz	All Frequencies	All Frequencies
1	**Buildings used for commercial purposes, industrial buildings and buildings of similar design**	**20**	**20 to 40**	**40 to 50**	**40**	**20**
2	**Dwellings and buildings of similar design and/or occupancy**	**5**	**5 to 15**	**15 to 20**	**15**	**20**
3	Structures that, because of their particular sensitivity to vibration, cannot be classified under lines 1 and 2 and are of great intrinsic value (e.g., listed buildings under preservation order)	3	3 to 8	8 to 10	8	20



Graph 1. Graph of lines 1, 2 and 3 as per Table 2.

1.7 Monitoring Frequency

The vibration monitors were operational from 06:45 to 19:00, throughout the month of **February 2021.** Works were only conducted between 7am and 6pm, Monday – Friday for the month of February 2021 and only data within this range has been considered.

1.8 Survey Instrumentation and Methodology

The vibration measurements were recorded using Profound Vibra+ vibration monitors. These vibration monitors are enclosed in a tough case which is placed on the ground and covered with a tarp to aid in keeping temperatures below 60°C, to ensure continuous monitoring. The accelerometer is placed firmly against the soil surface and covered with a sandbag to minimize external interference. The monitors are positioned within the Site along the boundary adjacent Cudgen Road.

2 Results

The results of the **total velocity** in mm/s from the monitoring performed for **February 2021** are summarised in Figures 1 – 3 (Section 2). Works were only conducted between 7am and 6pm, Monday – Friday for the month of **February 2021** and only data within this range should be considered. If the vibration criteria specified in section 1.6 are exceeded additional mitigation measures may be necessary.

On 18 February 2021, the monitor at location 001 went down due to manufacturer fault, ADE attended the site and removed the faulty monitor for replacement. A rental Vibra+ monitor was sourced and installed on 25 February. Due to this, there is a gap in the data recorded at location 001 between 18 February and 25 February.

Data measured at location 001 is presented below in **Figure 1**.

Figure 1 Vibration data at location 001 | Adjacent carpark | 1 February - 28 February 2021

Data measured at location 002 is presented below in **Figure 2.**

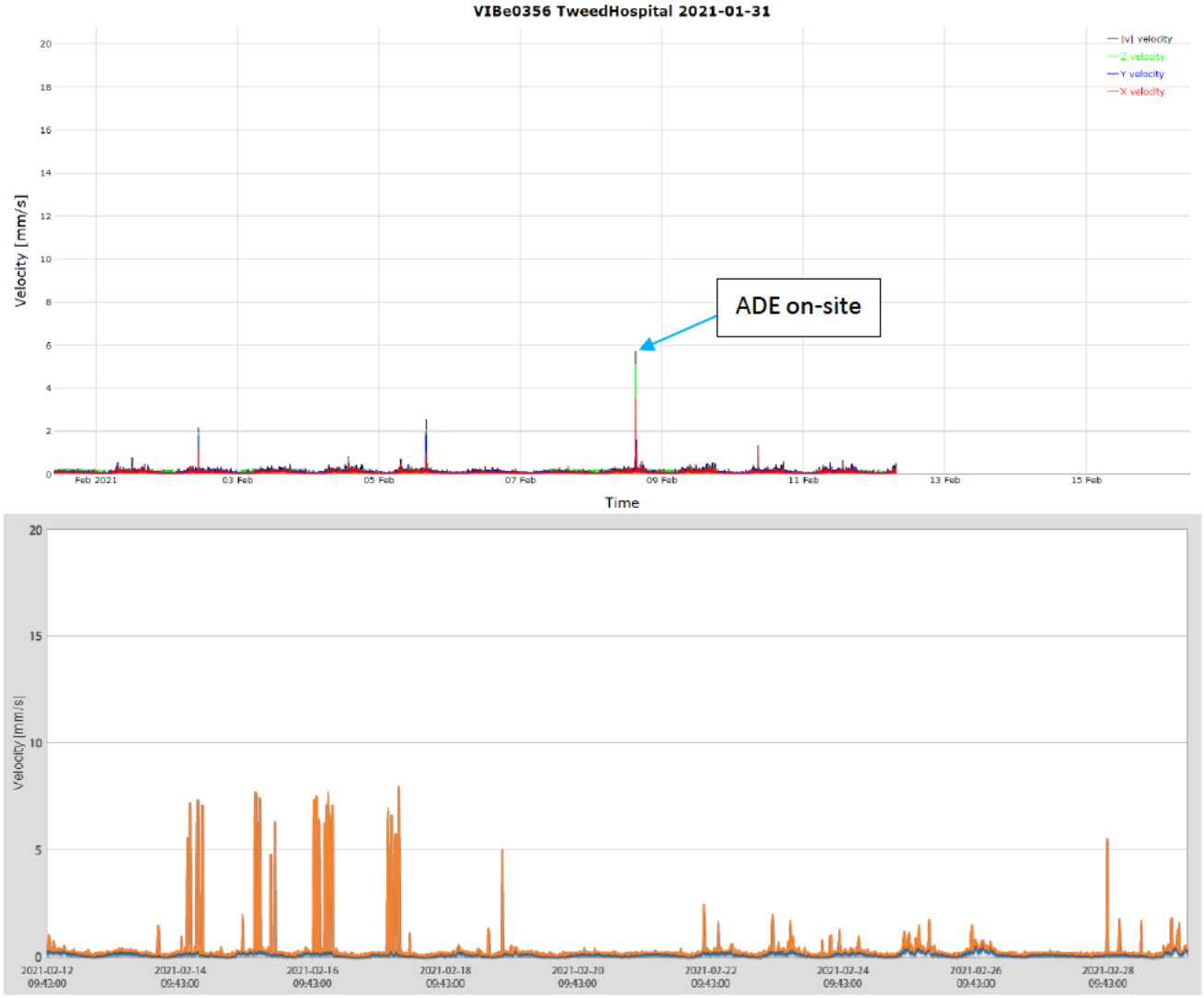


Figure 2 Vibration data at location 002 | Central monitor | 1 February - 28 February 2021

Data measured at location 003 is presented below in **Figure 3.**

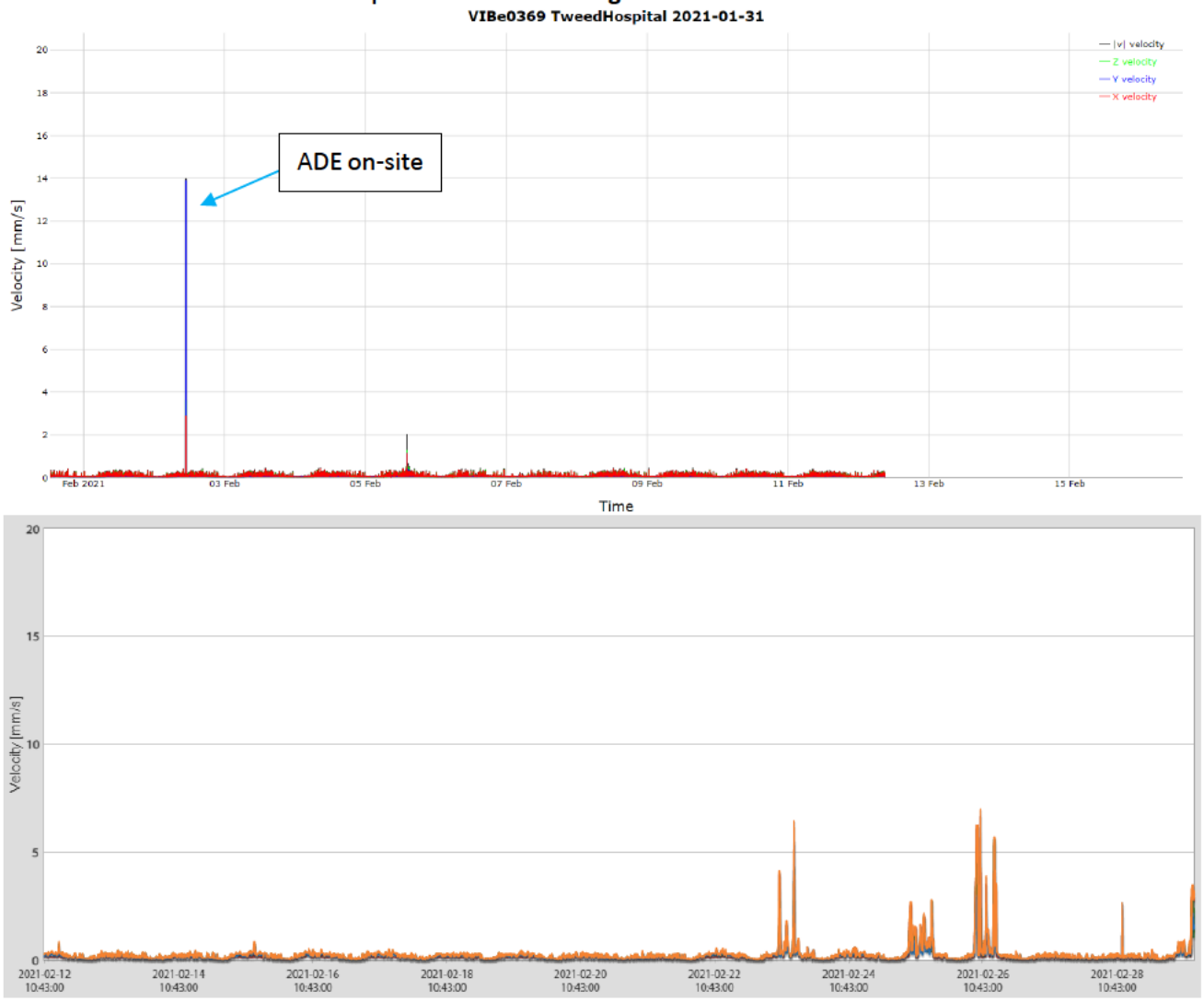


Figure 3 Vibration data at location 003 | Eastern section | 1 February - 28 February 2021

3 Discussion

During the monitoring period (1 February to 28 February 2021) no exceedance of DIN 4150 Line 1 or Line 2 PPV guideline values was observed.

The results presented over Figures 1 - 3 does not include a distance correction.

4 Conclusion

Results from vibration monitoring undertaken during the monitoring period [February 2021] were **below** the threshold used to assess the effects of short-term vibration on structures according to DIN 4150-3 and DIN4150-1. Therefore, the Site works had no impact on any surrounding priorities.

5 References

- Assessing Vibration: A Technical Guideline (February 2006), Department of Environment and Conservation (DEC).
- Construction Noise and Vibration Strategy (April 2019) Published by Transport for New South Wales (TfNSW)
- Development Consent SSD-10353, Department of Planning, Industry and Environment – Tweed Valley Hospital Stage 2 – 12 July 2020 (approval).
- German Standard DIN 4150-1:2001 Structural vibration – Part 1: Predicting vibration parameters
- German Standard DIN 4150-3:2016 Vibrations in buildings – Part 3: Effects on structures
- Tweed Valley Hospital Management Plan – Noise and Vibration, Lendlease Building Pty Ltd, 11 June 2019
- Tweed Valley Hospital – Noise and Vibration Impact Assessment for State Significant
- Development (SSD), SVM-2370, Revision: Issue 2, 17 October 2018 – Acoustic Studio

Appendix I – Aerial Photograph

Aerial photograph of the Tweed Valley Hospital Project at Cudgen, NSW (as of 30 November 2020).

Appendix II – Monitoring Locations

Photograph 1 Representative photograph of monitoring location 001 – Adjacent Carpark location, as observed 22/02/2021

Photograph 2 Representative photograph of monitoring location 002 – Central location, as observed 22/02/2021

Photograph 3 Representative photograph of monitoring location 003 – Eastern Section of Site, as observed 22/02/2021

Appendix III – ADE Site Visit Summary

Date of site visit	Time of site visit
02/02/2021	1015 to 1415
05/02/2021	1340 to 1640
08/02/2021	1445 to 1630
12/02/2021	0700 to 1100
22/02/2021	1200 to 1430
23/02/2021	1000 to 1530
25/02/2021	1400 to 1800

Appendix IV – Vibra Technical Specifications

VIBRA-series:
VIBRA, *VIBRA*+

Profound *VIBRA*-series

Vibrations from pile driving, construction, road or rail traffic, demolition work and blasting can create nuisance or cause damage to buildings and sensitive equipment. These vibrations are accurately quantified with a system of the Profound *VIBRA*-series.

The *VIBRA*'s robust aluminium housing is IP65 watertight. The system is easily portable, lightweight and battery-operated which allows for up to 4 weeks of continuous and unmanned operation.

Depending on the chosen model *VIBRA* or *VIBRA*+, the system complies with national and international standards and is according to DIN 45669-1:2010. The specific characteristics of each model are further outlined in the *VIBRA* features overview.

Setting up the system on site is easy: attach the 3-dimensional sensor to the structure to be monitored, switch on the system and start measuring. While measuring the *VIBRA* displays date, time, time interval and the current peak vibration values including frequency in all 3 directions. In advance an alarm level can be set.

Peak values including dominant frequencies, are directly stored in memory. For full interpretation measurement signals are transferred via USB to a computer for further analysis. The *VIBRA* pc software automatically generates tables and graphs of peak values and signals for use in reports. The data can also be easily exported as a csv-file.

The *VIBRA*+ can be set up for wireless automatic data transfer including sms alerts via the integrated 3G modem. Data can also be continuously uploaded to any FTP server for real-time online monitoring. As an alternative Profound offers a turnkey online monitoring service.

Technical specifications *VIBRA*-series	
Velocity (PPV), frequency and acceleration (PPA)	In x, y, z-direction per time interval
Displacement (*VIBRA*+ only)	In x, y, z-direction per time interval
Sensor type	3-channel geophone
Geophone correction	Digital IR filter
Velocity range	0 – 100 mm/s
Resolution display	0.01 mm/s
Resolution AD-converter	0.001 mm/s (24 bits ADC)
Frequency range and accuracy	DIN 45669-1:2010-09 or SBR – part A, B 2002
Storage capacity	4 MB. Fixed or ring memory incl. buffer
Storage interval	1, 2, 5, 10, 20, 30, 60 s
Data save level	Adjustable between 0.01-100.00 mm/s (or always)
Alarm level	Adjustable between 0.01-100.00 mm/s (or none)
Data retention	10 years (minimum) at 25 °C
Clock stability	Within 5 minutes/year at 25 °C
Temperature range (operating)	- 20 °C to + 60 °C
Housing	Robust hard anodized aluminium case
Protection rating	IP65 according to DIN 40 050/IEC 529
Dimensions (l x w x h)	216 x 160 x 50 mm
Weight	2 kg
Display	≥ 4 Lines; display backlight; anti-reflex coating; anti-scratch
Batteries	3 x 1.5 V Alkaline D-size batteries
Battery life	≈ 28 days (continuous operation)
I/O functionality	Geophone, mini-USB
PC operating system	WIN10/WIN8/WIN7
Accessories	VIB.00320 Cable reel (50m) VIB.00407 Alarm beacon VIB.00420 USB adapter. External power via USB adapter: V_{mains} 100 ↔ 240 V, 47 ↔ 63 Hz

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SOLUTIONS THROUGH INNOVATION

Further details regarding ADE's services are available via

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