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42 NORTH STEYNE, MANLY

Construction Noise and Vibration Management Plan

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IRIS

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Contents

1 Introduction

Renzo Tonin & Associates was engaged to prepare a site specific Construction Noise and Vibration Management Plant (CNVMP) associated with the demolition, excavation and construction phase for proposed alterations/additions to the mixed use development at 75 The Corso and 42 North Steyne Manly

This report has been prepared with reference to construction methods and equipment locations in *Buildability Report* by Xavier Knight dated October 2021.

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001. Appendix A contains a glossary of acoustic terms used in this report.

1.1 Consent conditions / Applicable Standards

This assessment has been conducted prior to development approval. As such, there are no conditions of consent governing construction noise at this stage.

This report has been prepared to address the noise management requirements of the EPA *Interim Construction Noise Guidelines*.

The assessment includes:

- Identification of the site and proposed works the subject of assessment.
- Identification of background noise levels, acoustic criteria and noise/vibration emission goals.
- Identification of the work methods and expected types of equipment. Prediction of construction noise levels and assessment with reference to the EPA guidelines.
- Where necessary, recommendations with respect to noise and vibration mitigation treatments.

1.2 Hours of construction

For the purpose of this assessment as we assume that similar hours would be adopted.

Table 1: Construction Hours

Typical Construction Hours	
Monday to Friday	7:00am to 5:00pm
Saturday	7:090am to 1:00pm

Notes: No work permitted on Sunday and Public Holidays

Any construction work to be carried out outside these hours shall be assessed separately if required.

2 Proposed Works and Nearby Noise Receivers

The subject site is located at 42 North Steyne, Manly.

The site is surrounded by residential and retail/commercial buildings on the north and west, and the Hotel Steyne to the South.

The works allow for the adaptive reuse of the existing buildings, and consists of:

- Demolition of existing facade elements and internal elements, building services and amenities (the Hotel Steyne Café).
- Additional basement excavation.
- Construction of retail/office premises at the ground floor and construction of seven (7) apartments across four building levels from level 1 and above.

See aerial photo below.

Figure 1: Site Surrounds and Noise Monitoring Locations

The nearest noise-sensitive receivers to the proposed development are set out in the table below.

Table 2: Noise Sensitive Receiver Locations

Receiver ID	Address	Description
Residential Receivers		
R1	43-45 North Steyne	3 to 4 storey apartment buildings to North of development
R2	9-15 Central Ave	Pacific Waves – 9 storey residential apartment block West of the development
Commercial Receivers		
C1	43-45 North Steyne	Ground floor commercial adjacent to North
C2	2-8 Sydney Road	Commercial development to South
C3	75 The Corso	Hotel Steyne to the South

2.1 Background noise logging

Long term unattended noise monitoring was undertaken on the roof of 42 North Steyne from 09/02/2021 to 19/02/2021.

The noise logger recorded noise levels on a continuous basis and stored data every fifteen minutes. The noise logger was calibrated before and after measurements and no significant deviation in calibration was noted. The noise monitoring equipment used here complies with Australian Standard 1259.2-1990 "Acoustics - Sound Level Meters" and is designated as Type 1 instruments suitable for field use.

The results of the long-term noise monitoring have been summarised in accordance with Noise Policy for Industry requirements published by Environment Protection Authority's Noise Policy for Industry and are presented in Table 3 below.

Table 3: Measured Site Background Noise Levels

Noise Monitoring		Representative L_{A90} Background Noise Levels in dB(A)		
Location	**Duration**	**Day[1]**	**Evening[2]**	**Night[3]**
L1: 42 North Steyne, Manly	09/02/2021 to 19/02/2021	56	57	54

Notes:

Day, Evening & Night assessment periods are defined in accordance NSW EPA's Noise Policy for Industry as follows.

1. Day is defined as 7:00am to 6:00pm, Monday to Saturday; 8:00am to 6:00pm Sundays & Public Holidays.
2. Evening is defined as 6:00pm to 10:00pm, Monday to Sunday & Public Holidays
3. Night is defined as 10:00pm to 7:00am, Monday to Saturday; 10:00pm to 8:00am Sundays & Public Holidays

3 Applicable Legislation / Guidelines

3.1 EPA Guidelines

The NSW *Interim Construction Noise Guideline* (ICNG, 2009) provides guidelines for assessing noise generated during the construction phase of developments.

The key components of the guideline that are incorporated into this assessment include:

- Use of L_{Aeq} as the descriptor for measuring and assessing construction noise.

  NSW noise policies, including the INP, RNP and RING have moved to the primary use of L_{Aeq} over any other descriptor. As an energy average, L_{Aeq} provides ease of use when measuring or calculating noise levels since a full statistical analysis is not required as when using, for example, the L_{A10} descriptor.

- Application of reasonable and feasible noise mitigation measures
- As stated in the ICNG, a noise mitigation measure is feasible if it is capable of being put into practice, and is practical to build given the project constraints.
- Selecting reasonable mitigation measures from those that are feasible involves making a judgement to determine whether the overall noise benefit outweighs the overall social, economic and environmental effects.

reproduced from the ICNG, sets out the noise management levels and how they are to be applied for residential receivers.

Table 4: Noise management levels at residential receivers

Time of day	Management level $L_{Aeq\ (15\ min)}$ *	How to apply
Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10dB	The noise affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured LAeq (15 min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
	Highly noise affected 75dB(A)	The highly noise affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: • times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences • if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise affected RBL + 5dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5dB(A) above the noise affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see section 7.2.2 *[of the ICNG*.

* Noise levels apply at the property boundary that is most exposed to construction noise, and at a height of 1.5 m above ground level. If the property boundary is more than 30 m from the residence, the location for measuring or predicting noise levels is at the most noise-affected point within 30 m of the residence. Noise levels may be higher at upper floors of the noise affected residence.

Table 5 sets out the ICNG noise management levels for other noise sensitive receiver locations.

Table 5: Noise management levels at other noise sensitive land uses

Land use	Where objective applies	Management level $L_{Aeq\ (15\ min)}$
Commercial premises	External noise level	70 dB(A)

Notes: Noise management levels apply when receiver areas are in use only.

3.2 Construction Noise Goals

The table below presents the construction noise management levels established for the nearest noise sensitive receivers based upon the long-term monitoring (outlined in section 1.4) and the EPA *Interim Construction Noise Guidelines* noise emission goals/management levels.

Table 6: Construction noise management levels at receivers

Receiver ID	Location description	Noise management level $L_{A(Av\ Max)}$[1]	
		Monday to Fridays	Saturdays
		7:00am to 6:00am	8:00am to 1:00pm
R1	43-45 North Steyne	66	66
R2	9-15 Central Ave	66	66
C1	43-45 North Steyne	70	70
C2	2-8 Sydney Road	70	70
C3	75 The Corso	70	70

3.3 Construction vibration

3.3.1 Disturbance to Building Occupants

Assessment of potential disturbance from vibration on human occupants of buildings is made in accordance with the EPA's '*Assessing Vibration; a technical guideline*' (DECC, 2006). The guideline provides criteria which are based on the British Standard BS 6472-1992 'Evaluation of human exposure to vibration in buildings (1-80Hz)'. Sources of vibration are defined as either 'Continuous', 'Impulsive' or 'Intermittent'. Table 6 provides definitions and examples of each type of vibration.

Table 6: Types of Vibration

Type of Vibration	Definition	Examples
Continuous vibration	Continues uninterrupted for a defined period (usually throughout the day-time and/or night-time)	Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).
Impulsive vibration	A rapid build-up to a peak followed by a damped decay that may or may not involve several cycles of vibration (depending on frequency and damping). It can also consist of a sudden application of several cycles at approximately the same amplitude, providing that the duration is short, typically less than 2 seconds	Infrequent: Activities that create up to 3 distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading.
Intermittent vibration	Can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude	Trains, nearby intermittent construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer, this would be assessed against impulsive vibration criteria.

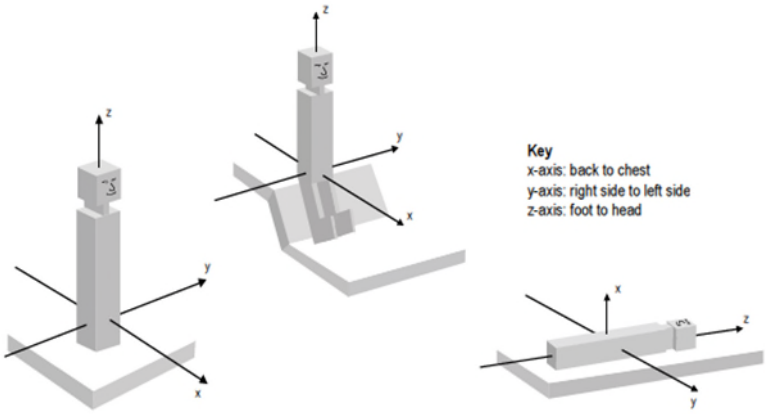
Source: Assessing Vibration; a technical guideline, Department of Environment & Climate Change, 2006

The vibration criteria are defined as a single weighted root mean square (rms) acceleration source level in each orthogonal axis. Section 2.3 of the guideline states:

> *'Evidence from research suggests that there are summation effects for vibrations at different frequencies. Therefore, for evaluation of vibration in relation to annoyance and comfort, overall weighted rms acceleration values of the vibration in each orthogonal axis are preferred (BS 6472).'*

When applying the criteria, it is important to note that the three directional axes are referenced to the human body, i.e. x-axis (back to chest), y-axis (right side to left side) or z-axis (foot to head). Vibration may enter the body along different orthogonal axes and affect it in different ways. Therefore, application of the criteria requires consideration of the position of the people being assessed, as illustrated in Figure 2. For example, vibration measured in the horizontal plane is compared with x- and y-axis criteria if the concern is for people in an upright position, or with the y- and z- axis criteria if the concern is for people in the lateral position.

Figure 2: Orthogonal Axes for Human Exposure to Vibration



The preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and the locations applicable to receivers surrounding the site are reproduced in Table 7 overleaf.

Table 7: Preferred and Maximum Levels for Human Comfort

Location	Assessment period[1]	Preferred values		Maximum values	
		z-axis	x- and y-axis	z-axis	x- and y-axis
Continuous vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
Critical areas[2]	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.010	0.0071	0.020	0.014
	Night-time	0.007	0.005	0.014	0.010
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028
Workshops	Day- or night-time	0.04	0.029	0.080	0.058
Impulsive vibration (weighted RMS acceleration, m/s^2, 1-80Hz)					
Critical areas[2]	Day- or night-time	0.005	0.0036	0.010	0.0072
Residences	Daytime	0.30	0.21	0.60	0.42
	Night-time	0.10	0.071	0.20	0.14
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92
Workshops	Day- or night-time	0.64	0.46	1.28	0.92

Notes:
1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am
2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. There may be cases where sensitive equipment or delicate tasks require more stringent criteria than the human comfort criteria specify above. Stipulation of such criteria is outside the scope of their policy and other guidance documents (e.g. relevant standards) should be referred to. Source: BS 6472-1992

The acceptable vibration dose values (VDV) for intermittent vibration are defined in Table 2.4 of the guideline and the locations applicable to receivers surrounding the site are reproduced in Table 9.

Table 9: Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Daytime[1]		Night-time[1]	
	Preferred value	Maximum value	Preferred value	Maximum value
Critical areas[2]	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes:
1. Daytime is 7:00am to 10:00pm and night-time is 10:00pm to 7:00am
2. Examples include hospital operating theatres and precision laboratories where sensitive operations are occurring. These criteria are only indicative, and there may be a need to assess intermittent values against the continuous of impulsive criteria for critical areas.
Source: BS 6472-1992

3.3.2 Building Damage

Potential structural damage of buildings as a result of vibration is typically managed by ensuring vibration induced into the structure does not exceed certain limits and standards, such as British

Standard 7385 Part 2 and German Standard DIN4150-3. Currently there is no existing Australian Standard for assessment of structural building damage caused by vibration energy.

Within British Standard 7385 Part 1: 1990, different levels of structural damage are defined:

- **Cosmetic** - *The formation of hairline cracks on drywall surfaces, or the growth of existing cracks in plaster or drywall surfaces; in addition, the formation of hairline cracks in mortar joints of brick/concrete block construction.*
- **Minor** - *The formation of large cracks or loosening of plaster or drywall surfaces, or cracks through bricks/concrete blocks.*
- **Major** - *Damage to structural elements of the building, cracks in supporting columns, loosening of joints, splaying of masonry cracks, etc.*

The vibration limits in Table 1 of British Standard 7385 Part 2 (1993) are for the protection against cosmetic damage, however guidance on limits for minor and major damage is provided in Section 7.4.2 of the Standard:

> *"7.4.2 Guide values for transient vibration relating to cosmetic damage*
>
> *Limits for transient vibration, above which cosmetic damage could occur are given numerically in Table 1 and graphically in Figure 1. In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for the building types corresponding to line 2 are reduced. Below a frequency of 4 Hz, where a high displacement is associated with a relatively low peak component particle velocity value a maximum displacement of 0.6 mm (zero to peak) should be used.*
>
> *Minor damage is possible at vibration magnitudes which are greater than twice those given in Table 1, and major damage to a building structure may occur at values greater than four times the tabulated values."*

Within DIN4150-3, damage is defined as "*any permanent effect of vibration that reduces the serviceability of a structure or one of its components*" (p.2). The Standard also outlines:

> *"that for structures as in lines 2 and 3 of Table 1, the serviceability is considered to have been reduced if*
>
> - *cracks form in plastered surfaces of walls;*
> - *existing cracks in the building are enlarged;*
> - *partitions become detached from loadbearing walls or floors.*
>
> *These effects are deemed 'minor damage." (DIN4150.3, 1990, p.3)*

While the DIN Standard defines the above damage as 'minor', based on the definitions provided in BS7385, the DIN standard is considered to deal with cosmetic issues rather than major structural failures.

British Standard

British Standard 7385: Part 2 'Evaluation and measurement of vibration in buildings', can be used as a guide to assess the likelihood of building damage from ground vibration. BS7385 suggests levels at which 'cosmetic', 'minor' and 'major' categories of damage might occur.

The cosmetic damage levels set by BS 7385 are considered 'safe limits' up to which no damage due to vibration effects has been observed for certain particular building types. Damage comprises minor non-structural effects such as hairline cracks on drywall surfaces, hairline cracks in mortar joints and cement render, enlargement of existing cracks and separation of partitions or intermediate walls from load bearing walls. 'Minor' damage is considered possible at vibration magnitudes which are twice those given and 'major' damage to a building structure may occur at levels greater than four times those values.

BS7385 is based on peak particle velocity and specifies damage criteria for frequencies within the range 4Hz to 250Hz, being the range usually encountered in buildings. At frequencies below 4Hz, a maximum displacement value is recommended. The values set in the Standard relate to transient vibrations and to low-rise buildings. Continuous vibration can give rise to dynamic magnifications due to resonances and may need to be reduced by up to 50%. sets out the BS7385 criteria for cosmetic, minor and major damage.

Regarding heritage buildings, British Standard 7385 Part 2 (1993) notes that "*a building of historical value should not (unless it is structurally unsound) be assumed to be more sensitive*" (p.5).

To determine whether the site buildings are structurally unsound, we recommend a dilapidation survey be conducted. The results of the survey will determine the adoption of the criteria for major or minor damage, rather than cosmetic damage.

Table 8: BS 7385 Structural Damage Criteria

Group	Type of Structure	Damage Level	Peak Component Particle Velocity[1], mm/s		
			4Hz to 15Hz	15Hz to 40Hz	40Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	Cosmetic		50	
		Minor[2]		100	
		Major[2]		200	
2	Un-reinforced or light framed structures Residential or light commercial type buildings	Cosmetic	15 to 20	20 to 50	50
		Minor[2]	30 to 40	40 to 100	100
		Major[2]	60 to 80	80 to 200	200

Notes:
1. Peak Component Particle Velocity is the maximum peak particle velocity (PPV) in any one direction (x, y, z) as measured by a tri-axial vibration transducer
2. Minor and major damage criteria established based on British Standard 7385 Part 2 (1993) Section 7.4.2

German Standard

German Standard DIN 4150 - Part 3 'Structural vibration in buildings - Effects on Structure' (DIN 4150-3), also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration and are generally recognised to be conservative.

DIN 4150-3 presents the recommended maximum limits over a range of frequencies (Hz), measured in any direction, and at the foundation or in the plane of the uppermost floor of a building or structure. The vibration limits increase as the frequency content of the vibration increases.

The structural damage vibration criteria adopted for this project is presented in Table 9: .

Table 9: DIN 4150-3 Structural Damage Criteria

Group	Type of Structure	Vibration Velocity, mm/s			
		At Foundation at Frequency of			Plane of Floor Uppermost Storey
		1Hz to 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Group 1 or 2 and have intrinsic value (eg buildings under a preservation order)	3	3 to 8	8 to 10	8

4 Construction Noise Assessment

4.1 Proposed works

The DA seeks consent for partial demolition of structures, and the construction of a new mixed use development. The proposed development includes a basement car park, mixed use ground floor and four levels of residential apartments above. Retention of some existing structure on the site is proposed.

Indicative list of work items is set out below.

Table 10: Indicative list of work items

Stage	Description
Stage 1 - Demolition and Excavation/Ground Retention	
Demolition	Demolition of Café Hotel Steyne Building, inclusive of load bearing walls and ground floor slab.
Excavation	Additional excavation of basement (sand excavation) at basement level 1.
Ground retention	Geocast retaining wall, micro-piles.
Stage 2 – Construction of Structure	
Construction	Form-working – powered hand tools around site perimeter. Concrete Pours – concrete truck, vibrators, mobile crane. Façade/External Works – powered hand tools, mobile crane. Internal Works

4.2 Proposed construction noise sources

The schedule of items of plant and equipment likely to be used during the demolition, excavation and construction of the proposed development is presented in the table below.

Table 11: Typical construction equipment & sound power levels, dB(A) re 1pW

Plant item	Plant description	Sound power levels
Phase 1 – Demolition, Excavation and Piling		
1.	Concrete/rock saws	120*
2.	Excavator with Hydraulic Hammer	120*
3.	Excavator with bucket	108
4.	Truck and dog/tipper	105
5.	Bobcat	100
6.	Piling (Bored)	105
Phase 2 and 3 – Construction		
7.	Delivery Trucks	105
8.	Powered Hand tools	105
11.	Concrete Pump	105
12.	Tower Crane (Mobile/Electric)	105

*Inclusive of 5dB(A) penalty for tonality/impulsiveness.

The sound power levels for the majority of construction plant and equipment presented in the above table are based on maximum noise levels given in Table A1 of Australian Standard 2436 - 2010 'Guide to Noise Control on Construction, Demolition and Maintenance Sites', the Interim Construction Noise Guideline (ICNG), information from past projects and/or information held in our library files.

4.3 Predicted Noise Levels

Noise levels at any receiver location resulting from construction works would depend on the location of the receiver with respect to the area of construction, shielding from intervening topography and structures, and the type and duration of construction being undertaken.

The table below presents noise levels likely to be experienced at the nearby affected receivers based on the construction activities and plant and equipment associated with the proposed site.

For receivers R1, C1 and C3, which adjoin the site but does not have windows directly facing the site, predicted noise levels are made at the nearest windows.

Predicted noise levels and assessment with reference to noise emission criteria is presented overleaf.

Table 12: Predicted $L_{A(Av\ Mx))}$ noise levels for typical construction plant, dB(A)

Plant Item	Plant Description	Predicted $L_{A\ av\ max}$ Construction Noise Levels				
		R1	R2	C1	C2	C3
Noise Criteria	*Mon-Fri – 7:00am to 8:00am*	*66*	*66*	*70*	*70*	*70*
	Mon-Fri – 8:00am to 7:00pm	*66*	*66*	*70*	*70*	*70*
	Sat – 7:00am to 8:00am	*66*	*66*	*70*	*70*	*70*
	Sat – 8:00am to 1:00pm	*66*	*66*	*70*	*70*	*70*
Phase 1 – Demolition, Excavation and Piling						
1	Concrete/rock saws	70-85	65-75	70-85	65-75	70-85
2	Demolition using Hydraulic Hammer	70-85	65-75	70-85	65-75	70-85
3	Bulk excavation (Excavator with bucket)	65-75	60-70	65-75	60-70	65-75
4	Truck and dog/tipper	60-70	50-60	60-70	50-60	60-70
5	Bobcat	55-70	50-60	55-70	50-60	55-70
6	Piling (Bored)	60-75	55-65	60-75	55-65	60-75
Cumulative Noise Level						
Phases 2 and 3 – Construction						
7	Delivery Trucks	60-70	60-70	60-70	60-70	60-70
8	Powered Hand tools	50-73	65-75	50-73	65-75	50-73
11	Concrete Pump	67	73	67	73	67
12.	Crane (Electric)	65	70	65	70	65
Cumulative Noise Level						

In light of the predicted noise levels above, it is recommended that a feasible and reasonable approach towards noise mitigation measures be applied to reduce noise levels as much as possible to mitigate the impact from construction noise.

Further details on construction noise mitigation and management measures are provided in Section 4.4 overleaf.

4.4 Construction noise mitigation measures

Given the proximity of the site to nearby land users (including residential development), noise and vibration mitigation/management is required.

Noise and vibration mitigation is presented below, both general (section 4.4.1) and the site specific (section 4.4.2).

4.4.1 General engineering noise controls

The following section outlines typical noise mitigation options. Their site specific application is set out in section 3.4.2.

Implementation of noise control measures, such as those suggested in Australian Standard 2436-2010 'Guide to Noise Control on Construction, Demolition and Maintenance Sites', are expected to reduce predicted construction noise levels.

Reference to Australian Standard 2436-2010, Appendix C, Table C1 suggests possible remedies and alternatives to reduce noise emission levels from typical construction equipment. Table C2 in Appendix C presents typical examples of noise reductions achievable after treatment of various noise sources. Table C3 in Appendix C presents the relative effectiveness of various forms of noise control treatment.

Table 13: below presents noise control methods, practical examples and expected noise reductions according to AS2436 and according to Renzo Tonin & Associates' opinion based on experience with past projects.

Table 13: Relative effectiveness of various forms of noise control

Noise control method	Practical examples	Typical noise reduction possible in practice, dB(A)		Maximum noise reduction possible in practice, dB(A)	
		AS 2436	Renzo Tonin & Assoc.	AS 2436	Renzo Tonin & Assoc.
Distance	Doubling of distance between source and receiver	6	6	6	6
Screening	Acoustic barriers such as temporary or permanent noise barriers where barrier breaks line-of-sight between the source and receiver	5 to 10	5 to 10	15	15
Acoustic Enclosures	Engine casing lagged with acoustic insulation and plywood	15 to 25	10 to 20	50	30
Engine Silencing	Residential class mufflers	5 to 10	5 to 10	20	20
Substitution by alternative process	Use electric motors in preference to diesel or petrol	-	15 to 25	-	40

The Renzo Tonin & Associates' listed noise reductions are conservatively low and should be referred to in preference to those of AS2436.

Table 14: below identifies possible noise control measures, which are applicable on the construction plant likely to be used on site.

Table 14: Possible noise control measures for likely construction plant

Plant Description	Screening	Acoustic enclosures	Silencing	Alternative process
Tracked excavator	✔	✖	✔	✖
Machine mounted hydraulic drill	✔	✖	✔	✖
Concrete truck	✔	✖	✔	✖
Delivery trucks	✔	✖	✔	✖
Electric crane	✔	✔	✖	✖
Hand tools	✔	✖	✔	✖

These measures (and their effectiveness) are taken into account when developing site specific management controls, identified below.

4.4.2 Noise Management Measures

A significant project initiative to minimise construction related noise, vibration and other disruption from the proposed redevelopment is the retention and adaptive reuse of the majority of the existing concrete structure of 42 North Steyne as part of the proposed redevelopment scheme leading to:

- A reduction in overall required demolition of the existing concrete structure and subsequent construction of new replacement structure.
- A reduction in construction traffic and construction traffic noise and disruption within Henrietta lane to and from the project during the construction phase resulting in circa 100 concrete truck deliveries and circa 20 steel reinforcement deliveries being eliminated from the construction schedule
- An estimated 2-3 month reduction in the overall construction program (and commensurate reduction in construction noise, vibration, traffic impacts etc within Henrietta Lane)

The following recommendations provide feasible and reasonable noise control solutions to reduce noise impacts to sensitive receivers.

4.4.2.1 General Management Measures/Good Practice

The following general noise management measures are recommended for all receiver locations:

- Construction related Plant and equipment must be properly maintained.
- Avoid any unnecessary noise when carrying out manual operations and when operating construction related plant. Construction related Plant used intermittently to be throttled down or shut down when not in use where practicable.

- Any construction related equipment not in use for extended periods during construction work should be switched off.
- The offset distance between stationary noisy construction plant and adjacent sensitive receivers should be maximised where practicable (eg – unloading material deliveries, concrete pumping station).
- In addition to the noise mitigation measures outlined above, a management procedure will be implemented to deal with noise complaints that may arise from construction related activities. Complaints will be investigated and appropriate noise amelioration measures put in place to mitigate future occurrences, where the noise in question is in excess of allowable limits.
- Engagement with stakeholders living and working in the vicinity of the construction site should be established at the beginning of a project and be maintained throughout the project. Keeping neighbouring stakeholders informed of progress and addressing complaints with them expeditiously is important. The person selected to liaise with the community should be adequately trained and experienced in such matters.
- All employees, contractors and subcontractors are to receive site induction and toolbox talks and ongoing training so that the proposed noise management measures can be implemented accordingly. Content within toolboxes will include, location of nearest sensitive receivers; relevant project specific and standard noise and vibration mitigation measures; permissible hours of work, truck route and truck loading restrictions and construction employee parking areas.

4.4.2.2 Site Specific Recommendations

Other potential management/mitigation measures include:

- Notification and Consultation:
    - Construction Contractor should notify neighbouring stakeholders (including North Steyne, 9-15 Central Ave) by letter box drop and/or notification to building manager of estimated duration of critical work items (demolition, bulk excavation, ground retention and erection of structure).
    - Concrete pump truck is proposed to be located on Henrietta Lane. Building management of the west facing residents at 45 North Steyne and 9-15 Central Ave building management should be notified of days of proposed concrete pours.
    - Any notification should provide details of the site contact to enable ongoing communication – refer to section 5.
- Equipment selection:
    - For both the demolition and excavation stages, a hierarchy of equipment usage (from least noise/vibration intensive to most) must be investigated and adopted:

    - For demolition - use of excavator with bucket used preferentially to pulveriser, used preferentially to excavator with hydraulic hammer other excavation/demolition items.
    - For excavation, use excavator with bucket noting that rock rippers, and excavators with hydraulic hammers are unlikely required because the buildings are typically founded on sand.

- Demolition Stage:
    - To the extent feasible, internal demolition work to be conducted prior to demolition of external elements (to maximise the period of time where the building shell provides noise shielding to adjacent development).
    - To minimise structure borne noise and vibration impacts on 45 North Steyne and on the existing Hotel building:
        - Ensure any wall or slab that is proposed to be demolished is separated from structure to be retained prior to demolition. If feasible, this should be done using rotary equipment (concrete saw) where practicable as opposed to percussive equipment (hydraulic hammers).
        - Where feasible, use of excavator with bucket and/or concrete pulveriser as opposed to hydraulic hammer is recommended to reduce both airborne noise and vibration generation. Note – this is not always feasible, depending on the size of the concrete slab element being demolished.
- Excavation/Ground Retention Stage:
    - The development is founded over deep sands as described in the geotechnical report prepared by Foundation Earth Services (October 20221). While unlikely required, the use of hydraulic hammer for bulk excavation should be minimised where practicable. Where feasible, excavation using excavator with bucket attachment and should be used preferentially to using hydraulic hammers.
    - If a hydraulic hammer will be required, use rock saw to create a cut around the perimeter of the zone to be excavated (saw cut as deep as possible, limited by blade size. Progressively repeat saw cut as excavation progresses.
    - If ground retention is required - Bored/rotary piles to be adopted where practicable as opposed to vibrated/sheet piling if feasible.
- Construction Stage:
    - We note that the final cranage approach will be finalised at the construction certificate phase. If a small tower crane is to be utilised, consideration should be given to making such a crane electric.
    - If feasible, locate the temporary concrete pumping equipment in the existing loading dock of 42 North Steyne (avoid locating on public roadway).

- Respite periods:
    - Respite periods to be developed and implemented in consultation with relevant neighbouring stakeholders where required.
    - Where relevant, any respite period should be scheduled to provide benefit of various landuses groups. This could potentially involve inter-day day respite period (say 11.30am to 12.30pm), to benefit both residential and commercial noise receivers.
    - In the event of complaint, the procedure outlined in Appendix D should be followed.

4.4.3 Noise Monitoring

The need for noise monitoring should be determined through communication with effected stakeholders. Communication with 45 North Steyn and 9-15 Central Ave should be undertaken from commencement of demolition works.

Noise monitoring can be carried out to further examine specific noise impacts where relevant. Reasonable and feasible noise reduction measures can be investigated, where necessary. Typically short term (attended) noise monitoring (as opposed to ongoing monitoring using noise logger) would be undertaken to investigate a complaint as opposed to ongoing noise logging as this will enable a faster response time.

Details of the procedures for noise monitoring are presented in APPENDIX B.

5 Construction vibration assessment

The vibration generated from construction works will vary depending on the level and type of activity carried out at each site during each activity.

Potential vibration generated at receivers for this project will be dependent on separation distances, the intervening soil and rock strata, dominant frequencies of vibration and the receiver building's construction and structure. The recommended minimum working distances for vibration intensive plant are presented in Table 15: .

Table 15: Recommended minimum working distances for vibration intensive equipment

Plant item	Minimum working distance, m			
	Cosmetic damage			Human disturbance
	Commercial and industrial buildings[1]	Dwellings and similar structures[1]	Sensitive structures (e.g. heritage)[1]	Residences Day[2]
Pneumatic Hammer	5-10	5	5	10

Notes: 1. Criteria referenced from DIN 4150 Structural Damage - Safe Limits for Short-term Building Vibration.
2. Daytime is 7 am to 10 pm;

Site specific buffer distances for vibration significant plant items must be measured on site where plant and equipment is likely to operate close to or within the minimum working distances for cosmetic damage.

Unlike noise, vibration cannot be 'predicted' due to many variables from site to site, for example soil type and conditions; sub surface rock; building types and foundations; and actual plant on site. The data relied upon in this assessment (tabulated above) is taken from a database of vibration levels measured at various sites or obtained from other sources (eg. BS5228-2:2009). They are not specific to this project as final vibration levels are dependent on many factors including the actual plant used, its operation and the intervening geology between the activity and the receiver.

5.1 Potential vibration impacts and Vibration Monitoring

Based on the proposed plant items presented, vibration generated by construction plant was estimated and potential vibration impacts are summarised in Table 16: below. The assessment is relevant to the identified structures in the project area.

Table 16: Potential Vibration for nearest sensitive receivers – Demolition using Hydraulic Hammer

Receiver Location	Approx. Distance to Nearest Buildings from Works	Type of Nearest Sensitive Buildings	Assessment on Potential Vibration Impacts		
			Structural Damage Risk	Human Disturbance	Vibration Monitoring
Hotel Steyne	<5m	Heritage Elements to be retained.	Medium to high risk of cosmetic/structural damage from construction works	Low/medium risk if Hotel guest rooms are occupied during construction.	Vibration monitoring to be conducted from commencement of demolition works.
45 North Steyne	<5m	Residential	Medium risk of cosmetic/structural damage from percussive construction works	Medium risk of adverse comment as a result of construction works	Vibration monitoring to be conducted from commencement of demolition works.
9-15 Central Ave	10m	Residential	Low risk of cosmetic/structural damage from percussive construction works	Medium risk of adverse comment as a result of construction works	Vibration monitoring conducted in the event of sustained complaint relating to vibration.

Table 17: Potential Vibration for nearest sensitive receivers – Bulk Excavation Using Bucket

Receiver Location	Approx. Distance to Nearest Buildings from Works	Type of Nearest Sensitive Buildings	Assessment on Potential Vibration Impacts		
			Structural Damage Risk	Human Disturbance	Vibration Monitoring
Hotel Steyne	<5m	Heritage Elements to be retained.	Low risk of cosmetic/structural damage from construction works	Low risk if Hotel guest rooms are occupied during construction.	Vibration monitoring conducted in the event of sustained complaint relating to vibration.
45 North Steyne	<5m	Residential	Low risk of cosmetic/structural damage from construction works	Low risk if Hotel guest rooms are occupied during construction.	Vibration monitoring conducted in the event of sustained complaint relating to vibration.
9-15 Central Ave	10m	Residential	Low risk of cosmetic/structural damage from construction works	Low risk if Hotel guest rooms are occupied during construction.	Vibration monitoring conducted in the event of sustained complaint relating to vibration.

Plant and equipment vibration measurement procedure is further detailed in APPENDIX C.

Recommendations for reducing potential vibration impacts are provided in the sections below.

5.2 Vibration Mitigation Measures and Management

The following vibration mitigation measures are recommended to minimise vibration impact from construction activities to the nearest affected receivers:

1. A management procedure must be implemented to deal with vibration complaints. Each complaint must be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures must be put in place to mitigate future occurrences.

2. Where vibration is found to be excessive, management measures must be implemented to ensure vibration compliance is achieved. Management measures may include modification of construction methods such as using smaller equipment when working near property boundaries (if feasible) and if necessary, time restrictions for the most excessive vibration activities. Time restrictions may be negotiated with affected receivers.

3. Dilapidation surveys must be conducted at all receivers neighbouring the construction site (Hotel, 45 North Steyne at a minimum).

4. Notification by letterbox drop and communication with building manager would be carried out for all buildings in the vicinity of the construction site (R2, R3, and R4 at a minimum).

5. Vibration Monitoring and Monitoring Triggers:

    - Attended vibration measurement are to be conducted as detailed below (paragraphs 6 and 7).

    - Long term vibration monitoring (during demolition and excavation periods) is also recommended. This is to be commenced prior to the commencement of demolition works. Monitoring locations to include as a minimum:

        - Steyne Hotel (heritage elements)

        - 45 North Steyne.

    - Indicatively, monitors to be located at lowest suspended slab level of the two locations outlined above (as close as possible to the work site). This is typically where the highest level of construction vibration will occur. An additional logger is potentially required at theupper level within the Steyne in the event that there is vibration increase in upper levels in the building.

    - Monitors to have SMS warning triggers to enable building contractor to be notified immediately in the event that vibration limits are reached.

    - Triggers are to be determined based on DIN4150-3, as detailed below (unless structural or geotechnical engineer advises of difference triggers):

        - Heritage elements – DIN4150-3 Curve 3.

        - Other Elements – DIN4150-3 Curve 2.

6. With respect to the heritage elements of the Steyne Hotel and impact on 45 North Steyne:

    - On site testing (using vibration logger) to be conducted at the commencement of works in order to determine safe working distances for excavators and hydraulic hammers. In the event that exceedance of Building Damage acoustic criteria are expected at the required work locations, changes in work method will need to be considered.

    - This will typically involve use of a rock/concrete saw to cut away concrete slab around the perimeter of area to be demolished/excavated.

    - In the event that this does not produce the required vibration reduction, a series of additional saw cuts would typically be made into the material to be excavated (a 90 degrees to the cut around the perimeter). This will effectively divide the rock into blocks which can then typically be removed using the hydraulic hammer but with less vibration generated.

6 Complaints Management and Community Consultation

Noise and vibration levels generated by construction activities associated with the construction of the development must aim to comply with the noise and vibration goals set by the relevant regulations and guidelines.

The contractor is responsible for implementing this Construction Noise and Vibration Management Plan and ensuring that all reasonable measures are implemented such as the provision of a Noise and Vibration Complaints Program, to minimise the generation of excessive noise and/or vibration levels from the site to nearby sensitive areas.

Owners and occupants of nearby affected properties are to be informed by direct mail of a direct telephone line and contact person where any noise and/or vibration complaints related to the operation of the construction activities are to be reported.

All noise and/or complaints shall be investigated in accordance with the Noise / Vibration Complaint Management Procedure identified in APPENDIX D of this report.

7 Conclusion

This Construction Noise and Vibration Management Plan has been prepared by Renzo Tonin & Associates for the proposed development at the 42 North Steyne, Manly.

Noise and vibration impacts have been assessed with reference to relevant EPA guidelines.

The expected construction noise levels have been predicted and presented in Section 4.3. Noise mitigation and management measures have been presented in Section 4.4 to aid in providing additional noise reduction benefits where exceedance of the objective occurs.

Vibration impacts and management measures have been presented in Section 5 to aid in minimising any potential vibration impacts.

APPENDIX A Glossary of terminology

The following is a brief description of the technical terms used to describe noise to assist in understanding the technical issues presented.

Adverse weather	Weather effects that enhance noise (that is, wind and temperature inversions) that occur at a site for a significant period of time (that is, wind occurring more than 30% of the time in any assessment period in any season and/or temperature inversions occurring more than 30% of the nights in winter).
Ambient noise	The all-encompassing noise associated within a given environment at a given time, usually composed of sound from all sources near and far.
Assessment period	The period in a day over which assessments are made.
Assessment point	A point at which noise measurements are taken or estimated. A point at which noise measurements are taken or estimated.
Background noise	Background noise is the term used to describe the underlying level of noise present in the ambient noise, measured in the absence of the noise under investigation, when extraneous noise is removed. It is described as the average of the minimum noise levels measured on a sound level meter and is measured statistically as the A-weighted noise level exceeded for ninety percent of a sample period. This is represented as the L90 noise level (see below).
Decibel [dB]	The units that sound is measured in. The following are examples of the decibel readings of every day sounds: 0dB The faintest sound we can hear 30dB A quiet library or in a quiet location in the country 45dB Typical office space. Ambience in the city at night 60dB CBD mall at lunch time 70dB The sound of a car passing on the street 80dB Loud music played at home 90dB The sound of a truck passing on the street 100dB The sound of a rock band 115dB Limit of sound permitted in industry 120dB Deafening
dB(A)	A-weighted decibels. The A- weighting noise filter simulates the response of the human ear at relatively low levels, where the ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter.
dB(C)	C-weighted decibels. The C-weighting noise filter simulates the response of the human ear at relatively high levels, where the human ear is nearly equally effective at hearing from mid-low frequency (63Hz) to mid-high frequency (4kHz), but is less effective outside these frequencies.
Frequency	Frequency is synonymous to pitch. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Impulsive noise	Having a high peak of short duration or a sequence of such peaks. A sequence of impulses in rapid succession is termed repetitive impulsive noise.
Intermittent noise	The level suddenly drops to that of the background noise several times during the period of observation. The time during which the noise remains at levels different from that of the ambient is one second or more.
L_{Max}	The maximum sound pressure level measured over a given period.
L_{Min}	The minimum sound pressure level measured over a given period.

L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L90 noise level expressed in units of dB(A).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Reflection	Sound wave changed in direction of propagation due to a solid object obscuring its path.
SEL	Sound Exposure Level (SEL) is the constant sound level which, if maintained for a period of 1 second would have the same acoustic energy as the measured noise event. SEL noise measurements are useful as they can be converted to obtain Leq sound levels over any period of time and can be used for predicting noise at various locations.
Sound	A fluctuation of air pressure which is propagated as a wave through air.
Sound absorption	The ability of a material to absorb sound energy through its conversion into thermal energy.
Sound level meter	An instrument consisting of a microphone, amplifier and indicating device, having a declared performance and designed to measure sound pressure levels.
Sound pressure level	The level of noise, usually expressed in decibels, as measured by a standard sound level meter with a microphone.
Sound power level	Ten times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power.
Tonal noise	Containing a prominent frequency and characterised by a definite pitch.

APPENDIX B Specification for Construction Noise Monitoring

B.1 Scope

This document specifies methods for undertaking noise monitoring during the construction phase of the project.

B.2 Referenced Standards and Guidelines

- Australian Standard AS IEC 61672.1 2004 '*Electroacoustics - Sound Level Meters - Specifications*'
- Australian Standard AS 1259.2-1990 '*Acoustics - Sound Level Meters*'
- Australian Standard AS 1055-1997 '*Acoustics - Description and Measurement of Environmental Noise*'
- NSW '*Interim Construction Noise Guideline*' (Department of Environment and Climate Change 2009)
- NSW '*Industrial Noise Policy*' (Environment Protection Authority 2000)

B.3 Testing Procedures

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking acoustic measurements.

All noise monitoring equipment used must be at least Type 2 instruments as described in AS 1259.2-1990 and calibrated to standards that are traceable to Australian Physical Standards held by the National Measurement Laboratory (CSIRO Division of Applied Physics). The calibration of the monitoring equipment shall also be checked in the field before and after the noise measurement period, and in the case of long-term noise monitoring, calibration levels shall be checked at minimum weekly intervals.

Long-term noise monitoring equipment or Noise Loggers, consist of sound level meters housed in weather resistant enclosures. The operator may retrieve the data at the conclusion of each monitoring period in person or remotely if the logger is fitted with mobile communications.

All environmental noise measurements shall be taken with the following meter settings:

- Time constant: FAST (ie 125 milliseconds)
- Frequency weightings: A-weighting
- Sample period: 15 minutes

All outdoor noise measurements shall be undertaken with a windscreen over the microphone. Windscreens reduce wind noise at the microphones.

Measurements of noise should be disregarded when it is raining and/or the wind speed is greater than 5m/s (18km/h).

B.4 Long-Term (Unattended) Noise Monitoring

Noise monitoring shall be undertaken in accordance with the environmental noise measurement requirements stipulated in the reference standards and documents listed above.

Noise monitoring equipment shall be placed at positions which have unobstructed views of general site activities, while acoustically shielded as much as possible from non-construction site noise (eg. road traffic, rail noise and other surrounding noise).

Noise levels are to be recorded at a minimum rate of 10 samples per second. Every 15 minutes, the data is to be processed statistically and stored in memory. The minimum range of noise metrics to be stored in memory for later retrieval is the following A-weighted noise levels: L_{min}, L_{90}, L_{eq}, L_{10}, L_1 and L_{max}.

Where the noise monitors are placed within 3.5 metres of building facades, walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures. Presence of impulsive and tonal noise, and subsequent penalty, is to be determined in accordance with the provisions of Table 4.1 Modifying Factor Corrections of INP. Attended measurements may be required to determine modifying factor corrections in the first instance.

Meteorological conditions including wind velocity, wind direction and rainfall shall be monitored over the entire noise monitoring period, either on site or recorded from the nearest weather station to the project site.

B.5 Short-Term (Attended) Monitoring

Where noise complaints or requests from relevant authorities are received, attended short-term noise monitoring shall also be conducted at the requested location and at any other relevant noise receiver location with closest proximity to the construction activities.

Short-term noise monitoring shall be used to supplement long-term noise monitoring undertaken at nearby locations, and to establish whether noise levels measured by the long-term noise monitors are determined by construction activities carried out on site.

All attended short-term noise monitoring shall be recorded over 15 minute sample intervals. Noise levels are to be recorded at a minimum rate of 10 samples per second. Every 15 minutes, the data is to be processed statistically and stored in memory. The minimum range of noise metrics to be stored in memory and reported is the following A-weighted noise levels: L_{min}, L_{90}, L_{eq}, L_{10}, L_1 and L_{max}.

In addition to measuring and reporting overall A-weighted noise levels, statistical L_{90}, L_{eq}, L_{10} noise levels shall be measured and reported in third-octave band frequencies from 31.5Hz to 8kHz.

Where the noise monitors are placed within 3.5 metres of building facades, walls or cliffs, then a reflection correction of up to -2.5dB(A) shall be applied to remove the effect of increased noise due to sound reflections from such structures. Presence of impulsive and tonal noise, and subsequent penalty, is to be determined in accordance with the provisions of Table 4.1 Modifying Factor Corrections of INP.

Outdoor noise monitoring is to be undertaken with the microphone at a height of 1.2 – 1.5m from the ground, unless noise measurements are taken from a balcony or veranda, in which case the same microphone height shall apply off the floor.

Noise measurements inside buildings should be at least 1m from the walls or other major reflecting surfaces, 1.2 m to 1.5m above the floor, and 1.5m from windows.

Noise monitoring shall be undertaken in accordance with the environmental noise measurement requirements stipulated in the reference standards and documents listed above.

The following information shall be recorded:

- Date and time of measurements;
- Type and model number of instrumentation;
- Results of field calibration checks before and after measurements;
- Description of the time aspects of each measurement (ie sample times, measurement time intervals and time of day);
- Sketch map of area;
- Measurement location details and number of measurements at each location;
- Weather conditions during measurements, including wind velocity, wind direction, temperature, relative humidity and cloud cover;
- Operation and load conditions of the noise sources under investigation;
- Any adjustment made for presence or absence of nearby reflecting surfaces; and
- Noise due to other sources (eg. traffic, aircraft, trains, dogs barking, insects, etc.).

APPENDIX C Specification for Construction Vibration Monitoring

C.1 Scope

This document specifies methods for undertaking vibration monitoring during the construction phase of the project, where it may be deemed to be required. The vibration monitoring shall be conducted in accordance with DIN 4150.3 Structural Vibration in Buildings – Effects on Structures.

C.2 Referenced Standards and Guidelines

- AS 2775 Mechanical Mounting of Accelerometers
- AS 2670.2 Part 2: Evaluation of human exposure to whole body vibration
- DECC NSW Assessing Vibration: A Technical Guideline
- DIN 4150.3 Structural Vibration in Buildings – Effects on Structures
- BS 7385:1 Evaluation and Measurement for Vibration in Buildings – Part 1: Guide for measurement of vibrations and evaluation of their effects on buildings
- BS 7385:2 Evaluation and Measurement for Vibration in Buildings – Part 2: Guide to Damage Levels from Groundborne Vibration
- ISO 4866 Mechanical Vibration & Shock – Vibration of Buildings – Guidelines for the Management of the Vibrations and Evaluation of their Effects on Buildings

C.3 Testing Procedures

The following procedures are to be followed by personnel suitably qualified and experienced in undertaking vibration measurements.

All vibration monitoring equipment used must be calibrated at least once every two years to standards that are traceable to Australian Physical Standards held by the National Measurement Laboratory (CSIRO Division of Applied Physics). The monitoring system should also have a measurement frequency range down to 1Hz.

C.3.1 Short-Term (Attended) Monitoring

Vibration monitoring shall be undertaken:

- at the commencement of operation for each plant or activity on site, which has the potential to generate significant vibration levels, so to refine the indicative minimum working distances and provide a site-specific table of minimum working distances

- vibration sensitive locations determined to fall within the 'buffer distances' established for each item of plant. Areas likely to require vibration monitoring are identified in this report; and
- where vibration complaints or requests from relevant authorities, at the requested location and at any other relevant vibration receiver location with closest proximity to the construction activities.

Vibration monitoring shall be undertaken over the following period(s):

- for plant operating within the 'buffer distances', during the commencement of use of each plant on site until site-specific minimum working distances are established; and
- for complaints or requests from relevant authorities, during the of use of requested plant until site-specific minimum working distances are established.

All attended short-term vibration monitoring shall be recorded over 15 minute sample intervals. The magnitude of vibration is to be recorded at a minimum rate of 10 samples per second. The minimum range of vibration metrics to be stored in memory and reported are the following:

- Vibration Dose Values (VDVs)
- root-mean-square (rms) – maximums and statistical levels
- peak-particle velocity (ppv) – maximums and statistical levels.

In addition to measuring and reporting overall vibration, statistical vibration shall also be measured and reported in third-octave band frequencies from 1Hz to 250Hz.

Vibration monitoring shall be undertaken in accordance with the vibration measurement requirements stipulated in the reference Standards and documents listed above. The following notes of importance are included here:

- vibration monitoring equipment shall be placed outside at the footings or foundations of the building of interest, closest to the vibrating plant;
- the surface should be solid and rigid in order to best represent the vibration entering the structure of the building under investigation;
- the vibration sensor or transducer shall not be mounted on loose tiles, loose gravel or other resilient surfaces;
- the vibration sensor or transducer shall be directly mounted to the vibrating surface using either bees wax or a magnetic mounting plate onto a steel washer, plate or bracket which shall be either fastened or glued to the surface of interest; and
- where a suitable mounting surface is unavailable, then a metal stake of at least 300mm in length shall be driven into solid ground adjacent to the building of interest, and the vibration sensor or transducer shall be mounted on that.

The following information shall be recorded:

- Date and time of measurements;
- Type and model number of instrumentation;
- Description of the time aspects of each measurement (i.e. sample times, measurement time intervals and time of day);
- Sketch map of area;
- Measurement location details and number of measurements at each location;
- Operation and load conditions of the vibrating plant under investigation; and
- Possible vibration influences from other sources (eg domestic vibrations, other mechanical plant, traffic, etc).

C.3.2 Long-Term (Unattended) Monitoring

Vibration monitoring shall be undertaken at vibration sensitive locations determined to fall within the 'minimum working distances' established for each item of plant during the commencement of use of each plant on site.

Vibration monitoring shall be undertaken over the following period(s):

- continuously whilst the vibrating plant is operational within the pre-determined 'minimum working distance' from the potentially affected building.

Vibration monitoring equipment shall be placed outside at the footings or foundations of the building of interest, closest to the vibrating plant.

Vibration is to be recorded at a minimum rate of 10 samples per second. The data is to be processed statistically and stored in memory. The minimum range of vibration metrics to be stored in memory for later retrieval is the following:

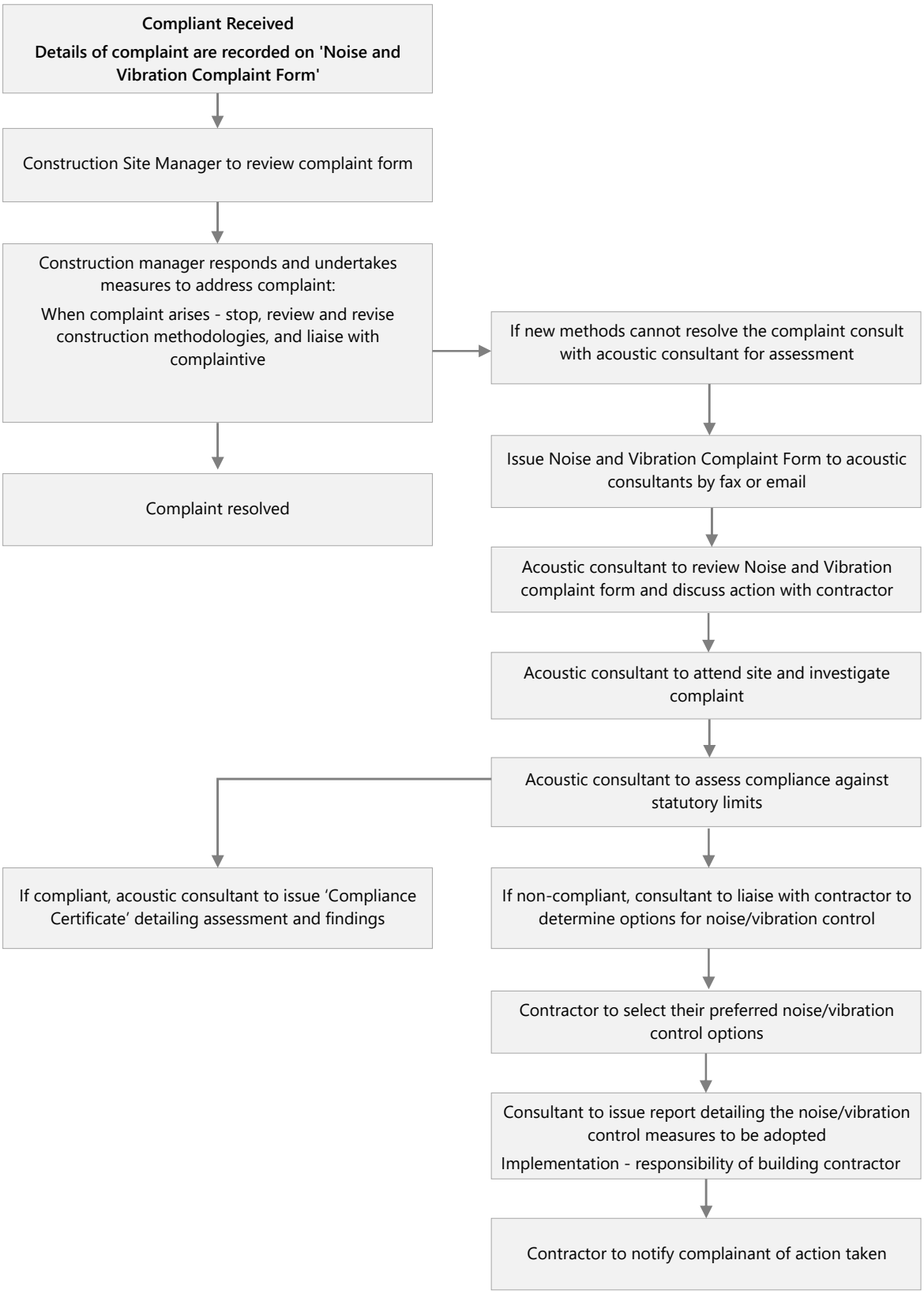
- Vibration Dose Values (VDVs)
- vector-sum root-mean-square (rms) – maximums and statistical metrics; and
- vector-sum peak-particle velocity (ppv) – maximums and statistical metrics.

Vibration monitoring shall be undertaken in accordance with the vibration measurement requirements stipulated in the reference Standards and documents listed above. The following notes of importance are included here:

- vibration monitoring equipment shall be placed outside at the footings or foundations of the building of interest, closest to the vibrating plant;

- the surface should be solid and rigid in order to best represent the vibration entering the structure of the building under investigation;
- the vibration sensor or transducer shall not be mounted on loose tiles, loose gravel or other resilient surfaces;
- the vibration sensor or transducer shall be directly mounted to the vibrating surface using bees wax or a magnetic mounting plate onto a steel plate or bracket either fastened or glued to the surface of interest;
- where a suitable mounting surface is unavailable, then a metal stake of at least 300mm in length shall be driven into solid ground adjacent to the building of interest, and the vibration sensor or transducer shall be mounted on that; and
- a flashing light alarm should be attached in a visible position from the construction work area. When vibration exceeds the set threshold, the light will flash notifying the operator that works in that area should cease immediately.

APPENDIX D Noise/Vibration Complaint Management Procedure



NOISE/ VIBRATION COMPLAINT FORM

Project title: _____ **Date:** _____

Site contractor: _____ **Phone:** _____

Site contact: _____ **Email:** _____

Complaint details

Received by (circle): Phone / Email / In person / Other: _____

Name: _____ H Ph: _____

Address: _____ W Ph _____

Email: _____ M Ph _____

Describe when the problem occurred (date and time), what equipment caused the complaint (if known) and where person was standing when he/she experienced the noise/vibration:

Investigation

Question foreman responsible on site and obtain information on what equipment or processes would most likely have caused the complaint:

Following approval from the Project Manager, email/fax this form to Renzo Tonin & Associates