RENZO TONIN & ASSOCIATES
inspired to achieve

Consultants in Acoustics, Vibration & Structural Dynamics
email: sydney@renzotonin.com.au
website: www.renzotonin.com.au

UTS THOMAS STREET BUILDING

CONSTRUCTION NOISE & VIBRATION MANAGEMENT PLAN

TF557-01F02 (REV 2) CNVMP.DOC

13 DECEMBER 2011

Prepared for:

University of Technology, Sydney

Attention: MR GREG MOORE

25 1982-2007 ACOUSTIC ENGINEERING EXCELLENCE

AAAC
Member of the Association of Australian Acoustical Consultants

Sydney (Head Office)
Renzo Tonin & Associates (NSW) Pty Ltd
ABN 29 117 462 861
1/418A Elizabeth St., SURRY HILLS, NSW 2010
PO Box 877 STRAWBERRY HILLS, NSW 2012
Ph (02) 8218 0500 Fax (02) 8218 0501

Melbourne
Brisbane
Gold Coast
Kuwait

DOCUMENT CONTROL

Date	Revision History	Non-Issued Revision	Issued Revision	Prepared By (initials)	Instructed By (initials)	Reviewed & Authorised by (initials)
30/11/2011	Report generation	-	0	MCH	-	MCH
08/12/2011	Revise report	-	1	MCH	-	MCH
13/08/2011	Revise report	-	2	MCH	-	MCH

The work presented in this document was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on Australian Standard / NZS ISO 9001.

This document is issued subject to review and authorisation by the Team Leader noted by the initials printed in the last column above. If no initials appear, this document shall be considered as preliminary or draft only and no reliance shall be placed upon it other than for information to be verified later.

This document is prepared for our Client's particular requirements which are based on a specific brief with limitations as agreed to with the Client. It is not intended for and should not be relied upon by a third party and no responsibility is undertaken to any third party without prior consent provided by Renzo Tonin & Associates. The information herein should not be reproduced, presented or reviewed except in full. Prior to passing on to a third party, the Client is to fully inform the third party of the specific brief and limitations associated with the commission.

The information contained herein is for the purpose of acoustics only. No claims are made and no liability is accepted in respect of design and construction issues falling outside of the specialist field of acoustics engineering including and not limited to structural integrity, fire rating, architectural buildability and fit-for-purpose, waterproofing and the like. Supplementary professional advice should be sought in respect of these issues.

CONTENTS

1 INTRODUCTION 5

2 PROJECT DESCRIPTION 6

2.1 Location 6

2.2 Proposed Construction 6

3 NOISE MANAGEMENT PLAN 8

3.1 Purpose 8

3.2 Noise Criteria 8

3.2.1 Interim Construction Noise Guideline 8

3.2.2 Time Restrictions 9

3.3 Proposed Construction Noise Sources 9

3.4 Estimated Noise Levels 10

3.5 Noise Mitigation Measures 11

3.5.1 General Engineering Noise Controls 11

3.5.2 Noise Management Measures 12

4 VIBRATION MANAGEMENT PLAN 14

4.1 Vibration Criteria 14

4.2 Buffer Distances for Vibration Control 17

4.3 Vibration Management Measures 18

5 COMPLAINTS MANAGEMENT 19

6 CONCLUSION 20

APPENDIX A - GLOSSARY OF ACOUSTIC TERMS 21

APPENDIX B - SPECIFICATION FOR DETERMINING THE SOUND POWER LEVELS OF CONSTRUCTION PLANT 24

APPENDIX C - SPECIFICATION FOR CONSTRUCTION NOISE MONITORING 28

APPENDIX D - SPECIFICATION FOR CONSTRUCTION VIBRATION MONITORING 31

APPENDIX E - NOISE / VIBRATION COMPLAINT MANAGEMENT PROCEDURE 35

List of Tables

Table 3.1 – Noise at Sensitive Receivers Using Quantitative Assessment 9

Table 3.2 – Typical Construction Equipment & Sound Power Levels, dB(A) 10

Table 3.3 – Predicted Construction L_{Aeq} Noise Levels at Receiver Locations, dB(A) 10

Table 4.1 – Preferred and Maximum Weighted rms Values for Continuous and Impulsive Vibration Acceleration (m/s^2) 1-80Hz 15

Table 4.2 – Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$) 15

Table 4.3 – BS 7385 Structural Damage Criteria 16

Table 4.4 – DIN 4150-3 Structural Damage Criteria 17

1 INTRODUCTION

Renzo Tonin & Associates were engaged to prepare a Construction Noise and Vibration Management Plan (CNVMP) for the proposed University of Technology, Sydney (UTS) Thomas Street Building development on the corner of Jones Street and Thomas Street, Ultimo. This management plan will provide guidelines to reduce noise and vibration impacts to nearby affected receivers during construction works only. Noise and vibration impacts as a result of excavation works on the site have been addressed within the approved concept plan (modification no. 3 MP 08_0116 Mod 3) and will not be addressed as part of this CNVMP.

Furthermore, this management plan has been prepared in response to the Director General's Requirements (DGRs) for noise.

The work documented in this report was carried out in accordance with the Renzo Tonin & Associates Quality Assurance System, which is based on the Australian Standard / NZS ISO 9001.

2 PROJECT DESCRIPTION

2.1 Location

The construction site is located on the corner of Jones Street and Thomas Street, Ultimo and is bound by Jones Street to the west and Thomas Street to the north. UTS Buildings CB02 and CB04 bound the site to the south and to the north east, respectively, and share common boundaries with the site. UTS Building CB10 and the Ultimo TAFE College are located to the west across Jones Street and to the south across Thomas Street, respectively.

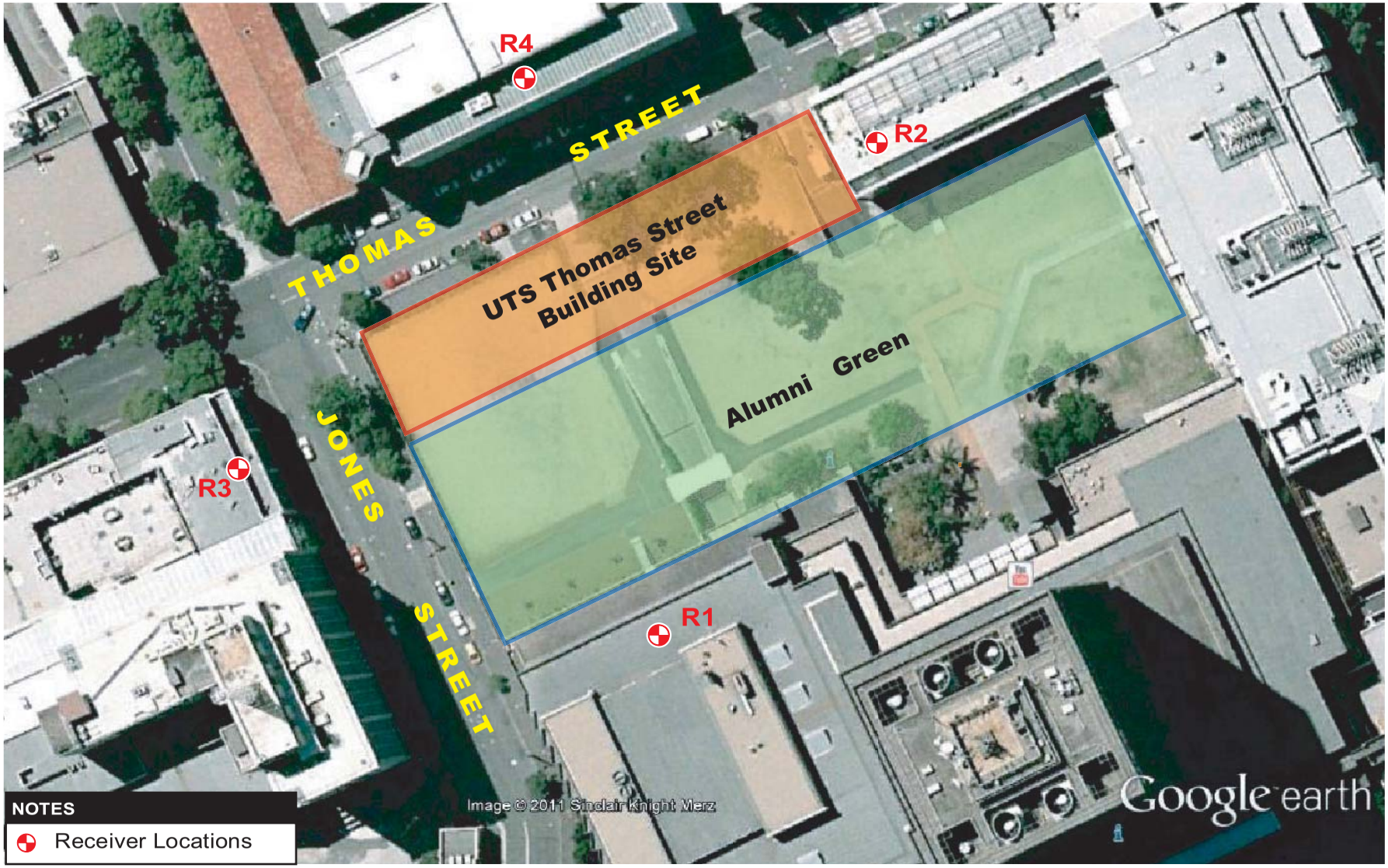
The nearest and potentially worst affected sensitive receivers were identified during a site inspection. These sensitive receivers are as follows:

- **Receiver R1** – **UTS Building CB02**
  Building with teaching spaces located directly to the south of the construction site and sharing a common boundary.
- **Receiver R2** – **UTS Building CB04**
  Building with teaching spaces located directly to the north east of the construction site and sharing a common boundary.
- **Receiver R3** – **UTS Building CB10**
  Building with teaching spaces, offices and commercial spaces located to the west of the construction site and across Jones Street.
- **Receiver R4** – **Ultimo TAFE College**
  Building with teaching spaces located to the north of the construction site and across Thomas Street.

Figure 1 is a locality map showing the site and its surrounding area.

2.2 Proposed Construction

Construction activities will involve the construction of the UTS Thomas Street Building on the site and other associated works, such as the provision for access from the new UTS Thomas Street Building to the existing UTS Building CB04.



RENZO TONIN & ASSOCIATES
inspired to achieve
Consultants in Acoustics, Vibration and Structural Dynamics
Email: acoustics@rtagroup.com.au www.renzotonin.com.au
Sydney - Ph: (02) 8218 0500 Fax: (02) 8218 0501
Melbourne - Ph: (03) 9606 0041 Fax: (03) 9606 0042
Brisbane - Ph: (07) 3211 9155 Fax: (07) 3211 9188
Gold Coast - Ph: (07) 5593 5633 Fax: (07) 5593 5635
Kuwait - Ph: +0011 965 653 1520
Member of the Association of Australian Acoustical Consultants

Title : Figure 1 - Site, Surrounds and Receiver Locations

Date : 07/12/11

Scale: NTS

Project: UTS Thomas Street Building

Ref : TF557-01P01 (rev 1)

3 NOISE MANAGEMENT PLAN

3.1 Purpose

This section provides an assessment of construction noise emissions from the site and recommends noise mitigation measures and management measures that can be used to minimise noise impacts at receivers surrounding the site.

3.2 Noise Criteria

3.2.1 Interim Construction Noise Guideline

Chapter 171 of the NSW 'Environmental Noise Control Manual' (ENCM, Environment Protection Authority 1994) provides guidelines for assessing noise generated during the construction phase. However, the NSW Office of Environment and Heritage's (OEH) 'Interim Construction Noise Guideline' (ICNG) has become the standard policy for assessing construction noise. This guideline supersedes Chapter 171 of the ENCM.

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

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

   In recent years NSW noise policies including OEH's NSW Industrial Noise Policy (INP) and the NSW Environmental Criteria for Road Traffic Noise (ECRTN) 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.

   Consistent with the ICNG we recommend the use of L_{Aeq} as the key descriptor for measuring and assessing construction noise.

2. 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.

3. Quantitative and qualitative assessment

   The ICNG provides two methods for assessment of construction noise, being either a quantitative or a qualitative assessment.

   A quantitative assessment is recommended for major construction projects of significant duration, and involves the measurement and prediction of noise levels, and assessment against set criteria.

A qualitative assessment is recommended for small projects with a duration of less than three weeks and focuses on minimising noise disturbance through the implementation of reasonable and feasible work practices, and community notification.

Given the significant scale of the construction works proposed for the UTS Thomas Street Building, a quantitative assessment is carried out herein, consistent with the ICNG's requirements.

Management Levels

Table 3.1 below sets out the noise management levels for sensitive receivers. Given that all the receiver locations (R1, R2, R3 and R4) include teaching spaces, the management levels for school classrooms would be applicable. Furthermore, the office and commercial spaces of Receiver R3 will be assessed against the management levels presented in the ICNG for commercial premises.

Table 3.1 – Noise at Sensitive Receivers Using Quantitative Assessment

Sensitive Receiver Type	Management level, $L_{Aeq\ (15\ min)}$
Classrooms at Schools and other educational institutions[1]	Internal noise level = 45 dB(A)
Commercial (such as offices and retail outlets)	External noise level = 70 dB(A)

Notes: 1. Applicable for the internal teaching spaces in UTS Buildings CB02, CB04 and CB10 and the Ultimo TAFE College building directly affected by construction noise

As a general rule, masonry / brick type building structures would typically provide a minimum 15dB(A) reduction from external noise levels to internal noise levels. Therefore, the equivalent external management noise level for classroom areas of Receivers R1, R2, R3 and R4 is **60dB(A)**.

3.2.2 Time Restrictions

In accordance with the ICNG, the standard work hours are:

- Monday to Friday, 7am to 6pm.
- Saturday, 7am to 1pm if inaudible on residential premises, otherwise 8am to 1pm.
- No construction work to take place on Sundays or Public Holidays.

3.3 Proposed Construction Noise Sources

Actual construction plant and equipment to be used during the construction phase of the UTS Thomas Street Building are not yet known. Therefore, typical plant and equipment likely to be used during the construction works are provided in Table 3.2 below.

Table 3.2 – Typical Construction Equipment & Sound Power Levels, dB(A)

Plant Item	Plant Description	L_{Aeq} Sound Power Levels
1	Concrete Floating Machine	112
2	Pneumatic Hand Tools (general)	110
3	Tower Crane	110
4	Concrete Truck	106
5	Delivery Truck	105
6	Concrete Pump	102
7	Welder	102
8	Concrete Vibrator	100
9	Silenced Air Compressor	95
10	Hoists	92

The sound power levels for the majority of activities presented in the above table are based on maximum levels given in Table A1 of Australian Standard 2436 - 2010 "Guide to Noise and Vibration Control on Construction, Demolition and Maintenance Sites", information from past projects and information held in our library files.

3.4 Estimated Noise Levels

The estimated noise levels at the nearest affected receiver locations due to construction activities were calculated and are shown in Table 3.3 below. It is noted that for a conservative assessment the predicted noise levels based on a 'worst case' scenario where all the construction plant and equipment are operating concurrently are also presented.

The predicted noise levels above are based on construction plant and equipment generally operating in the areas closest to the corresponding nearby critical receivers. Calculations take into consideration attenuation due to distance between the receiver and the construction activity only and does not consider shielding provided by intervening structures. Furthermore, the predicted noise levels are based on no noise mitigation treatment applied to plant and equipment on site.

Table 3.3 – Predicted Construction L_{Aeq} Noise Levels at Receiver Locations, dB(A)

Plant Item	Plant Description	Receiver R1	Receiver R2	Receiver R3	Receiver R4
1	Concrete Floating Machine	72	84	76	76
2	Pneumatic Hand Tools (general)	69	82	74	74
3	Tower Crane	69	82	74	74
4	Concrete Truck	66	78	70	70
5	Delivery Truck	64	77	69	69
6	Concrete Pump	61	74	66	66
7	Welder	62	74	66	66
8	Concrete Vibrator	60	72	64	64

Plant Item	Plant Description	Receiver R1	Receiver R2	Receiver R3	Receiver R4
9	Silenced Air Compressor	54	67	59	59
10	Hoists	52	64	56	56
All Equipment Operating Concurrently		**77**	**89**	**81**	**81**

Based on Table 3.3 above, noise emission from construction activities will generally exceed the set noise criteria for all receiver locations. A reasonable and feasible approach towards noise management measures will be required to reduce noise levels as much as possible to manage the impact from construction noise.

It is noted that construction activities will begin within the excavated site, and as such the natural ground will form a noise barrier providing noise shielding to nearby sensitive receivers during the early stages of the construction works. Therefore, the predicted noise levels presented in the table above may be lower in practice due to this.

3.5 Noise Mitigation Measures

3.5.1 General Engineering Noise Controls

Typical noise treatment options that may be considered for the construction activities on the site are summarised below. Note that the ability to implement these measures is subject to site practicality.

1. ***Noise Control Kits*** Where possible, 'noise control kits' could be fitted to plant engines to reduce noise level emissions. Such 'noise control kits' comprise:
   - high performance 'residential-grade' exhaust mufflers,
   - additional engine cowling / enclosure lined inside with sound absorbent industrial-grade foam, and
   - air intake and discharge silencers / louvres.

2. ***Partial Acoustic Enclosures*** Where noise exceedance occurs, partial acoustic enclosures may be constructed around noisy plant and equipment, for example air compressors.

   Acoustic enclosures should be checked by a suitable acoustic engineer once they are constructed.

3. ***Hoarding*** Where stationary equipment (ie. non-transient activities) is used on site, temporary hoarding between the source and receiver may be erected.

   Hoarding should be checked by a suitable acoustic engineer once erected.

4. *Truck Movement* Potential noise impact from truck movement will be limited by managing the movement of trucks around the site. The number of trucks around the site should be kept to a minimum, where possible.

3.5.2 Noise Management Measures

In addition to physical and engineering mitigation measures described above, the following noise management measures shall be considered to minimise adverse noise impacts to nearby receivers.

1. *Time Management* Where noise level exceedance cannot be avoided or where physical noise control measures are not reasonable or feasible, then consideration should be given to implementing time restrictions and/or providing periods of repose for neighbours. That is, daily periods of respite from noisy activities may be scheduled for building occupants during business hours in UTS Buildings CB02, CB04 and CB10 and the Ultimo TAFE Building.

Some items of plant may exceed noise limits even after noise treatment is applied. To reduce the overall noise impact, the use of noisy plant should be restricted to within certain time periods, to be negotiated with stakeholders.

2. *Relocation of Affected People* Given that most areas potentially affected by noise impacts from the construction activities are teaching spaces, relocation of classes to quieter areas of the building or to a different building altogether may be considered as an option.

Office areas impacted by the construction activities may also be considered for relocation if deemed necessary after consultation with affected stakeholders.

3. *General*

- Plant and equipment should be properly maintained.
- Provide special attention to the use and maintenance of 'noise control' or 'silencing' kits fitted to machines to ensure they perform as intended.
- Strategically position plant on site to reduce the emission of noise to the surrounding neighbourhood and to site personnel.
- Avoid any unnecessary noise when carrying out manual operations and when operating plant.
- Any equipment not in use for extended periods should be switched off.
- Good relations with people living and working in the vicinity of the

construction site should be established at the beginning of the works and be maintained throughout the works, as this is of paramount importance.

- Keep stakeholders informed of progress.
- Take complaints seriously and deal with them expeditiously. The person selected to liaise with the stakeholders should be adequately trained and experienced in such matters.

4. Regular Periodic Noise Monitoring

Noise monitoring should be undertaken at the commencement of works and regular periods at all affected receiver locations identified in this study to provide feedback to management on any noise exceedances, so necessary actions can be taken. Noise monitoring should be undertaken in accordance with Appendix C.

5. Complaints Handling Procedure

A complaint handling procedure should be put in place to deal with noise complaints that may arise from construction activities. A contact number for complaints to be made on should be established for affected stakeholders to inform the site of unsatisfactorily high noise levels. This number should be displayed clearly on signage at the site perimeter. Each complaint would need to 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. See Appendix D for an example of a complaint handling procedure and form.

4 VIBRATION MANAGEMENT PLAN

4.1 Vibration Criteria

The management objective for the site is to limit vibration from construction activities so as to avoid building damage and human discomfort associated with the construction works for the UTS Thomas Street Building site.

The effects of ground vibration on buildings near construction sites may be broadly defined by the following three categories:

1. Disturbance to building occupants - Vibration in which the occupants or users of the building are inconvenienced or possibly disturbed,
2. Effects on building contents - Vibration where the building contents may be affected, and,
3. Effects on building structures - Vibration in which the integrity of the building or structure itself may be prejudiced.

In general, vibration criteria for human disturbance (1) are more stringent than vibration criteria for effects on building contents (2) and building structural damage (3). Hence, compliance with the more stringent limits dictated by Category 1, would ensure that compliance is also achieved for the other two categories.

Category 1 – Disturbance to Buildings Occupants

For disturbance to human occupants of buildings, we refer to the OEH's *'Assessing Vibration; a technical guideline'*, published in February 2006. This document provides criteria which are based on the British Standard BS 6472-1992, *'Evaluation of human exposure to vibration in buildings (1-80Hz)'*.

Vibration sources are defined as C*ontinuous, Impulsive or Intermittent.* Section 2 of the technical guideline defines each type of vibration as follows:

> ***'Continuous*** *vibration continues uninterrupted for a defined period (usually throughout the day-time and/or night-time).*
>
> ***Impulsive*** *vibration is 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.*
>
> ***Intermittent*** *vibration can be defined as interrupted periods of continuous or repeated periods of impulsive vibration that varies significantly in magnitude'.*

The criteria are to be applied to 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).'*

Preferred and maximum values for continuous and impulsive vibration are defined in Table 2.2 of the guideline and are reproduced below specific to the type of receivers surrounding the proposed UTS Thomas Street Building.

Table 4.1 – Preferred and Maximum Weighted rms Values for Continuous and Impulsive Vibration Acceleration (m/s^2) 1-80Hz

Location	Assessment period[1]	Preferred values		Maximum values	
		z axis	x & y axis	z axis	x & y axis
Continuous vibration					
Offices, schools, educational institutions and places of worship	Day- or night-time	0.020	0.014	0.040	0.028
Impulsive vibration					
Offices, schools, educational institutions and places of worship	Day- or night-time	0.64	0.46	1.28	0.92

Notes: 1. Daytime is 7.00 am to 10.00 pm and night-time is 10.00pm to 7.00 am

Intermittent vibration is to be assessed using vibration dose values (VDVs). The VDV method is a fourth power approach which is more sensitive to peaks in the acceleration waveform and makes corrections to the criteria based on the duration of the source's operation. The VDV can be calculated using the overall weighted rms acceleration of the vibrating source in each orthogonal axis and the total period during which the vibration may occur. Weighting curves are provided in each orthogonal axis in the guideline. Preferred and maximum VDV values are defined in Table 2.4 of the guideline and are reproduced below.

Table 4.2 – Acceptable Vibration Dose Values for Intermittent Vibration (m/s$^{1.75}$)

Location	Daytime [1]		Night-time [1]	
	Preferred values	Maximum values	Preferred values	Maximum values
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80

Notes: 1. Daytime is 7.00 am to 10.00 pm and night-time is 10.00pm to 7.00 am

<u>Category 2</u> – Effects on building contents

The typical frequency range of construction induced ground vibration is approximately 8 Hz to 100 Hz. Over this range the threshold of visible movement of building contents such as plants,

pictures, blinds etc is approximately 0.5 mm/s. At vibration levels higher than 0.9 mm/s, audible rattling of loose objects such as crockery can be expected.

Category 3 – Structural Damage to Buildings

Currently there exists no Australian Standard for assessment of structural building damage caused by vibrational energy. Therefore, reference is made to both the British and German standards below which are relevant to the assessment of structural damage.

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.

BS7385 recommends that the peak particle velocity is used to quantify vibration and specifies damage criteria for frequencies within the range 4Hz to 250Hz, which is the range usually encountered in buildings. At frequencies below 4Hz, a maximum displacement value is recommended. The levels from the standard are given below in Table 4.3.

Table 4.3 – BS 7385 Structural Damage Criteria

Group	Type of Structure	Peak component particle velocity, mm/s		
		4Hz to 15Hz	15Hz to 40Hz	40Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50		
2	Un-reinforced or light framed structures Residential or light commercial type buildings	15 to 20	20 to 50	50

The peak vibration limits set for minimal risk of 'cosmetic' damage are: 15mm/s for un-reinforced or light framed structures, for example residential or light commercial buildings (Line 2; increasing as the frequency content of the vibration increases) and 50mm/s for reinforced or framed structures, for example industrial and heavy commercial buildings (Line 1; constant across all frequencies). '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.

These values 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%.

The levels set by this standard are considered 'safe limits' up to which no damage due to vibration effects has been observed for certain particular types of buildings. 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.

This standard states that it considers sources of vibration including blasting, demolition, piling, ground treatments, compaction, construction equipment, tunnelling, road and rail traffic and industrial machinery.

As stated in the standard, it sets guide values for building vibration based on the lowest levels above which damage has been credibly demonstrated. That is, it gives guidance on the levels of vibration above which building structures could be damaged.

German Standard

The German standard DIN 4150 - Part 3 - "Structural vibration in buildings - Effects on Structures", also provides recommended maximum levels of vibration that reduce the likelihood of building damage caused by vibration. This standard too, presents recommended maximum limits over a range of frequencies measured in any direction at the foundation or in the plane of the uppermost floor.

The minimum 'safe limit' of vibration at low frequencies for commercial and industrial type buildings, which are representative of the surrounding receivers, is 20mm/s. This limit increases as the frequency content of the vibration increases. These values are presented in Table 4.4 below and are generally recognised to be conservative.

Table 4.4 – DIN 4150-3 Structural Damage Criteria

Group	Type of Structure	Vibration Velocity, mm/s			
		At Foundation at Frequency of			Plane of Floor Uppermost Storey
		< 10Hz	10Hz - 50Hz	50Hz - 100Hz	All Frequencies
1	Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40

4.2 Buffer Distances for Vibration Control

The relationship between vibration and the probability of causing human annoyance or damage to structures is complex. This complexity is mostly due to the magnitude of the vibration source, the particular ground conditions between the source and receiver, the foundation-to-footing interaction and the large range of structures that exist in terms of design (eg dimensions, materials, type and quality of construction and footing conditions). The intensity, duration, frequency content and number of occurrences of a vibration, all play an important role in both the annoyance caused and the strains induced in structures.

As the pattern of vibration radiation is very different to the pattern of airborne noise radiation, and is very site specific, detailed site specific buffer distances should be determined once vibration emission levels are measured from each plant item prior to the commencement of their regular use on site.

4.3 Vibration Management Measures

Further to buffer distances, to ensure vibration impacts are minimised during the construction period, the following vibration management control measures are provided:

1. The proper implementation of a vibration management plan is required to avoid adverse vibration disturbance to affected occupancies. Consultation with occupants and property owners is recommended and should be aimed at providing a communication path directly to the contractor.

2. A management procedure will be implemented to deal with vibration complaints. Each complaint will be investigated and where vibration levels are established as exceeding the set limits, appropriate amelioration measures shall be put in place to mitigate future occurrences. An example of a vibration complaint management procedure and complaint form is presented in Appendix E of this report.

3. Carry out vibration testing of actual equipment on site prior to the construction works to determine acceptable buffer distances to the sensitive receivers.

4. Carry out periodic vibration monitoring when complaints arise and assess the vibration levels for compliance with the set vibration limits. This monitoring shall be undertaken in accordance with the vibration monitoring program described in Appendix D.

5. Where vibration is found to be excessive, management measures shall be implemented to ensure vibration compliance is achieved. Management measures may include vibration monitoring incorporating a warning light, modification of construction methods such as using smaller construction plant, establishment of safe buffer zones and if necessary, time restrictions for the most excessive vibration activities. Time restrictions are to be negotiated with affected receivers.

6. Before, during and after the construction works, preparation of a dilapidation report on the state of the existing buildings surrounding the construction site is recommended.

5 COMPLAINTS MANAGEMENT

Noise and vibration levels generated by construction activities associated with the construction of the UTS Thomas Street Building should aim to comply with the noise and vibration goals set by the relevant regulations and guidelines.

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

Occupants of nearby affected properties shall be informed by direct mail of a direct 24-hour telephone line where any noise and / or vibration complaints related to the construction activities will be recorded. Additionally, occupants will be notified of any periods of noisy construction activities at least 24 hours prior to their commencement.

All noise and vibration complaints shall be investigated by the site in accordance with the Noise / Vibration Complaint Management Procedure identified in Appendix E of this report.

6 CONCLUSION

A Construction Noise and Vibration Management Plan (CNVMP) has been prepared for the UTS Thomas Street Building construction site on the corner of Jones Street and Thomas Street, Ultimo. Specifically, this report aims to manage noise and vibration impact during the construction of the UTS Thomas Street Building through noise and vibration management measures, to achieve compliance with relevant guidelines and standards.

In-principle recommendations are provided in Section 3.5 and Section 4.3 to limit the potential impact of noise and vibration generated by construction activities to acceptable levels. In addition, buffer distances for vibration compliance have been provided as guidance; however, should be determined in more detail prior to the start of construction works through on-site measurements of vibration.

Procedures to manage complaints are also provided in Section 5 and Appendix E to ensure complaints are dealt with accordingly.

APPENDIX A - GLOSSARY OF ACOUSTIC TERMS

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 $\mathbf{L_{90}}$ 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 Martin Place 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 ear is not as effective in hearing low frequency sounds as it is 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.
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 L_{90} 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 DETERMINING THE SOUND POWER LEVELS OF CONSTRUCTION PLANT

B.1 SCOPE

This document specifies methods for determination of sound power levels for construction plant including earthmoving equipment and other ancillary plant and equipment used during construction.

B.2 REFERENCED STANDARDS

- Australian Standard 1259 – 1990: "Acoustics - Sound Level Meters",
- Australian Standard 2012.1-1990: "Acoustics - Measurement of airborne noise emitted by earth-moving machinery and agricultural tractors - stationary test condition - Part 1: Determination of compliance with limits for exterior noise"
- ISO 6395: "Acoustics & Measurement of airborne noise emitted by earthmoving machinery - Dynamic test conditions"
- AS1217.5-1985: "Acoustics – Determination of sound power levels of noise sources – Part 5 – Engineering methods for free-field conditions over a reflecting plane"
- AS1217.7-1985: "Acoustics – Determination of sound power levels of noise sources – Part 5 – Survey method"

B.3 TESTING PROCEDURES – EARTHMOVING MACHINERY

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

Each significant plant item shall be tested in terms of both the 'stationary' and the 'dynamic' testing procedures detailed below.

All sound level meters used must be Type 1 instruments as described in Australian Standard 1259.2-1990 "Acoustics - Sound Level Meters" 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 meters shall be checked in the field before and after the noise measurement period.

B.3.1 STATIONARY TESTING

Stationary measurements shall be performed on all earthmoving plant according to the method of AS2012.1-1990.

In addition to measuring overall A-weighted noise levels, octave band frequency $L_{Aeq,T}$ noise levels shall also be measured at each measurement location from 63Hz to 8kHz inclusive.

Background noise shall also be recorded in the same octave band frequency range, and corrections to measured octave-band noise levels shall be applied as described in Table 1 of AS2012.1-1990.

Each plant item should be tested in isolation, without any other noisy plant on site operating. Where this cannot be done for practical reasons, then the noise of the plant being tested shall be at least 5dB greater than the background noise from other nearby plant, both in terms of the overall A-weighted level and in all octave band frequencies.

Measured octave-band $L_{Aeq,T}$ noise levels shall also be processed as described in Section 8 of that Standard to establish octave-band sound power levels.

The overall A-weighted sound power levels to be determined shall be in terms of both the $L_{Aeq,T}$ and $L_{A10,T}$ noise metrics. The measurement sample time shall be selected so that it is representative of the operating cycle/s of the plant being tested.

Where the plant tested or noise measurements are taken within 3.5 metres of large 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.

All measured noise level data and determined sound power levels shall be included in the test reports.

B.3.2 DYNAMIC TESTING

Details of equipment operation during testing will vary depending on the equipment type. Dynamic measurements shall be performed on all earthmoving plant according to the method in International Standard ISO 6395.

In addition to measuring overall A-weighted noise levels, octave band frequency $L_{Aeq,T}$ noise levels shall also be measured at each measurement location from 63Hz to 8kHz inclusive. Background noise shall also be recorded in the same octave band frequency range, and corrections to measured octave-band noise levels shall be applied as described in International Standard ISO 6395.

Each plant item should be tested in isolation, without any other noisy plant on site operating. Where this cannot be done for practical reasons, then the noise of the plant being tested shall be at least 5dB greater than the background noise from other nearby plant, both in terms of the overall A-weighted level and in all octave band frequencies.

Measured octave-band $L_{Aeq,T}$ noise levels shall also be processed to establish octave-band sound power levels.

Where the plant tested or noise measurements are taken within 3.5 metres of large 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.

The overall A-weighted sound power levels to be determined shall be in terms of both the $L_{Aeq,T}$ and $L_{A10,T}$ noise metrics. The measurement sample time shall be selected so that it is representative of the operating cycle/s of the plant being tested.

All measured noise level data and determined sound power levels shall be included in the test reports.

B.4 TESTING PROCEDURES – OTHER CONSTRUCTION PLANT

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

All sound level meters used must be Type 1 instruments as described in Australian Standard 1259.2-1990 "Acoustics - Sound Level Meters". The calibration of the meters shall be checked in the field before and after the noise measurement period.

Noise measurements shall be performed on all non-earthmoving construction plant according to the methods of either AS1217.5-1985 or AS1217.7-1985, whichever is applicable to the items of plant being tested.

Machinery shall be operated at high idle speed. In the case of drilling, boring and rock-breaking machines, the testing location shall allow for these machines to be operated in rock of characteristics that are typical for the project site.

In addition to measuring overall A-weighted noise levels, octave band frequency $L_{Aeq,T}$ noise levels shall also be measured at each measurement location from 63Hz to 8kHz inclusive. Background noise shall also be recorded in the same octave band frequency range, and corrections to measured octave-band noise levels shall be applied as described in Table 1 of AS2012.1-1990.

Each plant item should be tested in isolation, without any other noisy plant on site operating. Where this cannot be done for practical reasons, then the noise of the plant being tested shall be at least 5dB greater than the background noise from other nearby plant, both in terms of the overall A-weighted level and in all octave band frequencies.

Measured octave-band $L_{Aeq,T}$ noise levels shall also be processed as described in Section 8 of that Standard to establish octave-band sound power levels.

The overall A-weighted sound power levels to be determined shall be in terms of both the $L_{Aeq,T}$ and $L_{A10,T}$ noise metrics. The measurement sample time shall be selected so that it is representative of the operating cycle/s of the plant being tested.

Where the plant tested or noise measurements are taken within 3.5 metres of large 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.

All measured noise level data and determined sound power levels shall be included in the test reports.

APPENDIX C - SPECIFICATION FOR CONSTRUCTION NOISE MONITORING

C.1 SCOPE

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

C.2 REFERENCED STANDARDS & GUIDELINES

- Australian Standard 1259–1990: "Acoustics - Sound Level Meters",
- Australian Standard 1055-1989 "Acoustics - Description and Measurement of Environmental Noise",
- NSW Environment Protection Authority's "Environmental Noise Control Manual", and
- NSW Environment Protection Authority's "Industrial Noise Policy".

C.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 Australian Standard 1259.2-1990 "Acoustics - Sound Level Meters" 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 and computers housed in weather resistant enclosures. The operator may either retrieve the data at the conclusion of each monitoring period either in person or via a telephone modem if the logger is fitted with a mobile phone option. The nominated long-term environmental noise level monitors are to be of the RTA Technology Pty Ltd [phone (02) 8218 0500] type or equivalent.

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 the wind speed is greater than 5 m/s (18 km/hr).

C.3.1 LONG-TERM (UNATTENDED) 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, whilst 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.

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

C.3.2 SHORT-TERM (ATTENDED) MONITORING

Attended short-term noise monitoring shall be conducted at noise receiver locations with closest proximity to the construction activities.

Short-term noise monitoring shall be conducted within the first month of commencement of construction works, and then every 1 to 2 months thereafter, dependent on the level of complaint from construction activities.

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 are 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.

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 verandah, in which case the same microphone height shall apply off the floor.

Conditions such as wind velocity, wind direction, temperature, relative humidity and cloud cover shall also be recorded during short-term noise monitoring.

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
- Operation and load conditions of the noise sources under investigation
- Any adjustment made for presence or absence of nearby reflecting surfaces
- Noise due to other sources (eg traffic, aircraft, trains, dogs barking, insects etc)

APPENDIX D - SPECIFICATION FOR CONSTRUCTION VIBRATION MONITORING

D.1 SCOPE

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

D.2 REFERENCED STANDARDS & GUIDELINES

- AS 2775 Mechanical Mounting of Accelerometers
- AS 2670.2 Part 2: Evaluation of human exposure to whole body vibration
- EPA ENCM Chapter 174 – Vibration in Buildings
- 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

D.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.

Long-term vibration monitoring equipment or Vibration Loggers consist of a computer unit connected by cable to a triaxial vibration transducer which senses vertical, axial and horizontal vibration. Vibration levels are continuously monitored, and the data is processed statistically and stored in the computer memory. The operator may either retrieve the data at the conclusion of each monitoring period either in person or via a telephone modem if the logger is fitted with a mobile phone option. The nominated long-term Vibration Loggers are to be of the RTA Technology Pty Ltd [phone (02) 8218 0570] type or equivalent.

D.3.1 LONG-TERM (UNATTENDED) MONITORING

Vibration monitoring shall be undertaken at vibration sensitive locations determined to fall within the 'buffer 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 'buffer distances' 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 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 vibration metrics to be stored in memory for later retrieval is the following:

- Vector-sum root-mean-square (rms) – maximums and statistical metrics
- 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 levels 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.

D.3.2 SHORT-TERM (ATTENDED) MONITORING

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

Short-term vibration monitoring shall be used to supplement long-term vibration monitoring undertaken at nearby locations, and to check whether or not the vibration levels measured by the long-term vibration monitors are caused by construction activities carried out on site.

All attended short-term vibration monitoring shall be recorded over 15 minute sample intervals. Vibration levels are 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:

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

In addition to measuring and reporting overall vibration levels, statistical vibration levels 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:

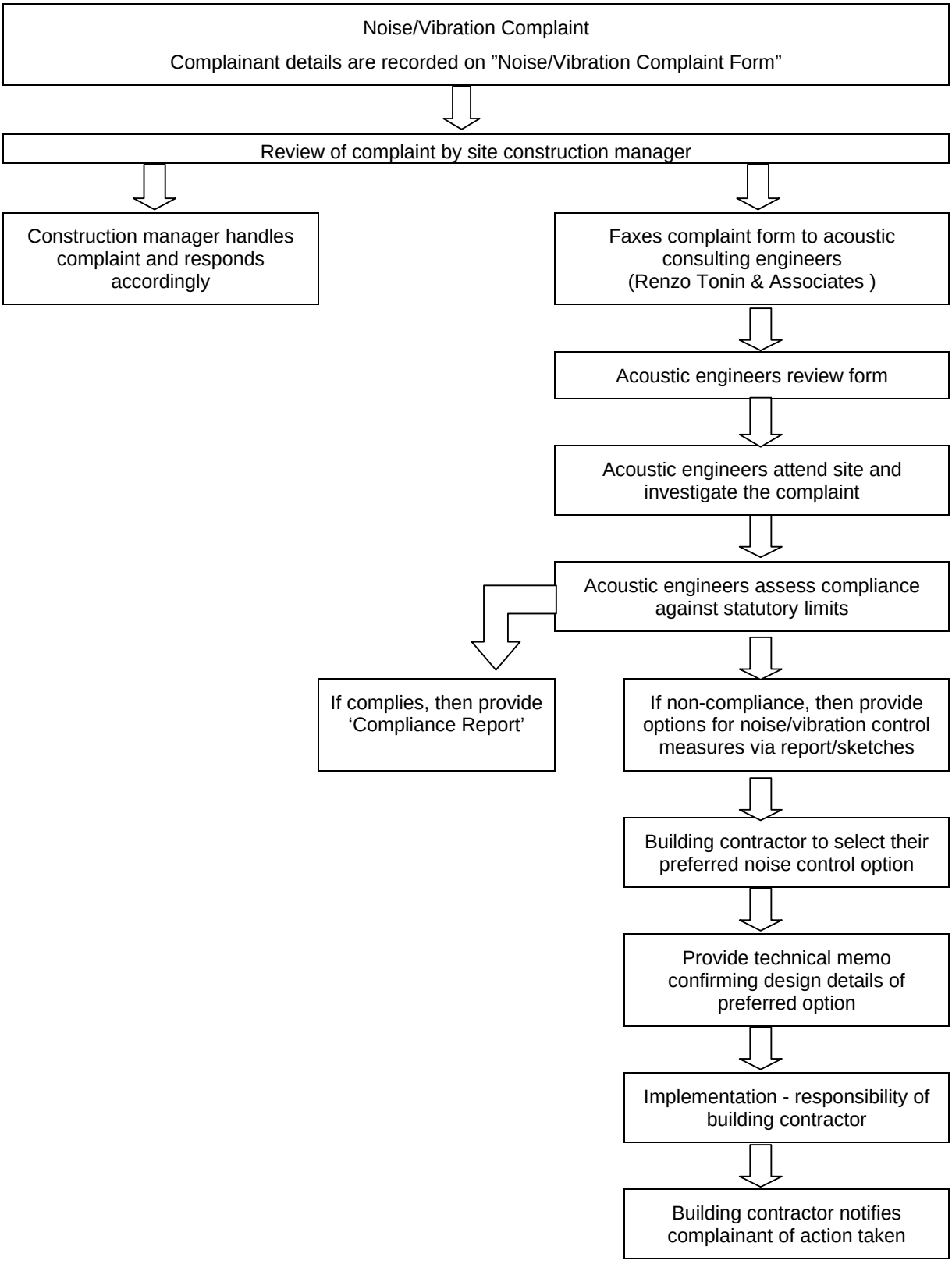
- vibration monitoring equipment shall be placed outside at the footings or foundations of the building of interest, closest to the vibrating plant.
- the surface should be solid and rigid in order to best represent the vibration levels entering the structure of the building under investigation
- the 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
- 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 (ie 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
- Possible vibration influences from other sources (eg domestic vibrations, other mechanical plant, traffic, etc)

APPENDIX E - NOISE / VIBRATION COMPLAINT MANAGEMENT PROCEDURE



NOISE/VIBRATION COMPLAINT FORM

COMPLAINANT'S DETAILS

Date :		**Received by** (tick a box) **:**	**Phone** ☐	**Written in** ☐	**Person** ☐		
Complaint Received By:			**Complainant's Name:**				
Complainant's Address:							
Complainant's Contact Numbers:	**Home:**		**Work:**		**Mob:**		

COMPLAINT DETAILS

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:

.....

.....

.....

.....

.....

.....

.....

.....

Please fax this form to Renzo Tonin & Associates Pty Ltd for processing after obtaining approval from the Project Manager - Fax: (02) 8218 0501